Revealing Australia's Underground Economy*

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Abstract

This study, using currency demand model, finds Australia's underground economy to be around 2 to 3 per cent of gross domestic product. We extend the related literature (see, *inter alia*, Bajada, 1999 and Breusch, 2005) in three novel ways. First, we use Austrian levels of taxes and welfare payments as the minimum levels of taxes and welfare payments. Secondly, we employ the currency demand measurement as in Cagan (1958), i.e., cash and currencies as a proportion of total money supply. Third, we use Cagan's original assumption regarding equalities of velocities of currencies in both the legal and illegal economies in order to estimate the underground economy.

JEL classification: E26, E41, E51, E62

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I. Introduction

This study focuses on revealing Australia's underground economy. OECD (2002) refers to legal but concealed (from authorities to evade taxes or regulation) production activities as 'underground economy'. Estimating the extent of such an economy remains important from policy making perspective. For instance, presence of a large underground economy would imply authorities like Australian Taxation Office are losing potentially large tax revenue. It would also signal inefficient law enforcement mechanisms at the federal and the state level. Policies are, therefore, needed to plug these twin loopholes. In a series of papers, Bajada (1999, 2001, 2002) finds a large underground economy in Australia, with estimates of unrecorded income hovering around 15 per cent of official gross domestic product. The Australian Bureau of Statistics (ABS, 2004), however, disagrees and puts forward a modest 1 per cent to 2 per cent estimate for underground economy. Bruesch (2005) argues that Bajada's method is non-robust as results in Bajada (1999, 2001, 2002) would change considerably with simple changes in the units of measurement of variables. In addition, Bruesch (2005) also points that Bajada's (1999) key assumption regarding the equal velocities of currencies in both the official and underground sectors may not make much sense.

This paper makes a number of novel contributions in the above debate after addressing the non-robustness issue coming out from the units of measurements of variables. First of all, we resolve the non-robustness problem by incorporating a "benchmarking" idea to reflect real life situations of excess sensitivity to taxes and welfare payments. In particular, we incorporate Austrian taxation and welfare rates as benchmarks for taxes and welfare payments. Austrian tax rates and welfare payments are the lowest among OECD countries. In addition, the existing literature (see, Schneider, 1994 and Johnson *et al.*, 1998) points that Austria has a considerably smaller underground economy when compared to an average across OECD countries. Secondly, unlike the previous studies[1], we interpret currency demand as in Cagan (1958), i.e., cash and currencies (M0 money) as a proportion of total money supply (M3 money). Currency demand model, proposed by Cagan (1958) is widely used in the literature to unearth the potential magnitude of an underground economy. Third, following Cagan (1958) and Schneider and Enste (2000), we provide justification to possible equality (or, otherwise) in velocities of currencies in both the official and underground sectors. Our results, using Austrian tax rates and welfare payments as benchmarks show that the underground economy estimate in Australia tends to be within 2 to 3 per cent of gross domestic product for the time period September 1959 to March 2006.

Many methods, including direct methods (using surveys and tax auditing data) and indirect methods (calculating discrepancies between income gross national product and expenditure gross national product, transactions approach, currency demand approach and physical input method) have been used in the literature to uncover the extent of underground economy around the world. Schneider and Enste (2000) and Bajada (2002, Chapter 3) provide surveys of these methodologies. The currency demand approach (pioneered by Cagan, 1958) is the most popular of all the above approaches. The basic intuition of the currency demand model is the fact that almost all underground activity is

[1] Tanzi's (1983) approach comes closer to our approach in this paper. However, Tanzi (1983) uses the ratio of cash holdings to current and deposit accounts as a proxy for currency demand whereas we use the ratio of cash and currencies to total money supply.

solely carried out with cash (notes and coins). Furthermore, it is understood that there are at least two potential reasons for delving into the underground economy: (i) high level of tax rates and (ii) higher welfare payments. The higher tax rates may induce under-reporting of income in order to pay less tax. Relatively high and easily obtainable welfare payments may encourage people to take up work in an all-cash transaction underground economy while receiving these benefits. The high tax rate and high welfare payments are, therefore, taken as measures of "excess sensitivity" on currency demand.

Researchers investigate whether changes in taxes and welfare payments affect currency holdings in two settings: in presence of excess sensitivity (high tax rates and welfare payments) and in absence of excess sensitivity. This approach has been applied to a number of OECD countries (see, for instance, Schneider, 1997; Schneider, 1998; Johnson, Kaufmann and Zoido-Lobaton, 1998 and Williams and Windebank, 1995). Bajada (1999) also uses excess sensitivity of real currency holdings per capita to average tax rates and welfare benefits to measure the extent of underground economy in Australia between June 1966 and June 1996. Bruesch (2005), however argues that this is improper as it is sensitive to the units of measurement of the variables. For example, if the tax rate measurement unit is changed from percentage to decimal fraction, it produces a totally different inference about the size of the underground economy. Breusch (2005) proposes using mean corrected logarithm of tax rate as a solution to the above identified problem and reports that measurement of underground economy varies between –1.5 per cent and +0.8 per cent of observed GDP once he implements that solution.

In this paper, we employ an extended version of currency demand model, similar to Bajada (1999). However, we use Austrian tax rates and welfare payments as "benchmarks", i.e., we investigate what would be the extent of underground economy in Australia if taxes and welfare payments are set at the Austrian level. This benchmarking takes care of the non-robustness issue pointed out by Breusch (2005, 2006). Breusch (2005, 2006) shows that when Bajada (1999, 2006) drops tax rates and welfare payments completely in his version of currency demand model, it generates a mathematical representation violating actual empirical reality. Additionally, it leads to incorrect inference regarding the size of the underground economy. Intuitively, it is also not appealing to drop taxes and welfare payments completely, as these are important fiscal and social policy instruments and it is difficult to envisage that tax rates and welfare payments are zero in the real economic world. In the existing literature, Tanzi (1982), Schneider (1986) and Hill and Kabir (2000) employ the historically low tax variables as their representation of "absence of excess sensitivity". These low taxes were observed at a time when the underground economy was thought either to be non-existent or before some major change was made to the tax regimes.

Cagan (1958) puts forward high income tax rate as the main reason for tax evasion and consequent surge in the demand for currency as a proportion of total money supply during war times. Following Cagan (1958), we use cash and currencies (M0 money) as a proportion of total money supply (M3 money) as a proxy for currency demand in Australia. This ratio is important to track down cash usage in the economy. With the onset of technological improvement in the financial sector, all cash transactions seem to be a thing of the distant past. However, currencies and coins still remain in demand, especially for the consumers operating in the legal economy. For the underground economy, all-cash transactions are omnipresent. All cash and currencies in both legal and underground economies are part of the total money supply in the economy[2]. A ratio can therefore capture the currency demand better than using cash and currencies alone. It is important to note that tax rates in Australia are also quite high, and, this high tax rate can provide some justification in operating in the all cash underground economy.

In order to disentangle the extent of underground economy, researchers using currency demand modeling technique have to rely on one assumption: that the velocities of currencies or number of transactions carried out in currencies are the same in the legal as well as in the illegal (underground) economy. Cagan (1958, pp. 315) himself puts forward that assumption and argues that it is a conservative one. The conservatism comes from the fact that number of transactions involving currencies would be more in the underground economy than in the legal economy, as underground economy is nothing but an all-cash transaction economy. Schneider and Enste (2000) cite Klovland's (1984) work for Scandinavian countries and Hill and Kabir's (1996) study for Canada, where they are skeptical about the equality of velocities in both the legal and illegal economies, as they argue that there are uncertainties about the velocity of money in the official economy to begin with. For our study we rely on Cagan's assumption that equality of velocities may be an understatement, but it gives one the tool to measure the baseline conservative scenario. Even if the estimates are on the conservative side, policies can still

[2] We are assuming no counterfeit currencies are present in both legal and underground economies.

be formulated and adjusted to tackle the conservative baseline scenario regarding the extent of underground economy first.

The rest of the paper is organized in the following way. In the next section we describe the extended version of the currency demand model and the data we use in our study. Section three outlines the methodology and estimation strategy. Section four contains discussion of results. Section five concludes.

II. Currency Demand Model and Data

Currency Demand Model

We use the following extension of the currency demand model[3] similar to Bajada (1999):-

$$Cd = f(Y - Tx + Wf, R, \pi, E, Tx, Wf, Tr) \tag{1}$$

where,

$Cd =$ Real currency per capita where, currency is defined as M0 divided by M3.

$Y - Tx + Wf = YD$, which is real disposable income in per capita terms, where $Y =$ income GDP, $Tx =$ direct taxes on income, and $Wf =$ government welfare payments.

$R =$ the interest rate, measured as 90-day bank bill rate.

$\pi =$ rate of inflation, measured as the change in the GDP deflator.

$E =$ private consumption expenditure expressed as a percentage of GDP.

$Tx =$ direct taxes on income, expressed as a percentage of income GDP.

[3] Please refer to Appendix 1 for a complete description of the variables.

Wf = government welfare payments, expressed as a percentage of YD.

Tr = technological trend variable to control for the growth in electronic methods of payment.

The above function estimates the real currency held per capita controlling for certain shocks on the amount of money in the economy. A substantial deviation from Bajada (1999) and prior literature in the above model comes from our interpretation of real currency. In our setup, the real currency is the level of currency holding (M0) as a proportion of total money supply (M3). Currency holdings include private non-bank sector holdings of notes and coins, and M3 money includes currency holdings plus bank current deposits of the private non-bank sector plus all other Authorized Deposit-Taking Institution (ADI) deposits of the private non-ADI sector (RBA).

Disposable income is calculated as the income measure of gross domestic product minus taxation on income plus government welfare payments. This practice is known as 'excess sensitivity' to both taxes and welfare. While taxes and welfare both affect disposable income, we are also interested in finding the effect taxes and welfare levels have on currency. Following Cagan (1958), we assume that with higher taxes there are greater incentives for individuals to move into the underground economy by underreporting income. In addition, we think that higher welfare payments would give individuals enough incentives to move into the underground economy by earning income while also receiving unemployment benefits. To uncover the extent of underground economy, we estimate the above currency demand function twice: one time in the presence of the above high level of taxes and welfare payments and for the second time, in the presence of a minimum level of taxes and welfare which may eliminate the incentive to participate in the underground economy. We use Austrian tax rates and welfare payments[4] as the minimum level of taxes and welfare payments because of two facts: (i) Austrian taxes and welfare payments are far less than Australian tax rates and welfare payments (ii) Schneider (1994) reports that Austria has the smallest evidence of underground economy among the OECD countries. The difference between the above two levels of currency demands will help us to conjecture about the extent of underground economy in Australia.

We incorporate inflation and interest rates to control for the cost of holding money. The interest rate is measured as a 90-day bank bill rate, which is the monetary policy tool used by the Reserve Bank of Australia to change interest rates in the Australian economy. Interest rates in banks are based on the changes in these bill rates. Therefore, we think it is a good proxy for the interest rate prevailing in the economy. We also incorporate the private consumption expenditure as a proportion of GDP, as this may reflect additional demand for currency for private final consumption as a proportion of total money supply. The technology trend variable is used to control for the advancement in technology that eliminates the need to hold cash as a means of payment. The technology includes advancements in the Electronic Funds Transfer at Point of Sale (EFTPOS) system and the use of credit cards, internet banking, etc.

[4] Please refer to Appendix 1 for complete description of Austrian data used in this study.

Data

We use quarterly seasonally unadjusted data from September 1959 until March 2006, which comprises of 187 observations. We also use data for Austria in order to set a base of taxes and welfare in a country that has historically low taxes and welfare and from previous literature, a considerably smaller underground economy when compared to an average across OECD countries. The Austrian data spans the same time frame from September 1959 until March 2006. Austrian data collected comprises of government welfare payments, taxes on income and gross domestic product. Please refer to Appendix 1 for a complete description of the Austrian variables.

Before model based estimation, we check for unit roots and stationarity for all time series variables in the dataset. We take the natural logarithms of all variables except inflation[5] and then test for unit roots using augmented Dickey-Fuller test. The test results are reported in Table 1. The results show some evidence of unit roots in levels for all variables except for logarithm of tax rates. First differencing the variables eliminates the unit root problem and all variable now become stationary. Our estimation analysis is carried out with these first differenced data alongwith the variables in levels.

III. Methodology and Estimation

We use the following versions of error correction models (similar to Bajada, 1999) to unearth the potential magnitude of underground economy. Equation (2) is estimated with Australian variables and equation (3) is estimated with Austrian variables.

[5] By taking the logarithm of inflation we lose observations as the log of a non positive number is impossible, therefore, we do not take the log of inflation in order to maintain the accuracy of the model. Furthermore, the model is no better off when the log of inflation is taken.

$$\begin{aligned}\Delta \ln Cd_t = {} & \alpha_0 + \alpha_1 \Delta INF_t + \alpha_2 \Delta \ln Tx_t + \alpha_3 \Delta \ln R_t + \alpha_4 \Delta \ln E_t + \alpha_5 \Delta \ln YD_t \\ & + \alpha_6 \Delta \ln Wf_t + \alpha_7 \ln Tx_{t-1} + \alpha_8 \ln R_{t-1} + \alpha_9 \ln E_{t-1} + \alpha_{10} \ln YD_{t-1} \\ & + \alpha_{11} \ln Cd_{t-1} + \alpha_{12} D_2 + \alpha_{13} D_4 + \varepsilon_t \end{aligned} \tag{2}$$

where,

$\Delta \ln Cd_t$ = the differenced logarithm of real currency demand per capita defined as M0 divided by M3, at time, t.

ΔINF_t = the differenced change in the GDP Deflator, at time, t.

$\Delta \ln Tx_t$ = the differenced logarithm of direct taxes on income as a percentage of GDP, at time, t.

$\Delta \ln R_t$ = the differenced logarithm of interest rates, at time, t.

$\Delta \ln E_t$ = the differenced logarithm of private consumption expenditure as a percentage of GDP, at time, t.

$\Delta \ln YD_t$ = the differenced logarithm of real disposable income per capita, calculated as income GDP minus taxes plus welfare, at time, t.

$\Delta \ln Wf_t$ = the differenced logarithm of government welfare payments as a percentage of YD, above, at time, t.

D_2 and D_4 = the seasonal dummies representing quarter two and quarter four respectively.

ε_t = the error term that controls for deviations form expected values. We assume the error term exhibits normal least squares characteristics of zero mean, constant variance and zero covariance[6].

[6] E (ε_t) = 0, Var (ε_t) = σ^2 , and Cov (ε_t, ε_s) = 0, where $t \neq s$

Lagged variables are one period before (in comparison to current period) observations of levels of tax, interest rate, private consumption expenditure and disposable income. The lagged variable of currency demand included in the above equation as an independent variable controls for the fluctuation in currency demand. Seasonal dummies have been included as the data we have used is seasonally unadjusted[7].

We now repeat the estimation regression by incorporating taxation and welfare variables as those for Austria as a base for no underground economy. The model we use is similar to the previous model equation (2) and is presented below:

$$\begin{aligned}\Delta \ln Cd_t^{**} &= \alpha_0^* + \alpha_1^* \Delta INF_t + \alpha_2^* \Delta \ln Tx_t^* + \alpha_3^* \Delta \ln R_t + \alpha_4^* \Delta \ln E_t + \alpha_5^* \Delta \ln YD_t \\ &\quad + \alpha_6^* \Delta \ln Wf_t^* + \alpha_7^* \ln Tx_{t-1}^* + \alpha_8^* \ln R_{t-1} + \alpha_9^* \ln E_{t-1} + \alpha_{10}^* \ln YD_{t-1} \\ &\quad + \alpha_{11}^* \ln Cd_{t-1}^{**} + \alpha_{12}^* D_2 + \alpha_{13}^* D_4 + \varepsilon_t^*\end{aligned} \tag{3}$$

The main difference between equations (2) and (3) lies in the values of taxes and welfare payments, indicated in the above equation as Tx^* and Wf^* respectively. These two new variables are:-

Tx^* = Direct taxes on income in Austria as a percentage of Austrian GDP.

Wf^* = Government welfare payments in Austria as a percentage of Austrian disposable income; Austrian disposable income is calculated as Austrian income GDP minus Austrian taxes plus Austrian welfare payments.

[7] Seasons two and four have only been included as the other seasons prove to be insignificant. Also the lagged welfare variable is not included as it also proves to be insignificant. In addition, the technological trend variable is omitted due to its statistical insignificance.

Table 2 reports the estimation results[8] for currency demand as a proportion of total money supply from Equation 2. The estimated coefficients are consistent in a majority of cases and have expected signs. For our purpose, we specifically highlight the behavior of income taxes and welfare payments. The variable for taxes is positive which is reflective of the fact that as taxes increase there is greater incentive to use cash in transactions. All cash transactions reduce the risk of detection by authorities. The negative coefficient of welfare payments indicates that an increase in the growth of welfare payments decreases the growth of currency demanded. Bajada (1999) indicates this may be the result of trading work in either the underground or official economy for leisure[9]. Table 4 depicts the diagnostic test results from Equation 2 (refer to the first column). These results show that residuals from the model/equation are reasonably well behaved[10], i.e., they show no evidence of heteroskedasticity or omitted variable bias. The estimated parameters are stable from the CUSUM test figure listed in Appendix 2. The above findings are robust in the sense that the same conclusion can be reached if we use different specifications of the model: linear-linear, log-linear, log-log, and linear-log. The robustness check results are not reported here but are always available on request from the corresponding author.

[8] Before estimation, we check for possible endogeneity between currency demand, disposable income, taxes, welfare payments and consumption expenditure and find no evidence of endogeneity among these variables. These results are not reported here but are always available on request from the corresponding author.

[9] From our results we find a negative response on currency demand to an increase in welfare. We attribute this to a greater tendency to substitute work for leisure with higher welfare. This exceeds the effect of individuals increasing work in the underground economy as welfare increases.

[10] There is some evidence of autocorrelation from the model residuals. MA(1) and MA(2) terms take care of these autocorrelations. However, we decided to report the estimations without MA terms as estimates do not change very much when we include these MA terms. The extent of underground economy will be affected when we include MA terms.

Table 3 shows results from Equation 3, where we employ Austrian tax and welfare rates as "benchmarks" or minimum tax and welfare rates. With these lower taxation and welfare rates, the coefficients are mostly small and hence their signs are negligible. The lower rates result in less sensitivity to changes in tax or welfare. We can see from the table that most of the *t*-statistics are significant at the 1 per cent level. From Table 4 (refer to the second column), the residuals, like from earlier model, are also reasonably well behaved with no heteroskedasticity or omitted variable bias problem. CUSUM test result from Appendix 2 points to the stability of model parameters. The statistical insignificance of the relevant variables, welfare and taxes, comes from the fact that they are actually Austrian figures and do not represent the Australian currency demand variable. The findings remain robust like the previous model.

Estimating the Underground Economy

We manipulate equations (2) and (3) at the first instance to obtain raw values of currency demand. Thereafter, we use the equal velocities of legal and illegal currencies argument to unearth the magnitude of underground economy. We begin with Cd_t from equation (2), written here,

$$\begin{aligned}\Delta \ln Cd_t &= \alpha_0 + \alpha_1 \Delta INF_t + \alpha_2 \Delta \ln Tx_t + \alpha_3 \Delta \ln R_t + \alpha_4 \Delta \ln E_t + \alpha_5 \Delta \ln YD_t \\ &\quad + \alpha_6 \Delta \ln Wf_t + \alpha_7 \ln Tx_{t-1} + \alpha_8 \ln R_{t-1} + \alpha_9 \ln E_{t-1} + \alpha_{10} \ln YD_{t-1} \\ &\quad + \alpha_{11} \ln Cd_{t-1} + \alpha_{12} D_2 + \alpha_{13} D_4 + \varepsilon_{\mathrm{t}}\end{aligned} \tag{2}$$

We now expand the above equation to obtain Cd_t. Following steps describe the calculation:-

$$\begin{aligned}\ln Cd_t - \ln Cd_{t-1} = \hat{\alpha}_0 &+ \hat{\alpha}_1[INF_t - INF_{t-1}] + \hat{\alpha}_2[\ln Tx_t - \ln Tx_{t-1}] + \hat{\alpha}_3[\ln R_t - \ln R_{t-1}] \\ &+ \hat{\alpha}_4[\ln E_t - \ln E_{t-1}] + \hat{\alpha}_5[\ln YD_t - \ln YD_{t-1}] + \hat{\alpha}_6[\ln Wf_t - \ln Wf_{t-1}] \\ &+ \hat{\alpha}_7 \ln Tx_{t-1} + \hat{\alpha}_8 \ln R_{t-1} + \hat{\alpha}_9 \ln E_{t-1} + \hat{\alpha}_{10} \ln YD_{t-1} + \hat{\alpha}_{11} \ln Cd_{t-1} \\ &+ \hat{\alpha}_{12} D_2 + \hat{\alpha}_{13} D_4\end{aligned} \tag{2a}$$

Now, Cd_t is calculated in per capita terms and hence,

$$\Delta \ln Cd_t = \Delta\left(\frac{\ln Cd_t}{\ln Pop_t}\right) \tag{2b}$$

$$\Delta \ln Cd_t = \Delta(\ln Cd_t) - \Delta(\ln Pop_t)$$

After incorporating the above population variable into equation (2a), we obtain

$$\begin{aligned}\ln Cd_t - \ln Cd_{t-1} = \hat{\alpha}_0 &+ \hat{\alpha}_1[INF_t - INF_{t-1}] + \hat{\alpha}_2[\ln Tx_t - \ln Tx_{t-1}] + \hat{\alpha}_3[\ln R_t - \ln R_{t-1}] \\ &+ \hat{\alpha}_4[\ln E_t - \ln E_{t-1}] + \hat{\alpha}_5[\ln YD_t - \ln YD_{t-1}] + \hat{\alpha}_6[\ln Wf_t - \ln Wf_{t-1}] \\ &+ \hat{\alpha}_7 \ln Tx_{t-1} + \hat{\alpha}_8 \ln R_{t-1} + \hat{\alpha}_9 \ln E_{t-1} + \hat{\alpha}_{10} \ln YD_{t-1} + \hat{\alpha}_{11} \ln Cd_{t-1} \\ &+ (\ln Pop_t - \ln Pop_{t-1}) + \hat{\alpha}_{12} D_2 + \hat{\alpha}_{13} D_4\end{aligned} \tag{2c}$$

In addition to the population variable, we must also take note of the GDP deflator, represented in the above equation by INF. Inflation represents the change in the GDP deflator and therefore, the differenced inflation contains a form of double differencing. We show this double differencing issue in notational form below and subsequently we incorporate this information in the functional form (2c).

$$\begin{aligned}&INF = \Delta(GDP\ Deflator) \\ &and \therefore \Delta INF = \Delta[\Delta(GDP\ Deflator)] \\ &\Delta INF_t = \Delta(GDP\ Deflator_t - GDP\ Deflator_{t-1}) \\ &\Delta INF_t = GDP\ Deflator_t - GDP\ Deflator_{t-1} - GDP\ Deflator_{t-1} + GDP\ Deflator_{t-2} \\ &\Delta INF_t = (\Delta GDP\ Deflator_t) - (GDP\ Deflator_{t-1} - GDP\ Deflator_{t-2})\end{aligned} \tag{2d}$$

Incorporating the last line of (2d) into equation (2c) we obtain:

$$
\begin{aligned}
\ln Cd_t - \ln Cd_{t-1} = {} & \hat{\alpha}_0 + \hat{\alpha}_1[GDP\ Deflator_t - GDP\ Deflator_{t-1}] + \hat{\alpha}_2[\ln Tx_t - \ln Tx_{t-1}] \\
& + \hat{\alpha}_3[\ln R_t - \ln R_{t-1}] + \hat{\alpha}_4[\ln E_t - \ln E_{t-1}] + \hat{\alpha}_5[\ln YD_t - \ln YD_{t-1}] \\
& + \hat{\alpha}_6[\ln Wf_t - \ln Wf_{t-1}] + \hat{\alpha}_7 \ln Tx_{t-1} + \hat{\alpha}_8 \ln R_{t-1} + \hat{\alpha}_9 \ln E_{t-1} \\
& + \hat{\alpha}_{10} \ln YD_{t-1} + \hat{\alpha}_{11} \ln Cd_{t-1} + (\ln Pop_t - \ln Pop_{t-1}) \\
& + (GDP\ Deflator_{t-1} - GDP\ Deflator_{t-2}) + \hat{\alpha}_{12} D_2 + \hat{\alpha}_{13} D_4
\end{aligned} \tag{2e}
$$

Next, we calculate the amount of cash and currencies as a proportion of total money supply in the hand of public in presence of high tax rates and high welfare payments in Australia. We denote this by Cd_t^* which has the following expression:

$$
\begin{aligned}
Cd_t^* = \exp[& \hat{\alpha}_0 + \hat{\alpha}_1[GDP\ Deflator_t - GDP\ Deflator_{t-1}] + \hat{\alpha}_2[\ln Tx_t - \ln Tx_{t-1}] \\
& + \hat{\alpha}_3[\ln R_t - \ln R_{t-1}] + \hat{\alpha}_4[\ln E_t - \ln E_{t-1}] + \hat{\alpha}_5[\ln YD_t - \ln YD_{t-1}] \\
& + \hat{\alpha}_6[\ln Wf_t - \ln Wf_{t-1}] + \hat{\alpha}_7 \ln Tx_{t-1} + \hat{\alpha}_8 \ln R_{t-1} + \hat{\alpha}_9 \ln E_{t-1} \\
& + \hat{\alpha}_{10} \ln YD_{t-1} + (\hat{\alpha}_{11} + 1) \times (\ln Cd_{t-1}) + (\ln Pop_t - \ln Pop_{t-1}) \\
& + (GDP\ Deflator_{t-1} - GDP\ Deflator_{t-2}) + \hat{\alpha}_{12} D_2 + \hat{\alpha}_{13} D_4]
\end{aligned} \tag{2f}
$$

We now have our currency demand function, equation (2f), where there is an excess sensitivity to taxes and welfare at the rates applicable to Australia. We now repeat the steps we have taken to transform equation (2) into equation (2f) using equation (3). We denote this currency demand as Cd_t^{**}.[11] Our currency demand equation with an excess sensitivity to the lower tax and welfare rates applicable to Austria is presented below,

$$
\begin{aligned}
Cd_t^{**} = \exp[& \hat{\alpha}_0^* + \hat{\alpha}_1^*[GDP\ Deflator_t - GDP\ Deflator_{t-1}] + \hat{\alpha}_2^*[\ln Tx_t^* - \ln Tx_{t-1}^*] \\
& + \hat{\alpha}_3^*[\ln R_t - \ln R_{t-1}] + \hat{\alpha}_4^*[\ln E_t - \ln E_{t-1}] + \hat{\alpha}_5^*[\ln YD_t - \ln YD_{t-1}] \\
& + \hat{\alpha}_6^*[\ln Wf_t^* - \ln Wf_{t-1}^*] + \hat{\alpha}_7^* \ln Tx_{t-1} + \hat{\alpha}_8^* \ln R_{t-1} + \hat{\alpha}_9^* \ln E_{t-1} \\
& + \hat{\alpha}_{10}^* \ln YD_{t-1} + (\hat{\alpha}_{11}^* + 1) \times (\ln Cd_{t-1}^{**}) + (\ln Pop_t - \ln Pop_{t-1}) \\
& + (GDP\ Deflator_{t-1} - GDP\ Deflator_{t-2}) + \hat{\alpha}_{12}^* D_2 + \hat{\alpha}_{13}^* D_4]
\end{aligned} \tag{3a}
$$

[11] We are not reporting the steps involved as they are exactly the same as those from (2) to (2f). Interested readers can always contact the corresponding author for those details.

The difference between Cd_t^* from (2f) and Cd_t^{**} from (3a) gives us the illegal currency as a proportion of total money supply in the economy. In order to calculate the extent of the underground economy in Australia, we use the velocity of circulation of currency in Australia. As we have mentioned before, Cagan (1958) assumes that velocities from legal and illegal transactions are equal and terms it as a conservative assumption. We follow Cagan (1958) here and allow that velocities of currencies in the legal and illegal economies are equal with the following important note: by making velocities equal, we may underestimate the extent of underground economy; however, it still remains a useful exercise which is significant in policy making. The argument is, even if we are underestimating the size of the underground economy, the policies can be made to wipe out the smaller extent of underground economy first and afterwards, these policies can be suitably adjusted to tackle the bigger magnitude of underground economy.

We calculate velocity from the following:-

$$V_t = \frac{Y_t}{Cd_t} \tag{4}$$

where,

V_t = the velocity of money, at time, t.

Y_t = income GDP, at time, t.

Cd_t = currency demand, at time, t.

Equation (4) shows that velocity is equal to income GDP divided by currency demanded. We now manipulate this equation in order to find underground income that becomes our measure of the underground economy.

$$\frac{Y_{ue}}{Cd_t^*} = \frac{Y_{GNI}}{Cd_t^{**}} \tag{5}$$

where,

Y_{ue} = income in the underground economy.

Cd_t^* = currency demand from equation (2f), where Australian taxes and welfare have been used as the excess sensitivity variables.

Y_{GNI} = official measure of income GDP, in this case represented by gross national income.

Cd_t^{**} = base currency demand from equation (3a), where Austrian taxes and welfare have been used as the excess sensitivity variables and is the state where the underground economy does not exist.

Transposing equation (5) we obtain the following equation (6) for underground income,

$$Y_{ue} = \frac{Cd_t^* \times Y_{GNI}}{Cd_t^{**}} \tag{6}$$

We further manipulate equation (6) in order to obtain an equation for estimating the extent of the underground economy using the variables we have used in this study. We show this in equation (7) below,

$$Underground\ economy = \frac{Cd_t^* \times GNI_{AUT}}{Cd_t^{**}} \tag{7}$$

where,

GNI_{AUT} = Gross national income of Austria, which is the country we used as a base for no underground economic activity in Australia.

Equation (7) shows that the underground economy is calculated as currency demand multiplied by gross national income in Austria all divided by currency demand with Austrian taxes and welfare. We calculate the underground economy as a percentage of GDP by dividing equation (7) by Australia's gross domestic product, GDP_{AUS}, as below,

$$Underground\ economy\ as\ a\ \%\ of\ GDP = \frac{\left(\dfrac{Cd_t^{*} \times GNI_{AUT}}{Cd_t^{**}}\right)}{GDP_{AUS}} \tag{8}$$

IV. Results

We perform the calculation of underground economy using both equations (8) and (9). The results are presented in Table 5. Figure 1 shows the graphical representation of the extent of the underground economy in Australia. From the results, we find the underground economy estimates are much lower (in comparison to existing Australian studies[12]) indicating a small underground economy in Australia. The findings are consistent with those of the Australian Bureau of Statistics findings. From Figure 1, there are small fluctuations in the underground economy, which is hovering around 2.5 per cent for most of the time. In recent periods, there is a decline in the underground economy heading towards 1 per cent of GDP in March 2006. It is interesting to note the decline in the underground economy in the 1960s: it shrinks from nearly 4.5 per cent in

[12] Please refer to Table 6.

1960 to around 2 to 2.5 per cent in 1970. From 1970 onwards, it seems that the underground economy is very stable and follows the fluctuating trends of business cycle. In the 1990s, the evidence of underground economy shows an upward rise in the early to mid 90s and for the rest of the sample time period, underground economy registers a consistent decline. We attribute the recent drop in the underground economy to the decreasing tax rate, which further supports our analysis that taxes affect the extent of the underground economy.

V. Conclusion

In this paper, we attempt to unravel the extent of underground economy in Australia. Our analysis incorporates suggestions from Bruesch (2005) and, therefore, is an improvement over Bajada (1999). We use the original definition of currency demand, cash and currencies as a proportion of total money supply (Cagan, 1958) as the dependent variable in our study. To address the non-robustness problem identified by Breusch (2005), we employ a "benchmarking" idea. In particular, we set the minimum level of tax rates and welfare payments as that of Austrian tax rates and welfare payments (benchmarks), as these are the lowest amongst the OECD countries. In addition, Austria has the smallest underground economy (Schneider, 1994). In this way, we don't have to assume zero taxes and zero welfare payments as in Bajada (1999), which lead to non-robustness of estimates problem (Breusch, 2005). Equality of velocities of currencies in both the underground and legal economies, which is another problem identified by Breusch (2005) in Bajada's (1999) approach has also been addressed in this study relying on Cagan's (1958) assumption. Cagan (1958) mentions that equalities of currencies can be treated as a conservative assumption as one would expect velocity of currency in the underground economy to be at least higher than the legal economy. We argue that our estimation of underground economy in Australia may be on the under-estimation side, but policies can still be formulated to take care of the smaller extent of the underground economy to begin with. Our results, using Austrian tax rates and welfare payments as benchmarks show that the underground economy estimate in Australia tends to be within 2 to 3 per cent of gross domestic product for the time period September 1959 to March 2006. Future work will focus on uncovering underground economy in other OECD countries as well as in rapidly developing countries like China and India.

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Tables

Table 1: Augmented Dickey-Fuller Unit Root Test

Table 1: Augmented Dickey-Fuller Unit Root Test	Level		First Difference	
Variable	t-Statistic	Prob.	t-Statistic	Prob.
$\ln Cd_t$	-1.499	0.532	-5.437	0.000
$\ln YD_t$	-1.672	0.444	-5.139	0.000
$\ln Tx_t$	-3.015	0.035	-19.789	0.000
$\ln Wf_t$	-1.405	0.579	-5.970	0.000
$\ln R_t$	-2.071	0.257	-9.493	0.000
π_t	-2.251	0.189	-14.542	0.000
$\ln E_t$	-2.608	0.093	-4.107	0.001

Notes: Cd is real per capita currency demand, M0 divided by M3; YD is income GDP minus taxes plus welfare payments; Tx is direct taxes on income; Wf is government welfare payments; R is the interest rate; π is the inflation rate and E is private consumption expenditure. The null hypothesis for the unit root test is: there exists a unit root and the alternative hypothesis is: there is no evidence of unit root. The critical t-Statistic is -3.47.

Table 2: Estimation Output for Currency Demand Equation 2

Dependant Variable: Differenced Logarithm of Real Currency per Capita ($\Delta \ln Cd_t$)		
Data Series: Quarter 3, 1959 to Quarter 1, 2006		
Number of Observations		186 after adjustment
Variable	**Coefficient**	**t-Statistic**
ΔINF_t	0.146	1.386
$\Delta \ln Tx_t$	0.052	2.390
$\Delta \ln R_t$	0.003	0.223
$\Delta \ln E_t$	0.208	3.444
$\Delta \ln Wf_t$	-0.049	-1.989
$\Delta \ln YD_t$	-0.044	-0.456
$\ln Tx_{t-1}$	0.018	1.133
$\ln R_{t-1}$	0.005	1.027
$\ln E_{t-1}$	0.037	0.473
$\ln YD_{t-1}$	-0.014	-2.411
$\ln Cd_{t-1}$	-0.036	-2.213
D_2	0.010	2.272
D_4	-0.009	-1.623
Constant	0.212	1.916
Adjusted R-Squared		0.313
Standard Errors of Regression		0.016

Table 3: Estimation Output for Currency Demand Equation 3

Dependant Variable: Differenced Logarithm of Real Currency per Capita ($\Delta \ln Cd_t^{**}$)

Data Series: Quarter 3, 1959 to Quarter 1, 2006

Number of Observations		186 after adjustment
Variable	**Coefficient**	**t-Statistic**
ΔINF_t	0.118	1.090
$\Delta \ln Tx_t^*$	0.003	0.237
$\Delta \ln R_t$	0.006	0.402
$\Delta \ln E_t$	0.169	2.856
$\Delta \ln Wf_t^*$	0.001	0.061
$\Delta \ln YD_t$	-0.153	-1.832
$\ln Tx_{t-1}^*$	-0.001	-1.065
$\ln R_{t-1}$	0.007	1.483
$\ln E_{t-1}$	-0.021	-0.276
$\ln YD_{t-1}$	-0.011	-2.022
$\ln Cd_{t-1}$	-0.041	-2.544
D_2	0.007	1.837
D_4	-0.006	-1.170
Constant	0.116	1.240
Adjusted R-Squared		0.292
Standard Errors of Regression		0.017

Table 4: Diagnostic Tests from Residuals

	Equation 2		Equation 3	
Variable	**Test statistic**	**Prob.**	**Test statistic**	**Prob.**
Durbin Watson	1.990	na	1.990	na
LM Statistic	17.999	0.000	19.230	0.000
Ramsey Reset (2)	0.212	0.809	0.178	0.837
Ramsey Reset (3)	1.614	0.188	0.417	0.741
Bruesch Pagan	0.908	0.546	0.908	0.546

Notes: *Durbin Watson* denotes Durbin Watson test statistic; *LM Statistic* denotes Bruesch-Godfrey serial correlation LM test statistic; *Ramsey Reset* test statistics indicate Ramsey Regression Specific Error tests for omitted variables with two and three additional regressors respectively. *Bruesch Pagan* denotes Bruesch-Pagan-Godfrey test for heteroskedasticity.

Table 5: The Underground Economy in Australia (March 1960 to September 1984)

Quarter	Underground Economy ($m)	Underground Economy % of GDP	Quarter	Underground Economy ($m)	Underground Economy % of GDP	Quarter	Underground Economy ($m)	Underground Economy % of GDP
Mar-1960	13123.07641	3.371807916	**Jun-1968**	15855.00969	2.270840689	**Sep-1976**	55362.14334	2.669470242
Jun-1960	14414.1121	3.614371138	**Sep-1968**	17670.60405	2.441365577	**Dec-1976**	65182.47415	3.050043243
Sep-1960	16653.42392	4.093762025	**Dec-1968**	18433.20832	2.468623051	**Mar-1977**	52871.8119	2.420205617
Dec-1960	16778.8614	4.095401855	**Mar-1969**	15647.60952	2.05106954	**Jun-1977**	56727.13776	2.542107899
Mar-1961	14683.56832	3.600678842	**Jun-1969**	17167.24113	2.205735722	**Sep-1977**	61892.65316	2.719719346
Jun-1961	15544.30057	3.847599152	**Sep-1969**	19286.27786	2.415313445	**Dec-1977**	73906.40922	3.184660198
Sep-1961	17485.74091	4.3432044	**Dec-1969**	19816.95049	2.399727596	**Mar-1978**	62145.16223	2.616858777
Dec-1961	17562.87824	4.30462702	**Mar-1970**	17482.29801	2.056740942	**Jun-1978**	65956.72927	2.706472272
Mar-1962	14648.30334	3.500191957	**Jun-1970**	19736.64026	2.280901452	**Sep-1978**	72806.88781	2.884697801
Jun-1962	15486.21215	3.615739469	**Sep-1970**	21671.74198	2.469151417	**Dec-1978**	82544.31914	3.145504121
Sep-1962	17108.80756	3.924038431	**Dec-1970**	22759.02524	2.53582454	**Mar-1979**	73387.64072	2.702148118
Dec-1962	17115.04651	3.878324612	**Mar-1971**	20544.02968	2.211413314	**Jun-1979**	78013.67864	2.787596607
Mar-1963	14130.37646	3.140083658	**Jun-1971**	22583.21199	2.35021459	**Sep-1979**	88214.86027	3.065357574
Jun-1963	15438.29034	3.329370356	**Sep-1971**	26011.03242	2.647433326	**Dec-1979**	101182.4086	3.410604667
Sep-1963	17139.18721	3.589358578	**Dec-1971**	25627.28256	2.566321105	**Mar-1980**	80818.66259	2.643378773
Dec-1963	17154.40637	3.508776104	**Mar-1972**	24174.95824	2.376851661	**Jun-1980**	88943.09089	2.827899367
Mar-1964	14014.93068	2.814243109	**Jun-1972**	25881.54383	2.481451949	**Sep-1980**	88948.13217	2.737286726
Jun-1964	14763.0773	2.911275351	**Sep-1972**	28772.29035	2.674750428	**Dec-1980**	86738.07476	2.576046888
Sep-1964	16135.37037	3.108335653	**Dec-1972**	27789.50889	2.495690067	**Mar-1981**	71518.65767	2.052126414
Dec-1964	16350.76073	3.071719093	**Mar-1973**	23891.65447	2.05537289	**Jun-1981**	68536.18365	1.900404383
Mar-1965	13317.85394	2.44633614	**Jun-1973**	28196.85563	2.304794477	**Sep-1981**	74365.73342	1.999240084
Jun-1965	14435.19054	2.613177144	**Sep-1973**	30596.39556	2.370894658	**Dec-1981**	82696.16992	2.15894345
Sep-1965	16022.24832	2.888973733	**Dec-1973**	29225.18388	2.170777975	**Mar-1982**	71561.18556	1.818720247
Dec-1965	16054.84465	2.887042735	**Mar-1974**	28031.29666	2.015045407	**Jun-1982**	78497.14347	1.944827894
Mar-1966	13292.24216	2.357616559	**Jun-1974**	30237.5833	2.089674036	**Sep-1982**	84670.81115	2.054618082
Jun-1966	13677.0375	2.362590689	**Sep-1974**	38928.34339	2.566816787	**Dec-1982**	90908.01548	2.182613034
Sep-1966	15295.09154	2.553864008	**Dec-1974**	46262.36351	2.913430538	**Mar-1983**	88005.7498	2.093132353
Dec-1966	15979.55474	2.578179209	**Mar-1975**	40356.83678	2.450472814	**Jun-1983**	89585.05557	2.086090154
Mar-1967	13594.89399	2.136554139	**Jun-1975**	42973.25853	2.52042572	**Sep-1983**	86433.68623	1.935891557
Jun-1967	15026.80224	2.315377849	**Sep-1975**	44488.07279	2.514586977	**Dec-1983**	92085.54359	1.970081374
Sep-1967	16324.88521	2.485140084	**Dec-1975**	46668.46835	2.540195316	**Mar-1984**	79385.7016	1.636447437
Dec-1967	17070.82352	2.567041131	**Mar-1976**	43661.99351	2.283099431	**Jun-1984**	88368.92588	1.778011024
Mar-1968	14487.81064	2.138737916	**Jun-1976**	46745.55217	2.341257747	**Sep-1984**	86270.08626	1.704403474

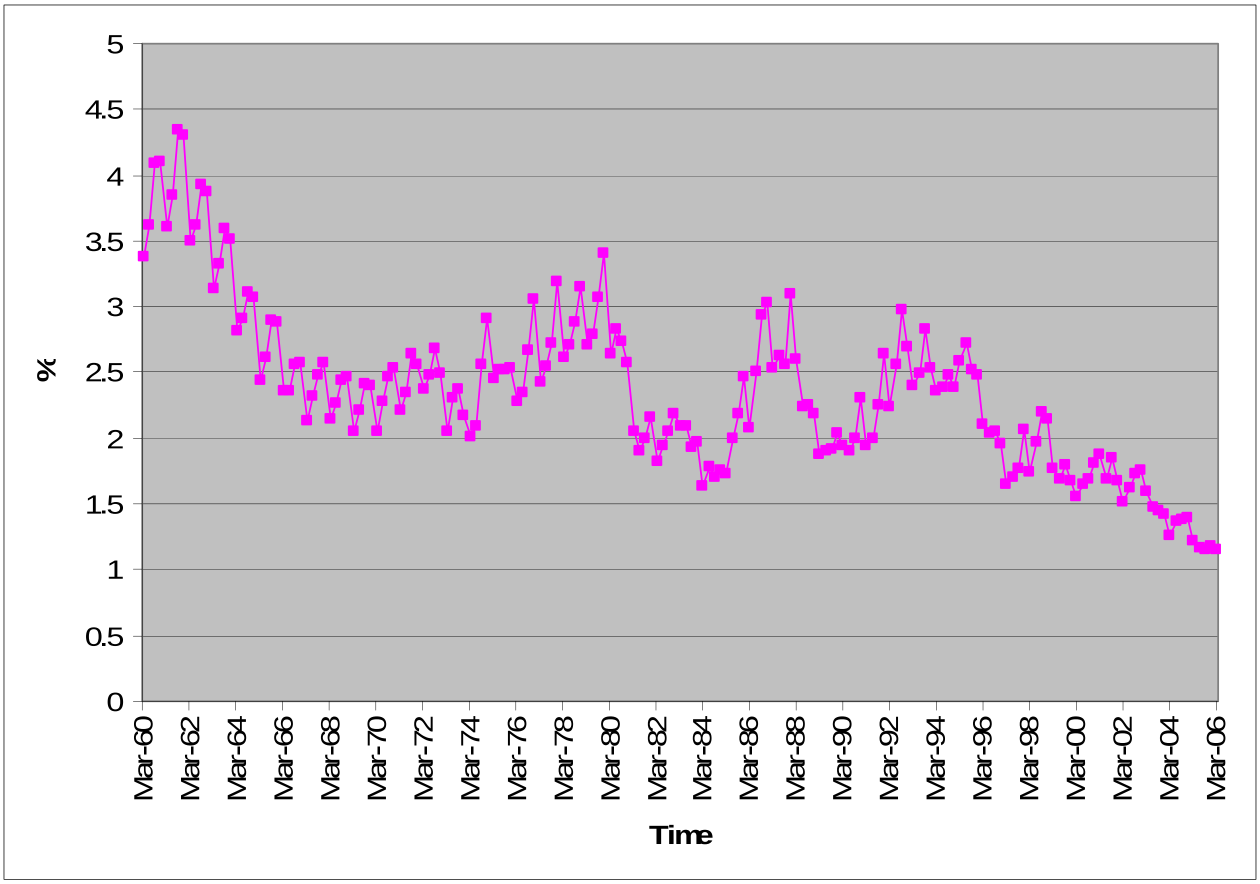
Table 5 (continued): The Underground Economy in Australia (December 1984 to March 2006)

Quarter	Underground Economy ($m)	Underground Economy % of GDP	Quarter	Underground Economy ($m)	Underground Economy % of GDP	Quarter	Underground Economy ($m)	Underground Economy % of GDP
Dec-1984	90571.02649	1.757329915	**Mar-1992**	208771.3247	2.23756283	**Jun-1999**	231018.2197	1.689038345
Mar-1985	91321.29838	1.726365806	**Jun-1992**	242049.3093	2.560203393	**Sep-1999**	249131.5987	1.798303693
Jun-1985	108550.3336	1.996878838	**Sep-1992**	285431.916	2.973713767	**Dec-1999**	238293.2007	1.68225569
Sep-1985	122083.1519	2.185833128	**Dec-1992**	263337.774	2.695260931	**Mar-2000**	226835.4655	1.556097642
Dec-1985	140763.8275	2.462671277	**Mar-1993**	238184.5515	2.401659203	**Jun-2000**	246426.9827	1.654005576
Mar-1986	120931.8507	2.077795448	**Jun-1993**	248944.9085	2.490445263	**Sep-2000**	253615.2897	1.684390373
Jun-1986	148149.5564	2.500034702	**Sep-1993**	284393.423	2.822427334	**Dec-2000**	273995.8643	1.812501583
Sep-1986	177926.8186	2.937685846	**Dec-1993**	258675.2206	2.5304497	**Mar-2001**	286124.3147	1.878627194
Dec-1986	188139.4251	3.026160511	**Mar-1994**	245208.6135	2.356664779	**Jun-2001**	261303.795	1.687976299
Mar-1987	162304.7007	2.52897723	**Jun-1994**	251495.5059	2.380571782	**Sep-2001**	293842.9127	1.855724958
Jun-1987	174387.3432	2.629721373	**Sep-1994**	265459.5643	2.485553172	**Dec-2001**	270714.4719	1.674239439
Sep-1987	175363.7723	2.561401207	**Dec-1994**	257510.5713	2.389955835	**Mar-2002**	250550.97	1.520813424
Dec-1987	218307.7857	3.095466653	**Mar-1995**	282011.5897	2.587072414	**Jun-2002**	271590.3837	1.62643581
Mar-1988	188256.0916	2.597603129	**Jun-1995**	300733.8809	2.717564867	**Sep-2002**	293445.429	1.735131439
Jun-1988	166645.2685	2.232145258	**Sep-1995**	283960.3311	2.520372882	**Dec-2002**	301128.8626	1.757821366
Sep-1988	173631.2568	2.250304654	**Dec-1995**	283912.4678	2.474808168	**Mar-2003**	276465.7021	1.593939982
Dec-1988	174561.9746	2.186178421	**Mar-1996**	245487.5403	2.107949134	**Jun-2003**	260849.3356	1.480920493
Mar-1989	154516.7349	1.873225295	**Jun-1996**	239964.6	2.033563838	**Sep-2003**	260486.0397	1.451264644
Jun-1989	161994.7926	1.909415282	**Sep-1996**	245329.5412	2.05635685	**Dec-2003**	261285.1459	1.426026578
Sep-1989	166250.525	1.915085934	**Dec-1996**	235672.9084	1.95457523	**Mar-2004**	234573.4244	1.255699328
Dec-1989	180079.0912	2.03364304	**Mar-1997**	200841.815	1.643267646	**Jun-2004**	258930.8334	1.365258511
Mar-1990	174314.4058	1.93749409	**Jun-1997**	210771.208	1.697550039	**Sep-2004**	264710.4382	1.37703628
Jun-1990	173537.7321	1.904705654	**Sep-1997**	222456.5805	1.764814088	**Dec-2004**	272833.4454	1.395653162
Sep-1990	183271.0484	1.999967791	**Dec-1997**	263136.8004	2.059247321	**Mar-2005**	241931.3832	1.213315061
Dec-1990	210437.0672	2.301770511	**Mar-1998**	225745.2752	1.743731898	**Jun-2005**	236476.3718	1.160215933
Mar-1991	176809.4731	1.947155115	**Jun-1998**	258892.0644	1.968910673	**Sep-2005**	238404.5573	1.147140899
Jun-1991	180578.2385	1.997436409	**Sep-1998**	292641.4952	2.193582808	**Dec-2005**	248791.7646	1.177467248
Sep-1991	204375.8045	2.249546565	**Dec-1998**	290131.7345	2.150446085	**Mar-2006**	245702.5304	1.146273276
Dec-1991	242639.2903	2.635721939	**Mar-1999**	240569.7805	1.770105885			

Table 6: Estimates of the Underground economy in Australia (as per cent of GDP)

Country	Time Period	Size of Underground Economy	Study
Australia	1978-79	10.7	CBA (1980)
	1970-95	15.1	Bajada (1999)
	1989-90	10.1	Schneider (1994)
	1990-93	13.1	Johnson et. al. (1998)
	1960-2006	2.4	This study

Figure 1 – The Underground Economy in Australia (as per cent of GDP)



Appendix 1: Description of Data

Australian Data

Data is seasonally unadjusted in millions of Australian dollars

Cd Currency Demand, calculated as currency divided by M3 (Reserve Bank of Australia- Table D03).

YD Disposable income calculated as GDP(I) (current prices) minus direct taxes on income (Tx below) plus personal benefits payments (Wf below), (Australian Bureau of Statistics- Table 5206.0-G12-18-19).

Tx Direct taxes on income (current prices; Australian Bureau of Statistics- Table 5206.0-18) expressed as a percentage of GDP (I).

Wf Government Welfare Payments, total personal benefits payments (current prices; Australian Bureau of Statistics- Table 5206.0-19) expressed as a percentage of disposable income (YD above).

E Private Final Consumption Expenditure (current prices, Australian Bureau of Statistics- Table 5206.0) expressed as a percentage of GDP (current prices).

R Interest Rate, expressed as the 90-day bank bill rate (Reserve Bank of Australia- Table F01).

π Inflation Rate, expressed as the percentage change of the GDP price deflator (Australian Bureau of Statistics).

P Price deflator, expressed as the ratio of GDP (E) (current prices; Australian Bureau of Statistics- Table 5206.0) and real GDP (E) (Australian Bureau of Statistics- Table 5206.0).

L Population (‘000) (The World Bank- World Development Indicators).

Y National Income (Australian Bureau of Statistics- Table 5206.0).

Austrian Data

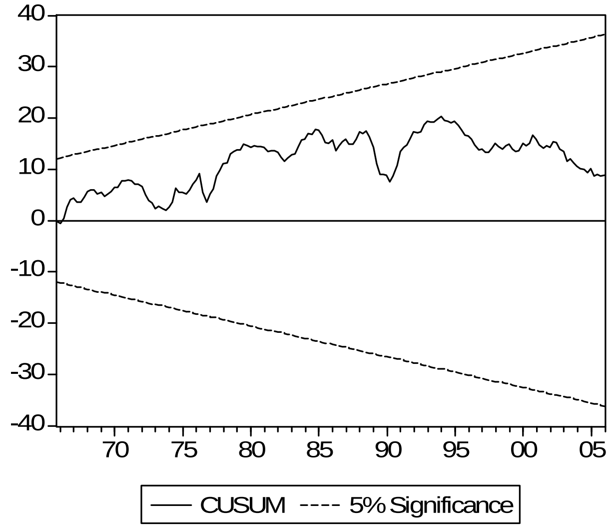
Y* Austrian disposable income calculated as GDP (I) (current prices) minus direct taxes on income (Tx* below) plus personal benefits payments (Wf* below), (World Development Indicators, The World Bank).

Tx* Direct taxes on income, expressed as payroll taxes (current prices; World Development Indicators, The World Bank) expressed as a percentage of GDP(I).

Wf* Austrian Government welfare payments, expressed as social security payments (current prices; World Development Indicators, The World Bank) as a percentage of Austrian disposable income (YD* above).

Appendix 2: Parameter Stability

CUSUM test from Equation 2



CUSUM test from Equation 3