Government Size, Government Debt and Economic Performance with particular application to New Zealand[1]

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Abstract

Many countries have been concerned recently whether government size and government debt have become large enough to encroach excessively on their private economic performance. New Zealand, in contradistinction, has undergone a period of reversal over the past two decades in which both government size and the ratio of government debt to GDP have been reduced substantially. This paper examines whether there has been a cost to government debt and government size in New Zealand and thus whether a policy of deliberate contraction would have been associated with an output premium. The analysis suggests that in the long run government size and private per capita output have had an inverted U-shaped relationship with the positive effect of government size peaking at close to thirty percent of GDP. In addition larger government debt is found to be associated with lower levels of private output. Hence the contraction in government size and the debt ratio in New Zealand would have resulted in an output premium. After accounting for the process of convergence to the long run, the short run analysis suggests that the inverse relationship found between changes in government size and economic growth may be attributable more to the response of fiscal expenditure policy to unanticipated changes in growth than to the perverse effect of government expenditures on growth and output. This reinforces the traditional expenditure role of fiscal policy while at the same time cautioning against any longer run spillover into larger government size and debt.

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1. Introduction

Economists and policy makers have been concerned with the potentially negative effects of government size on the private economy from as early as Thomas Hobbes (1651) and Adam Smith (1776), but recent experience with fiscal instability following the 2007-2008 financial crisis has added government debt to the list of size related concerns. The perceived inability or unwillingness of governments to fund expenditure levels from current taxes has led to the rapid growth of fiscal deficits that in turn have resulted in potentially unsustainable levels of government debt. The burden of supporting that debt has then imposed on governments such as Ireland, Greece, Portugal, Spain and Italy levels of financial austerity that are widely viewed as weighing down the performance of their private economies. In this paper I am interested in assessing whether or not a reduction in government expenditure size can increase private economic performance and whether or not government debt does impose a real output burden on the private economy.

In the following pages I explore these questions in relation to New Zealand, chosen as one of the first countries to recognize and respond explicitly to these issues. New Zealand academics and policy makers have for some time been worried over whether growing government size had interfered with their economic performance (Bairam, 1988; Scully, 1989, 1996; Grimes, 2003; and Cook, Schousboe and Law, 2011). As was also the case with Canada, the rapid growth of government debt in the late 1980's and early 1990's led to a more specific concern with the potential burden and operational constraints imposed by growing debt levels. This led to the adoption of The New Zealand Fiscal Responsibility Act in 1994 which established "principles of responsible fiscal management" designed to promote greater transparency in government's short-run fiscal intentions while requiring the more explicit targeting of long term fiscal objectives. Coming to grips with these two size related concerns introduced a period of growing fiscal prudence that in turn led to a fall in levels of both government size and government debt.

Hence one question that can be asked of New Zealand is whether such prudence translates into an output premium.

While policy interest in government size and economic performance is most often posed as the effect of government size on economic growth, for many countries, perhaps even most, there is no meaningful long run empirical relationship between these two measures.[2] For most developed countries government size has only increased over the past century while economic growth has not, typically varying about a more or less constant mean.[3] That a meaningful relationship is unlikely to arise between these time series can be illustrated most clearly diagrammatically, and this is done in Figure 1 for New Zealand. In the bottom diagram of that figure, the growth rate of private output per capita (GROWTH_PYPC)) is shown to vary more or less randomly about its long run mean of 1.1 per cent, while in the top diagram, central government size (GSIZE, left axis) is shown to rise more or less continuously from the early 1900's through the 1990's.[4] Visually at least, it is government size and the level of private income per capita in the top diagram (PYPC, right axis) that appear related in their pattern of movement through time and thus offer a greater likelihood of being meaningfully interrelated. In econometric terms, per capita economic growth appears to be stationary or I(0), while both the levels of private output per capita (PYPC) and government size (GSIZE) appear nonstationary or I(1). In economic terms this suggests that a theory seeking to link performance with size should be structured in terms of the levels of these two variables.

--- Figure 1 about here ---

The paper proceeds in Section 2 by discussing the channels by which government size and debt are expected to affect the level of private per capita output and then combines these hypotheses into a

[2] Government size is defined here as the share of total central government expenditures in GDP, while economic growth is defined as the rate of growth of private real output per capita D(LNPYPC).
[3] On this see Ericsson, Irons and Tryon (2001) and Romero-Avila (2006).
[4] As a fraction of GDP, New Zealand's central government size rose from a little over 13 percent in 1890 to over 40 percent in 1993 before falling back to 30 percent in the period immediately prior to the 2007/8 financial crisis.

model that can be estimated. The discussion highlights the expected inverted U-shaped relationship private output and size predicted by public choice theory, a shape that implies a unique government size that would maximize private output per capita.[5] Section 3 discusses the variables used to test the derived hypotheses and presents the cointegration model that emerges as the result of these tests. The results suggest that real output per capita in New Zealand would be maximized at a level of government size somewhat smaller than its current size. Section 4 presents the short run - error correction version of the model. This allows the results of our analysis to be compared to the New Zealand literature seeking to link government size with economic growth. That discussion emphasizes the advantage of the error correction framework in its ability to separate shorter run fiscal policy changes in government expenditure unrelated to the long run issue of optimal government size from those short run changes in government size that reflect the process of convergence to an evolving long run size. Section 5 presents a vector error correction model that allows interpretation of the negative short run effect arising between changes in government size and economic growth (usually found in the literature) as reflecting the short run countercyclical response of fiscal policy (both automatic and discretionary) to the business cycle. Section 6 provides a simulation that explores the economic significance of the long run effects found in model and hence provides one measure of the output premium that followed New Zealand's success in imposing a greater degree of fiscal responsibility. Section 7 concludes the paper.

2. Channels of government influence and derivation of the estimating model

To model New Zealand's private sector, I assume that private output at time t, y_t, arises from an aggregate production function that depends on the services produced by physical capital, K_t, human capital, H_t, and labour force size, N_t, in combination with the provision of government services, G_t. That is,

[5] I refrain from characterizing the tipping point or peak effect of government size on private output as the optimal size of government because such an optimal consideration should incorporate other dimensions of value besides output (such as redistribution) which may come at the cost of private output.

$$y_t = F(K_t, H_t, N_t, G_t). \tag{1}$$

$F(.)$ is assumed to be linear homogenous so that we can rewrite the function in per capita form as[6]

$$\left(\frac{y}{N}\right)_t = f\left(\left(\frac{K}{N}\right)_t, \left(\frac{H}{N}\right)_t, \left(\frac{G}{N}\right)_t\right). \tag{2}$$

Ambiguity over the nature of government services, over the extent to which government services are concurrent rather than private, leads to the adoption of a more specific form to capture the way that government services interacts with the private economy. Here our focus is on the hypothesis that the government affects private per capita output directly through its aggregate size relative to the overall economy, GSIZE = *G/Y*, and indirectly through the relative size of its outstanding debt, CGDebt = D_G/Y. That is,

$$\left(\frac{y}{N}\right)_t = f\left(\left(\frac{K}{N}\right)_t, \left(\frac{H}{N}\right)_t, \left(\frac{G}{N}\right)_t\right) \approx f'\left(\left(\frac{K}{N}\right)_t, \left(\frac{H}{N}\right)_t, \left(\frac{G}{Y}\right)_t, \left(\frac{D_G}{Y}\right)_t\right), \tag{3}$$

where $Y_t = y_t + G_t$ and D_{G_t} is central government debt.

Increases in government size itself are viewed as producing two opposing effects on the output of the private sector. Initial levels of government service are assumed to confer significant benefit to individuals first by providing security from internal and external harm. Further increases generate larger levels of stability and predictability for individuals in their dealing with others through the provision of policing and legal services that in turn encourage greater volumes of trade and production (Coase, 1960; Becker, 1983; Wittman, 1995). Moreover, to the extent that health, sanitation, social welfare, and research and development are provided directly or funded indirectly by the government sector, larger levels of government spending increase the quality of productive inputs and thus the output of the private sector (Dahlman, 1991; Thomson and Jensen, 2013). Perhaps even more directly, the

[6] The absence of a log time series on labour force led to use of population and per capita measures.

government's provision of capital goods such as roads, rail and air infrastructure provide inputs that complement private capital, enhancing private output (Karras, 1997; Sturm, Kuper and de Haan, 1998). It is then assumed that governments will undertake socially more productive projects first so that productivity is expected to fall as government size expands. The opposing channel of influence recognizes that all government services must be financed so that as government grows in size ever larger levels of resources must be obtained from the private sector. Their acquisition through the taxation of inputs such as labour and capital and the differential taxation of uses of private income (savings versus different types of consumption) decreases private output by discouraging the supply of productive inputs and by distorting its provision (Stuart, 1984; Usher, 1986). Thus as government size grows, the tax price of government services only increases. This has led writers such as Grossman (1987), Scully (1989, 2000) and Facchini and Melki (2013) to argue that on net, larger government size must encounter diminishing returns and at some point reach a size where further increases will reduce rather than increase private output.[7] In a similar way, and for any given level of government size, an increase in government debt as a proportion of Y, CGDebt, will require more resources to be raised from the private sector to service that debt.[8] Even if interest payments to debt holders remain internal to the economy as a whole (so that there is no net wealth effect arising within the community) the incidence of higher tax collections creates an increasing disincentive to produce and accumulate which further harms both present and future production (Reinhart, Reinhart and Rogoff, 2012).

The two opposing effects of government size on private per capita output are illustrated in Figure 2 below where the level of government size that maximizes per capita private output is

[7] Theories directed at explaining why government size may become too large include Niskanen's (1968) theory of the expansionary incentives of the government bureau, Meltzer and Richard's (1981) median voter theory, and Buchanan and Tullock's (1962) emphasis of common pool problems in modern democracies.

[8] While some level of government borrowing is clearly productive in allowing the matching current investments with future benefits, Buchanan and Wagner (1977) use the short time horizons of legislators and presence of fiscal illusion in voters to argue for a democratic bias towards excessive levels of government debt.

illustrated. Here increases in the stocks of physical and human capital per capita are viewed as shifting upwards the benefit curve while an increase in the size of government debt is viewed as tilting upwards (increasing at an increasing rate) the slope of the real cost of government size. The latter effect would shift downwards the net benefit curve and thus reduce the level at which the marginal effect of government size on y/N falls to zero.

--- insert Figure 2 about here ---

Representing the $f'(.)$ function as Cobb-Douglas, allowing for the separation of government's impact into these two effects and taking logarithms, we can derive a linear form of the per capita production function as

$$\ln\left(\frac{y}{N}\right)_t = \alpha_k \ln\left(\frac{K}{N}\right)_t + \alpha_h \ln\left(\frac{H}{N}\right)_t + \alpha_g \ln\left(\frac{G}{Y}\right)_t + \alpha_d \ln\left(\frac{D_g}{Y}\right)_t. \qquad (3)$$

where the $\alpha's$ represent the output elasticities of the different factors influencing production. The specific hypothesis to be tested is whether government size is nonlinear in its effect on per capita output and if so, whether government size has grown so large as to reduce private per capita output. This is tested for by using the quadratic form

$$\ln\left(\frac{y}{N}\right)_t = \alpha_k \ln\left(\frac{K}{N}\right)_t + \alpha_h \ln\left(\frac{H}{N}\right)_t + \alpha_g \ln\left(\frac{G}{Y}\right)_t + \alpha_{gg}\left[\ln\left(\frac{G}{Y}\right) * \ln\left(\frac{G}{Y}\right)\right]_t + \alpha_d \ln\left(\frac{D_g}{Y}\right)_t + e_t. \qquad (4)$$

Here the addition of the random error term, e_t, leads to our estimating model where $\frac{H}{N}$ will be proxied by the level of educational attainment. The predicted signs of the coefficient estimates are $\alpha_k, \alpha_h, \alpha_g > 0$ and $\alpha_{gg}, \alpha_d < 0$ and the tipping point for the effect of government size on per capita output can be solved for as $\left(\frac{G}{Y}\right)^* = antilog(-\frac{\alpha_g}{2\alpha_{gg}})$.

3. Applying the model and presenting the cointegration results

The multiple channels by which government size can influence private output argue for the most inclusive measure of government size—total expenditure rather than the more narrowly focused consumption or investment expenditures—as the magnitude appropriate to test our hypothesis of government's effects. The public choice basis of the above model assumes that government will look across all the dimensions of government provision when deciding on expenditures, choosing to target levels of consumption, investment and transfers where they can be most productive. From a purely political perspective, the productivity of additional spending would be measured in terms of expected votes or re-election potential. But with effective political competition across political parties, what is most highly valued by voters will be translated into policies that produce higher votes and ultimately better electoral success.[9] An expansion in government size would then be expected to produce a more or less simultaneous expansion across all dimensions of government service (taking into account the rising finance and deadweight costs of additional size). In New Zealand, total central government expenditures comprise approximately ninety per cent of all government expenditures and have averaged over twenty three percent of GDP over the 1890 – 2011 time period.[10]

The specific data used in this study come from a variety of sources. Government expenditure, real GDP and population appear in the long-run online database maintained by Statistics New Zealand for the years 1890 through 2002. This was updated through 2012 with more recent data from Statistics New Zealand (Infoshare) and the New Zealand Treasury. All variables were converted into per capita terms and logarithmic form, the former indicated by the use of PC and the latter by the prefix LN(.). The data used as control variables—N.Z. capital stock and levels of educational attainment--were obtained

[9] This appears in the probabilistic voting literature as the representation theorem. See Coughlin (1994) and Winer and Ferris (2008).

[10] The corresponding measure of economic performance is private per capita output, PYPC, measured in 2000 NZ dollars. By subtracting real government expenditures from real GDP, a measure of private performance is derived that does not vary directly with changes in government expenditures.

from Jacob Madsen (2007 and 2013). More specific descriptions of the variables used and their sources are provided in a data appendix. The appendix also includes a table describing the statistical characteristics of the data with particular emphasis on their time series properties.

The difficulty with doing time series analysis on annual data is that long time periods are required to generate a sufficient number of observations so that econometric techniques can filter out randomness and reveal longer term trends. The use of a long time period, however, poses problems of its own since a long time series does not necessarily mean that each drawing comes from the same distribution. In this respect New Zealand is one of a small number of countries whose fundamental political, legal and economic institutions have remained sufficiently unchanged to justify an assumption of stability.[11] On the other hand, the small size and export orientation of the New Zealand economy makes it more susceptible to external shocks. In New Zealand's case two great twentieth century shocks —the Great Depression and WW2—can easily be seen in the raw data. For this reason these exogenous shocks are included as potential breaks in the endogenous cointegration relationships. Finally, another difficulty with long run data is that it is rare to find consistent detail on the composition of many aggregates. In New Zealand, for example, information on the composition of government expenditures is difficult to find before the 1980's and when it is available—such as for government transfers from 1876 onward—there is often a significant break in its coverage (1939-51). It is a second reason why the test was structured in terms of aggregate government expenditure.

With this background I present in Table 1 the results of the hypothesis tests outlined in equations (3) and (4). Before discussing the individual results, however, I note that despite the high R^2's and low Durbin Watson statistics being the potential sign of a spurious relationship among this set of I(1) variables, the residuals of these equations are all found to be stationary, as the adjusted Dickey Fuller

[11] In addition, New Zealand has no provincial or state sub-national governments that complicate the analysis of government size in countries with comparable political and legal systems (such as Australia, Canada, India and the United States).

statistics indicate. This means that the estimated linear relationships among the set of variables, all of which are trending upwards, are consistent with cointegration and thus consistent with the hypothesis that the estimated equation describes a long run equilibrium relationship among these variables.

In columns (1) and (2) of Table 1 the OLS estimates of equations (3) and (4) are presented. While both estimates provide results that are consistent with cointegration, equation (2) suggests that the insignificant effect of LNGSIZE found in column (1) may arise from the nonlinear effect that government size has on output. Unfortunately, while the coefficient estimates of the OLS equation may be super consistent, the standard errors that suggest the nonlinear effect are typically biased upwards by the presence of correlations among the explanatory variables across time. Hence in equations (3) and (4) I present the FMOLS and DOLS estimates to correct for this bias. Doing so confirms the expected positive productivity of physical and human capital on private output while providing evidence consistent with the inverted U-shaped effect of government size on private output illustrated in Figure 2. The results permit rejection of the hypothesis that government size has no interrelationship with private output per capita and are broadly supportive of the government size is nonlinear with an inverted U-shaped in its effect on private output.[12] Finally while the specific coefficient estimates for LNGSIZE and LNGSIZE_SQ vary somewhat across columns (2)-(4), the ratios of the coefficients that determine the tipping point are remarkably consistent across the three equations. Together they imply a government size, somewhere between twenty five and thirty percent of GDP, would be consistent with maximizing the effect of government size on private output.

4. Short Run variation about the Long Run and Convergence

A long run equilibrium, such as that implied by the cointegrating equations of Table 1 column (2) through (4), is economically meaningful only if it is stable and this implies that transitory departures

[12] While the coefficient estimates all have their expected sign and the FMOLS estimates are significant at the five percent level, the DOLS estimates are significantly different from zero at only the ten percent level.

from the equilibrium path must be reversed through time. This implies that any short run model of the effect of government size on per capita output should account for changes in government size that form part of the process of adjustment back to the longer run equilibrium. Hence to account for the presence of a short run transition process back to long run equilibrium, I present the second stage Engel Granger error correction model. Here the focus on how changes in the growth rate of government size affect the growth rate of per capital income creates a way in which I can compare the results of this approach with the existing literature on government size in New Zealand.

---insert Table 2 about here ----

In columns (1) and (2) of Table 2 I present two versions of the second stage Engle-Granger error correction model. In both cases the significantly negative sign on the error correction term reinforces the earlier finding of cointegration in that random departures from the estimated long run cointegration path are reversed through appropriate changes in the covariates through time. The size of the error correction terms, however, indicates that the process of adjustment to the long run is relatively long which helps to explain the persistent in the residuals of the long run. The results also suggest that it is changes in the physical stock of capital and changes in the size of central government debt that are relatively more important explaining changes in private output than are changes in the level of educational attainment. The different versions of short run adjustment represented by columns (1) and (2) allow a closer focus on the way that changes in the expenditure size of government affects output in the short as opposed to the long run. That is, column (1) shows little evidence of the inverted U-shaped effect of government size on output witnessed in the long run. Column (2), on the other hand, indicates that there is a significant negative relationship arising linearly between short run changes in government size and changes in private output. Taken literally this suggests that fiscal policy (short run change in government expenditure) has been perverse in its effect on private output. However the inability to tie

causality directly to correlation allows for the possibility that the negative relationship reflects the countercyclical role played by fiscal policy over the business cycle. That is, the negative relationship could be capturing the positive (negative) response of government expenditure to unexpected decreases (increases) in the growth rate of private per capita output. I return shortly to examine this possibility more closely in the context of a vector error correction model.

There is a relatively long empirical literature on the effect of government size in New Zealand, but a concern with the implications of the time series dimensions of that debate has been relatively recent.[13] As is true of the literature more generally, the key question of policy interest has been the relationship between the *level* of government size and the *rate* of economic growth.[14] In an early paper that covered the relatively short 1960-1980 time period, Bairam (1988) modified Ram's (1986) empirical method of regressing the growth rate of government size on the growth rate of real output to regress the annual growth rate of government size in New Zealand on the growth rates of consumption and private investment (all I(0)). But while the statistical relationship found between these two stationary growth rates is not spurious, it is also not clear that the regression coefficient can measure the long run effect of government size on consumption and private investment. Because all of these growth rates are stationary, there can be no permanent effect on either growth rate from a permanent increase (decrease) in the growth rate of government expenditures. Rather the results tell us that transitory changes in the rates about a constant mean are correlated. Nevertheless the finding of no government size effect on consumption growth and a significant positive effect on investment growth reinforced ideas present in the broader literature that growth was the relevant performance measure affected by

[13] For an alternative analysis linking of the levels of government size with the level of output see Kumar, Webber and Fargher (2012) who focus on cointegration in relation to a test of Wagner's Law.

[14] The consensus view of this large literature, surveyed recently by Bergh and Henrekson (2011) and Facchini and Melki (2013), is that government size while typically ambiguous in its effect is more often found to have a negative rather than positive effect on growth.

government size and that it was the composition rather than the level of government size that would matter.

In a complementary empirical paper, Grimes (2003) challenged the empirical findings of Gwartney, Holcombe and Lawson (1998) who had found a strongly negative effect of government size on decade average growth rates for a panel of twenty three OECD countries (including New Zealand) between 1960 and 1996. In reproducing that work for New Zealand to correct for what Grimes argued were model misspecifications (i.e., using income rather than income per capita, leaving out convergence considerations and not using a number of country specific dummies), Grimes found that government size now had a much smaller (i.e., insignificantly negative) effect on the growth rate of per capita income.[15] This finding was seen as broadly in line with other disaggregated studies and again taken to suggest that "the *structure* of the government budget has much more impact on growth outcomes than the *size* of the budget" (Grimes p. 172, emphasis in original).

At the opposite extreme, however, lies the work of Scully (1989, 1996 and 2000). Using a production function relationship and a nonlinear specification, Scully attributed the lower growth rates experienced by New Zealand following WW2 to high levels of taxation. His empirical work suggested the growth maximizing size of government for New Zealand was about twenty percent of GDP and that would be achieved if the optimal tax rate were cut to roughly half its then current size (i.e., from roughly 40 to 20 per cent).

In their most recent review of the literature on government size in New Zealand, the New Zealand Treasury [Cook, Schousboe and Law (2011, p. 1)] took a more moderate approach by concluding that "theory and evidence suggest that high levels of government expenditure, as a percentage of the economy, can be detrimental to economic growth due to the economic costs of raising taxation to

[15] See Grimes (2003, p.161, Table 3 columns 2, 2a, 3, and 4). It is not clear how Gwartney, Holcombe and Lawson who originate the form used by Grimes interpret the presence of the change in G/Y appearing columns 1 and 1a (other than it is smaller and less significant than the coefficient on G/Y).

finance expenditure…However, both theory and empirical research emphasize that we cannot divorce the economic growth impact of the *level* of expenditure from the *mix* of expenditure and revenue". Rather than simply reducing size, they argue, the better route is to restrain non-growth promoting expenditures while reducing growth-distorting taxation.[16]

In Columns (3) through (5) of Table 2 I illustrate the time series problems these papers raise by estimating directly the relationship between government size and economic growth for New Zealand in the context of a simple growth model that utilizes the current set of explanatory variables. Column (3) presents the regression result when the growing level of government size is used (together with changes in the capital stock and level of educational attainment) to explain New Zealand's stationary growth rate. As the different orders of integration suggest, no significant relationship can be found between the size *level* and the growth *rate*. Column (4), on the other hand, replaces the level of government size with the growth rate of that size. In essence it replicates column (2) but without the error correction term.[17] Here a significantly negative relationship is again found (as in column (2)) but not between government size and growth. Rather the correlation links variations in the non-trending growth rate with variations in the growth rate of government size. The significant negative relationship then means only that contemporaneous deviations in the growth path of government size are associated with transitory rather than permanent changes in the rate of economic growth.[18] As was the case with column (2), whether this implies short run fiscal policy is perverse or a reflection of the countercyclical response of fiscal policy to the business cycle remains to be seen.

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[16] While not directed specifically at the issue of government size and economic performance, New Zealand has a flourishing literature examining the size of the multiplier effects produced by fiscal policy that uses VARs. This intersects with this paper in terms of short run fiscal variations about longer run trends but differs in its exclusive concern with the consequences of "pure" fiscal shocks. The concern here is with both long and short run reasons for expenditure and debt changes and their effects on economic performance, whether the fiscal response is built to respond automatically to the business cycle or is the result of explicit and discretionary policy choice. For examples of VAR multiplier analysis, see Claus et. al. (2006) and Parkyn and Vehbi (2013).

[17] Note that the lower adjusted R^2 (4) in comparison with (2) reflects the additional explanatory power given to the equation by use of the error correction term.

[18] This interpretation remains no matter what alternative detrending procedure is used to induce stationarity.

Before turning to this question I include, for completeness, column (5) that includes the effect of adding a squared term in the growth rate of government size to the equation. This formally tests the hypothesis that with the appropriate time series adjustment to the size variable, it is the growth rate in government size that will produce the expected (inverted U-shaped) effect on growth. The result rejects this hypothesis, confirming the superiority of the linear effect found in columns (2) and (4) and thus the suggestion that short run effect of changes in government size on the rate of growth is qualitatively different from long term or permanent change in that size. That is, the short run interrelationship appears as both negative and linear while the long run remains positive overall but exhibits diminishing returns.

5. Joint estimation and Impulse Responses

One weakness with the method used to illustrate the long and short run relationships arising among government size and economic performance is that each step has been estimated in isolation. In practice, however, the long and short run fiscal dimensions of fiscal policy are chosen simultaneously and their effects become comingled in the same aggregate data. Because our interest is in how the multiple effects of fiscal policy affect output, this suggests that the two steps should be estimated jointly so that estimation can capture the long run considerations in determining government size and output interacting with the shorter run objectives of countercyclical policy. There is also the complication that short run changes in output per capita can affect changes in government size at the same time that changes in size affect output per capita.[19] Hence to account for the presence in the short run of transition process back to long run equilibrium and to explore the possibility of two way causation among the key variables, I estimate a vector error correction model.

[19] A Granger causality test (two lags) allows us to reject the hypotheses that LNPYPC does not Granger cause LNGSIZE ($p = 0.0045$) and that LNGSIZE does not cause LNRPRIVYPC ($p = 0.0184$).

In economic terms, the vector error correction model (VECM) does two important things. First it estimates the long run cointegrating relationship as part of its estimation of the shorter run adjustment process. By incorporating error correction terms the estimation procedure can distinguish among the potentially different objectives of fiscal policy in the short run—separate counter-cyclical variations in expenditure to smooth the business cycle while accounting for the adjustment process back to long run equilibrium—as well as distinguish the short run from the longer run interaction between government size and private per capita output implicit in the cointegrating equation. By estimating both dimensions simultaneously, the short and long run models interact to each other and hence can provide a superior estimate of the processes than can separate estimation through the 2-step Engle-Granger procedure. The second important benefit of the VECM is that the structure provides a method for disentangling opposing causal effects. That is, the technique provides one way of distinguishing the short run effect of government size on per capita output from the effect of short run changes in per capita output on government size. Moreover, the method allows these effects to be represented conveniently and diagrammatically in terms of impulse response functions.

The VECM associated with the long run model of Table 1 column (2) is presented as Table 3 where the existence of cointegration is indicated by the sign and significance of the error correction terms. Note that the scaling of the level variables and the order they appear in the cointegrating equation imply different signs for error correction terms when indicating convergence. Hence the error correction coefficients in the D(LNPYPC) and D(LNGSIZE) short run equations both indicate that realized transitory departures from the long run equilibrium path will be reversed through the appropriate response of per capita output and government size. The error correction coefficient in output equation is significantly negative as required (indicating the fall in private per capita output back towards the equilibrium path) while the error correction coefficients on the government size variables are significantly positive indicating a closing of that gap through an increase in size. The insignificance of

error correction terms in the capital stock and educational attainment equations does mean that while these variables may be important determinants of the long run, they do not play a strong role in the re-adjustment process to the long run. The size of the two government size coefficients indicates the relative importance of changes in government size in restoring the long run relationship.

-- insert Table 3 about here --

In terms of the cointegrating equation itself, the equation estimates confirm the inverted U-shaped relationship between government size and private per capita output estimated earlier for the long run. The two government coefficient estimates have their predicted sign and are significantly different from zero at the 1 percent level. Together they imply a tipping point for the effect of government size on private output of 33.2 per cent of GDP, somewhat larger than our earlier estimates. Similarly the effect of an increase in the ratio of central government debt (to GDP) is found to have a significantly negative effect on private output per capita. These two results then confirm the hypothesis tests undertaken earlier for the effect of government size on private per capita output in the long run. On the other hand, neither the level of the capital stock nor the level educational attainment is found to exhibit the significant positive effect on output found earlier. This is despite the contemporaneous coefficients of change in both variables being positive and the sum of the short run coefficients for the capital stock seeming to indicate a more positive correlation over the long run.

The short run adjustment process appears in the six error correction equations found in the bottom half of the table. Because the VAR structure allows for each variable to affect and to be affected by every other variable, the coefficient estimates embody a complicated mixture of simultaneous contemporary effects. Hence to disentangle the different contemporaneous indicators, assumptions must be made about which contemporaneous effect is not present and/or what long run coefficient restrictions should be applied. The ordering of our variables in the Cholesky decomposition implies that

while government size can respond contemporaneously to changes in per capita income, per capita income can respond only with a lag to changes in government size.[20] The impulse responses of a one standard deviation shock to government size and per capita income can then be determined from the coefficient estimates. The impulse response functions of interest are illustrated in Figure 3.

-- insert Figure 3 about here --

In the top left hand diagram in Figure 3, the short run response of private output to a one standard deviation shock to government size is shown. Here the shock to government expenditure can be seen as leading private output to rise slowly and persistently through time. On the other hand, in the top right hand diagram, an unexpected shock to private output is shown to produce a sharply negative rather than positive response, with the size of that response falling off rapidly. The contemporaneous response of government expenditure to an unexpected change in income is then consistent with counter-cyclical fiscal policy, as the government responds in a classically Keynesian manner to the business cycle. The two short run relationships indicated by the VECM then help to explain the seemingly opposing relationships found in the overall positive effect of government size appearing in Table 1 with the strongly negative linear effect captured in columns (2) and (4) of Table 2. The two opposing causal effects also make more understandable why countercyclical fiscal intervention would be undertaken if the negative short run effect found in Table 2 had meant only that greater government spending reduced rather than increased real output.

A similar indication of counter-cyclical intervention in the short run is indicated by the impulse response of central government debt to a real income shock shown in the second diagram of the second row of Figure 3. While the left hand diagram represents the expected negative effect of rising debt on

[20] As is true of most VARs a reordering of the variables does change somewhat the pattern described by the impulse response function. Hence while it may be reasonable to assume a lag to fiscal response, the results portrayed are conditional on that assumption.

per capita income found throughout this analysis, the second diagram shows that government debt responds immediately and in the opposite direction to a real income shock. Because a government deficit increases the debt to GDP ratio, a spending response resulting in a deficit to an unexpected fall in per capita income would imply the negative relationship implied in that diagram.

Finally in the bottom row of Figure 3 the impulse responses linking government size and the government debt ratio through time are presented. The first diagram shows that while there is no immediate increase in government debt to an increase in government size, government debt does tend to rise with an increase in government size. In the second, government size increases with a shock to government debt. Hence while there is no necessary reason why government size and government debt ratios should be related positively through time, they have tended to be so related in New Zealand's case.

6. Economic Significance and Policy Implications

While the discussion explaining the theoretical model and the interpretation of the empirical results is written in terms of the growth in government size that has occurred over the past century in New Zealand, the 1994 passage of Fiscal Responsibility Act in New Zealand brought about or coincided with a dramatic reversal of this trend. By the period leading immediately into the 2007/8 financial crisis, central government size had fallen from over forty percent of GDP in 1993 to roughly thirty percent (a fall of twenty five percent) by 2007. Similarly, central government debt was also reduced significantly, falling from over sixty percent of GDP in 1993 to roughly twenty percent by 2008. In the period since, both ratios have risen somewhat, due at least in part to counter-cyclical measures and deficits adopted to shelter the New Zealand economy from this external shock. However, even with this later rebound, the improvement in the central government's overall fiscal position has been quite remarkable.

It follows from this analysis that the reduction in government size from a level well in excess of any of the tipping points estimated in Tables 1 or 3 and the even more substantive reduction in central government debt should have increased private output per capita above what it would otherwise have been. There should have been an output level premium. Hence to test for its presence and to provide a quantitative measure of the magnitude of this effect I simulated the FMOLS model estimated as column (3) in Table 1 over the post 1994 time period under the assumption that government size, government size squared and the central government debt ratio had stayed constant at the 1994 values. Intuitively, this produces a measure of how the economy would have performed in the long run after allowing physical and human capital to accumulate unaltered but holding the fiscal dimensions of government constant. These results are shown in Figure 4.

--- insert Figure 4 around here –

Figure 4 plots three time series. The solid line plots the actual values of the logarithm of private income per capita, LNPYPC, over the 1890 – 2011 time period. The dashed line plots the expected values that arise from error correction equation of Table 1 column (2), labelled as LNPYPC_Forecasted between 1890 and 2011. The third dotted line is the same as LNPYPC_Forecasted through 1994, however, from 1995 through 2011, LNPYPC94 plots the model's estimate of what LNPYPC would have been had government size and the central government debt ratio been held constant at their 1994 values. The visual result—the slowly increasing dotted line--illustrates the simulation's prediction that as both physical and human capital continued to grow in the post 1994 period, private output per capital would have continued to rise even with no change in government size or the government debt ratio. Nevertheless the faster rise in LNPYPC_Forecasted (and actual) indicates that the rise in per capita output would have been much faster with the realized decline in both ratios.

The gap between the actual and predicted values of LNPYPC and the dotted line simulating the predicted outcome holding government size and the debt ratio constant is then one measure of the

output premium realized by lowering these values. The diagram shows that that gap continued to rise for some time, capturing the increased premium realized by the continuing fall in size and debt ratios. While the growing output gap on the diagram appears large relative to the residuals that arise between actual and predicted LNPYPC, the logarithmic scaling of the diagram tends to understate the magnitude of the output premium and its relative significance. For example, in 2011 the output premium or dollar measure of the gap (in NZ 2000 dollars) was roughly $2,285 per capita. This means that New Zealanders in 2011 would have received an income that was on average 11 percent lower than their then current per capita income of $20,885.57 (had contraction not taken place). The rise in government size and government debt that has recently taken place in response to the recent recession means that this comparison understates the aggregate progress that had been made. For example, in the period immediately before the financial crisis took hold in 2008, the output premium peaked at $4,500 per capita or roughly 20 percent of the $23,000 per capita received in 2008. Finally, because the current (i.e., 2012) size of the New Zealand central government (33.0%) is close to our estimates of the tipping point (25-30%) and likely to be temporarily large because of its position in the current business cycle, further per capita output gains from reducing long run government size seem unlikely.

Simulation results such as these remain subject to the well-known Lucas critique. All other dimensions of the analysis will not remain constant when the policy parameters change (or do not change as is the current case). This means that the large savings generated by this analysis should not be taken literally for policy purposes. What should be taken seriously, however, is that size and significance of the coefficient estimates mean that the output premium realized in New Zealand's case has not been trivial. In this sense it is a useful method to consider for countries considering a similar restructuring. In addition, New Zealand's period of deliberate retrenchment seems to have served them in the short run. That is, by entering the current recession with a substantially reduced the level and

burden to its debt, New Zealand found itself with much greater financial flexibility in its ability to respond to the crisis.

7. Conclusion

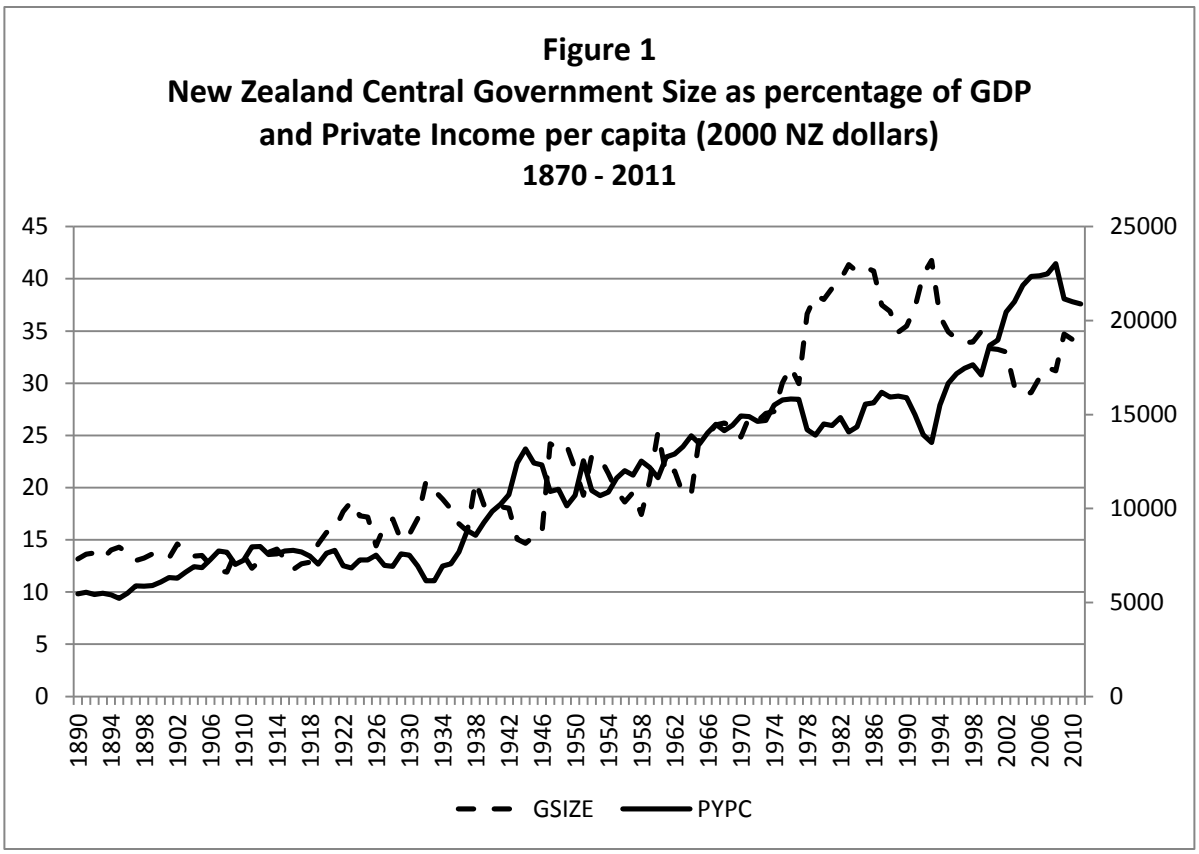
For all countries the relationship between private economic performance and government size is complex and multidimensional, involving a number of different short and long run effects that become bundled together in single fiscal and output time series. My purpose in this paper was to unbundle a number of these dimensions in the case of New Zealand. To do so the analysis began with an Engle-Granger cointegration and error correction approach and then supplemented that with a vector error correction model that provided one way of examining causality in the short run.

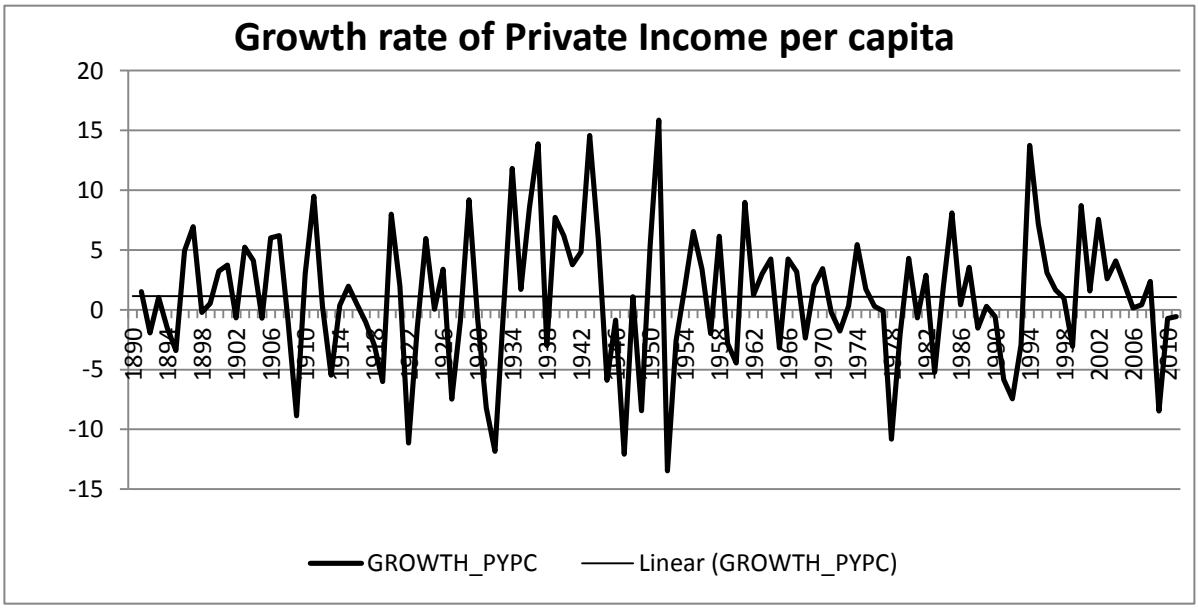
Application of this approach to New Zealand suggests that government size and private output per capita have an inverted U-shaped relationship in the long run that implies the existence of diminishing returns in the provision of government services as government size has grown over time. The coefficient estimates of the empirical work suggest that the positive effect of government size on private performance peaks at around thirty percent of GDP (very close to its current size). The empirical work also suggests that there is a long run burden to servicing government debt. The latter need not imply that any accumulation of any government debt is counterproductive, but should focus attention on the reason for its accumulation.

The short run relationships are more complex but just as insightful. First, a significant part of the short run movement in these variables is attributable to the relatively slow convergence of government size and income per capita on their long run cointegrating/equilibrium time path in response to both transitory and permanent shocks. Second, accounting for the error correction process allows a sharper focus on the shorter run aspects of fiscal policy with short run changes in government size found to be inversely related to transitory changes in per capita output. The VECM provided one

way of examining the two way causality arising between economic performance and government size. The impulse responses reveal time paths consistent with a fiscal policy response to the business cycle that is both transitory and counter-cyclical in nature. At the same time, however, short run changes in government spending are associated increases in per capita output. The pattern of findings then suggests that while causality can run in both directions, outcomes in the very short run are consistent with government spending responding to the cycle and over the longer short run with causality running from government size to per capita income.

The New Zealand case has particular interest because of the explicit efforts made in the recent past to reduce the outstanding ratio of government debt and to control or contract the growth rate of government size. To a large extent this effort has been successful. The simulation results of this paper suggest that while the political and economic costs of cutting back may have been difficult, the effort did pay off in terms of increasing per capita private output. Moreover, while the long run results suggest that there is little more to be gained, and perhaps something to lose, from further contraction, the magnitude of the gain arising from this contraction does appear to have been quite large, perhaps sufficient enough to have offset other dimensions of welfare foregone in the contraction (but arising outside the framework of this analysis). Finally, the analysis suggests that the traditional countercyclical role for fiscal policy has been used and has been effective. At the same time the analysis warns of the long run cost of any asymmetry in its implementation spilling over into larger government size and/or higher levels of government debt.





Source: Statistics New Zealand and the New Zealand Treasury (see Appendix for Details)

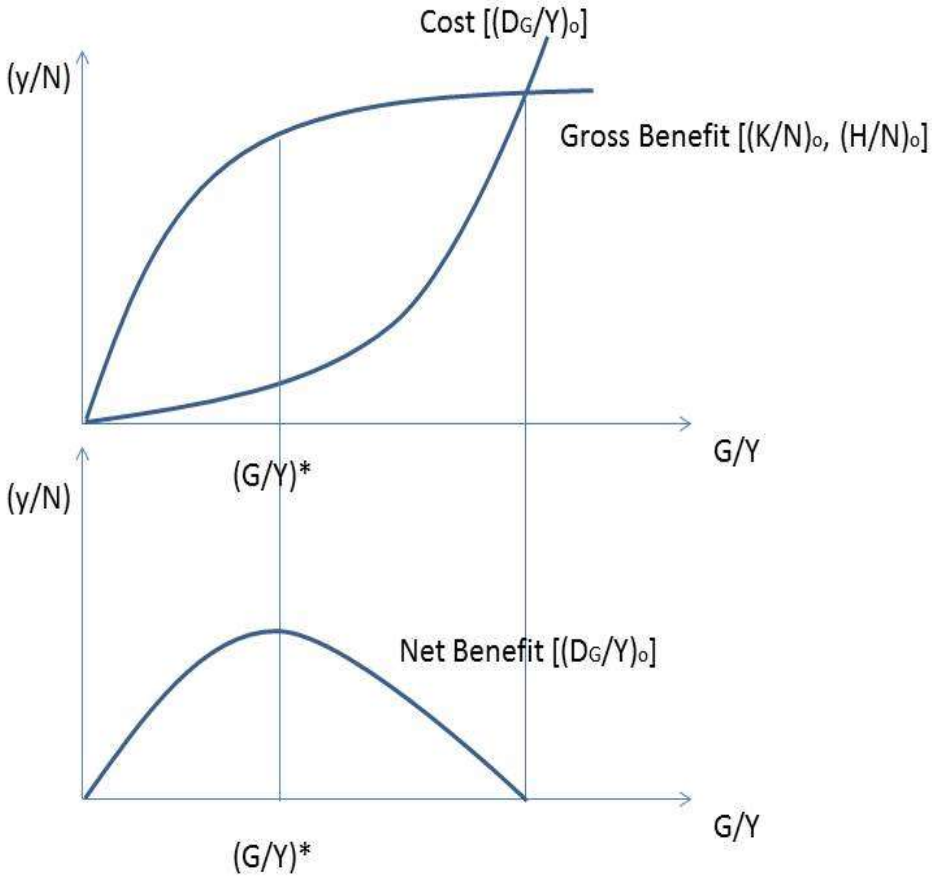


Figure 2 The Effects of Government Size and Government Debt on Private Output

Table 1
The Effect of Government Size on Private Output per capita
New Zealand: 1870 - 2011
(absolute value of t-statistics in brackets)

Dependent Variable	(1) LNPYPC OLS	(2) LNPYPC OLS	(3) LNPYPC FMOLS[1]	(4) LNPYPC DOLS[1]
LNKPC	0.321 (3.74)	0.372 (4.30)	0.233 (1.60)	0.293** (2.41)
LNED_ATTAINMENT	0.487 (6.33)	0.391 (4.59)	0.448*** (3.01)	0.673*** (3.14)
LNGSIZE	0.013 (0.350)	0.937 (2.43)	1.44** (2.26)	1.26* (1.74)
LNGSIZE_SQ		-0.145 (2.41)	-0.213** (2.14)	-0.189* (1.73)
LNCGDEBT	-0.275 (8.58)	-0.266 (8.41)	-0.306*** (5.89)	-0.222*** (3.36)
DEPRESSION	-0.120 (3.75)	-0.130 (4.11)	-0.105** (2.03)	-0.131*** (2.75)
WW2	0.246 (7.94)	0.249 (8.18)	0.294*** (5.93)	0.247*** (4.23)
Constant	10.45 (26.13)	9.36 (15.61)	8.02*** (8.19)	7.59*** (9.27)
Statistics				
no. of obs	122	122	121	119
Adj.R^2	.975	.976	.973	
DW	0.604	0.709	0.752	
ADF[2]	-4.76**	-5.18***	-5.25***	-4.94**
Estimated Tipping point (G/Y)*		25.3%	29.4%	28.0%

*** (**)[*] significantly different from zero at 1% (5%) [10%].

[1] FMOLS and DOLS use Bartlett kernel and Newey-West fixed bandwidth = 5.0 to estimate long run covariance with a maximum of three lags and one fixed lead and lag for the DOLS. The leads and lagged differences of the independent variables are omitted from the table and WW2, DEPRESSION and LNCGDEBT treated as cointegrating equation deterministics.

[2] MacKinnon (1996) 5% critical value for 5 variables (-4.17) and 6 variables (-4.51); 1% critical value for 6 (-5.11).

Table 2

Engle-Granger Error Correction and Growth models for New Zealand 1890 – 2011

(absolute value of t-statistic in brackets)

	(1) D(LNPYPC)	(2) D(LNPYPC)	(3) D(LNPYPC)	(4) D(LNPYPC)	(5) D(LNPYPC)
Error Correction Term[1]	-0.204*** (4.80)	-0.200** (4.71)			
D(LNK_PC)	0.569*** (3.08)	0.562 (2.99)	0.748*** (2.62)	0.570*** (2.84)	0.572*** (2.84)
D(LNED_ATTAINMENT)	.172 (0.61)	0.174 (0.60)	-0.183 (0.28)	0.081 (0.792)	0.078 (0.25)
LNGSIZE			-0.014 (0.97)		
D(LNGSIZE)	-0.035 (0.11)	-0.316*** (9.95)		-0.360*** (11.06)	-.265 (0.76)
D(LNGSIZE_SQ)	-0.047 (0.87)				-0.016 (0.28)
D(LNCGDEBT)	-0.287*** (8.59)	-0.287*** (8.53)	-0.372*** (7.66)	-0.256*** (7.21)	-0.255*** (7.15)
WW2	0.030** (2.56)	0.030** (2.47)	0.041** (2.08)	0.027** (2.08)	0.027** (2.08)
Constant	-0.0004 (0.10)	-0.0004 (0.09)	0.042 (0.82)	0.002 (0.42)	0.002 (0.43)
Statistics No. of Obs. Adj. R^2	 121 0.741	 121 0.753	 121 0.426	 121 0.707	 121 0.705

*** (**)[*] significantly different from zero at 1% (5%) [10%].

[1] Ericsson and MacKinnon (2002) 1% (5%) critical value for 6 variables -4.80 (-4.19)

Table 3
Vector Error Correction Estimates
New Zealand: 1893 2011 after adjustments
(absolute value of t-statistics in brackets)

Cointegrating Eq:	CointEq1
LNPYPC(-1)	1.000000
LNK_PC(-1)	-0.122408
	[0.54327]
LNED_ATTAINMENT(-1)	0.390985
	[0.92044]
LNGSIZE(-1)	-4.242838***
	[4.11921]
LNGSIZE_SQ(-1)	0.609272***
	[3.89981]
LNCGDEBT(-1)	0.381359***
	[4.13172]
C	-5.060541

Error Correction:	D(LNPYPC)	D(LNK_PC)	D(LNED_ATTAINMENT)	D(LNGSIZE)	D(LNGSIZE_SQ)	D(LNCGDEBT)
CointEq1[t]	-0.229507**	-0.009987	3.54E-05	0.391212**	2.217715**	0.031930
	[4.75798]	[0.89989]	[0.02110]	[4.77018]	[4.40176]	[0.43940]
D(LNPYPC(-1))	-0.012519	-0.002212	0.003765	0.230602	1.430840	-0.176994
	[0.08101]	[0.06222]	[0.70062]	[0.87771]	[0.88650]	[0.76030]
D(LNPYPC(-2))	-0.272149*	-0.021989	8.70E-05	0.062700	0.212371	0.878369
	[1.76365]	[0.61934]	[0.01622]	[0.23898]	[0.13176]	[3.77846]
D(LNK_PC(-1))	1.912027***	0.648812***	-0.031631**	-2.788998***	-16.56392***	-1.663539**
	[4.37152]	[6.44729]	[2.07988]	[3.75044]	[3.62573]	[2.52466]
D(LNK_PC(-2))	-0.753489*	0.002613	0.014432	1.295163*	7.706678*	1.256143*
	[1.70272]	[0.02566]	[0.93795]	[1.72141]	[1.66735]	[1.88424]
D(LNED_ATTAINMENT(-1))	2.948468	0.981688	0.440796***	-1.728955	-15.69019	-13.16326***
	[1.10264]	[1.59563]	[4.74089]	[0.38029]	[0.56177]	[3.26763]
D(LNED_ATTAINMENT(-2))	-6.203705**	-1.017572*	0.471628***	7.271599	46.51596*	13.11279***
	[2.36176]	[1.68372]	[5.16378]	[1.62821]	[1.69543]	[3.31368]
D(LNGSIZE(-1))	0.328232	0.201982	0.012146	-0.009125	-0.530916	-1.877278**
	[0.59482]	[1.59089]	[0.63300]	[0.00973]	[0.09211]	[2.25822]

D(LNGSIZE(-2))	-0.006941	-0.086260	0.025097	-0.359287	-1.385702	-0.738125
	[0.01209]	[0.65312]	[1.25740]	[0.36813]	[0.23111]	[0.85354]
D(LNGSIZE_SQ(-1))	-0.065688	-0.035035*	-0.001798	0.029866	0.256612	0.300771**
	[0.71906]	[1.66690]	[0.56596]	[0.19229]	[0.26894]	[2.18549]
D(LNGSIZE_SQ(-2))	-0.013091	0.014397	-0.004120	0.062159	0.231540	0.178888
	[0.13778]	[0.65857]	[1.24716]	[0.38479]	[0.23332]	[1.24979]
D(LNCGDEBT(-1))	-0.062282	-0.012784	0.004031	0.003070	0.041373	0.354404***
	[0.75653]	[0.67495]	[1.40824]	[0.02193]	[0.04811]	[2.85756]
D(LNCGDEBT(-2))	0.069998	-0.017079	-0.001494	-0.064882	-0.392590	0.185053
	[0.91945]	[0.97508]	[0.56444]	[0.50127]	[0.49372]	[1.61352]
C	0.032527***	0.005634**	0.000645	-0.031100	-0.161520	-0.012764
	[2.82870]	[2.12945]	[1.61444]	[1.59077]	[1.34483]	[0.73684]
WW2	0.091099***	-0.000475	8.85E-05	-0.138145***	-0.788119***	-0.012577
	[3.81751]	[0.08659]	[0.10665]	[3.40482]	[3.16192]	[0.34984]
DEPRESSION	-0.043223**	-0.004998	-0.000602	0.056238	0.303218	0.028855
	[1.97323]	[0.99163]	[0.79104]	[1.51003]	[1.32529]	[0.87441]
R-squared	0.384783	0.486797	0.965589	0.324495	0.296993	0.390847
Adj. R-squared	0.295188	0.412059	0.960577	0.226120	0.194614	0.302135
Sum sq. resids	0.224512	0.011885	0.000271	0.649005	24.49353	0.509539
S.E. equation	0.046688	0.010742	0.001623	0.079379	0.487649	0.070335
F-statistic	4.294700	6.513362	192.6798	3.298566	2.900903	4.405818
Log likelihood	204.3869	379.2366	604.1047	141.2269	-74.80118	155.6219
Akaike AIC	-3.166166	-6.104817	-9.884112	-2.104653	1.526070	-2.346587
Schwarz SC	-2.792502	-5.731154	-9.510448	-1.730990	1.899734	-1.972923
Mean dependent	0.011318	0.013174	0.009592	0.007779	0.047979	-0.009221
S.D. dependent	0.055611	0.014009	0.008176	0.090234	0.543382	0.084195

Determinant resid covariance (dof adj.)	1.25E-20
Determinant resid covariance	5.27E-21
Log likelihood	1765.021
Akaike information criterion	-27.94993
Schwarz criterion	-25.56783

***(**)[*] significantly different from zero at 1% (5%)[10%]. Lag length determined by minimization of the Akaike Criterion.

[t] Ericsson and MacKinnon (2002) 1% (5%) critical values: 6 variables -4.80 (-4.19)

Lag length determined by a Chi-squared lag exclusion test.

Figure 3

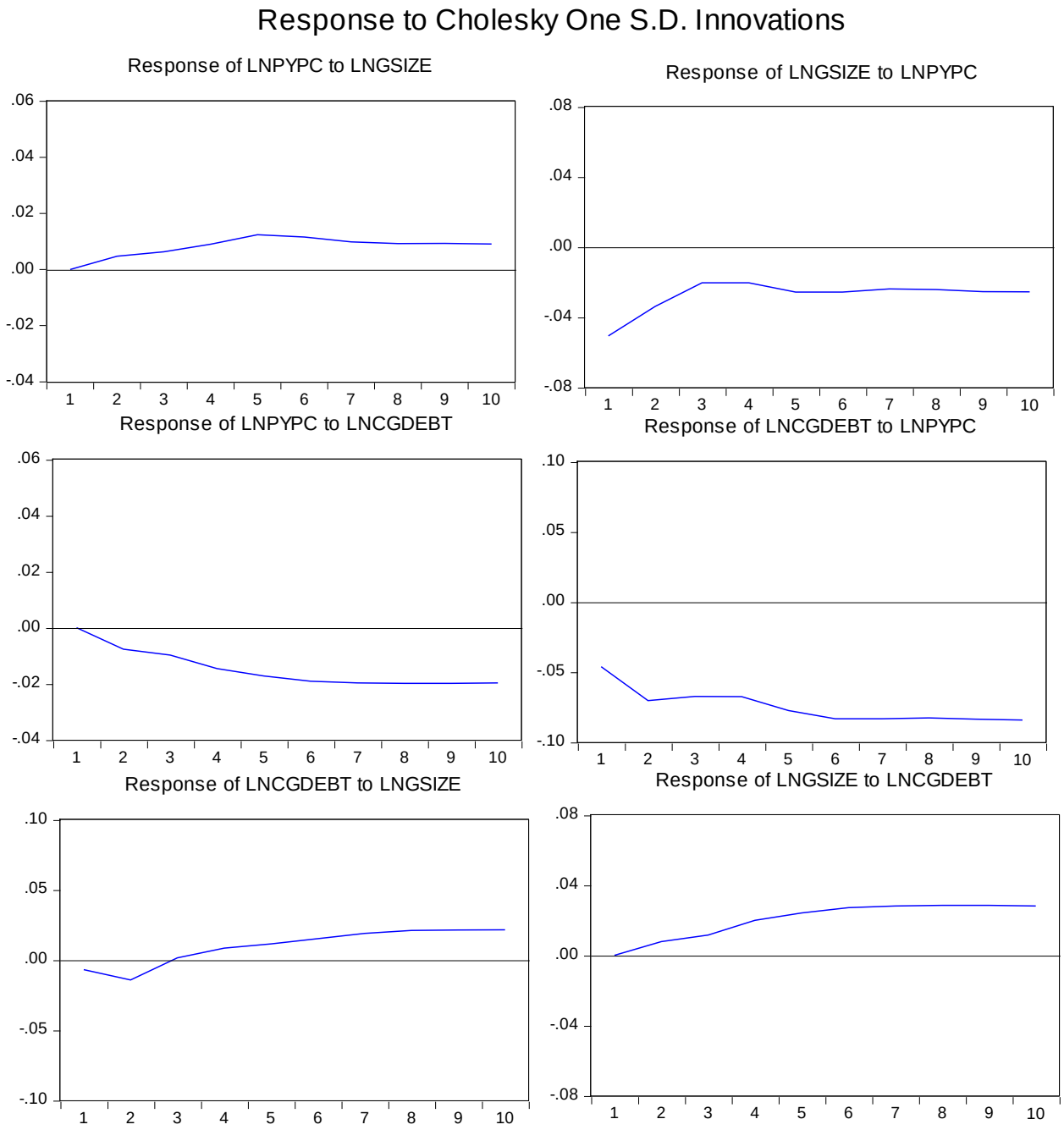
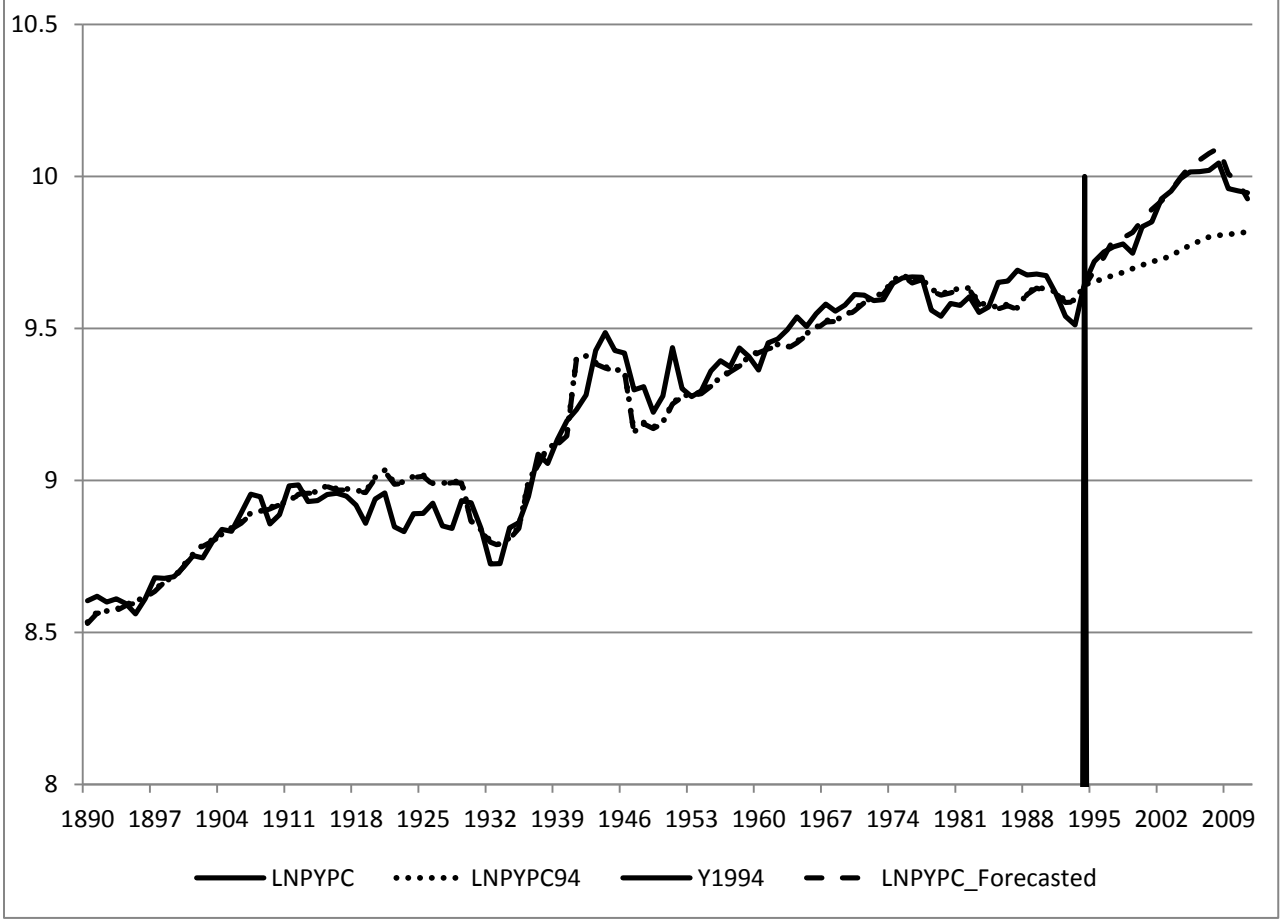

Response to Cholesky One S.D. Innovations
Response of LNPYPC to LNGSIZE
Response of LNGSIZE to LNPYPC
Response of LNPYPC to LNCGDEBT
Response of LNCGDEBT to LNPYPC
Response of LNCGDEBT to LNGSIZE
Response of LNGSIZE to LNCGDEBT

Figure 4
The Logarithmic values of Private output per capita in NewZealand: actual, predicted and simulated post 1994



Sources: Statistics New Zealand and the forecasted values of the OLS equation in Table 1 column (2). LNYPPC94 uses the coefficient estimates of the cointegration equation in Table 1 column (2) and actual covariate values for each year except for the period following 1994 when government size, government size squared and the central government debt ratio are held constant at their 1994 values.

Appendix on New Zealand data sources: 1890 – 2012

A. Data 1890 – 2002, downloaded from the web site below (on October 20 2011): http://www.stats.govt.nz/browse_for_stats/economic_indicators/NationalAccounts/long-term-data-series.aspx (terminated in 2002).

RGDP = Real Gross Domestic Product (Table e1-2 column AH in 2000$)
RGDPPC = Real Gross Domestic Product per capita (Table e1-2, column AK in 2000$)
D(.) = first difference operator ; LN(.) = log(variable)
D(LNRGDPPC) = growth rate of real GDP per capita
RCGDebt = consolidated real central government debt (Table d4-1 column AJ in 2000$)
LNCGDEBT = LN(RCGDebt/RGDP)
RCGE = Real Central government expenditure (Table d2-1 column AP in 2000$)
LNGSIZE = LN[(RCGE/RGDP)*100]; LNGSIZE_SQ = LNGSIZE*LNGSIZE
PYPC = Real private sector output per capita (2000$) = (RGDP-RCGE)/Pop
LNPYPC= LN(RYPC)
D(LNPYPC) = Growth_pypc = growth rate of private income per capita
CGREV = Central government revenues (Table d1-1, 1867 -2002 breakdown sheet, Column U)
RCGREV = Real Central Government Revenues/CPI_2000 (Table d1-1 data sheet column U 2000 = 100)

B. Updating from 2002-2011/2:

1. Statistics New Zealand Infoshare: Long Term Data Series 2001-2012, www.stats.govt.nz/infoshare/long-term_data_series, downloaded February 20 2013

RGDP (1995/6) = GDP nominal in constant 1995/6 dollars
POP = Population estimates in NZ – DPEA
RGDPPC (1995/96) = RGDP(1995/6)/POP converted to 2000 $ at 2002 (adjustment factor = 1.01592309).

Terms_of Trade: Table 1.02 Overseas merchandise trade price and terms of trade index, series STTZZ5 http://www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/OverseasTradeIndexesPrices_HOTPSep12qtr.aspx, downloaded February 25 2013.

2. New Zealand Treasury: www.treasury.govt.nz/budget/forecasts/befu2010/befu10-pt5of6.pdf

Government Revenue and Expenses as a ratio of GDP: Times Series of Fiscal Indicators p.159. (downloaded Feb 25 2013).
CGDebt_ratio = Gross Central Government Debt incl. RB settlement cash and bank bills/GDP nominal. Time Series of Fiscal and Economic Indicators, 2012 Half-year economic and fiscal update, B.6 p.126 online source at http://www.treasury.govt.nz/budget/forecasts/hyefu2012/hyefu12-pt10of11.pdf (downloaded Feb 26 2013).

C. Educational Attainment and Capital Stock Data 1890 – 2011 (Jakob Madsen data)

Madsen, J.B., (2013) "Human Capital and the World Technology Frontier." *Review of Economics and Statistics*, forthcoming. (for educational attainment)

Madsen, J.B., (2007) "Technology Spillover through Trade and TFP convergence: 135 Years of Evidence for the OECD countries." *Journal of International Economics*, 72(2), 464-480. (for real capital stock).

Descriptive Statistics of Variables Used (1890 -2012)

	Mean	Max	Min	Std Dev	ADF H_o Series has a unit root	KPSS H_o Series is stationary
LNPYPC	9.27	10.04	8.56	0.41	-0.773 intercept	1.28***
D(LNPYPC)	1.10	15.9	-13.5	5.52	-9.99*** intercept	0.036*
LNGSIZE	3.06	3.73	2.48	0.39	-1.26 intercept	1.22***
D(LNGSIZE)					-11.6*** intercept	0.500*
LNGSIZE_SQ	9.54	13.93	6.14	2.43	-1.18 intercept	1.20***
D(LNGSIZE_SQ)					-11.6*** intercept	0.236
LNCGDEBT	4.34	5.35	3.01	0.53	-1.10 intercept	1.01***
D(LNCGDEBT)					-7.32*** intercept	0.085
LNKPC	-3.46	-2.63	-4.21	0.418	-0.032 intercept	1.31***
D(LNKPC)					-5.01*** intercept	0.138
LNED_Attainment	2.24	2.60	1.38	0.309	-2.04 intercept	1.24***
D(LNED_Attainment)					-5.30*** intercept	0.262

Rejection of H_o at 1% (5%) [10%] indicated by *** (**) [*]
ADF uses Schwartz info criteria for automatic lag length selection (12 max); KPSS uses Barlett kernels with automatic Newey-West bandwidth selection.

References

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