MODELLING THE HIDDEN ECONOMY AND THE TAX-GAP IN NEW ZEALAND

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Abstract

This paper develops and estimates a structural, latent variable, model for the hidden economy in New Zealand, and a separate currency-demand model. The estimated latent variable model is used to generate an historical time-series index of hidden economic activity, which is calibrated via the information from the currency-demand model. Special attention is paid to data non-stationarity, and to diagnostic testing. Over the period 1968 to 1994, the size of the hidden economy is found to vary between 6.8% and 11.3% of measured GDP. This, in turn, implies that the total tax-gap is of the order of 6.4% to 10.2% of total tax liability in that country. Of course, not all of this foregone revenue would be recoverable, as not all of the activity in the underground economy is responsive to changes in taxation or other policies.

I. INTRODUCTION

Foregone tax revenue resulting from the underground economy is a major, and apparently growing, problem. We describe a modelling methodology which yields a time-series of the underground economy for New Zealand, from which a series of the "tax-gap" can be obtained. there have been no previous attempts to obtain such measures for New Zealand previously, but this is a topical issue in view of the current political debate on taxation policy and taxation compliance in that country.

The hidden economy and tax-gap have sizeable budgetary implications, and implications for taxation incidence and income distribution. For instance, if a principal cause of growth in the hidden economy is an actual, or perceived, increase over time in the tax burden, then an increase in (average or marginal) tax rates may reduce revenue and worsen the budget deficit. Similarly, if there is a significant hidden component to economic activity, then many economic indicators will be measured with error. Finally, there are political and social implications - a flourishing informal sector may reflect dissatisfaction, on the part of the electorate, with the degree of regulation of their activities.

There is an extensive literature on the measurement of the hidden economy, and section II discusses the major methods that have been used to address this issue. Our own econometric methodology is described in section III; data issues are discussed in section IV; and sections V and VI discuss the formulation and estimation of our models. section VII provides estimated time-paths for the hidden economy and the tax-gap in New Zealand, and our conclusions are summarized in section VIII.

II. MEASURING THE HIDDEN ECONOMY

The evidence on the actual size of the hidden economy is very mixed. Frey and Weck-Hanneman (1984) report that for seventeen OECD countries in 1978, the size of the underground economy (relative to GNP) varied from 4.1% for Japan, through 8.0% for the UK and 8.3% for the USA, to 13.2% in the case of Sweden, and with Canada at the sample mean of 8.8%. In more recent work, Schneider (1997) found that the average OECD figure had risen to about 15% of GDP by 1994, with Canada still close to this international average. The latter figure can be compared with the 5% to 7%

of GDP that Mirus and Smith (1994) estimate for Canada in 1976, rising to almost 15% in 1990. Spiro (1994) estimates the Canadian underground economy at between 8% and 11% of GDP in 1993.

Other studies summarised by Aigner et al. (1988) report figures for the USA in 1978 which range from 4% (Park (1979)) to 33% (Feige (1982)) of GNP. On the other hand, evidence for the USA in 1970 yields a range, for this ratio, from 2.6% (Tanzi (1983)) to 11% (Schneider and Pommerehne (1985)). Bhattacharyya (1990) estimates the hidden economy for the UK to be 3.8% of GNP in 1960, with a peak of 11.1% in early 1976, and averaging around 8% during 1984; while a British Inland Revenue analysis reported by Chote (1995) suggests that the hidden economy comprises 6% to 8% of GDP. The available evidence is varied and imprecise, but the results of our study are consistent with the more robust of the above numbers. There are several surveys of the literature on measuring the hidden economy, including those of Blades (1982), Boeschoten and Fase (1984), Carter (1984), Frey and Pommerehne (1982, 1984), Gaertner and Wenig (1985), Kirchgaessner (1984), Weck (1983), and Tedds (1998).

As well as providing information about the range of the international estimates, these surveys discuss the different techniques (and their strengths and weaknesses) that have been used by various authors. One criticism of most of these approaches is that they focus on one cause of underground economic activity, and one indicator. In contrast, Frey and Weck-Hannemann (1984), Aigner *et al*. (1988), and Tedds (1998) use "latent variable" structural modelling to measure the size of the hidden economy. The (unobservable) latent variable here is the extent of underground activity, perhaps expressed as a percentage of measured real GDP. The MIMIC ("Multiple Indicators, Multiple Causes") model of Zellner (1970), Goldberger (1972), Jöreskog and Goldberger (1975), and others allows for several "indicator" variables and several "causal" variables in forming structural relationships to "explain" the latent variable. This latent variable/MIMIC model approach forms the basis for our own analysis here.

III. A MODELLING METHODOLOGY

The MIMIC model is a variant of the LISREL ("Linear Interdependent Structural Relationships") models, of Jöreskog and Sörbom (1993a,b) and others. A MIMIC model uses observable data on a range of "causal" variables, and a range of data on observable "indicator" variables, to "predict" the values for one or more unobserable ("latent") varaibles. This type of model yields only an time-series index for the latent variables - in our case there is just one such variable, namely the size of the underground economy relative to the size of measured GDP. Accordingly, some sort of extraneous information is needed to calibrate the index so that we can then construct a cardinal time-path of the underground economy. Once the underground activity is measured, the effective tax rate (i.e., the ratio of tax revenue to GDP) can be used to obtain an estimate of the size of the "tax-gap", and to address other policy issues.

We calibrate our hidden economy index via the estimation of a particular currency demand equation. Our currency-demand equation differs from the interesting model proposed by Bhattacharyya (1990), also in the context of underground activity. We allow for different velocities of circulation in the "hidden" and "recorded" sectors; explicitly "explain" hidden activity; and avoid a functional approximation in his approach. We allow for the non-stationarity of our time-series data, which he, and others, do not. Interestingly, our results imply a long-run average value for the "size" of the hidden economy that is almost identical to that obtained by using Bhattacharyya's approach in an earlier version of our work (Giles (1995, 1997a)), as is discussed briefly in Appendix II.

In our model, measured (nominal) currency demand is :

$$M_t = \beta_0' \; Y_{Rt}^{\beta_1} Y_{Ht}^{\beta_2} R_t^{\beta_3} P_t^{\beta_4} , \tag{1}$$

where Y_{Rt} and Y_{Ht} are "recorded" and "hidden" real output or income, R_t is a short-term interest rate variable, and P_t is the price level. The unobservable ratio of "hidden" to "recorded" activity is taken to be a function of variables such as the rate of growth in measured output; the inflation rate and the change in the latter; variables measuring the extent of the tax burden; and one to allow for the introduction of the Goods and Services Tax (GST) in October 1986. The latter is included because Inland Revenue Department (IRD) records suggest that the introduction of this tax in 1986 (together with the simultaneous abolition of sales taxes and dramatic changes to the personal and sales tax scales) had a negative impact on unrecorded activity, especially among the self-employed. The inflation rate is included to allow for the upward "creep" of taxpayers through the tax brackets that it causes, and the associated incentive for tax-payers to engage in unreported activities. A more pervasive effect of inflation is that, as it tends to be uneven across sectors, it alters income distribution, and this may induce disrespect for tax law. The change in the rate of inflation is included in equation (2) below because such variability adds to uncertainty, and strengthens the incentive to enter the hidden economy as a means of risk or cost reduction. So, we have:

$$(Y_{Ht} / Y_{Rt}) = \alpha_1 + \alpha_2 GST_t + \alpha_3 \Delta\log Y_{Rt} + \alpha_4 \Delta\log P_t + \alpha_5 \Delta(\Delta\log P_t). \tag{2}$$

Solving (2) for Y_{Ht}, substituting in (1), taking (natural) logarithms, adding an error term and dummy variables to allow for deterministic seasonality, and for the introduction of "EFTPOS" ("Electronic Fund Transfer at Point of Sale"), bank debit card electronic retail transactions in lieu of cash in 1987.2:

$$\begin{aligned} m_t = \beta_0 + (\beta_1 + \beta_2) y_{Rt} + \beta_2 \log[\alpha_1 + \alpha_2 GST_t + \alpha_3 \Delta gdp_t + \alpha_4 \Delta p_t + \alpha_5 \Delta(\Delta p_t)] \\ + \beta_3 r_t + \beta_4 p_t + \delta_1 S_{1t} + \delta_2 S_{2t} + \delta_3 S_{3t} + \delta_4 DEFT + \epsilon_t , \end{aligned} \tag{3}$$

where $\beta_0 = \log(\beta_0')$, lower case symbol denote natural logarithms of the variables, S_i is the i'th seasonal dummy, and DEFT is the EFTPOS dummy. (We also considered adding a variable for the *value* of EFTPOS transactions as a regressor, without success. A "dynamic" version of the model, incorporating a lagged value of the dependent variable as an additional regressor was also considered, as were the inclusion of various "tax burden" variables in equation (2). None of these refinements produced satisfactory results

In Table 1 below we also report on specifications of (1) which include (P_t / P_{t-1}), (P_t / P_{t-4}), or their lagged values, as regressors with a coefficient denoted β_5. Estimates of the α_i's and of γ can be used with (2) to measure (Y_{Ht} / Y_{Rt}) at each point in the sample. These values are of less interest than those obtained from the MIMIC model, as they are based rather narrowly on a single-equation model, but they provide a useful cross-check on orders of magnitude. The estimate of α_1 in Table 1 is also especially important in its own right as it measures the "long-run average" value for this ratio, and is used for the calibration of the MIMIC model.

Our MIMIC model of the hidden economy is formulated mathematically as follows: η is the scalar (unobservable) "latent" variable (the size of the hidden economy); $\mathbf{y}' = (y_1, y_2, ..., y_p)$ is a vector of "indicators for η; $\mathbf{x}' = (x_1, x_2, ..., x_q)$ is a vector of "causes" of η; $\boldsymbol{\lambda}$ and $\boldsymbol{\gamma}$ are $(p\times1)$ and $(q\times1)$ vectors of parameters; and $\boldsymbol{\epsilon}$ and ζ are $(p\times1)$ and scalar random errors. It is assumed that ζ and all of the elements of $\boldsymbol{\epsilon}$ are Normal and mutually uncorrelated, with Var.$(\zeta) = \psi$, and Cov.$(\boldsymbol{\epsilon}) = \Theta_\epsilon$. The MIMIC model is :

$$\mathbf{y} = \boldsymbol{\lambda}\eta + \boldsymbol{\epsilon} \tag{4}$$

$$\eta = \boldsymbol{\gamma}'\mathbf{x} + \zeta \; . \tag{5}$$

Substituting (5) into (4), the MIMIC model can also be viewed as a multivariate regression model,

$$\mathbf{y} = \Pi\mathbf{x} + \mathbf{z} \, , \tag{6}$$

where $\Pi = \boldsymbol{\lambda}\boldsymbol{\gamma}'$, $\mathbf{z} = \boldsymbol{\lambda}\zeta + \boldsymbol{\epsilon}$, and Cov.$(\mathbf{z}) = \boldsymbol{\lambda}\boldsymbol{\lambda}'\psi + \Theta_\epsilon$.

The p-equation model in (6) has a regressor matrix of rank one, and the error covariance matrix is also constrained. Accordingly, we cannot obtain cardinal estimates of all of the parameters. Only certain "estimable functions" of the parameters can be identified, so we can estimate the <u>relative</u> magnitudes of the parameters, but not their levels. Thus, the estimation of (4) and (5) requires a normalization for (4), which is generally achieved by constraining one element of $\boldsymbol{\lambda}$ to a pre-assigned value. As both **y** and **x** are observable data vectors, the multi-equation model in (6) can then be estimated by conventional (restricted) Maximum Likelihood Estimation - in our case we have used the LISREL package (Jöreskog and Sörbom (1993a,b)) to obtain consistent and asymptotically efficient estimates of the elements of Π, and hence of λ and γ.

Given an estimate of the γ vector, and setting the error term ζ to its mean value of zero, equation (5) enables us to "predict" ordinal values for η (which in our case is the hidden economy) at each sample point. Then, if we have a specific value for η at some sample point, obtained form some other source, we can convert the within-sample predictions for η into a cardinal series. We use the "average" value for (Y_{Ht} / Y_{Rt}) from our estimated currency demand equation (i.e., our estimate of α_1) to calibrate our time-series for the hidden economy by setting the latter to this value in 1981.

IV. DATA ISSUES

The variables are defined in Appendix I. Given the limitations of quarterly New Zealand time-series data, our MIMIC models have been estimated with annual data, for 1968 to 1994, but some experimentation with simple quarterly MIMIC models yielded strikingly similar results. Our currency demand model has been estimated with quarterly data for 1975.1 1994.4. Considerable attention has been paid to testing for stationarity and cointegration, and this appears to be the first application of a MIMIC model which addresses these issues.

The logarithms or levels of the series, as appropriate, have been tested for unit roots at the appropriate frequencies. Complete details of these unit root test results are given by Giles (1995, 1997a). Following Dickey and Pantula (1987), we test I(3) against I(2). If we reject I(3) we then test I(2) against I(1). Then we test I(1) against I(0), as appropriate. We have used the "augmented" Dickey-Fuller (ADF) test (e.g., Said and Dickey (1984)) to test for unit roots at the zero frequency. The quarterly data are not seasonally adjusted, and in this case we include a drift and seasonal dummy variables in the ADF regression and choose an augmentation level of at least three. This is based on the evidence provided by Ghysels et al. (1994). The lower limit of p=3 was never binding, as can be seen from Table 1. The dummy variables (S_{1t}, S_{2t}, and S_{3t}) allow for deterministic seasonality in the data, and in this case the ADF regression is always fitted with a "drift" term. Dods and Giles (1995) show that for samples of our size a preferred method involves choosing this number so that the autocorrelation and partial autocorrelation functions for the residuals of the ADF regression are "clean", and this is the procedure followed here. To determine if a time-trend should also be included in the ADF regression, we follow the Dolado et al. (1990) sequential testing strategy. The series PUBEMP exhibits a major structural break in its trend from 1988, and as this will distort the ADF "t-tests" in favour of not rejecting a unit root, Perron's (1989) modified test has been used in this case.

With the quarterly data we also allow for stochastic seasonality, and test for unit roots at the zero, π, and $(\pi/2)$ frequencies, following Hylleberg et al. (1990) (or HEGY hereafter) and Ghysels et al. (1994). We have determined the augmentation levels in the HEGY regressions in the same way as for the ADF tests. Following the recommendations of Ghysels et al. (1994), we include a trend, drift, and seasonal dummy variables in the HEGY regressions.

V. ESTIMATING THE CURRENCY DEMAND MODEL

Our currency demand model is given in equation (3), and it contains several non-stationary variables. The stationarity of the regressor in (3) whose coefficient is β_2 is unclear - this term is both non-linear and unobservable; but p_t and m_t are both I(2), and y_t and r_t are I(1), so we have an "unbalanced regression". We cannot simply "filter" the series according to their orders of integration, as this generates many negative observations, making the estimation of the model impossible. Estimating the model without filtering the data would result in a "spurious regression" (Granger and Newbold (1974)). One possibility is to exploit any cointegration among the variables, and estimate (3) directly as a long-run cointegrating relationship, resulting in valid asymptotic inferences. Testing for cointegration is complicated, here, given the mixture of I(1) and I(2) variables, the non-linear model, and the possibility of seasonal cointegration. Given these problems, a simple but somewhat indirect cointegration testing strategy has been followed. The HEGY tests indicate that the only potential for cointegration is at the zero frequency, but this is rejected when standard Engle-Granger tests are applied. We then apply Haldrup's (1994) tests for cointegration involving I(2) data, using within-sample predictions for the series, $\log[\alpha_1 + \alpha_2 GST_t + \alpha_3 \Delta gdp_t + \alpha_4 \Delta p_t + \alpha_5 \Delta(\Delta p_t)]$. The null of no cointegration is again easily rejected, providing reasonable justification treating our estimated "unbalanced" regressions as long-run equilibrium relationships. More complete details of this aspect of the modelling work are given by Giles (1997a).

The results of estimating the currency demand model, by Maximum Likelihood, using the SHAZAM (1993) package, over the period 1975.1 to 1994.4, appear in Table 3 for our preferred specification, together with some alternative specifications, including several in which the inflation rate enters the basic equation (1), with a coefficient denoted β_5. (In Models 3 and 5 the regressor associated with β_5 is the current quarterly rate of inflation; in Model 2 it is this rate lagged one period; and in Model 4 it is the lagged annual inflation rate.) These results illustrate the robustness of our estimate of the long-run average ratio of "hidden" to "measured" output, α_1. A range of conventional diagnostic tests for the preferred specification appear in Table 4.

The within-sample <u>averages</u> of the "predicted" (Y_{Ht} / Y_{Rt}) ratio, from equation (2), range from 8.4% to 8.7% across the models. In "Model 1" this estimated ratio varies from 5.5% to 10.8% over the sample, and these values may be compared with the data in Figure 1 below. The estimates of α_1, which represent long-run average values for (Y_{Ht} / Y_{Rt}) generally are very "sharp", and are consistent with the value arrived at from a different currency-demand model - a modification of that of Bhattacharyya (1990) - in Appendix II. The estimate of α_1 is 8.9% for Model 1, and that the corresponding sample average of (Y_{Ht} / Y_{Rt}) is 8.7%, so we use 8.8% in 1981.4, which is where the sample mean of the GDP series occurs, to calibrate our MIMIC models below by setting the "predicted" hidden economy series to this value in 1981.

The sample correlation between actual and "fitted" m_t is 0.99 for all of the models in Table 3, and the estimated coefficients have the expected signs. As $\beta_0 = \log(\beta_0')$, its sign is ambiguous, even though we expect $\beta_0 > 0$. The anticipated sign of β_5 is also ambiguous: we might expect high inflation to lead to a <u>reduction</u> in the holding of nominal balances, including currency; or, as the estimated Models 2 to 4 are non-homogeneous in prices, a <u>positive</u> estimate of β_5 may reflect the effect of inflationary expectations. This is <u>not</u> an issue in the preferred Model 1. Although the significance of the individual parameter estimates is "mixed", many of the key parameters are precisely estimated. Testing the appropriate non-linear restrictions on the parameters with Wald tests, we reject income homogeneity, but cannot reject (short-run) price homogeneity at the 10% significance level, or lower in Model 1.

In Table 4, GOF is the goodness-of-fit test for normal errors, and JB is the corresponding Jarque-Bera (1980) test statistic. There is no evidence of non-normal errors. RESET2, RESET3 and RESET4 are asymptotic versions of Ramsey's (1969) test for a mis-specified functional form and/or omitted variables, constructed as Wald tests and using powers of the predicted values of m_t. The RESET2 and RESET4 statistics are significant at the 2.5% level, but the latter is not significant at the 1% level. DeBenedictis and Giles (1998) show that the RESET test has extremely poor power, and is often a "biased" test. (That is, its power can fall below its significance level over part of the parameter space.) They propose an alternative test using a Fourier approximation, and show that it has excellent power. Their FRESET2, FRESET3 and FRESET4 tests in Table 4 are asymptotically valid in the present context. FRESET2 is based on two sine terms plus two cosine terms, etc. The outcomes of these tests clearly support the this model's specification.

LM1 to LM4 are Lagrange Multiplier tests for serial independence against the respective alternatives of first, and general second, third and fourth order autoregressive (or moving average) errors. There is no evidence of serial correlation. H1, H2 and H3 are tests for heteroscedasticity based on regressing the recovered squared residuals from the non-linear regression on the fitted values, the square of the fitted value, and the logarithm of the square of the fitted values respectively. Although the various tests have only asymptotic justification here, given the non-linearity of the model, the results in Table 4 strongly support our preferred currency demand model, and its use as the basis for calibrating the predictions from our structural MIMIC model.

VI. ESTIMATING THE"MIMIC" MODEL OF THE HIDDEN ECONOMY

Prior to the estimation of the MIMIC model by the LISREL package, all of the data have been filtered to make them stationary, according to the orders of integration in Table 2. For instance, logCPI is second-differenced, logGDP and UN are first-differenced, but PUBEMP and REGS are not differenced at all prior to the estimation of the model. The coefficient of the labour force participation rate "indicator" is constrained to unity, without loss of generality, in order to ensure the identification of the models, in view of the shortage of rank noted earlier in section III. The Maximum Likelihood estimates of the coefficients (γ) of the "causal" variables ($\mathbf{x}$) in the structural equation for the hidden economy (η) in equation (5) provide the basis for predicting η (the size of the hidden economy) over the sample period. These estimates of the elements of γ are obtained only up to a scale factor, and they are used as relative weights to obtain a time-series index for η. The actual (not differenced) values of the causal variables are used with the estimated elements of γ. This index is then scaled to take a value of 8.8% in 1981, and this provides a series for the hidden economy, as a percentage of recorded real GDP.

Several MIMIC model specifications have been considered. Following earlier such studies for other countries, our "causal" variables allow for unemployment and income effects; the degree of economic regulation; the development of taxation legislation; the tax-bracket "creep" effect of inflation; and measures of the "tax burden". Up to three "indicator" variables are incorporated - the rate of growth in real GDP; the proportion of currency to M3; and the male labour force participation rate. As noted already, we have constrained the coefficient of the latter variable to unity to identify the models. Although Frey and Weck-Hanneman (1984) and Aigner et al. (1988) argue that this variable should be a negative indicator of the size of the hidden economy, in the New Zealand case it is clear from audit records and other evidence that most unrecorded economic activity is undertaken by agents who are also in the recorded workforce, suggesting a positive relationship. Indeed, we have found no models involving a negative coefficient for MPRT, and in which the signs of the various causal variable coefficients are all of the anticipated signs.

The implied series for the hidden economy are generally insensitive to the model specification. Representative results appear in Table 5. Model 1 is very sparsely specified, and Model 5 generates an implausible historical time-series for the hidden economy. It is included, however, to illustrate that the statistical significance of the individual variables may not be the most important issue. The overall "fit" of the model is also important, as is the economic "believability" of the model's implications. For reasons given below, Model 2 is our preferred specification.

The results in Table 5 permit some interesting interpretations. Unlike the situation in a conventional regression model, because of the normalizations that have been introduced in the estimation of a MIMIC model the values of the estimated coefficients can be compared in relative terms. For instance, as we have normalized the coefficient of the male labour force participation rate (MPRT) variable to unity when identifying the model, the estimated coefficients on the "logGDP" indicator variable suggest not only a significant positive relationship between the size of the hidden economy and growth in measured GDP, but they also suggest that the effect of the hidden economy on the rate of growth in GDP is 1.2 to 2.8 times as great as its effect on the male labour force participation rate. The predicted positive effect of the hidden economy on the ratio of currency to M3 (i.e., CM3) is more stable (and quite significant) across the different versions of the model, being of the order of 0.75 times that of the effect of the hidden economy on the male labour force participation rate. These values have obvious implications regarding the relative merits of these "indicator" variables as reflections of movements in the unobservable underground economy in New Zealand.

Although the "causal" variables have the anticipated signs, many of them lack individual significance. Exceptions include the inflation rate and the (separate) ratios of corporate and "other" taxes to GDP in most of the models. An inspection of the coefficients of the causal variables is also revealing. For example, if we consider Model 2 (which we focus on below as a "preferred" specification), then the following emerges if we "distribute" the sum of the absolute coefficients across the various general types of causal factors: taxation effects (in terms of both the overall "burden" and the make-up of the tax-take) account for 52% of the causal effects; inflation accounts for 24%; regulatory effects for 11%; real personal income for 8%; and the unemployment rate for 5%. So, for example, the (positive) effects of an increase in inflation on the size of the underground economy are estimated to be roughly twice as important as the (positive) effects of an increase in the amount of regulation in the economy. This is not surprising when one takes into account the secondary effect of inflation whereby it induces "bracket-creep" with respect to the statutory tax schedule, and effectively increases the average marginal tax rate, ceteris paribus.

Other inferences are also interesting. For instance, the introduction of the GST (and the simultaneous dramatic reductions in direct taxes) in 1986 were roughly twice as important in reducing the size of the hidden economy as are reductions in the average tax rate for average tax payers. Similarly, the increase in the GST rate from 10% to 12.5% in mid-1989 took effect in conjunction with a halving of the land tax rate, and a very recent reduction of the corporate tax rate from 45% to 28% and a simplification of the personal tax schedule to a two-step system. These changes to the tax burden and tax-mix led to a reduction in the hidden economy, but the effect of these changes was only about 80% as important as the earlier such changes in 1986. Finally, we see increase in the unemployment rate lead to an <u>increase</u> in the size of the underground economy, and the associated impact is almost identical to the <u>reduction</u> in the underground economy that results from a tightening of taxation regulations.

The Chi Square statistics in Table 6 test the specifications of the MIMIC models against the alternative that the covariance matrix of the observed variables is unconstrained (see Jöreskog and Sörbom (1993a, pp.121-122)). Small values reflect a good "fit" of the models. The other statistics relate to criteria for measuring the overall performance of a MIMIC model. (See Jöreskog and Sörbom (1993a, Chap. 4).) <u>Small</u> values of Akaike's (1974) Information Criterion (AIC); of Bozdogan's (1987) CAIC measure; of the single-sample Cross-Validation Index (ECVI); and of the Root Mean Square Residual (RMR) measure favour the model. <u>Large</u> values of the Adjusted Goodness of Fit Index (AGFI), and the Parsimony Goodness of Fit Index (PGFI), reflect a good model fit. These measures should <u>not</u> be compared across models with different sets of indicator variables (and hence different likelihood functions).

The results in Table 6 are satisfactory. The various measures favour Models 2 and 4 over Model 3, so we focus on the more comprehensive Model 2, this being least prone to mis-specification bias.. We have used the estimated "Π matrix" to construct conventional regression residuals series, these being the difference between the fitted and actual values for these "dependent" variables at each sample point for the GDP, MPRT and CM3 equations, scaled to have a zero sample mean in each case. We have then tested them for normality and serial correlation, in Table 7. The notation is as in Table 4, and the results further support Model 2. The use of these diagnostic tests must be treated cautiously in the context of a MIMIC model. While the tests will have asymptotic justification, our sample is quite small, and diagnostic testing in such models is largely unexplored in the literature, and certainly worthy of further attention in the future.

VII. THE HIDDEN ECONOMY AND THE TAX-GAP

Figure 1 provides an annual time-series of the New Zealand hidden economy, as a percentage of real measured GDP. This series was generated by multiplying the causal variables' data, by their associated estimated coefficients (the elements of $\boldsymbol{\gamma}$ in equation (5)) as shown for MIMIC Model 2 in Table 5. The hidden economy series was then scaled to match the long-run average figure of 8.8% in 1981 implied by our currency demand equation results discussed earlier. Corresponding hidden economy series based on the other MIMIC models are given by Giles (1995). Except when the series for the number of public sector employees (which has a major distortive break in its trend in 1988) is included as a "causal" variable, the time-paths are strikingly similar in their overall cyclical movement, and differ only slightly in terms of actual magnitudes. In all cases there is a pronounced downward shift in the relative size of the hidden economy immediately after the introduction of the GST, and the simultaneous reductions in the sales, personal and corporate tax rates in October 1986. Actual real hidden and measured GDP are presented as separate time-series over our sample in Figure 2.

The hidden economy follows the phases of the business cycle in New Zealand. Unrecorded economic activity increased from around 6.8% of measured real GDP in 1968 to a peak of 11.3% in 1987, then fell to 8.7% of GDP in 1992 before increasing to around 11.3% in 1994. There is a secondary effect in the cyclical decline at the time of the increase in the GST rate from 10% to 12.5% on 1 July 1989. Clearly, underground economic activity in New Zealand is positively tied to the business cycle and to the tax burden. Giles and Caragata (1998) and Caragata and Giles (1998) provide simulation results for the responsiveness of the size of the hidden economy to changes in the tax burden and tax mix. The rapid rise in the size of the hidden economy in the early 1970's is consistent with the expansion in real output which took place at that time in New Zealand prior to the international oil price shocks. The cyclical movements during the mid-1970's to mid 1980's follow the (less pronounced) pattern in measured output; and the trough in 1992 (and subsequent expansion), is also associated with the general cyclical movements in the economy. The absolute size of the hidden economy exhibits greater volatility than does measured real output - the associated sample coefficients of variation are 25.9% and 15.0% respectively.

On the basis of these data, Giles (1997b) finds clear evidence of Granger causality from measured to hidden activity, and weak evidence of reverse causality. This poses a dilemma for policy-makers wishing to stimulate economic growth, but contain the "tax-gap". These data are also used by Giles (1997d, 1999) to test for asymmetries in the measured and hidden business cycles. No asymmetries are found, implying that fiscal and monetary policy changes that respond to the observed business cycle are likely to have consistent effects on the hidden cycle. Finally, Giles (1997c) finds strong evidence of Granger causality from tax-related prosecutions to the size of the hidden economy in New Zealand, suggesting that the compliance efforts of the IRD are pro-active, rather than reactive.

Unrecorded economic activity is untaxed, implying a shortfall between actual and potential tax revenue. The total "tax-gap" can be estimated by multiplying the hidden/measured GDP ratio by total tax revenue, and the associated results (as percentages of total tax liability or of nominal GDP) appear in Figure 3. (The tax-gap, as a percentage of total tax liability is a monotonic increasing function of the Hidden/measured GDP ratio, so the "shape" of the former graph in Figure 3 is identical to that of the latter in Figure 1.) The tax-gap ranged from 6.4% to 10.2% of total tax liability over the sample, representing NZ$0.07Billion to NZ$3.18Billion in foregone nominal revenue. This compares with IRS audit-based tax-gap estimates for the United States of the order of 19%, 18% and 17% (of total tax liability) in 1985, 1988 and 1992 for individual tax-payers (Internal Revenue Service (1996)). Of course, this measure of the tax-gap has to be qualified, as it assumes that all hidden activity is taxable, and that the incidence of the existing tax structure would be the same within the hidden sector as it is within the currently measured sector of the economy. Some aspects of these issues are addressed by Caragata and Giles (1998) and Giles and Caragata (1998): they provide simulation evidence indicating that in the New Zealand context, about half of the tax-gap is responsive to fiscal instruments (on average over the cycle), the rest being hard-core criminal evasion. They also show that a shift in favour of indirect taxation, and away from direct personal income tax, can have a significant impact on hidden activity and the tax-gap.

VII. CONCLUDING COMMENTS

In this paper we have presented an econometric methodology for estimating the hidden economy, and have applied this methodology to New Zealand data. Our use of a structural MIMIC model, which treats the size of the hidden economy as a "latent" variable, is not novel in itself, but our coordination of this approach with a new currency demand model does distinguish our modelling methodology from others that have been used in this field. In addition, this study is the first such one to take proper account of the non-stationarity of the various economic time-series that are used in the estimation of the models.

We find that over the period 1968 to 1994, the New Zealand hidden economy averaged just under 9% of measured GDP, varying between 6.8% in 1968 and 11.3% in 1994. This ratio, and measured activity itself, were highly cyclical over this period, and these figures are consistent with the microeconomic evidence for New Zealand firms provided by Giles (1998a). The implied "tax-gap" ranged from 6.4% to 10.2% of total tax liability, or (equivalently) from 1.6% to 3.9% of GDP, in gross terms. Of course, only part of this tax-gap is recoverable in practice via fiscal means, and the results of Caragata and Giles (1998) and Giles and Caragata (1998) suggest that this amounts to about 50% of the total, on average over the cycle.

This same methodology can be applied to other countries, and recent such work for Canada by Tedds (1998) is being refined by her and the author. The availability of historical time-series data on the hidden economy provides new opportunities for empirical analyses of policy issues, with an explicit allowance for both measured and hidden sectors. For example, Giles (1998b) shows that the demand for money (M3) function in New Zealand is stable if its formulation allows for both hidden and recorded outputs. Johnson (1998) uses the data generated here to study money-income causality in New Zealand, and shows that allowing for the underground economy does not enhance the predictability of income from money. The results of these studies have important implications for monetary policy, but much more such work remains to be done if the policy implications of the underground economy in that and other countries are to be fully appreciated.

TABLE 1

Outcomes of Unit Root Tests

Currency Demand Models: Quarterly Logarithmic Data

Variable		ADF Tests		HEGY Tests
	I(3) vs. I(2)	I(2) vs. I(1)	I(1) vs. I(0)	
CPI	Reject I(3)	I(2)		SI(1)
CURR	Reject I(3)	I(2)		SI(1)
GDP	Reject I(3)	Reject I(2)	I(1)	SI(1)
RBILL	Reject I(3)	Reject I(2)	I(1)	Zero

TABLE 2

ADF Tests for Unit Roots

MIMIC Models : Annual Levels Data

Variable		ADF Tests	
	I(3) vs. I(2)	I(2) vs. I(1)	I(1) vs. I(0)
AATR	Reject I(3)	Reject I(2)	I(1)
AMTR	Reject I(3)	Reject I(2)	I(1)
log(CPI)	Reject I(3)	I(2)	
(CURR/M3)	Reject I(3)	Reject I(2)	I(1)
log(GDP)	Reject I(3)	Reject I(2)	I(1)
MPRT	Reject I(3)	Reject I(2)	I(1)
PUBEMP	Reject I(3)	Reject I(2)	I(0)
REGS	Reject I(3)	Reject I(2)	I(0)
RPDI	Reject I(3)	Reject I(2)	I(1)
TAXC	Reject I(3)	Reject I(2)	I(1)
TAXG	Reject I(3)	Reject I(2)	I(0)
TAXLEG	Reject I(3)	Reject I(2)	I(1)
TAXO	Reject I(3)	Reject I(2)	I(1)
UN	Reject I(3)	Reject I(2)	I(1)

Table 3

Estimated Currency Demand Models

Coefficient ("t value")	Expected Sign	Model 1	Model 2	Model 3	Model 4	Model 5
β_0	+/-	0.213	-0.578	0.326	n.a.	1.044
		(0.13)	(-0.39)	(0.21)	(n.a.)	(0.69)
β_1	+	0.035	0.244	0.007	0.128	0.034
		(0.08)	(1.34)	(0.03)	(0.35)	(0.18)
β_2	+	0.276	0.141	0.302	0.222	0.128
		(0.61)	(3.72)	(10.43)	(0.41)	(8.47)
β_3	-	-0.104	-0.082	-0.100	-0.062	-0.101
		(-3.89)	(-3.70)	(-4.62)	(-2.40)	(-4.56)
β_4	+	0.729	0.694	0.724	0.680	0.746
		(18.11)	(19.26)	(19.26)	(19.73)	(19.23)
β_5	+/-	n.a.	-0.425	0.732	-0.350	1.272
		(n.a.)	(-0.64)	(1.14)	(-1.69)	(2.23)
α_1	+	0.089	0.088	0.089	0.087	0.104
		(3.23)	(11.11)	(21.93)	(1.56)	(14.99)
α_2	-	-0.027	-0.002	-0.010	-0.002	-0.050
		(-0.85)	(-0.08)	(-0.90)	(-0.16)	(-5.52)
α_3	+/-	-0.076	n.a.	n.a.	n.a.	n.a.
		(-0.82)	(n.a.)	(n.a.)	(n.a.)	(n.a.)
α_4	+	0.362	n.a.	n.a.	n.a.	n.a.
		(0.71)	(n.a.)	(n.a.)	(n.a.)	(n.a.)
α_5	+	0.044	n.a.	n.a.	n.a.	n.a.
		(0.26)	(n.a.)	(n.a.)	(n.a.)	(n.a.)
δ_1	+/-	-0.102	-0.135	-0.117	-0.126	-0.084
		(-3.99)	(-6.39)	(-5.46)	(-6.66)	(-4.12)
δ_2	+/-	-0.159	-0.135	-0.135	-0.135	-0.125
		(-4.62)	(-8.15)	(-8.06)	(-8.28)	(-5.38)
δ_3	+/-	-0.157	-0.140	-0.144	-0.142	-0.143
		(-7.05)	(-8.18)	(-8.48)	(-8.53)	(-6.86)
δ_4	+/-	n.a.	-0.098	-0.061	-0.089	n.a.
		(n.a.)	(-2.10)	(-1.32)	(-2.33)	(n.a.)

Table 4

Diagnostic Tests for Currency Demand Model 1

"Problem"	Test	Null Distribution	Statistic Value	p-Value
Non-Normality	GOF	$\chi^2(3)$	1.292	0.731
	JB	$\chi^2(2)$	0.536	0.765
Omitted Variables/ Wrong Functional Form	RESET2	$\chi^2(1)$	12.927	0.000
	RESET3	$\chi^2(2)$	2.150	0.341
	RESET4	$\chi^2(3)$	10.745	0.013
	FRESET2	$\chi^2(4)$	0.314	0.990
	FRESET3	$\chi^2(6)$	4.283	0.638
	FRESET4	$\chi^2(8)$	5.051	0.752
Autocorrelation	LM1	$\chi^2(1)$	2.606	0.106
	LM2	$\chi^2(1)$	1.871	0.171
	LM3	$\chi^2(1)$	0.871	0.351
	LM4	$\chi^2(1)$	2.927	0.087
Heteroskedasticity	H1	$\chi^2(1)$	2.479	0.115
	H2	$\chi^2(1)$	2.463	0.117
	H3	$\chi^2(1)$	2.491	0.115

Table 5

MIMIC Model Results: Parameter Estimates

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Indicators					
logGDP	1.234	2.759	2.546	2.358	1.427
[+]	(1.89)	(1.88)	(2.02)	(2.13)	(2.72)
MPRT	1.000	1.000	1.000	1.000	1.000
[?]	(n.a.)	(n.a.)	(n.a.)	(n.a.)	(n.a.)
CM3		0.700	0.711	0.668	0.863
[+]		(1.49)	(1.47)	(1.41)	(2.00)
Causes					
AATR	0.126	0.054	0.058	0.060	
[+]	(0.57)	(0.93)	(0.97)	(0.94)	
AMTR	0.146				
[+]	(0.65)				
CPI		0.289	0.310	0.330	0.340
[+]		(1.65)	(1.83)	(1.94)	(2.58)
GST	-0.149	-0.095	-0.198	-0.122	-0.731
[-]	(-0.91)	(-0.56)	(-1.33)	(-1.32)	(-2.59)
GST2		-0.075			
[-]		(0.56)			
PUBEMP					-0.582
[-]					(-2.51)
REGS		0.078	0.071	0.094	0.252
[+]		(0.98)	(0.93)	(1.12)	(1.97)
RPDI		0.090	0.091	0.104	0.268
[?]		(0.82)	(1.10)	(1.16)	(2.10)
TAXC	0.272	0.153	0.156	0.170	
[+]	(1.55)	(1.47)	(1.56)	(1.62)	
TAXG			0.097		
[?]			(0.84)		
TAXLEG		-0.060	-0.055	-0.069	-0.307
[-]		(-0.76)	(-0.75)	(-0.86)	(-2.50)
TAXO	0.216	0.242	0.282	0.295	0.400
[+]	(1.24)	(1.63)	(1.77)	(1.86)	(2.65)
UN		0.064			
[?]		(0.45)			

Notes: Anticipated signs appear in brackets.
Asymptotic "t-values" appear in parentheses below the estimated coefficients.

Table 6

MIMIC Model Results: Goodness-of Fit

	Model 1	Model 2	Model 3	Model 4	Model 5
Summary Statistics					
Chi Square	1.57	31.77	26.02	24.41	34.75
(n.c.p.; d.o.f.)	(0 ; 4)	(11.8 ; 20)	(8.0 ; 18)	(6.4 ; 16)	(20.8 ; 14)
[p-value]	[0.81]	[0.47]	[0.46]	[0.36]	[0.47]
AIC	49.57	173.77	146.02	122.41	116.75
CAIC	103.77	334.10	281.51	235.32	209.33
ECVI	1.98	6.95	5.84	4.90	4.67
AGFI	0.88	0.43	0.48	0.52	0.31
PGFI	0.14	0.19	0.20	0.21	0.21
RMR	0.04	0.10	0.10	0.10	0.12

Notes: n.c.p. = non-centrality parameter; d.o.f. = degrees of freedom.

Table 7

MIMIC Model 2 : Diagnostic Tests of "Conventional Residuals"

	GOF	JB	LM1	LM2	LM3	LM4
CM3	3.047	0.469	0.679	0.112	0.353	0.221
	(0.38)	(0.79)	(0.41)	(0.74)	(0.55)	(0.64)
logGDP	3.047	0.476	0.729	0.096	0.349	0.243
	(0.38)	(0.79)	(0.39)	(0.76)	(0.55)	(0.62)
MPRT	3.047	0.508	0.741	0.090	0.374	0.239
	(0.38)	(0.78)	(0.39)	(0.76)	(0.54)	(0.62)

Note: Asymptotic p-values appear in parentheses.

APPENDIX I

DATA DEFINITIONS

Variable	Definition	Source
AATR	Average Average Tax Rate (%)	IRD
AMTR	Average Marginal Tax Rate (%)	IRD
CM3	CURR/M3	RBNZ
CPI	Consumer's Price Index, All Groups (1993.4=1,000)	STATNZ
CURR	Currency (Notes and Coins) in Circulation ($ Millions)	RBNZ
DEFT	EFTPOS Transactions Dummy Variable	
GDP	Real Gross Domestic Product (1982/1983 $ Millions)	STATNZ
GST	GST Introduction Dummy Variable	
GST2	GST Increase Dummy Variable	
MPRT	Male Labour Force Participation Rate (%/100)	STATNZ
M3	Money Supply, M3 ($ Millions)	RBNZ
PUBEMP	Public Service Employees , Regulatory Depts. (Number)	BERL
RBILL	90-Day Treasury Bill Rate (Quarterly Average, % p.a.)	RBNZ
REGS	Index of Degree of Regulation of N.Z. Economy	BERL
RPDI	Real Personal Disposable Income/Labour Force	STATNZ
TAXC	[(TCOMP/CPI)/GDP]*10,000	IRD; STATNZ
TAXG	[(TGST/CPI)/GDP]*10,000	IRD; STATNZ
TAXLEG	Number of Sections in Income Tax Legislation	IRD; BERL
TAXO	[(TOTHER/CPI)/GDP]*10,000	IRD; STATNZ
TCOMP	Gross Tax Revenue - Companies ($ Millions)	IRD
TGST	Tax Revenue - Goods & Services Tax ($ Millions)	IRD
TOTHER	Gross Tax Revenue - Other Persons ($ Millions)	IRD
UN	Unemployment Rate (Total : Males + Females; %)	STATNZ

Note: BERL = Data Constructed by Business and Economic Research Limited; IRD = Series Compiled from Official Data by Inland Revenue Department; RBNZ = Official Data Supplied by Reserve Bank of New Zealand; STATNZ = Oficfial Data Published by Statistics New Zealand

APPENDIX II

An earlier version of this work formulated the currency demand model in the manner suggested by Bhattacharyya (1990) in his study of the hidden economy in the United Kingdom. As noted in section III above, our preferred cueency demand model is more flexible than that of Bhattacharyya, and it does not involve any functional approximations. However, as the application of several versions of his model to our data provides estimates of the long-run average ratio of hidden to measured output are almost identical to our 8.8%, we present here a brief summary of these earlier results.

Demand for currency comprises two parts - that for recorded activity and that for hidden activity:

$$M_t = M_{Rt} + M_{Ht}$$

where, with lower case symbols (in our earlier notation) denoting natural logarithms,

$$m_{Rt} = \log\alpha_0 + \beta_1 y_{Rt} + \beta_2 r_t + \beta_3 p_t + \epsilon_t$$

$$m_{Ht} = \beta_4 y_{Ht}.$$

Combining these equations, taking a first-order Taylor series approximation, and using the proxy:

$$Y_{Ht} = \alpha_1 Y_{Rt} + \alpha_2 Y_{Rt}^2 + \alpha_3 Y_{Rt}^3 + \alpha_4 Y_{Rt}^4 + \dots\dots\dots + \alpha_n Y_{Rt}^n + \omega_t$$

we get the non-linear estimating equation (which includes the EFTPOS dummy variable):

$$m_t = \log\alpha_0 + \delta_1 DEFT_t + \beta_1 y_{Rt} + \beta_2 r_t + \beta_3 p_t + [(\alpha_1 Y_{Rt})^{\beta_4} / (\alpha_0 Y_{Rt}^{\beta_1} R_t^{\beta_2} P^{\beta_3})] + \text{error},$$

where we have taken n=1, so that α_1 is the long-run average ratio of Y_{Ht} to Y_{Rt}. Allowing for an AR(1) process in the error, with autocorelation parameter ρ, we obtain the following results (with the diagnostic tests defined as in Table 4 above):

	α_0	α_1	β_1	β_2	β_3	β_4
Estimate	1.160	0.086	0.711	-0.100	0.731	-34.647
"t-value"	(2.443)	(20.143)	(8.287)	(-3.285)	(21.418)	(-19.406)

	δ_1	ρ
Estimate	-0.108	-0.009
"t-value"	(-2.981)	(-0.079)

$R^2 = 0.982$;	LM1 = 0.016;	LM2 = 0.668;	JB = 10.262;	GOF = 11.975
	$[\chi^2(1)]$	$[\chi^2(1)]$	$[\chi^2(2)]$	$[\chi^2(3)]$

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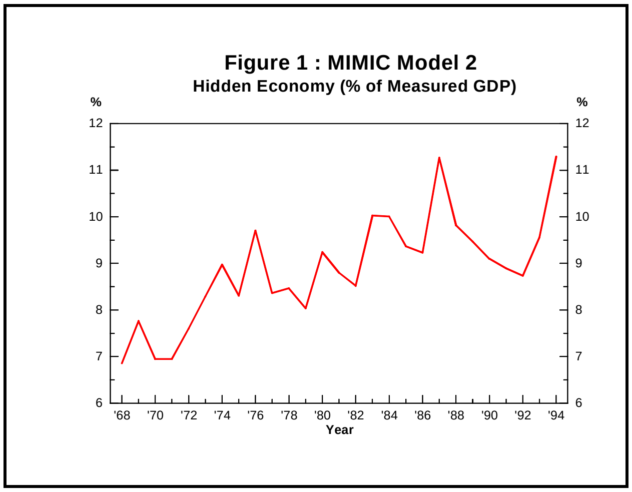
Figure 1 : MIMIC Model 2
Hidden Economy (% of Measured GDP)

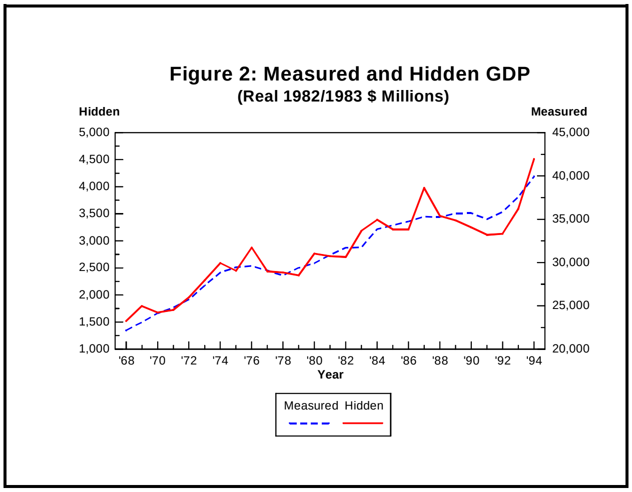
Figure 2: Measured and Hidden GDP
(Real 1982/1983 $ Millions)

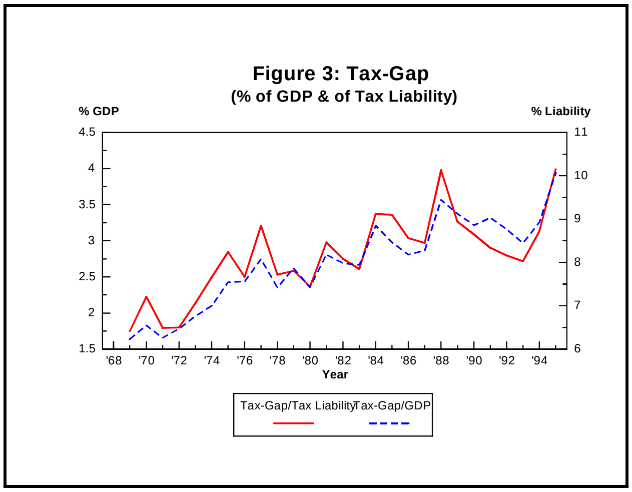
Figure 3: Tax-Gap
(% of GDP & of Tax Liability)