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**Working Paper**

## An Empirical Study of Sectoral-Level Capital Investments in New Zealand

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# An Empirical Study of Sectoral-Level Capital Investments in New Zealand

Weshah Razzak

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WORKING PAPER  
14/04**

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New Zealand

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# Abstract

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I extend the Glick and Rogoff (1995) aggregate time-series, empirical, intertemporal model of country-investment (and the current account) to a sectoral-level, and estimate it for New Zealand. I fit the model to panel data of eleven industries from 1988-2009. The sectoral-level investment growth is a function of lagged investment level, sector-specific TFP shocks, country-specific TFP shocks, and global TFP shocks. The estimates seem robust to government spending shocks and Terms of Trade shocks.

**JEL CLASSIFICATION**     E2, C2, C3

**KEYWORDS**     Investments, sectoral-level, TFP shocks, panel data

## Executive Summary

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There is a general agreement among economists that capital investments are shallow in New Zealand, and that might have been a result of relatively low productivity; ie, there is a positive association between the two.

This paper uses an empirical model to estimate the responsiveness of growth in sectoral level investment to a number of productivity shocks. Intuitively, it says that one would expect investments to increase in productive industries, and cease to grow in non-productive activities.

Productivity is measured as Total Factor Productivity (TFP), which accounts for the changes in output not caused by changes in labour and capital inputs. TFP growth represents the effect of technological change, efficiency improvements, and our inability to measure the contribution of all other inputs. There are three shocks that drive growth in investment at the sectoral level; a sector-specific TFP shock; a country-specific TFP shock, and a global TFP shock. Investment growth at the sectoral-level is also driven by past investment level. Past investment reflects adjustment costs, and may also reflect expectations.

The key findings confirm a positive association between investment growth and productivity shocks. It is found that sectoral-level investment growth responds significantly and contemporaneously to sector-specific and country-specific TFP shocks, but only responds significantly to past global TFP shocks with a two year lag. Further, the responsiveness to past sectoral-level investment also varies across industries because adjustment costs are differ across industries.

Government spending shocks, which are treated as a pure aggregate demand shocks, positively affect investment growth at the sectoral-level in New Zealand.

In addition, sectoral-level investment growth responds positively to shocks in the terms of trade, although the reactions vary from one sector to another, and with different lags.

To summarise, the main findings of this study are that various random productivity shocks have significant effects on current sectoral-level investment growth. This is consistent with the view that New Zealand's capital investments shallowness is associated with relatively low productivity.

The result, that the sectoral-level investments are driven by random productivity shocks, implies these are beyond the direct influence of policy. However, the fact that lagged investment levels are very significant determinants of investment growth gives policy a potential role. Policy can provide incentives to private investors to invest in a particular type of productive capital or lead to direct investment in productive capital. For example, the government can use fiscal policy and active labour market policy to increase labour supply and labour productivity, which in turn may stimulate additional investment.

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# An Empirical Study of Sectoral-Level Capital Investments in New Zealand

## 1 Introduction

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The consensus is that New Zealand has relatively low levels of both capital intensity and productivity, as measured by GDP per hour worked, because total factor productivity (TFP) is low (Treasury 2008).<sup>1</sup> TFP accounts for the changes in output not caused by changes in labour and capital inputs. TFP growth represents the effect of technological change, efficiency improvements, and our inability to measure the contribution of all other inputs. This argument is consistent with a number of different growth models.<sup>2</sup>

Essentially, TFP might be the main explanatory variable for capital investments. Prescott (1997) shows that cross-country differences in savings rates – even after correcting the capital stock data to include intangible capital – explain only very small portions of the income differentials between countries. A model with human capital also fails for similar reasons. In contrast, TFP is the most important variable that can explain differences in cross-country income differences.

Laabas and Razzak (2011) calibrated an aggregate, semi-endogenous growth-accounting model that accounts for the *quality* of human capital. They found that three-quarters of New Zealand's GDP per hour growth rate is attributed to TFP growth (not capital, labour, or human capital). And, TFP explains one-half of the productivity growth in Australia. But, at the firm level, lagged investments seem to explain all the variations of current investments.

Prescott (1997) emphasises that although the U.S. is overall the most productive nation in the world, it is not the most productive nation in *all* industries. He shows that sector-level productivity differences are not explained by differences in the stock of capital, human capital, or useable knowledge.

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<sup>1</sup> Investment, Productivity and the Cost of Capital: Understanding New Zealand's Capital Shallowness. Treasury Paper 08/3.

<sup>2</sup> The argument is consistent, for example, with the endogenous growth AK model, which assumes that output is given by the following simple production function:  $Y = B[K^\alpha (TL)^{1-\alpha}]$ , where  $Y$  is output,  $K$  is the stock of capital, and  $TL$  is labour-augmented technical progress, such as human capital. It is assumed that workers follow a process of learning-by-doing *a la* Arrow thus:  $T = \gamma K$ , Which says  $T$  is proportional to  $K$ , and  $\gamma$  is a constant term. In the Arrow model, workers also learn by working with the firms' capital and from knowledge spill over from other firms. Substituting for  $T$  in the production function and solve, we arrive at:  $Y = B(\gamma L^{1-\alpha})K = AK$ , hence the AK model, where  $B(\gamma L^{1-\alpha}) = A$ . The marginal product of capital is  $\partial Y / \partial K = A > 0$ . Thus, growth is perpetual since the MPK is positive.

Intertemporal models in this literature are usually simulated because they do not have closed-form solutions. Estimation might shed more light on the responsiveness of the sector-level investment growth to various shocks, which might vary across different industries. We could measure the size of these responses; policy responses may be different for different industries.

This paper attempts to explain the behaviour of sector-level capital investment. It draws on three different aspects of the investment literature. First, an intertemporal model, where investment growth is a function of past investment's level and productivity shocks; second it investigates investments at the sectoral level rather than the aggregate level; and finally the model is estimated rather than simulated.

The present paper extends Glick and Rogoff (1995). They follow Sachs (1981), Obstfeld (1986) and Frenkel and Razin (1987) who study the intertemporal effect of government spending and productivity shocks.<sup>3</sup> Their model, however, is an aggregate empirical model – where the investment-growth rate is a function of the lagged investment level, a country-specific TFP shock, and a global TFP shock. This model is extended to study the sectoral-level investments in New Zealand and introduce a third shock – and sector-specific TFP shock. In this version of the model, sectoral-level capital investment growth rate depends on lag investment level, sector-specific TFP shock, country-specific TFP shock, and a global TFP shock. The model controls for government spending shocks and terms of trade shocks (ToT). The former are assumed to be a pure aggregate demand shock as in Glick and Rogoff (1995) while the latter could be either a demand or a supply shock. This is done to reflect the evidence for the effect of ToT shocks on the real economy and optimal resource allocation (eg, Hunt, 2009, Grimes, 2009). Hunt (2009) uses the IMF macro model. Grimes calibrates a general equilibrium model. Both assume a two sector economy of tradable and non-tradable goods. Cassino (2012) provides evidence that subjectively splitting real GDP into tradable and non-tradable goods might be misleading. For example, some clearly non-tradable goods such as housing have intermediate inputs, which are largely tradables.<sup>4</sup> The present sectoral-level modelling and estimation method is consistent with Cassino (2012).

The results confirm the positive association between the shallowness of capital investments and productivity shocks in New Zealand at the sectoral level. On average, sector-specific TFP shocks have effects on sectoral-level investments, but the effects have different magnitudes for different industries; and country-specific TFP shocks are more important for the sectoral-level investment growth and more statistically significant. Contemporaneous global TFP shocks have no effect on investments at the sectoral level, but there is a very strong lagged effect. On average, the response of the sectoral-level investment growth to these shocks is twice as large in magnitudes as to country-specific TFP shocks; it is also five times larger than the response to sectoral-specific TFP shocks; further the effect of lagged investment's is very significant and varies across industries. On average, both government spending and ToT shocks have positive effects on the sectoral -level investment growth. However, there is evidence that the latter affects investment growth for some industries with a lag between one and two years.

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<sup>3</sup> Glick and Rogoff (1995) argue that a country-specific productivity shock can alter consumption rather than the complete markets open-economy real business cycle model. Baxter and Crucini (1992) show that the two approaches yield similar results for cross-country correlations unless the degree of persistence of the productivity shock is very high.

<sup>4</sup> Cassino (2012) is an internal New Zealand Treasury research memo, which illustrates that dividing GDP into tradable and non-tradable sectors lacks empirical evidence. Indeed, take housing for example. It is typically assumed to be a non-tradable goods sector even though most, if not all, intermediate inputs into housing are tradable goods.



The paper is organized as follows. Section 2 outlines the model, while Section 3 describes the data. Section 4 includes the estimation and analyse the results. Section 5 concludes and provides a short policy discussion.

## 2 The Model

### 2.1 Output Supply

The representative agent supplies labour inelastically so that the production function is given by:

$$Y_t = A_{ct} K_t^\alpha \left[ 1 - \frac{g}{2} \left( \frac{I_t^2}{K_t} \right) \right] \quad (1)$$

Where  $Y_t$  is output,  $K_t$  is the stock of capital, the term  $I_t^2 / K_t$  captures the adjustment costs in changing capital stock over time,  $A_{ct}$  is a country-specific TFP shock, where the subscript  $c$  denotes country and  $t$  is a time index. The stock of capital evolves according to:

$$K_{t+1} = K_t + I_t \quad (2)$$

The representative firm chooses an optimal path for investment  $I_t$  to maximize the present discounted value of future profits, discounted at the world interest rate.<sup>6</sup> Glick and Rogoff (1995) use solution methods found in Abel and Blanchard (1986), Shapiro (1986), and Meese (1980) to solve this optimisation problem. They take a linear approximation to the first-order conditions, which gives:

$$Y_t \cong \alpha_1 I_t + \alpha_2 K_t + \alpha_3 A_{ct} \quad (3)$$

Where  $\alpha_1 < 0$  due to adjustment costs, and  $\alpha_2; \alpha_3 > 0$

and

$$I_t \cong \beta_1 I_{t-1} + \eta \sum_{s=1}^{\infty} \lambda^s (E_t A_{c,t+s} - E_{t-1} A_{c,t+s-1}) \quad (4)$$

In equation (4), the coefficients are  $0 < \beta_1 < 1$ ,  $\eta > 0$ , and  $0 < \lambda < 1$ . The expectation operator is  $E$ , taken at time  $t$ . The first term captures the effects of lagged investment and the second term captures the impact of revision in expectations about the future path of productivity.

The following approach is used to derive an empirical equation for investment. Glick and Rogoff (1995) assume that the country-specific *exogenous* TFP shock ( $A_{ct}$ ) follows a first-order autoregressive process:

$$A_{ct} = \rho A_{c,t-1} + \varepsilon_t \quad (5)$$

<sup>5</sup> Glick and Rogoff (1995) do not have depreciation in the capital stock equation. They say it slightly complicates the empirical specification but does not appear to affect the results.

<sup>6</sup> The assumption is that the marginal utility of consumption and investment is time-invariant because country-specific TFP shocks cannot be diversified.

<sup>7</sup> It is assumed that productivity shocks are homosecedastic and that the variance terms that would appear in the second-order approximation are constants.

The autoregressive parameter,  $0 < \rho < 1$ , but this could be extended to a higher-order ARMA process. They assumed that  $\rho = 1$  because it is consistent with the unit root's test results, and for convenience too. This implies that country-specific TFP shocks are persistent and behave like a random-walk process. Assuming  $\rho = 1$  and combining equation (4) and (5) yields:

$$I_t = \beta_1 I_{t-1} + \beta_2 \Delta A_{ct} \quad (6)$$

where the coefficient  $\beta_2$  is  $= \eta[\lambda/(1-\lambda)] > 0$ .

Subtracting  $I_{t-1}$  from both sides results in the following empirical equation for investment:

$$\Delta I_t = (\beta_1 - 1)I_{t-1} + \beta_2 \Delta A_{ct} \quad (7)$$

Both equations (6) and (7) are estimable equations. The transformation of (6) to (7) does not affect the errors in (6). Glick and Rogoff (1995) address this issue in details. In any case, the estimation of the equations must involve a careful testing of the residuals.

## 2.2 Global TFP shocks

To introduce global productivity shocks to the model, Glick and Rogoff (1995) replaced the production function in equation (1) with:

$$Y_{ct} = (A_{gt} \quad A_{ct}) K_t^\alpha \left[ 1 - \frac{z}{2} \left( \frac{I_t^2}{K_t} \right) \right] \quad (8)$$

This states that output in country  $c$  is determined by its capital stock, and a country-specific TFP shock and a global TFP shock.

The empirical equation for investment (6) now becomes:

$$\Delta I_t = (\beta_1 - 1)I_{t-1} + \beta_2 \Delta A_{ct} + \beta_3 \Delta A_{gt} \quad (9)$$

Both the TFP shocks follow random walks,  $0 < \beta_3 < \beta_2$ . The effect depends on the permanency of the shocks. The coefficient  $\beta_3$  can be greater than  $\beta_2$ , if global TFP shocks are permanent while the country-specific TFP shocks are sufficiently transient.

## 2.3 Sectoral-specific TFP shocks

In this section we adjust the sectoral level model to incorporate sector-specific TFP shocks. Aggregate investment is the sum of the sectoral-level investments.

Equation (1) becomes:

$$Y_{it} = (A_{it} \quad A_{ct} \quad A_{gt}) K_{it}^\alpha \left[ 1 - \frac{z}{2} \left( \frac{I_{it}^2}{K_{it}} \right) \right] \quad (10)$$

And equation (2) becomes:

$$K_{i,t+1} = K_{i,t} + I_{i,t} \quad (11)$$

Where the subscript  $i$  denotes sector. The empirical investment equation now becomes:

$$\Delta I_{it} = (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t} + v_i + \varepsilon_{it} \quad (12)$$

The magnitude of the effect of the global TFP shock could be larger than both the country-specific TFP shock and the sector-specific TFP shock if the global TFP shock is permanent and the others are sufficiently transitory.

### 3 Data

The dependent variable in equation (12) is the sectoral-level investment growth rate. Data for sectoral level investments are from Statistics New Zealand. The data for the real stock of capital by sector ( $K_{it}$ ) are net of depreciation, and exclude land. Log investment ( $I_{it}$ ) is  $\Delta \log K_{it}$ , where  $\Delta$  is the difference operator and log is the natural logarithm (ln). Sector-specific annual TFP growth rates are from the Statistics New Zealand webpage. The sample sizes vary across sectors. There are eleven industries with complete time series data from 1988 to 2009: (1) Agriculture, Forestry and Fishing; (2) Mining; (3) Manufacturing; (4) Electricity, Water, and Waste Services; (5) Construction; (6) Wholesale Trade; (7) Retail Trade; (8) Accommodation and Food Services; (9) Transport, Postal, and Warehousing; (10) Information, Media, and Telecom; and (11) Financial & Insurance Services. New Zealand's TFP and the global TFP data are from the Conference Source Board Database. Figure 1 plots the sectoral-level log capital stocks; figure 2 plots investments and figure 3 plots the sectoral-level TFP growth rates. All the data used in the estimation of equation (12) are I(0).

Three different measures were examined for New Zealand's country-specific TFP growth shock. The first used Conference Board data; the second was based on the Solow residuals; and the third averages TFP growth over the eleven industries in the sample.<sup>8</sup> The last option was chosen as it relates directly to the sections used in this study. Also, the aggregate estimates in the first two measures include more service sectors whose outputs are difficult to measure. Barsky and Sims (2011) study the role of *news* shocks. They find that the surprise movements of the Solow residuals, which are called adjusted TFP series, are largely temporary but the permanent component has a predictable component. Figure 4 plots the three measures.

The global TFP growth shock represents the weighted-average of the shocks of the following countries: Australia, U.S., U.K., Germany, China, Hong Kong, Japan, Malaysia, Singapore, Korea, and India. The countries are chosen because they represent New Zealand's trading partners. The Conference Board estimates of TFP growth are residuals, which are computed by subtracting the sum of two-period average compensation share weighted input growth rates from the output growth rate. Log differences of the values level are used for growth rates, and hence TFP growth rates are Tornqvist indices. Two different weights are used: a GDP weighted-average of the eleven-country TFP shocks, and a trade-weighted average. (I also tried to split them into Asian countries with or without Australia, the U.S. alone, and the Euro area.) Figure 5 plots the data.

<sup>8</sup> The Solow residuals are computed as follows:  $Y_t / K_t^{0.4} H_t^{0.6}$ , where  $K_t$  is the aggregate stock of capital, which is approximated using the Perpetual Inventory Method. I assumed that initial stock of capital  $K_0$  is three times real GDP, depreciation rate is 8 percent annually, and Gross Capital formation plus the change in inventory as a proxy for investments. The share of capital 0.40 is approximately equal to the average ratio of gross operating surplus / GDP ratio over the period 1988-2011.

## 4 Estimation and results

Equation (12) is estimated using Least-Squares estimator because lagged investment is a pre-determined variable and the shocks are exogenous. The regression is a sector-fixed-effect panel regression, where T is 1988 to 2009 and N is eleven industries. The way this equation is derived does not involve differencing the fixed effect, and since T is greater than N, the least square estimator is appropriate. N is asymptotically identified as T goes to infinity.<sup>9</sup> White cross-section standard errors and a variance-covariance matrix are estimated, and a correction made for the number of degrees of freedom. Note, however, the capital stock is understated because it excludes *intangibles*,<sup>10</sup> this might introduce bias and inconsistency in the parameter estimates. This issue is beyond the scope of this paper, and cannot be resolved until some new data are made available.<sup>11</sup>

Table 1 reports the initial results of estimating equation (12). The lagged investment effect is statistically significant. The restriction  $\beta_1 - 1$  is estimated, and  $\beta_1$ , which is an estimate of the average across industries is, 0.57. Thus, as shown in equation (6), an increase in lagged investment positively affects current investment's level. This is consistent with the estimates reported in Glick and Rogoff (1995), and with Eberly *et al.* (2012) who provide evidence that the specification of investment adjustment costs proposed by Christiano *et al.* (2005) predicts the presence of a lagged investment effect, and that a generalized version of that model is consistent with the behaviour of firm-level data. In Christiano *et al.* (2005), there is a second order adjustment cost assumption that leads to this lagged effect, and also gives rise to the role of expectations in investment decisions. The sector-specific TFP shock has a coefficient of 0.06 and is significant. So – on average – a one percent sector-specific TFP shock raises investments growth by only 0.06 percent. The average effect of the country-specific TFP shock on sectoral-level investments is significant and has a larger effect on the sectoral-level investment growth rate than sector-specific shocks. On average, a 1 percent increase in New Zealand's TFP growth rate increases the sectoral-level investment growth by 0.15 percent. So on average, the industries are more sensitive to country-specific TFP shocks than to their own TFP shocks. Finally, on average, global TFP shocks have no significant effects on the growth rate of the sectoral-level investments in New Zealand.

In Table 2, reports same regression, but allowing global TFP shocks to affect sectoral-level investment growth with a lag. The typical interpretation of the lagged global TFP shock is that these shocks have a significant delayed effect. However, the lagged values can also be proxy for expected or anticipated shocks under rational expectations and perfect foresights. In the standard real business cycle model with fully-flexible prices, an increase in the expected future productivity raises the real interest rate, but decreases the current level of investment given a value for the intertemporal elasticity of substitution in consumption. Olivei (1999) shows that under price stickiness, the effect of anticipated productivity increases current investment, and the real interest rate. Positive and significant lagged effects of productivity shocks on investment growth in New Zealand might be consistent with price stickiness. Evens (1992) showed that productivity shocks, which are measured as Solow residuals like our measure, are in fact highly correlated with

<sup>9</sup> It could be argued that certain investments affect productivity as in endogenous growth models, hence linear least squares estimates are biased and inconsistent. An IV estimator must be used if the argument is correct, but there are no obvious adequate instruments, and the lags are short too.

<sup>10</sup> There is a small but growing literature on this issue. Countries are becoming interested in measuring intangible capital. See Arato and Yamada (2012) for Japan, a number of papers by McGrattan and Prescott (2000, 2004, 2005, 2010, and 2011) for the U.S. for example.

<sup>11</sup> It would possible to estimate a GMM regression if sectoral-level instruments are available, but they are not. One potential instrument might be the growth rate of human capital at the sectoral-level.

money, interest rate, and government spending, so these shocks can be anticipated. He found that money, real interest rate and governments pending to Granger-cause productivity shocks measured by the Solow residuals. He also found that  $\frac{1}{4}$  to  $\frac{1}{2}$  of the variations in these shocks can be attributable to aggregate demand fluctuations. Our finding seems to be highly consistent with such evidence.

The short time series precludes that use of formal methods to determine the lag structure. Instead, an arbitrary general lag structure of four lags was tested. The global TFP shock was only significant in the case of a two-year lag. A one percent positive global TFP shock increases investment growth at the sectoral-level two years later by 0.31 percent. This effect is twice as large as the country-specific contemporaneous shock and at least five times as large as the sector-specific TFP shock. The effect of global TFP shocks on New Zealand indicates that the global TFP shock maybe more permanent than the country-specific TFP shock and the sector-specific shock. The time series are tested for unit root and the hypothesis is rejected in all cases. However, the sector-specific TFP shock time series vary across industries, where the unit root hypothesis is also tested for the panel using commonly used panel unit root tests. The hypothesis of unit root can be rejected. Furthermore New Zealand is a small open economy and trades with the rest of the world. A similar estimation with lags on the country-specific TFP shock was tested, but none of the lags were significant. The global TFP shock will be lagged twice in the remaining regressions and the country-specific TFP shock will remain contemporaneous.

This model was then estimated allowing for lagged investment and for the sector-specific TFP shock to vary across industries. These two regressions were estimated separately to conserve degrees-of-freedom.

In Table 3 reports the results allowing lagged investments to vary across industries. The sectoral-level TFP effect is 0.08 and the country-specific TFP shock magnitude is 0.22, slightly larger than before. The global TFP shock is 0.27, slightly smaller than before. All these coefficients are statistically significant. Most importantly, lagged investment is significant and varies across industries. It is insignificant in three industries: Manufacturing, Wholesale Trade and Accommodation & Food Services. While Agriculture, Forestry and Fishery's has a significant coefficient of 0.90, Transport, Postal, and Warehousing has a significant coefficient of nearly 1, Manufacturing has an insignificant coefficient of 0.18. These results suggest that there is some idiosyncratic persistence at the sectoral level. It remains a puzzle that lagged investment's level does not affect current investment's level in manufacturing.

Table 4 reports the results, where the sector-specific TFP shock is allowed to vary across industries. There are no changes in the average estimates of lagged investment effect, the country-specific TFP shock, and the lagged global TFP shock. The sector-specific TFP shock also varies significantly across industries. The shock is insignificant in six industries, and has a negative effect in the Electricity, Water, and Waste Services and Transport, Postal, and Warehousing Services industries. These two negative signs are inconsistent with theory and it may be that allowing the parameters to vary with sectors introduced some misspecifications. It is significant in Construction (0.13), Retail Trade (0.37), and Information, Media, and Telecommunications Services. This confirms the average regression, which shows that the sectoral-level investment growth is not highly influenced by sector-specific TFP shocks.

The regressions are now re-estimated allowing for two shocks: a country-specific government spending shock and a (ToT) shock. Glick and Rogoff (1995) treat government spending shocks as pure aggregate demand shocks under the assumptions that the utility function is separable in private and public consumption and that government spending is financed by lump-sum taxes. Government spending shocks, whether country-specific or

global, can affect investment through the real interest rate. In Barro (1981) who pioneered this literature, permanent government spending shocks do not alter the real interest rate; hence have no effect on real investments. However, there are difficulties in estimating the effects of government shocks on the real economy. The difficulties arise from disentangling many effects operating at the same time when measuring transitory government spending shocks.<sup>12</sup>

Government spending is defined as total central-government real expenditures less defence spending and interest payments. It does not include real transfer payments to households. This measure was used with and without government investment. Statistics New Zealand's website reports the data, but they are incomplete time series and are, hence, unusable. Alternative sources are: the Haver Dataset, which has annual time series, and data compiled used in Claus *et al.* (2006) and used in Parkyn and Vehbi (forthcoming).<sup>13</sup> These data are based on (SNA) quarterly data, converted to an annual basis.

Measuring government spending shocks is difficult. The data was for unit roots using a variety of common statistical tests with different specifications and lags. The tests do not reject the unit root hypothesis. This result may be related to the weakness of the tests, but nevertheless the data have a trend. For this reason, the cyclical component of the HP filter was used as a measure of the government spending shock. Glick and Rogoff (1995) used the residuals from an IMA (1) model. However, the New Zealand data do not seem to fit this model well. Figure 6 plots the three different data series for government spending shock.

The results of estimating the model with government spending shocks are reported in Table 5. The estimation strategy is to augment the basic regression model in equation (12) with the above measures of the government spending shock, ie., the HP cyclical component of government spending, using three different data: the Haver dataset, which report an aggregate government spending chain measure; the Claus *et al.* (2006) data excluding government investments, and the Claus *et al.* (2006) data including government investments. Unlike Glick and Rogoff (1995) there are some government spending effects, but the level of significance depends on which measure was used. The measure of government spending shock based on the Haver dataset is insignificant, while those based on Claus *et al.* (2006) are. The cyclical component, which excludes government investments, is significant, but only at the 10 percent level. The inclusion of government investments in the measure of government spending increases the responsiveness of

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<sup>12</sup> According to the theory, permanent and transitory transfers do not affect anything, except the distribution of government spending. Permanent and transitory purchases, on the other hand, have real but different effects. Permanent purchases work through the wealth effect, where higher purchases reduce private wealth because they absorb income and make it unavailable to households. They have no interest rate effects, but they increase output by increasing hours-worked. People work more to compensate for the decline of wealth. Transitory purchases don't change wealth because they don't alter the present value of taxes (more accurately, of resource absorption by the government), but they do have intertemporal substitution effects for two reasons. First, they directly increase interest rates. Second, they change the timing of tax distortion. A temporary increase in government purchases, unmatched by a future temporary increase, has both a permanent component and a transitory component, so it has a mixture of the two kinds of effects. Both permanent and transitory changes in transfers have real effects if they involve marginal distortions. If the transfers are purely lump sum, they will not have any direct distorting effects, but they will have indirect effects if they cause changes in distorting taxes that are used to finance them. If the transfers are income-related, then they are themselves a kind of distorting (negative) tax and so will have real effects.

<sup>13</sup> This is the description of the Claus *et al.* (2006) data. "Quarterly aggregate data are collated for all variables from June 1982. All fiscal series cover central government with the exception of government investment, which also includes local government, because a central government investment series is unavailable. The purchase of frigates in 1997 and 1999 are removed from both the purchases of government goods and services and the goods and services tax (GST) series. Quarterly fiscal data were constructed using two data sources: Statistics New Zealand National Accounts Data and the New Zealand Crown Accounts (and their supporting financial data). Data on government purchases of goods and services (both current and capital) were drawn from the National Account (1993) expenditure GDP series for the period June 1987 to date, and were backdated to June 1982 using the National Accounts (1968) expenditure GDP series."



sectoral-level investment growth to transitory government spending shocks. The cyclical component of government spending plus government investments using Claus *et al.* (2006) data is statistical significant. On average, a 1 percent increase in government spending (consumption plus investment) increases sectoral-level investment growth rate by 0.18 percent. Most importantly, the rest of our parameter estimates are robust to the inclusion of the government spending shock.

In the case of ToT shocks, interest focuses on whether industries increase their investments in response to ToT shocks; and whether ToT shocks affect tradable-goods sectors differently from non-tradable-goods sectors. Data for the terms of trade (defined as the ratio of export to import prices) are from the Haver Dataset. They report quarterly data, which were averaged to obtain annual data. The ToT is for merchandise goods only. The ToT long quarterly data from 1957 display a mean-reverting behaviour. The unit root hypothesis is strongly rejected by a number of common statistical tests. However, the shorter annual sample from 1988 to 2009 exhibits a trend and the unit root hypothesis cannot be rejected. That said, an ARMA (1,1) fits the data reasonably well with an MA coefficient 0.92 and an AR coefficient 0.37. Given these results, the ToT shock is measured in two different ways: the residuals of an ARMA (1,1) model, and the cyclical component using an HP filter. The two measures are plotted in Figure (7). Visually, the two measures look similar. The investment equation is estimated with ToT both shocks, using both measures separately. Neither were statistically insignificant. The results are in Table 6.

However, the relationship between government spending and ToT shocks on one side, and real investment growth on the other may not be contemporaneous. It depends on expectations. For this reason the investment equation is with lagged government spending and ToT shocks. On average, a ToT shock has a significant effect on the sectoral-level investment growth one year later. The rest of the coefficient estimates are unchanged, but the sectoral-level TFP shock is more significant. Given these results, the government spending and the ToT shocks are allowed to vary across industries with different lags.

The results are reported in Tables 7 and 8, again with two separate regressions to conserve the number of degrees-of-freedom. In Table 7, I reports the lagged government spending shock effect across industries. Most sectoral-level investment growth rates respond contemporaneously to a government spending shock, which includes government investments. The results vary across industries. Agriculture, Forestry and Fishery reacts with a one year lag as does the Mining sector. The response of Mining is quite sizable. There is a  $\frac{3}{4}$  of a percent increase in investment growth for a one percent increase in government spending. Manufacturing investment growth is adversely affected two years after an increase in government spending, but the effect is only marginally significant, so manufacturing maybe irresponsible to such aggregate demand shock with contemporaneously and at any other lag. Construction and Wholesale Trade are unaffected. Electricity, Water and Waste Services investment growth rate is highly positively affected a year later; the increase in government spending increases investment growth a year later by more than  $\frac{1}{2}$  a percent. Construction and Wholesale Trade are unaffected by the shock at any lag. Retail Trade; Accommodation & Food Services; Transport, Postal, and Warehousing; and Information, Media & Telecommunication industries are positively and contemporaneously affected by the shock. The magnitudes of the increases in the growth rate of investments in response to the shock are large, 0.34, 0.68, 0.37 and 0.36 respectively. The rest of the parameter estimates of the model are robust and retain their estimated values.

Table 8 reports the estimated effects of lagged ToT shock on the industries investment growth rates. First, there is a ToT shock positive lagged effect, and more so than the

government spending shock. Second, the lag length varies across industries. Third, not all industries respond to ToT shocks. Two of the industries whose investment growth responds to ToT shocks are tradable goods industries (Agriculture, Forestry, and Fisheries and Mining) and three services industries (Electricity, Water, and Waste Services; Transport, Postal, and Warehousing; and Finance and Insurance Services). Fourth, the response is sensitive to how the shock is measured. The HP cyclical component of the ToT shows no association with sectoral-level investment growth, except for Agriculture, Forestry, and Fisheries while the ARIMA (1,1) residuals do.

Investment growth in the mining sector is only contemporaneously affected by ToT shocks, albeit with a very large coefficient. A one percent increase in the ToT increases investment growth by 0.74 percent. Agriculture, Forestry and Fisheries also respond within one year. Agriculture has a coefficient of 0.25. The services industries – such as Electricity, Water, and Waste Services and Transport, Postal, and Warehousing – respond significantly with a two-year lag, and coefficient magnitudes are relatively smaller than the rest. Finance and Insurance Services respond within one year with a very large coefficient of 0.50. For now obvious reasons, Information, Media, and Telecommunication services respond negatively to one-year lag ToT shocks.

## 5 Conclusions and Policy Issues

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This paper estimates an intertemporal model for sectoral-level investment growth in New Zealand using a panel data of eleven industries over the period 1988 to 2009. The empirical model is an extension of an aggregate time-series, empirical, intertemporal model by Glick and Rogoff (1995). Although the model differs from the real business cycle in some aspects, essentially three random total factor productivity shocks (TFP) drive investment growth at the sectoral level. These are, a sector-specific TFP shock, a country-specific TFP shock, and a global TFP shock. In addition, the level of current investment at the sectoral-level is driven by lagged investment levels. While investment growth responds significantly and contemporaneously to sector-specific and country-specific TFP shocks, it only responds significantly to global TFP shocks with a two-year lag. The response of sectoral-level investment growth to global TFP shocks is twice as large as its response to country-specific TFP shocks, and nearly five times as large as its response to the sector-specific TFP shocks. The lag effect implies that industries anticipate global TFP shocks, hence they react earlier. The responsiveness of sectoral-level investment growth to global TFP shocks rather than domestic TFP shocks (the country-specific TFP shock and the sectoral-specific TFP shock) reflects: (1) global TFP shocks may be more permanent while the sector-specific shocks are transitory. (2) New Zealand is a small open economy.

Government spending shocks, which are treated as a pure aggregate demand shocks, positively affect investment growth at the sectoral-level in New Zealand, but that depends on whether the measure of the shock includes public investments or not. It seems that government investments are important. Also, sectoral-level investment growth seems to react positively to ToT shocks. The reactions vary from one sector to another, and with different lags. While Mining responds contemporaneously and strongly, Agriculture, Forestry, and Fisheries respond with a one-year lag. Also, investment growth in three services industries (Wholesale Trade, Transport, Postal, and Warehousing, and Finance and Insurance Services) respond significantly with a one-year lag. Most importantly, the main estimates of the model are robust to the inclusion of the government spending shock and the ToT shock.

To summarise, the main results of this study are that various random TFP shocks seem to have significant effects on current sectoral-level investment growth. The responsiveness



of sectoral-level investments to TFP shocks vary across sectors. And, sectoral-level investment growth seems to increase when the economy as a whole is doing well and more so in anticipation of global TFP shocks. Past investment levels have very strong and relatively varied effects on current investment.

The result that the sectoral-level investment is driven by *random* productivity shocks presents a challenge to policy-making because random productivity shocks are beyond the direct control of policy. Global TFP shocks are strictly exogenous to New Zealand because New Zealand cannot exert any influence on them. Similarly, the model assumes that the country and sectoral TFP shocks to be exogenous too. However, the fact that lagged investment levels are very significant determinants of investment growth gives policy a role. Cross-sectoral variations of the responses of investment growth to various variables also suggest that a one-size-fits-all investment policy is not the right way to go. The government can change policies, eg, fiscal or labour policies, such that it can influence private investment decisions.

It should not be too contentious to argue that not all investments can lead to economic growth. In endogenous growth models investments in knowledge drive productivity growth (eg, R&D and human capital are inputs into the innovation process that are required to make *new* goods and services). Under imperfect competition, there is an increasing-returns-to-scale (externality effect), where doubling of output requires less than a doubling of inputs, which requires a non-diminishing marginal productivity of factor inputs.

That being said, policy may be able to influence labour and capital productivity, and hence increase productive investments. Simply put, the less input used to produce more output the higher TFP is. The government can either directly invest in private businesses or implement policies that influence the incentives of private businesses (either via price or regulatory mechanisms) to invest. There are arguments for and against direct government investments in private economic activities. However, investment is a process shrouded with uncertainty. That is evident in the large fluctuations of the data. There are risks involved, and some are hard to measure. The main concern is that in case the public investment fails to deliver output growth, taxpayer's money would be wasted. Alternatively, it will be argued that policy should provide incentives for the private enterprise to invest in productive capital such as R&D and human capital, training and up-skilling etc. because people respond to incentives.

Here is another example to the same effect. There is more creditable evidence, however, that the tax rate is an important explanatory variable of the supply of labour (hours worked). Labour productivity is pro-cyclical. During booms, firms hire more workers and productivity increases. Workers make decisions about consumption and leisure and on consumption and savings. The tax rate is the *intratemporal* factor that affects the supply of labour. It distorts the relative prices of consumption and leisure at a point in time. If people expect future taxes on income to increase, they will choose to consume less relative to their incomes, and work more (see Nickell (2003), Prescott (2004), and Shimer (2009)). The government has a variety of tax policies, which could influence the firm's decision to invest in productive capital, which affects growth and productivity directly.

**Table 1** – Growth of investment with sectoral-specific TFP shocks

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value
$\beta_1$	0.57	0.0000
$\beta_2$	0.06	0.0646
$\beta_3$	0.15	0.0310
$\beta_4$	-0.10	0.6228
Weighted $R^2$	0.26	
DW	2.05	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock.

The regressions include sector-fixed-effect.

The standard errors are White-cross section corrected.

Sample is 1988 to 2009, and N=11 industries.

**Table 2** – Growth of investment with lagged global TFP shocks

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t-2} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value
$\beta_1$	0.59	0.0000
$\beta_2$	0.07	0.0447
$\beta_3$	0.16	0.0236
$\beta_4$	0.31	0.0000
Weighted $R^2$	0.29	
DW	2.05	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock.

The regressions include sector-fixed-effect.

The standard errors are White-cross section corrected.

Sample is 1988 to 2009, and N=11 industries.

**Table 3** – Growth of investment with lagged investment varying across industries

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t-2} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value
$\beta_2$	0.08	0.0170
$\beta_3$	0.22	0.0000
$\beta_4$	0.27	0.0012
$\beta_{1,i}$ (lagged investments)		
1 Agriculture, forestry, fishing	0.90	0.0000
2 Mining	0.66	0.0000
3 Manufacturing	0.18	0.2433
4 Electricity, Water and Waste Services	0.73	0.0014
5 Constructions	0.54	0.0007
6 Wholesale Trade	0.12	0.3864
7 Retail Trade	0.47	0.0042
8 Accommodation & Food Services	0.28	0.3340
9 Transport, Postal & Warehousing	0.99	0.0000
10 Information Media & Telecom	0.41	0.0443
11 Financial & Insurance Services	0.62	0.0625
Weighted $R^2$	0.40	
$DW$	2.05	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock. The regressions include sector-fixed-effect. The standard errors are White-cross section corrected. Sample is 1988 to 2009, and N=11 industries. The coefficient  $\beta_1$  affects the level positively as shown in equation  $I_t = \beta_1 I_{t-1} + \beta_2 \Delta A_{ct}$ .

**Table 4** – Growth of investment with sector-specific TFP shocks varying across industries

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_{2,i}\Delta A_{i,t} + \beta_3\Delta A_{c,t} + \beta_4\Delta A_{g,t-2} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value
$\beta_1$	0.56	0.0000
$\beta_3$	0.13	0.1134
$\beta_4$	0.32	0.0000
$\beta_{2i}$ (Sectoral-level TFP)		
1 Agriculture, forestry, fishing	0.05	0.5932
2 Mining	0.09	0.4309
3 Manufacturing	0.11	0.2693
4 Electricity, Water and Waste Services	-0.11	0.0563
5 Constructions	0.13	0.0008
6 Wholesale Trade	0.16	0.1386
7 Retail Trade	0.37	0.0012
8 Accommodation & Food Services	-0.00	0.9972
9 Transport, Postal & Warehousing	-0.09	0.0285
10 Information Media & Telecom	0.50	0.0673
11 Financial & Insurance Services	-0.44	0.3182
Weighted $R^2$	0.35	
DW	2.15	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock. The regressions include sector-fixed-effect. The standard errors are White-cross section corrected. Sample is 1988 to 2009, and N=11 industries.

**Table 5** – Growth of investment with a transitory government spending shock

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t-2} + \beta_5 G_{c,t} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value	Estimate	P-value	Estimate	P-value
$\beta_1$	0.57	0.0000	0.57	0.0000	0.53	0.0000
$\beta_2$	0.08	0.0280	0.08	0.0433	0.08	0.0248
$\beta_3$	0.13	0.0380	0.18	0.0088	0.10	0.1382
$\beta_4$	0.35	0.0000	0.33	0.0000	0.18	0.0193
$\beta_5$ (i)	-0.04	0.1579	-	-	-	-
$\beta_5$ (ii)	-	-	0.15	0.1043	-	-
$\beta_5$ (iii)	-	-	-	-	0.18	0.0075
Weighted $R^2$	0.31		0.29		0.31	
$DW$	2.06		2.05		2.06	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock. The regressions include sector-fixed-effect. The standard errors are White-cross section corrected. Sample is 1988 to 2009, and N=11 industries.

- i The coefficient corresponds to the measure of government spending shock  $G$ , which is based on Haver Dataset.
- ii The coefficient corresponds to the measure of government spending shock  $G$ , which includes government purchases only. Source: Claus *et al.* (2006).
- iii The coefficient corresponds to the measure of government spending shock  $G$ , which includes government purchases plus government investments. Source: Claus *et al.* (2006).

**Table 6** – Growth of investment with a Terms of Trade Shock

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_2 \Delta A_{i,t} + \beta_3 \Delta A_{c,t} + \beta_4 \Delta A_{g,t-2} + \beta_5 ToT_{c,t} + v_i + \varepsilon_{it}$

Coefficient	Estimate	P-value	Estimate	P-value
$\beta_1$	0.58	0.0000	0.60	0.0000
$\beta_2$	0.07	0.0487	0.07	0.0432
$\beta_3$	0.21	0.0172	0.17	0.0272
$\beta_4$	0.38	0.0000	0.29	0.0000
$\beta_5$ (i)	-0.08	0.1371	-	-
$\beta_5$ (ii)	-	-	-0.009	0.7264
Weighted $R^2$	0.30		0.29	
$DW$	2.05		2.05	

$I_{i,t}$  is sectoral-level investment;  $\Delta$  is the difference operator;  $A_{i,t}$  is a sector-specific TFP shock;  $A_{c,t}$  is a country-specific TFP shock; and  $A_{g,t}$  is a global TFP shock. The regressions include sector-fixed-effect. The standard errors are White-cross section corrected. Sample is 1988 to 2009, and N=11 industries.

- i The shock is measured by the cyclical component of the HP filter.
- ii The shock is measured by the residuals of an ARIMA (1,1).

**Table 7** – Growth of investment with a transitory government spending shock varying across industries

**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_{2,i}\Delta A_{i,t} + \beta_3\Delta A_{c,t} + \beta_4\Delta A_{g,t-2} + \beta_{5i}G_{c,t-j} + v_i + \varepsilon_{it}$

Coefficient			Estimate	P-value
$\beta_1$			0.44	0.0000
$\beta_2$			0.07	0.1158
$\beta_3$			0.13	0.0369
$\beta_4$			0.17	0.0022
$\beta_5$	$j$ Lag (Year)			
1	Agriculture, forestry, fishing	1	0.18	0.0435
2	Mining	1	0.74	0.0589
3	Manufacturing	2	-0.11	0.0989
4	Electricity, Water and Waste Services	1	0.56	0.0000
5	Constructions	-	-	-
6	Wholesale Trade	-	-	-
7	Retail Trade	0	0.34	0.0419
8	Accommodation & Food Services	0	0.68	0.0166
9	Transport, Postal & Warehousing	0	0.37	0.0238
10	Information Media & Telecom	0	0.36	0.0644
11	Financial & Insurance Services	-	-	-
Weighted $R^2$			0.40	
$DW$			2.10	

Government spending includes government investments. -, denotes insignificant therefore not reported.

**Table 8** – Growth of investment with a ToT shock varying across industries

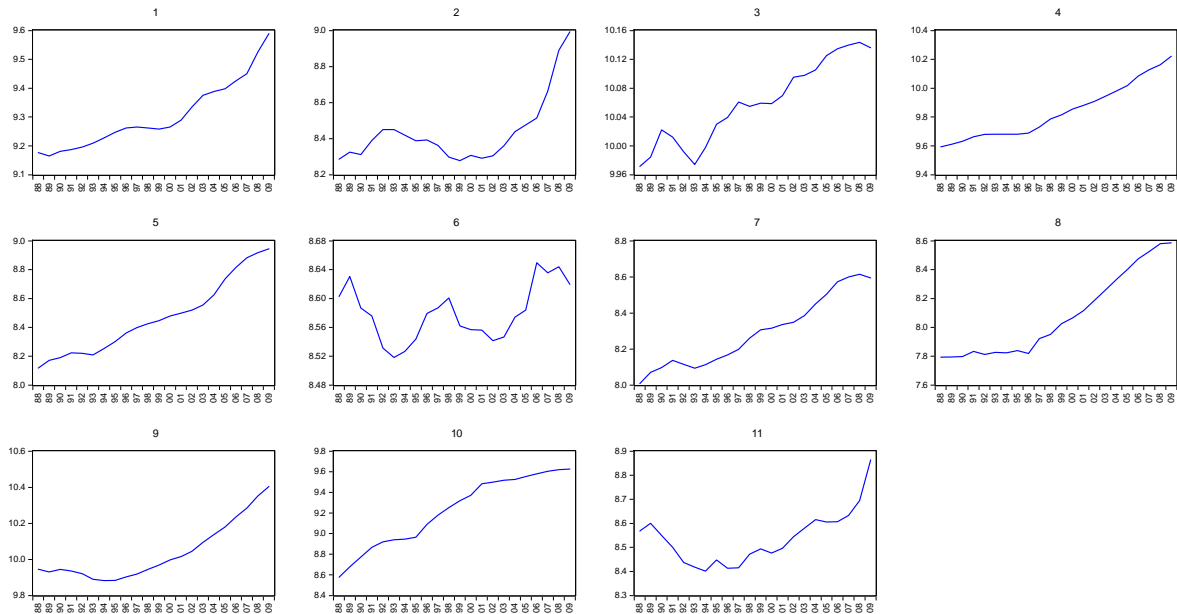
**Equation 12:**  $\Delta I_{it} = \beta_0 + (\beta_1 - 1)I_{i,t-1} + \beta_{2,i}\Delta A_{i,t} + \beta_3\Delta A_{c,t} + \beta_4\Delta A_{g,t-2} + \beta_{5i}ToT_{c,t-j} + v_i + \varepsilon_{it}$

Coefficient			Estimate	P-value
$\beta_1$			0.55	0.0000
$\beta_2$			0.07	0.0585
$\beta_3$			0.16	0.0044
$\beta_4$			0.22	0.0011
$\beta_5$	$j$ Lag (Year)			
1	Agriculture, forestry, fishing	1	0.24	0.0823
2	Mining	0	0.74	0.0143
3	Manufacturing	-	-	-
4	Electricity, Water and Waste Services	2	0.15	0.0889
5	Constructions	-	-	-
6	Wholesale Trade	-	-	-
7	Retail Trade	-	-	-
8	Accommodation & Food Services	-	-	-
9	Transport, Postal & Warehousing	2	0.14	0.0248
10	Information Media & Telecom	1	-0.28	0.0336
11	Financial & Insurance Services	1	0.49	0.0740
Weighted $R^2$			0.36	
$DW$			2.22	

- Denotes insignificant therefore not reported.

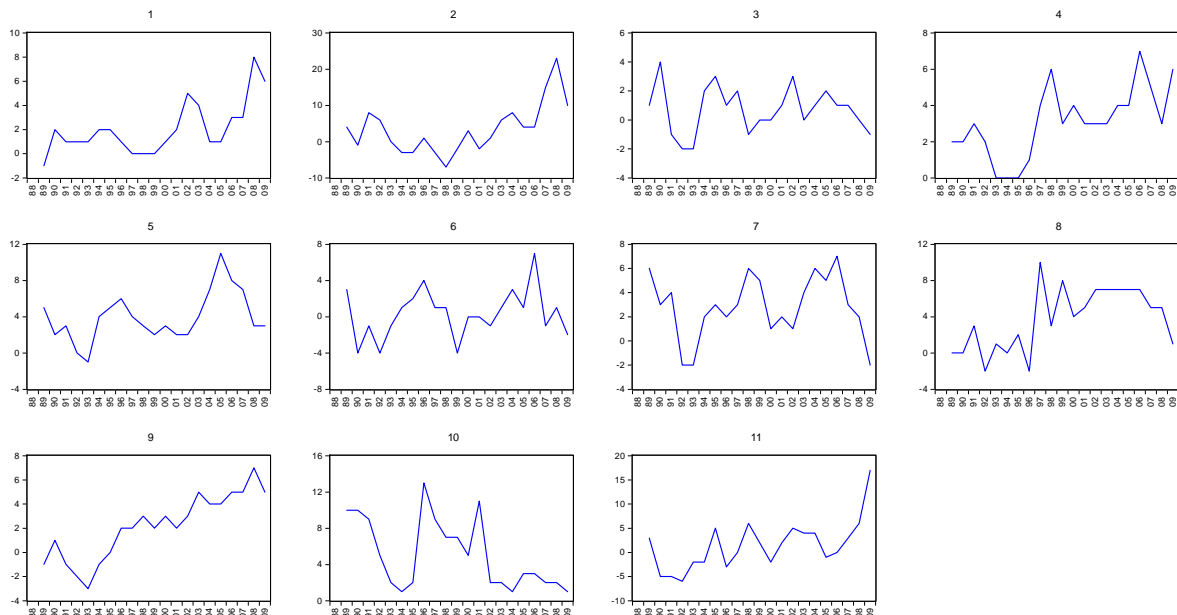


**Figure 1 – Sectoral-Level Capital Stocks (log form)**



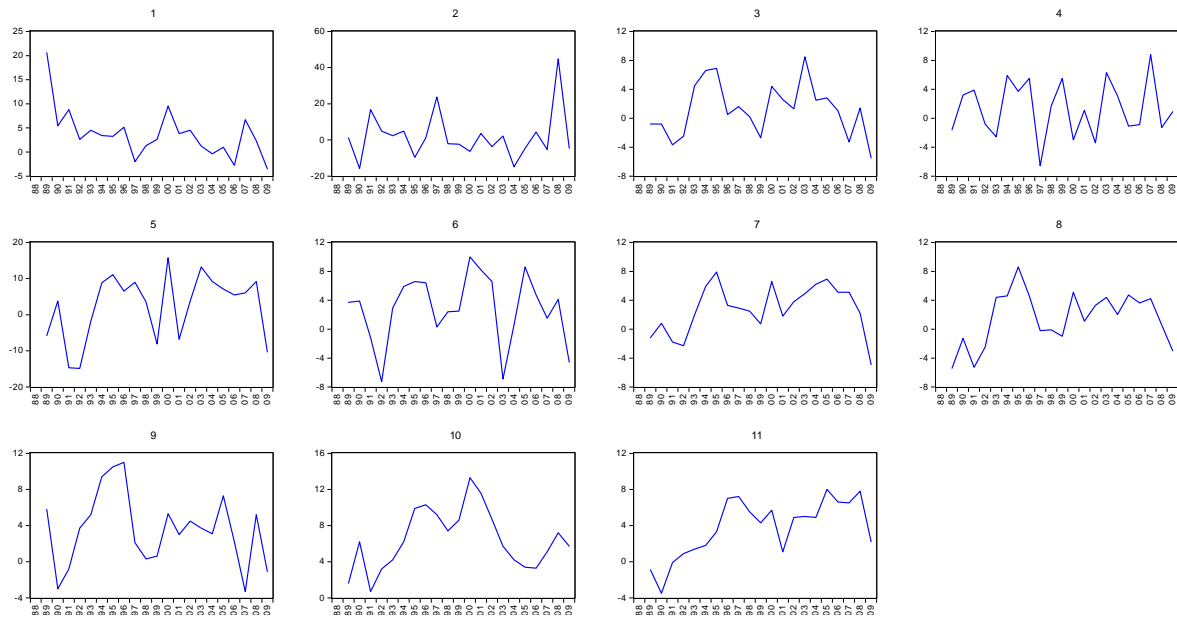
1) Agriculture, Forestry and Fishing; 2) Mining; 3) Manufacturing; 4) Electricity, Water and Waste Services; 5) Construction; 6) Wholesale Trade; 7) Retail Trade; 8) Accommodations and Food Services; 9) Transport, Postal, and Warehousing; 10) Information, Media and Telecommunications; and 11) Financial and Insurance Services. Source: Statistics New Zealand.

**Figure 2 – Sectoral-Level Investments (log form)**



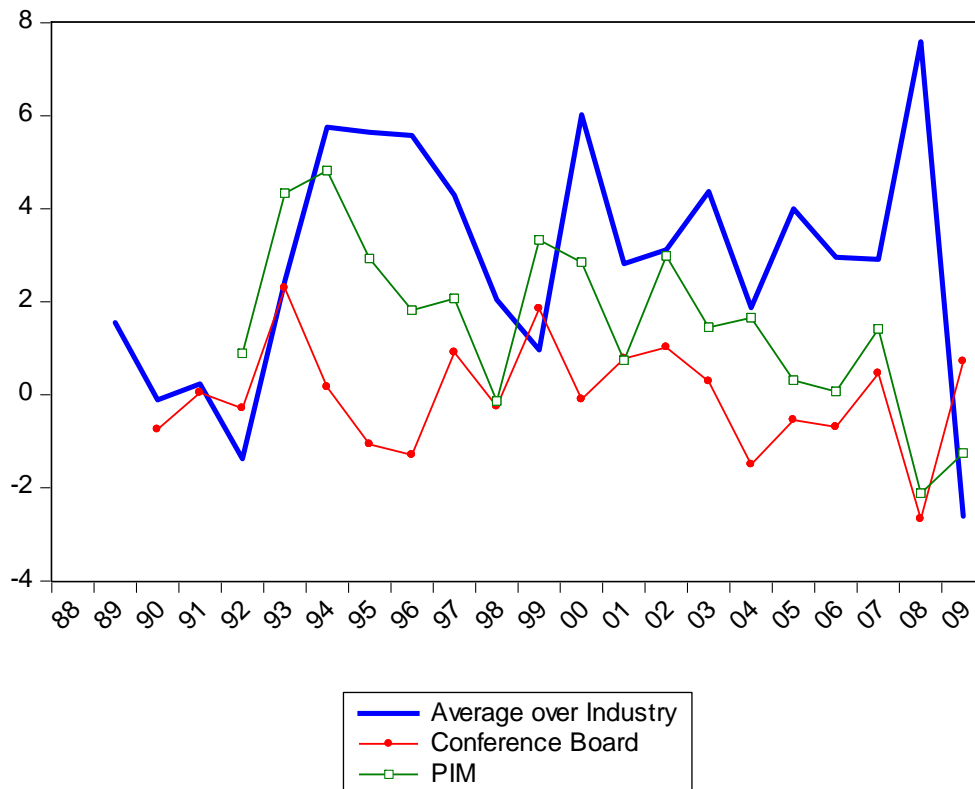
1) Agriculture, Forestry and Fishing; 2) Mining; 3) Manufacturing; 4) Electricity, Water and Waste Services; 5) Construction; 6) Wholesale Trade; 7) Retail Trade; 8) Accommodations and Food Services; 9) Transport, Postal, and Warehousing; 10) Information, Media and Telecommunications; and 11) Financial and Insurance Services. Source: Statistics New Zealand.

**Figure 3 – Sectoral-Level TFP Growth Shocks**



1) Agriculture, Forestry and Fishing; 2) Mining; 3) Manufacturing; 4) Electricity, Water and Waste Services; 5) Construction; 6) Wholesale Trade; 7) Retail Trade; 8) Accommodations and Food Services; 9) Transport, Postal, and Warehousing; 10) Information, Media and Telecommunications; and 11) Financial and Insurance Services. Source: Statistics New Zealand.

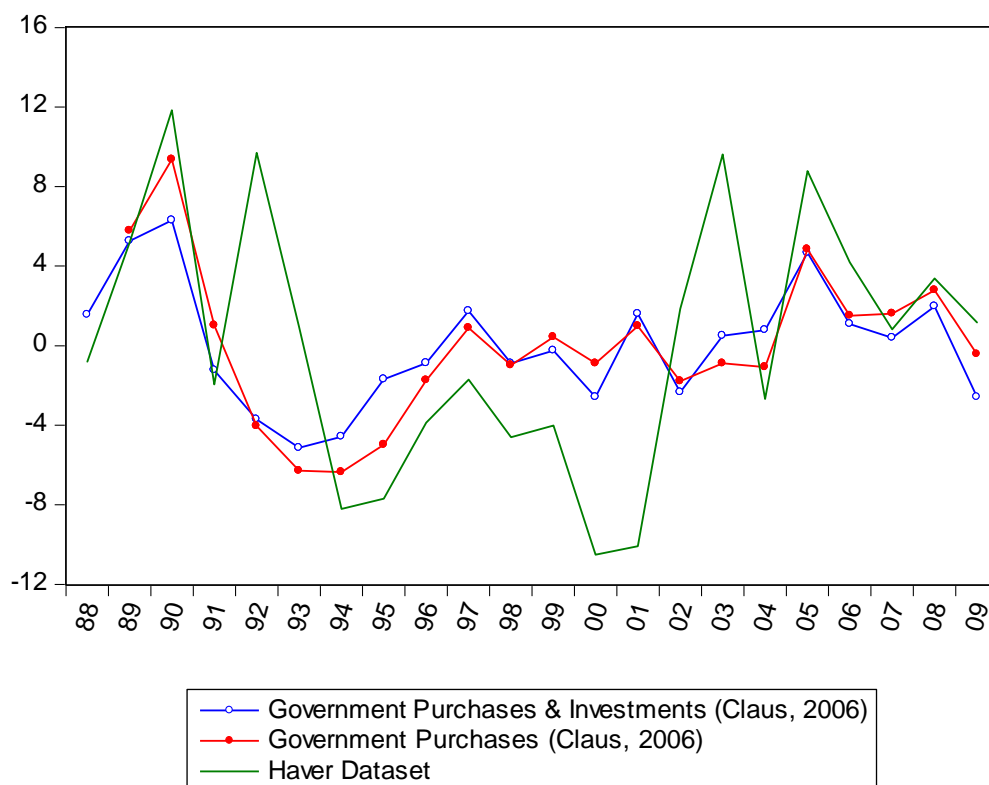
**Figure 4 – New Zealand Average TFP Growth Shock**



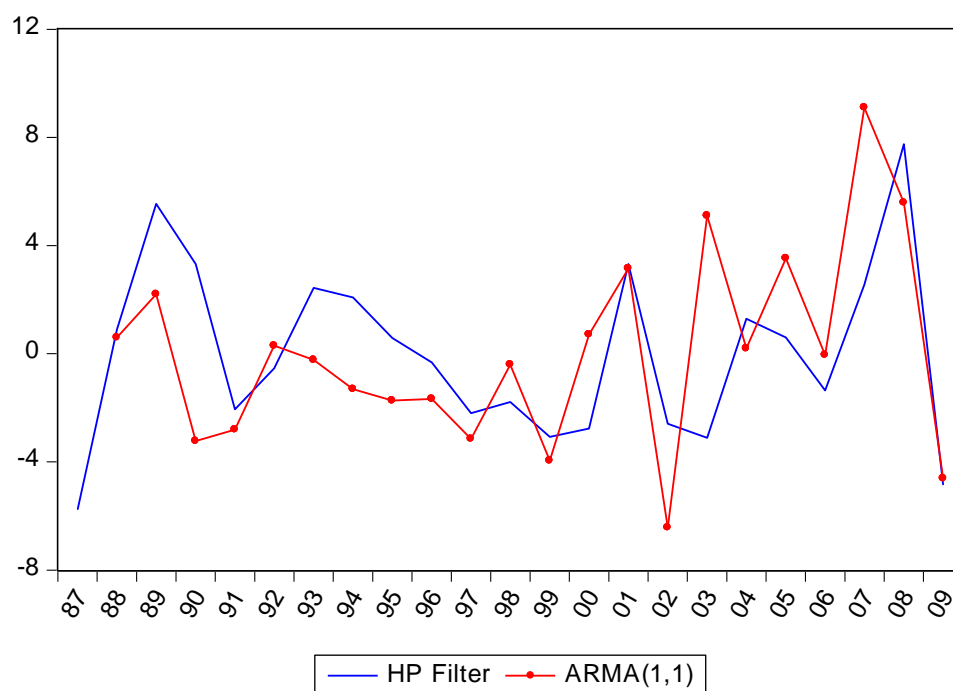
**Figure 5 – Global Average TFP Growth Shock**



**Figure 6 – Government Spending Shocks**



**Figure 7 – Terms of Trade Shocks**



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