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The Case of New Zealand.

By

Alfred V. Guender
and
Kirdan Lees
Department of Economics
University of Canterbury
Private Bag 4800
Christchurch, New Zealand

E-mail address: a.guender@econ.canterbury.ac.nz
FAX: (64)(3)364-2635

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Introduction.

There is a considerable amount of theoretical and empirical work in the field of optimal taxation policy. An initial study, undertaken by Diamond and Mirrlees (1971), shows that minimizing the cost of raising a given amount of government revenue requires that marginal distortionary costs are equated across all available tax instruments. This result was applied to seigniorage by Phelps (1975). Barro (1979) argues that in an intertemporal setting the optimal collection of revenue would involve equating the distortionary costs of raising revenue through time. More recently, Mankiw (1987) shows that if both fiscal and monetary policy are used optimally to finance an exogenous stream of government expenditures, tax rates and inflation will vary together over time. He runs regressions of the tax variable on inflation and the nominal interest rate and finds considerable support for the optimal theory of seigniorage in the United States. Other contributions to the literature report less favorable results about the empirical validity of the tax smoothing model. Poterba and Rotemberg (1990) find evidence for positive comovements between inflation and tax rates but cannot discern a systematic relationship between inflation and velocity in US data. Their study reveals no empirical evidence favorable to the revenue smoothing model in other countries except Japan. A similar conclusion is reached by Roubini and Sachs (1989) in a study covering 23 OECD countries. Using the Engle-Granger test for cointegration, Trehan and Walsh (1990) find no evidence of a common stochastic trend linking inflation and the tax rate in US data covering the 1914-1986 period. They do, however, find some mild support for the revenue smoothing hypothesis in the post-war period. Froyen and Waud (1995) pursue a slightly different approach. They compare the optimal theory of seigniorage to an alternative hypothesis of monetary policy, the interest rate smoothing hypothesis. Froyen and Waud cannot detect any evidence of a positive relationship between the tax rate and money creation in US data. Hence their results do not support the optimal theory of seigniorage. Some support is found for the interest rate smoothing hypothesis, however.

This paper examines the theory of optimal revenue generation for New Zealand. We show that the theory garners considerable empirical support during the period up to 1989 when the Reserve Bank of New Zealand became independent. In our view this finding is intimately linked to the status of the Reserve Bank. Before gaining independence, the Reserve Bank was obliged to follow the directives of the Treasury. In view of the authority vested in the Treasury before 1989, we argue that the Treasury embodied the omnipotent policymaker. Our findings suggest that during the pre-independence period adjustments in the setting of the two policy instruments occurred in just the fashion the optimizing framework of the tax smoothing model predicts. Relying on the Engle-Granger OLS method for verifying bivariate cointegrating relationships, we observe a long-run relationship between the rate of inflation and the average tax rate over the 1946-88 period. Extending the test to a multivariate setting and using the Johansen maximum likelihood test, we find substantial evidence for a cointegrating relationship among the rate of inflation, the tax rate and velocity over the same period. With the enactment of the Reserve Bank Act in 1989, the cointegrating relationships cease, however. The sudden break in the long-run relationship among the variables, in particular between the rate of inflation and the tax rate, is attributable to the demise of the omnipotent policymaker in 1989.

The remainder of this paper is organized as follows. In Section II we lay out the building blocks of the theory of optimal revenue smoothing. Section III describes the sample periods and the data before presenting the empirical results. Section IV concludes.

II. The Model:

The policymaker has two tools at his disposal to finance government spending. He can finance an increase in spending by issuing more money or by raising taxes. Both forms of taxation have distortionary effects which compromise the efficient working of the economy. Continuous financing of government budgets through printing more money leads to inflation. Inflation, in turn, distorts relative prices, thereby hampering the allocative role of price signals. Alternatively, increases in government spending could be financed exclusively through higher taxes. However, higher average or marginal tax rates have distortionary effects on labor supply and impair the motive to save and invest. Given his control over the rate of inflation and the tax rate, the policymaker attempts to minimize the social deadweight losses which arise from taxation(L^T) and inflation(L^S) subject to the intertemporal budget constraint:

$$E_t[L] = E_t \sum_{i=0}^{\infty} R^{-i}[L^T_{t+i}(\tau_{t+i}, \theta_{t+i}) + L^S_{t+i}(\pi_{t+i}, \epsilon_{t+i})] \tag{1}$$

s.t.

$$\sum_{i=0}^{\infty} R^{-i} E_t(\tau_{t+i} y_{t+i} + s_{t+i}) = Rb_{t-1} + \sum_{i=0}^{\infty} R^{-i} E_t g_{t+i}$$

where E_t denotes expectations at time t, $R^{-i} = (1+r)^{-i}$ = the discount rate in period i, τ_t = the tax rate, π_{t+1} = rate of inflation between period t and period t+1, y_t = the level of real income, s_t = real value of money creation through seigniorage, b_{t-1} = level of real value of interest bearing government debt, g_t = real value of government spending, and θ_t and ϵ_t are stochastic disturbances to be explained below.[1]

Following the approach by Poterba and Rotemberg (1989) and Trehan and Walsh (1990), we adopt constant elasticity functions describing the cost of collecting revenue. Stochastic disturbances are added to both functions in order to capture the impact of exogenous changes on the collection cost. In line with previous contributions, we restate the cost of inflation in terms of the benefits of deflation.

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[1] The real value of seigniorage s_t is defined as the change in the monetary base divided by the aggregate price level: $s_t = (M_t - M_{t-1})/p_t$.

$$L_t^T(\tau_t, \theta_t) = \frac{\tau_t^{1+\alpha}}{1+\alpha}\theta_t$$

$$-L_t^S\left(\frac{p_{t-1}}{p_t}, \epsilon_t\right) = \frac{\left(\frac{p_{t-1}}{p_t}\right)^{1-\beta}}{(1-\beta)}\epsilon_t \tag{2}$$

Both α and β are positive, implying that the losses arising from higher tax rates are increasing in the level of τ_t while the benefits accruing from higher deflation are decreasing in the level of p_{t-1}/p_t where p_t is the aggregate price level in period t. θ_t and ϵ_t are the stochastic shift variables which impinge upon the cost of collecting revenue through taxes and seigniorage, respectively.

Intratemporal optimizing behavior on the part of the policymaker requires that the marginal cost of raising an additional dollar of revenue through increasing taxes be equal to the marginal benefit accruing from lowering inflation revenue by one dollar.[2] Furthermore, intertemporal optimizing behavior implies that the policymaker set the expected marginal distortionary cost of either source of revenue equal across time.

The intratemporal optimizing condition can be expressed in log form as

$$\pi_t = c + \frac{\alpha}{\beta}\ln\tau_t - \frac{1}{\beta}(\ln y_t - \ln m_{t-1}) + \frac{1}{\beta}(\ln\theta_t - \ln\epsilon_t) \tag{3}$$

where π_t = rate of inflation, defined as $\ln(p_t/p_{t-1})$, m_{t-1} = stock of real base money in the previous period, and the remaining variables are as defined above.

The policymaker finances an increase in government spending partly by raising taxes and partly by printing more money. Hence the rate of inflation and the tax rate move in the same direction. The division of the additional revenue between tax revenue and seigniorage depends on the respective base (y_t in the case of taxes and m_{t-1} in the case of seigniorage) and the stochastic

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2 For a similar presentation of the tax smoothing model, the reader is referred to Trehan and Walsh (1990).

disturbances which impinge upon the collection costs. The log difference between y_t and m_{t-1} is interpreted as a measure of velocity.

The intertemporal optimizing conditions can be rendered in log form as

$$E_t \ln\tau_{t+1} = \ln\tau_t + \frac{1}{\alpha}[E_t \ln y_{t+1} - \ln y_t] - \frac{1}{\alpha}[E_t \ln\theta_{t+1} - \ln\theta_t]$$

$$E_t \pi_{t+1} = \pi_t + \frac{1}{\beta}[E_t \ln m_t - \ln m_{t-1}] - \frac{1}{\beta}[E_t \ln\epsilon_{t+1} - \ln\epsilon_t]. \tag{4}$$

Both the tax rate and the rate of inflation follow a nonstationary process. In the special case where there are no unexpected disturbances to real output, the stock of real base money, and revenue collection costs, the tax rate and the rate of inflation follow a random walk.

The intratemporal and the intertemporal optimizing conditions give rise to testable predictions about the time series behavior of the rate of inflation and the tax rate. First, according to the intertemporal optimizing conditions, both series should contain a unit root. Second, according to the intratemporal optimizing condition, the two series ought to be cointegrated. Third, if velocity is nonstationary, then the relationship between inflation, the tax rate, and velocity may be characterized by the presence of multiple, ie. two, cointegrating vectors.

III. Empirical Results:

A. The Sample Periods and the Data:

The sample period stretches from 1935 to 1994. All results reported are based on annual data. Apart from examining the relationship among inflation, the tax rate, and velocity over the whole sample period, we also consider three subperiods. The first subperiod begins in 1935, which coincides roughly with the founding of the Reserve Bank of New Zealand and ends in 1988, the year before the Reserve Bank was granted full independence from the Treasury. During this interval the Reserve Bank maintained a very close relationship with the government. Indeed the passage of the Reserve Bank Act of 1936 marks the beginning of the collaboration between the

Treasury and the Reserve Bank. The Act stipulates that the [Reserve Bank] "give effect as far as may be possible to the monetary policy of the Government as communicated to it from time to time by the Minister of Finance..."[3] In addition to enhancing the power of the Treasury to lean on the Reserve Bank, the act also gave the Treasury greater leeway in securing credit from the Reserve Bank. Subsequent amendments to the original Reserve Bank Act during this sample period provided for yet a closer relationship between the Treasury and the Reserve Bank. These changes eroded further the mandate of maintaining the value of the currency which the blueprint of the original Reserve Bank Act of 1933 had assigned to the central bank of New Zealand. Monetary policy centered on controls on interest rates and exchange rates as well as requiring financial institutions to hold a fraction of their assets in the form of government securities.[4] In essence, "monetary policy was built upon the implicit view that the government should have the maximum flexibility in fiscal and debt policy".[5] The Reserve Bank Act of 1989 forms a major break in the relationship between the Treasury and the Reserve Bank. The act sets out a clear objective for monetary policy and delineates clearly the responsibilities of the Reserve Bank vis-a-vis the government. In particular, the act delegates to the Reserve Bank the sole duty of maintaining price stability through appropriate monetary policies.[6] To eliminate the effects of WWII on the relationship among the variables of interest, we also distinguish between two post-war sample periods: 1946-1988 and 1946-1994.

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[3] Neil Quigley (1992), p.210.

[4] We do not address the issue of the endogeneity of monetary policy in a fixed exchange rate environment nor the issue to what extent the rate of inflation was imported from abroad. Gould (1982, pp.211-214) argues convincingly that the high inflation rates of the 1970s and 1980s were generated domestically and cannot be blamed on rising world trade prices. The New Zealand dollar was not floated until March 1985.

[5] ibid, p.219.

[6] For further details on the Reserve Bank Act of 1989, see Dawe (1992) and Walsh (1995).

The appendix to the paper provides a detailed description of the data and their sources. The tax rate is defined as the ratio of total revenue collected by the central government to nominal GNP. The measure of velocity is calculated as the ratio of nominal GNP to the value of liabilities the Reserve Bank had outstanding during the previous year. The rate of inflation is the log difference of the CPI. Figure 1 traces movements in the rate of inflation and the tax rate. It is apparent that during the war years and the period immediately following WWII, the tax rate and the rate of inflation move in opposite directions. This is attributable to the effect of price controls which kept inflation artificially low and the increase in taxation to finance the war effort. During the Korean conflict, inflation surges above ten percent only to revert to much lower single-digit levels in the following years. Beginning at around 1950, movements in the tax rate start to track closely movements in the rate of inflation. Both series begin to drift upward in the late 1960s and settle at higher average levels during the 1970s and 1980s. Inflation drops off markedly in the late 1980s while the average tax rate shows only a gradual decline. Notice that the gap between the rate of inflation and the average tax rate begins to widen enormously around 1988/89 with the granting of independence to the Reserve Bank. Figure 2 shows that during the post-war period velocity increases markedly. In addition, velocity also becomes much more volatile around 1970 with three spikes occurring in 1970, 1980, and 1989.

B. Tests for Nonstationarity in the Data:

The Phillips-Perron test and the Augmented Dickey-Fuller test (ADF) are used to examine the behavior of the four variables over the whole sample period and the individual subsample periods. Table 1 summarizes the findings of the test for nonstationarity in the time series data. As shown above, if the policymaker acts in accordance with the optimizing framework of the model, then the rate of inflation, the tax rate, and real government spending should contain a unit root.[7] We also test for a unit root in the velocity series. Our findings suggest that over the whole sample period, inflation, the tax rate, and velocity appear to be difference stationary. The null hypothesis of a unit root can be rejected only for government spending at the 5 percent level (Phillips-Perron) or at the 10 percent level (ADF). Unit root tests which span only the individual subperiods produce less clear-cut results. For instance, there are indications that the tax rate is trend stationary over the whole post-war period and that government spending exhibits trend stationary behavior over the 1935-1988 period. Notice though that the evidence over the 1946-1988 period points strongly to the existence of unit roots in the data. The null hypothesis of a unit root cannot be rejected at the 10 percent level for inflation, velocity, the tax rate and government spending on the basis of the Phillips-Perron test. For the tax rate, the ADF test can barely reject the null at the 10 percent level (-3.18) but not at the 5 percent level.[8]

C. Test for Cointegration:

In this section we concentrate on examining the hypothesis underlying the intratemporal optimizing condition of the tax smoothing model. We perform a battery of cointegration tests all of which revolve around the intratemporal optimizing condition. At the outset we use the Engle-Granger methodology to test for the presence of a cointegration relationship between the tax rate and inflation. This is followed by a maximum likelihood test for the existence of more than one cointegrating vector along the lines suggested by Johansen (1988).

The theoretical framework suggests that inflation and the tax rate should move in lock-step under certain conditions. In case of an exogenous increase in government spending, the policymaker increases both the tax rate and the money supply to raise the revenue needed. The

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[7] The model assumes that real government spending is exogenous.

[8] Price controls which kept inflation down were in effect in NZ during the war years. This may explain why the unit root tests for inflation covering the period including the war years rejects the null hypothesis of a unit root but not for the post-war periods.

presumed optimizing behavior of the policymaker should reveal itself in a positive comovement of the average tax rate and the rate of inflation over time as long as velocity is stationary and the disturbances to the cost of collecting revenue are both stationary. Alternatively, in case velocity is non-stationary and the disturbances are non-stationary, the rate of inflation and the average tax rate may still be cointegrated as long as velocity is cointegrated with the disturbances impinging upon the cost of collecting revenue.

Following Mankiw and Trehan and Walsh, we first examine the behavior of the rate of inflation and the average tax rate in isolation. Table 1 summarizes the results of the test for cointegration between inflation and the average tax rate over the four sample periods. Although the coefficient on the tax rate is positive as expected there is no evidence that the rate of inflation and the tax rate were locked into a systematic relationship over the whole sample period. Both the Cointegration Augmented Dickey-Fuller Test and the Cointegration Regression Durbin Watson statistic fail to reject the null hypothesis of a unit root in the residuals of the cointegration equation at conventional significance levels. This result is overturned, however, for the 1935-1988 period and, particularly, for the 1946-1988 period. For the 1935-1988 period the null hypothesis is rejected at the 10 percent level and for the 1946-1988 period at the 5 percent level. This is an interesting finding insofar as through 1988 the Reserve Bank functioned as the "extended arm" of the Treasury. Evidently, the spirit of cooperation between the Reserve Bank and the Treasury yielded an outcome which is in agreement with the optimizing conditions of the tax smoothing model. That this may be an appropriate interpretation of the behavior of the "policymaker" is underscored further by the absence of a cointegration relationship between the rate of inflation and the tax rate over the 1946-1994 period which includes the years since the Reserve Bank became independent. Notice also that the coefficient on the tax rate for the 1946-1994 period (.120) is less than half of the coefficient for the 1946-1988 period (.297). Overall, the findings support the conjecture that the passage and subsequent enactment of the Reserve Bank Act marked the beginning of the end of the long-run systematic relationship between the tax rate and inflation.

The theoretical framework permits the presence of a measure of velocity in the intratemporal optimizing condition. According to Table 1, the null hypothesis that velocity follows an I(1) process over all four sample periods cannot be rejected. By accounting for the presence of velocity, we now allow for the possibility of more than one cointegrating vector among inflation, the tax rate, and velocity. In our three variable system there can be at most two cointegrating combinations. To determine the number of cointegrating vectors, we follow the procedure outlined by Johansen (1988). This method suggests that the system of equations be written in error correction form:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \Omega Z_{t-1} + E_t \qquad (5)$$

where Z_t represents the vector $\begin{bmatrix} \pi_t \\ \tau_t \\ v_t \end{bmatrix}$

Ω and the Γ's are coefficient matrices while E_t is the vector of residuals. Two lags of each variable appear in the VAR system.[9] The rank of the matrix Ω determines the number of cointegrating vectors. The latter can be obtained by checking the significance of the eigenvalues of Ω. Two test statistics figure prominently in the multiple cointegration framework. The L-max statistic tests the null hypothesis that r equals the number of cointegrating vectors against the null hypothesis of r+1 cointegrating vectors. In contrast, the trace statistic is used in a test of the null hypothesis ($r=0$; $r \leq 1$, etc.) against a general alternative hypothesis ($r>0$; $r>1$, etc). The computed

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9 See the note to Table 3 for a brief explanation of what motivates the inclusion of two lags in the VAR representation.

values of both test statistics along with their critical values appear in Table 3.[10] As before, we estimated the VAR system for the whole sample period and separately for each subperiod.

Over the whole sample period the null hypothesis of no cointegrating relationship cannot be rejected. Both the L-max and the trace statistics are well below their respective 90 percent critical values. When we limit our investigation to the intervals during which the Reserve Bank was required to follow the policy directives of the Treasury the results change markedly. The findings for the 1946-1988 period indicate the existence of one cointegrating relationship among inflation, the tax rate, and velocity as the computed values of the L-max statistic (19.04) and the trace statistic (26.78) exceed their respective critical values at the 90 percent level (13.39; 26.70). For the same subsample period, the null hypothesis of one cointegrating vector against the alternative of two cointegrating vectors cannot be rejected. A conflicting result emerges from the test covering the 1935-1988 period. While the L-max statistic exceeds its critical value at the 90 percent level, thus rejecting the null of no cointegrating vector, the trace statistic falls below its critical value and hence fails to reject the null. For the remaining subsample period (1946-1994) there is no evidence of a cointegration relationship between inflation, the tax rate, and velocity.

Our analysis of the data uncovers substantial evidence for one cointegrating vector only during one subsample period, the 1946-1988 interval. The estimated cointegrating vector for this period, normalized on the rate of inflation, appears in part A of Table 4. Both the coefficient of the tax rate (.336) and the coefficient of velocity (-.002) have the expected sign.[11] Part B lists the individual adjustment parameters of the error correction model. All three adjustment parameters lie between zero and one, indicating that there is gradual adjustment towards the long-run

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[10] See the note to Table 3 for further details on how the test statistic is computed.

[11] It is worth reporting that our estimate of the coefficient of the tax rate is very close to the estimates that Poterba and Rotemberg report for the United States and Japan over the post-war period. For the United States their coefficient estimate is .320 while for Japan it is .313.

equilibrium. The adjustment parameter in the error correction equation for the rate of inflation, α_π, is negative and highly significant. If the rate of inflation lies above its long-run level relative to the tax rate and velocity in the current period, then the rate of inflation is required to fall in the following period to revert to the long-run equilibrium relationship characterizing the three variables. α_τ, the adjustment parameter in the error correction equation for the tax rate is positive and highly significant. If the equilibrium relationship between the three variables is temporarily perturbed, say by a relatively high rate of inflation, then the tax rate must rise in order to partially restore the long-run equilibrium relationship. The adjustment parameter in the error correction equation for velocity, α_V, is negative but only marginally significant. If velocity is currently high relative to inflation and the tax rate, it is required to fall in the next period. Note that the adjustment parameters for inflation and the tax rate are approximately of the same magnitude while the adjustment parameter for velocity is very close to zero.

IV. Summary and Conclusion:

Using OLS, we have discovered a cointegrating relationship between the rate of inflation and the average tax rate for the period during which the Reserve Bank of New Zealand enjoyed only a limited degree of independence as policy directives were issued by the Treasury.[12] Applying the Johansen maximum likelihood test for multiple cointegration, we have found one cointegrating relationship among the rate of inflation, the average tax rate, and velocity for the same period.[13] Furthermore, the adjustment parameters of the error correction model are highly significant for the rate of inflation and the tax rate and marginally significant for velocity.

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[12] We also tested for a bivariate cointegrating vector between the rate of inflation and velocity. The results indicate that inflation and velocity share no systematic long-run relationship in any one of the four sample periods.

[13] Recall that the OLS procedure also finds some support for the existence of a cointegrating relationship between inflation and the tax rate for the 1935-1988 period. For the same period, application of the Johansen procedure yields an ambiguous result.

However, if the sample period is extended beyond 1988, the cointegrating relationship between the variables in question disappears irrespective of which testing procedure is relied on to analyze the cointegrating relationships. Apparently, the Reserve Bank Act of 1989, which vests the central bank of New Zealand with the right to carry out monetary policy without seeking the advice of the Treasury, marks the end of the tenure of the omnipotent policymaker. The centerpiece of this act is a contract between the Governor of the Reserve Bank and the Minister of Finance to keep inflation between zero and two percent.[14] The act provides not only for the strict separation of the conduct of fiscal and monetary policy but also puts an end to the customary use of the printing press to create additional revenue as the act imposes a commitment on the Reserve Bank to maintain price stability. Within the theoretical framework of section II, the Reserve Bank Act makes the collection of revenue through seigniorage prohibitively expensive. This is because the Governor of the Reserve Bank, who is responsible for the conduct of monetary policy, can be dismissed if the inflation target is not met. In a fashion, in 1989 the cost function of collecting revenue through inflation shifted up permanently. Our findings thus suggest that the structural reforms which changed the institutional framework of the New Zealand economy have had important implications for the conduct of fiscal and monetary policy and hence for the comovement of economic variables like inflation and the average tax rate.

[14] This is the current width of the band agreed upon in the First Policy Target Agreement by the Governor of the Reserve Bank and the Minister of Finance in March 1990. If both the Governor and the Minister of Finance see fit, the width of the band can be changed.

References:

Barro, Robert J. "On the Determination of the Public Debt." *Journal of Political Economy* 87 (1979): pp.940-971.

Dawe, Stephen. "Reserve Bank of New Zealand Act 1989." *In Monetary Policy and the New Zealand Financial System*, Third Edition. Wellington (1992): pp.31-40.

Diamond, Peter A. and James A. Mirrlees. "Optimal Taxation and Public Production 2: Tax Rules." *American Economic Review* 61 (1971): pp.261-278.

Dickey, David A. and W.A. Fuller. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica* 49 (1981): pp.1057-72.

Engle, Robert F. and C.W.J. Granger. "Co-integration and Error Correction: Representation, Estimation and Testing." *Econometrica* 55 (1987): pp.251-276.

Froyen, Richard T. and Roger N. Waud. "Optimal Seigniorage Versus Interest Rate Smoothing." *Journal of Macroeconomics* 17 (1995): pp.111-129.

Gould, John. *The Rake's Progress: The New Zealand Economy Since 1945*. Hodder and Stoughton. Auckland (1982).

Johansen, S. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12 (1988): pp.231-254.

MacKinnon, J.G. "Critical Values for Cointegration Tests" in R.F. Engle and C.W.J. Granger (eds.) *Long-Run Economic Relationships*. Oxford University Press (1991): pp.267-276.

Mankiw, N. Gregory. "The Optimal Collection of Seigniorage." *Journal of Monetary Economics* 20 (1987): pp.327-342.

Phelps, Edmund S. "Linear Taxation of Wealth and Wages for Intergenerational Lifetime Justice: Some Steady State Cases." *American Economic Review* 65 (1975): pp.660-673.

Poterba, James M. and Julio Rotemberg. "Inflation and Taxation with Optimizing Governments". *Journal of Money, Credit, and Banking* 22 (1990): pp.1-18.

Quigley, Neil. "Monetary Policy and the New Zealand Financial System: An Historical Perspective. In *Monetary Policy and the New Zealand Financial System*, Third Edition. Wellington (1992) pp.205-231.

Roubini, Nouriel and Jeffrey Sachs. "Political and Economic Determinants of Budget Deficits in the Industrial Democracies." *European Economic Review* 33 (1989): pp.903-933.

Trehan, Bharat and Carl E. Walsh. "Seigniorage and Tax Smoothing in the United States: 1914-1986." *Journal of Monetary Economics* 25 (1990): pp.97-112.

Walsh, Carl E. "Is New Zealand's Reserve Bank Act of 1989 an Optimal Central Bank Contract?" *Journal of Money, Credit, and Banking* 27 (1995): pp.1179-1191.

Appendix:

Description of Data Sources:

Annual data was obtained from a variety of sources. We thank the New Zealand Institute of Economic Research in Wellington, NZ, for providing us with data on tax revenue. The inflation series was obtained from Statistics New Zealand's Consumer Price Index. The series detailing central government expenditure was collected directly from the consolidated government revenue account given in New Zealand yearbooks. The money variable is the total liabilities column in the Reserve Bank table which was sourced from the Monthly Abstract of Statistics.

Data References:

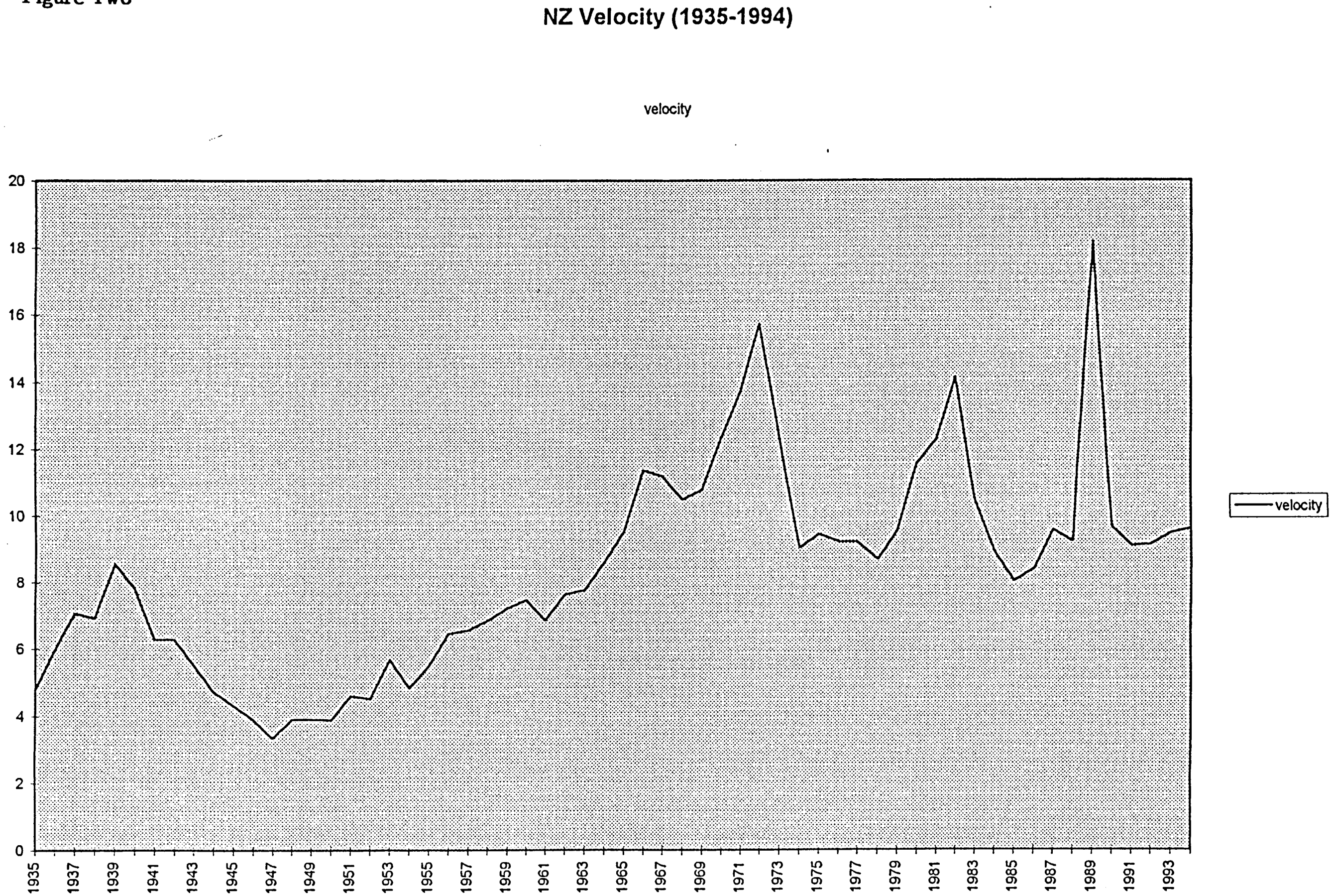
New Zealand Monthly Abstract of Statistics, Department of Statistics, Government Printer, Wellington.

New Zealand Official Yearbook, Department of Statistics, Government Printer, Wellington.

Figure One

Inflation and the Rate of Taxation

Figure Two



Source: NZ Yearbooks

Table 1 : Tests for Stationarity [a]

Variable	Constant, Trend		Constant, No Trend		No constant or trend	Constant, Trend		Constant, No Trend		No constant or trend
	t-test	F-test	t-test	F-test	t-test	t-test	F-test	t-test	F-test	t-test
	Phillips-Perron tests					**Augmented-Dickey Fuller tests**				
Critical Values(5 percent level) [c]						Critical Values(5 percent level)				
1935-1994	**-3.5**	**6.73**	**-2.93**	**4.86**	**-1.95**	**-3.5**	**6.73**	**-2.93**	**4.86**	**-1.95**
Inflation	-2.56	3.62	-2.59	3.36	-1.40	-2.58	3.66	-2.63#	3.45	-1.48
Tax Rate (log)	-2.53	3.23	-1.56	2.02	1.18	-2.59	3.58	-1.98	3.24	1.44
Velocity (log)	-2.40	2.93	-1.90	1.97	0.21	-2.44	3.03	-1.96	2.07	0.15
Government Spending(log)[d]	-3.52*	6.23#	-1.32	1.43	0.94	-3.47#	6.03#	-1.37	1.45	0.86
1935-1988										
Inflation	-3.39#	5.80#	-2.05	2.21	-0.70	-3.41#	5.8#	-2.28	2.77	-0.83
Tax Rate (log)	-2.62	3.50	-1.98	3.30	1.50	-2.44	3.05	-1.86	3.11	1.52
Velocity (log)	-1.85	1.72	-1.36	1.01	0.17	-1.67	1.49	-1.49	1.34	0.38
Government Spending(log)	-3.39#	5.75#	-1.13	1.27	1.04	-3.35#	5.61#	-1.2	1.3	0.95
1946-1994										
Inflation	-2.16	2.76	-2.36	2.77	-1.24	-2.16	2.76	-2.34	2.80	-1.29
Tax Rate (log)	-3.49#	6.81*	-0.89	0.52	0.51	-3.57*	7.01*	-1.16	0.77	0.4
Velocity (log)	-2.22	2.86	-2.12	2.57	0.44	-2.37	3.16	-2.2	2.69	0.31
Government Spending(log)	-3.04	4.70	-0.86	0.66	0.70	-1.64	1.37	-0.35	2.24	2.07
1946-1988										
Inflation	-3.16	5.00	-2.07	2.34	-0.55	-3.12	4.88	-2.12	2.43	-0.65
Tax Rate (log)	-3.05	6.08#	-0.80	0.47	0.59	-3.18#	6.29#	-1.14	0.78	0.47
Velocity (log)	-1.48	1.76	-1.82	2.18	0.63	-1.42	1.69	-1.81	2.2	0.67
Government Spending(log)	-3.05	4.98	-0.61	0.56	0.83	-3.13	5.78#	-0.07	0.75	1.23

Note:
a- For each sample period the following equation was estimated :

$$\Delta y_t = a_0 + a_1 t + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \varepsilon_t$$

b - Number of lags chosen by analyzing the autocorrelation function and the partial autocorrelation function.
c - Critical Values for the tests are given in Dickey and Fuller (1981 : 1063). The reported estimates of the coefficients and standard errors differ from the reported t-statistices because of rounding errors.
d- Government spending is defined as the log ratio of government spending to GNP multiplied by 100.
- Reject at the ten percent level.
* - Reject at the five percent level.

Method:

We tested inflation, the log of the tax rate and the log of velocity for stationarity over four different time periods using the Phillips-Perron and the Augmented Dickey-Fuller test. We first tested for the series being integrated of order two using the method outlined below but all of the series were clearly found to be integrated of a lower order.

The form of the data-generating process is unknown which implies that in order to test whether a series is non-stationary or stationary we should begin with the most general model (equation (1)), including both a trend and a constant. The testing strategy was to conduct a t-test on the null hypothesis that $\gamma=0$ against the alternative hypothesis that $\gamma < 0$ (implying the series is stationary) . If we could not reject the null hypothesis, we calculated an F-statistic that tested the appropriateness of including a trend term in the equation i.e. we tested the null that $\gamma=a_1=0$ against the alternative that $\gamma<0$, $a_1\neq0$. If we rejected the null we concluded that the trend is significant and that the series is stationary. If we could not reject the null we removed the trend term and re-estimated equation (1) without the trend term.

This same procedure of conducting a t-test and then an F-test was applied to equation(1) without the trend term. The constant was removed if we could not reject the null of $\gamma=a_0=0$.
Finally, we re-estimated equation (1) having removed both the trend and the constant and tested the null hypothesis of $\gamma=0$ against the alternative that $\gamma<0$.

This testing procedure produded a hierarchy of five separate statistics for testing for stationarity in each series. These test statistics are given in the final five columns of table one, and should be read left to right.

Table 2: Time Series Evidence on Inflation and Tax Rates:

Sample Period	Constant	Tax Rate	Adj. R^2	CRADF
1935-1994	.175** (.035)	.086** (.026)	.14	-1.78
1935-1988	.265** (.038)	.148** (.028)	.34	-2.61#
1946-1994	.220** (.053)	.120** (.041)	.14	-1.25
1946-1988	.460** (.052)	.297** (.039)	.57	-3.06*a

Note:
For each sample period we estimated the following cointegration equation:

$$\pi_t = a + b\tau_t + \epsilon_t$$

π_t is the log-difference of the CPI and τ_t is the log of the ratio of Taxation Revenue to Nominal GNP.
The test for cointegration follows the standard Engle-Granger procedure and consists of examining the residuals of the cointegration equation for the presence of a unit-root. The test statistics of the Cointegration Regression Augmented Dickey-Fuller test(CRADF) are reported in column 5.
The 5 and 10 percent critical values of the simple cointegration test based on 60 observations(1935-1994) are -2.91 and -2.59. For 43 observations(1946-1988) the respective critical values are -2.93 and -2.61.(Source: authors' own calculation based on McKinnon(1991)).

[a] The Cointegration Regression Durbin Watson statistic for the 1946-88 period(43 observations) is 1.03. For the 1935-88 period(54 observations) the statistic is .58. For 50 observations the respective critical value at the 1, 5, and 10 percent level is 1.00, .78, and .69.

** denotes significance at 1 percent level
* denotes significance at 5 percent level
# denotes significance at 10 percent level.
Because of the small sample size, the bias inherent in the coefficient estimate of the cointegrating vector may be substantial. Hence the standard interpretation of the t-values does not apply.

Table 3: Determining the Number of Cointegrating Vectors: The Johansen-Juselius Procedure.

1937-1994						
Eigenvalues	L-max	Trace	H_0: r =	p - r	L-max 90%	Trace 90%
.1355	8.16	14.55	0	3	13.39	26.70
.0774	4.51	6.39	1	2	10.60	13.31
.0330	1.88	1.88	2	1	2.71	2.71
1937-1988						
Eigenvalues	L-max	Trace	H_0: r =	p - r	L-max 90%	Trace 90%
.2945	17.44	22.73	0	3	13.39	26.70
.0707	3.67	5.29	1	2	10.60	13.31
.0319	1.62	1.62	2	1	2.71	2.71
1946-1994						
Eigenvalues	L-max	Trace	H_0: r =	p - r	L-max 90%	Trace 90%
.1856	9.85	15.31	0	3	13.39	26.70
.0731	3.64	5.45	1	2	10.60	13.31
.0370	1.81	1.81	2	1	2.71	2.71
1946-1988						
Eigenvalues	L-max	Trace	H_0: r =	p - r	L-max 90%	Trace 90%
.3714	19.04	26.78	0	3	13.39	26.70
.1565	6.98	7.74	1	2	10.60	13.31
.0184	.76	.76	2	1	2.71	2.71

Note:
a. The system of vector autoregressions consists of the rate of inflation, the tax rate and velocity. Two lags of each variable appear in the VAR representation.
To determine the lag structure of the VAR system, we performed a series of likelihood ratio tests. For each sample period we ran two sets of VARs, the distinguishing feature being the lag length of the variables. We started with five lags and continued to eliminate lags as long as the null hypothesis of a more parsimonious lag structure could not be clearly rejected. On the basis of the results of the likelihood ratio tests we chose to include two lags in the VAR system.
b. The trace and the L-max statistics are computed as follows:

$$\lambda_{Trace}(r) = -T\sum_{i=r+1}^{n} \ln(1-\lambda_i)$$
$$\lambda_{Max}(r,r+1) = -T\ln(1-\lambda_{r+1})$$

where λ_i is the eigenvalue of the estimated Ω matrix and T is the number of observations.

Table 4: The Cointegration Vector and the Adjustment Parameters: 1946-1988.

A. The Cointegration Vector Normalized on the Rate of Inflation.

Inflation	Tax Rate	Velocity
1.000	-.339	.002

B. The Adjustment Parameters in the Error Correction Model.

α_π	α_τ	α_V
-.400 (-2.356)	.394 (3.124)	-.003 (1.816)

Note: t-values appear in parentheses.

The Error Correction Model is of the following form:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \Omega Z_{t-1} + E_t$$

where Z_t represents the vector $\begin{bmatrix} \pi_t \\ \tau_t \\ v_t \end{bmatrix}$.

Since there is only one cointegration vector ΩZ_{t-1}can be written as

$$\Omega Z_{t-1} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \begin{bmatrix} \beta_1 & \beta_2 & \beta_3 \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ \tau_{t-1} \\ v_{t-1} \end{bmatrix}$$

After normalizing on the rate of inflation, we can restate individual equations such as the one for the change of the rate of inflation(omitting any lagged changes) as

$$\Delta \pi_t = \alpha_\pi \left[\pi_{t-1} + \frac{\beta_2}{\beta_1}\tau_{t-1} + \frac{\beta_3}{\beta_1}v_{t-1} \right] + \epsilon_{t,\pi}$$

where $\alpha_\pi = \alpha_1 \beta_1$ and is referred to as the adjustment parameter of inflation. Normalizing on the tax rate(velocity) and following the same procedure as above, we can obtain the convergence parameters for the tax rate(velocity).

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