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THE

RELATIVE PRICE BLOCK

in the

Treasury Macroeconomic (TRYM) Model

By

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TABLE OF CONTENTS

1. INTRODUCTION

TRYM is the Treasury Macroeconomic (TRYM) model of the Australian economy. It has been developed and used within the Commonwealth Treasury as an input into macroeconomic forecasting and analysing policy issues. The relative price block (RPB) of equations models the prices of the major expenditure aggregates. It describes how the general price level feeds into the different components of expenditure.

When the TRYM model was released in June 1993, a simple set of equations was used to model changes in the relative prices of the different components of expenditure. This consisted of simple static (levels) equations that did not capture the dynamic behaviour of these expenditure prices very well, and consequently, these equations performed poorly in diagnostic tests. This was a matter of concern firstly because some components of demand such as business investment and dwelling investment, are sensitive to relative prices through the effect on their respective Q-ratios. Secondly, relative prices are important in deriving savings, investment and net lending balances from the model and in balancing the expenditure and income sides of the economy.

This paper furthers the original TRYM research by re-estimating the RPB equations within dynamic equation specifications, using error correction mechanisms (ECMs). This allows time series properties such as cointegration to be assessed, thereby reducing the possibility of spurious regressions. The behaviour of the re-estimated equations are then examined in the full model context. There were definite improvements in the dynamics of the price equations and better diagnostic results, which consequently fed into other areas of the model.

This paper is arranged as follows: Section 2 looks at the limitations of the original RPB equations, with a small section on issues concerning the relative price data. Section 3 examines the estimation and behavioural properties of the new set of RPB equations. Section 4 compares the dynamics of the model for the new and old set of RPB equations, in relation to an increase in prices (monetary shock) and an increase in import prices, via an increase in government debt (fiscal shock). Section 5 concludes. Attachment A in Section 6, gives an overview of how prices are modelled in other macro models and Attachment B in Section 7 contains a list of TRYM mnemonics. The Appendix in Section 8 contains the equation specifications and graphs of the results and Section 9 contains a list of references.

2. RELATIVE PRICES IN TRYM

2.1 The Relative Price Block (RPB) - An Overview

In the TRYM model, prices are disaggregated into commodity and non-commodity prices. Commodity prices are determined in competitive world markets and are quite flexible. In contrast, non-commodity prices are determined in the domestic market, a function of wages and excess demand in the economy, and are relatively sticky. In TRYM, these two prices feed into the price of business output which, together with the price of imports, feeds into the price of supply, or the supply price (PT) in the economy.

The relative price block of equations describes how the overall supply price feeds into the price of different expenditure components of demand; that is, it shows how each expenditure price will change relative to the overall change in the supply price. The five expenditure prices considered are the price of non-rent consumption (PCNR), business fixed investment (PIB), dwelling investment (PIDW), government market demand (PGMD) and real estate transfer expenses (PIRET). To ensure model closure, a scaling factor is applied to the price of each expenditure item, once each of the relative prices has been determined, so that the price of demand equals the price of supply. Further, through the use of a scaling factor, the absolute levels of each of the expenditure price can be obtained.

A brief overview of how prices are modelled in other macro models, present and past, is given in Attachment A. Few macro models disaggregate expenditure prices as done in TRYM. The exceptions are the G-Cubed model by Warwick McKibbon and the latest version of the Murphy model with sectoral components.

Modelling prices in different sectors, as done in the RPB in TRYM, has its advantages. For instance, we are able to model the differing rate of pass through of the exchange rate to the each expenditure component. And secondly, prices in different sectors are allowed to vary, rather than being tied to the general price level, which would be the case if there was no relative price block. This in turn, has repercussions on other areas of the model. For example, consider the case when the exchange rate remained low in the mid-80s and prices rose. The increase in general prices will feed differently into different sectors and the relative price block is able to capture these different price changes. For example, price of business investment, which has a high import component in contrast to dwelling investment say, would increase more than the price of dwelling investment. This in turn, would affect their respective Q-ratios and hence, the levels of business and dwelling investment.

2.2 93 Conference Version of the RPB - Specifications and Limitations

In the original version of the RPB (the "93 Conference Version of the RPB"), the logarithm of each expenditure price (PCNR, PIB, PIDW, PGMD and PIRET) relative to the price of supply (PT), was modelled as a function of:

- the logarithm of the price of imports (PMGS) after tariffs (RTMGS), relative to the price of domestic supply (PD), adjusted for indirect taxes on each expenditure component; and

- a time trend (QTIME).

In this specification, it is the import intensiveness of each type of expenditure that determines the movement in their relative prices. Wages and excess demand conditions are assumed to affect each expenditure component equally (via the supply price), therefore not altering their relative price.

Seemingly Unrelated Regression (SUR) Estimation

Each equation had a simple distributed lag (with restrictions), and the equations were estimated collectively using the seemingly unrelated regressions (SUR) estimation technique. The SUR technique is a systems estimator, taking into account correlations in the residuals across equations, and hence, reflecting their interdependence. It does not however, take account of any simultaneity bias, as in three stage least squares (3SLS), another systems estimator. The advantage of using SUR, compared to 3SLS, is that it does not require any instruments. In the absence of simultaneity bias with the endogenous variables, SUR gives the same results as 3SLS and yields both consistent and correct standard errors. Another advantage of using SUR is that it provides more efficient estimates, compared to estimating the five equations separately using OLS.

The 93 Conference Version of the RPB had a number of limitations, which related to the simple dynamic specification of the equations. These included the following:

- some diagnostic problems with most of the equations, including evidence of autocorrelation (very low DW statistics in all equations), parameter instability (failing Chow tests for most equations), and some heteroscedasticity problems, particularly in the PGMD equation;

- a poor tracking performance, which related to the diagnostic problems above, suggesting some mis-specification in the equations, probably due to the absence of a dynamic structure in the equations; and

- concerns over whether the identified equations were truly cointegrated or "spurious regressions" arising from the *likely* non-stationarity of the data series. These concerns can not be tested from the levels specification. Indeed, if the data series are non-stationary, there is little that can be said of the significance of the estimates.

A full documentation of the specifications, results and diagnostics of the 93 Conference Version of the RPB is found in "Documentation of the Treasury Macroeconomic (TRYM) Model of the Australian Economy", TRYM Paper No. 2, pages 84 to 89.

2.3 Data Issues

The relative price series are either based on Australian Bureau of Statistics (ABS) expenditure implicit price deflators (PIDW, PIB and PIRET), or are derived from the ABS data (PCNR and PGMD). The price of non-rent consumption (PCNR) is based on the implicit price deflator for total private consumption less private rent expenditure (the price of rent is determined elsewhere in the TRYM model). The price of government market demand (PGMD) attempts to measure the price of government activity or expenditure that has a direct impact in the market. It is based on the implicit

price deflator for expenditure on government final demand less wages, salaries and supplements and consumption of fixed capital.

The price of business fixed investment (PIB) is a composite of the price of private fixed expenditure on plant and equipment (IPE) and price of private fixed non-dwelling constructions (IOB) ie other building and construction. The price of plant and equipment covers the price of machinery and equipment, including vehicles, aircraft and ships, and such items as new motors, lathes, office equipment and fixtures. The price of non-dwelling constructions covers assets such as buildings, wharves, railway and harbour constructions, roads and also lifts, heating and ventilation equipment and the like forming an integral part of the structure. The price of private fixed expenditure on dwelling construction (PIDW) consists of the price of houses and other dwellings (flats, home units, villa units, duplexes etc) including alterations and additions. The price of constructing hostel-type accomodation is included in the price of other building and construction, in PIB. The price of real estate transfer expenses (PIRET) attempts to measure the fees charged by lawyers and real estate agents in connection with the transfer of real estate, together with stamp duties and other associated government charges.

In the initial stages of re-estimating the RPB equations, the PIRET series proved to be very difficult to model. Upon further investigation with the ABS, we found that PIRET is not an independent price deflator. (The usual constant price methodology deflates the current value of an expenditure item by an independent survey based measure of the price of that expenditure item, thereby giving a constant price estimate of that expenditure.) The usual constant price methodology is not used for real estate transfer expenses, in that, there is no independent survey of the price of these services. PIRET is essentially a residual formed by deflating the current value of real estate transfer expenses (including stamp duties) by a scaled measure of turnover proxying constant price volumes. An unusually large long-run elasticity with respect to import prices was obtained in the initial stages of re-estimating the PIRET equation. This may just reflect a mixture of sampling errors and the peculiarity in the ABS data construction.

Further, real estate transfers include transfers of existing assets such as offices, not just residential dwellings. Therefore, relative movements in PIRET would reflect movements in both established house and office prices. This is unfortunately a measurement problem, which makes PIRET difficult to model in a way consistent with other price indices, which reflect the price of flows in the economy.

3. NEW RPB EQUATIONS: SPECIFICATIONS, ESTIMATIONS AND RESULTS

3.1 Re-specification and Re-estimation of the Relative Price Block

3.1.1 Partial Adjustment Mechanism

The initial attempt to improve the RPB equations was to simply add a lagged dependent variable to each of the equations, and allow an unrestricted distributed lag on the independent variables. The lagged dependent variable introduces time dynamics into the equations, and is consistent with the partial adjustment mechanism (PAM) of adjustment to desired levels. As expected, the lagged dependent variables were very significant and dominated the dynamics in all five equations, suggesting that the adjustment of relative prices is not instantaneous.

There were only slight improvements in the diagnostic statistics as a result of this change and there was still the question of cointegration to be resolved. Therefore, we decided to approach the problem using an ECM specification.

3.1.2 Error Correction Mechanism

In re-estimating the equations in an ECM format, the equations contained the same dependent variables as before, and were again estimated as a block using the SUR technique described earlier. In estimating the ECMs, both the short run and long run parameters are estimated simultaneously. This yields more efficient estimates than the traditional Engle and Granger (1987) two-step procedure. Following the general-to-specific methodology, the equations were simplified from the general specification (up to four lags) to a preferred specification by omitting insignificant variables.

To illustrate the general ECM specification, the PCNR equation is given below.

ECM Specification

$$\begin{aligned}\Delta\ln(PCNR/PT)_t = {} & \alpha_i * A(L)\Delta\ln(PCNR/PT)_{t-1} \\ & + \beta_i * B(L)\Delta\ln[(PMGS*(1+RTMGS)/PD*(1-RTCNR)]_t \\ & - \gamma_i * \{\ln(PCNR/PT)_{t-1} \\ & \quad - (C0 + C1*\ln[PMGS*(1+RTMGS)/PD*(1-RTCNR)]_{t-1})\}\end{aligned}$$

where A(L) and B(L) are polynomials in L, and L is the lag operator function. Put simply, A(L) and B(L) are distributed lags.

See Attachment B for TRYM mnemonics.

The diagnostic results for this ECM specification were an improvement on the original relative price block diagnostics, but still failed a number of tests. All five equations still fail the Chow test of parameter stability. The PIDW equation is of particular concern, as it fails every diagnostic test except the Jarque-Bera normality test. There appears to be strong evidence for autocorrelation and heteroscedasticity in this equation.

Diagnostic issues aside, the estimated elasticities from these equations imply some interesting results, these are as follows:

- An increase in wages or excess demand that boosts the supply price by one per cent, feeds into all expenditure components immediately and equally; that is, we get instantaneous price homogeneity in the relative prices in the short run. This however, is by constraint, and the equations could be re-specified to relax this assumption.

- A one per cent rise in import prices, produced plausible long run responses in four of the five equations. The relative price of business investment (PIB) increases the most, slightly more than the increase in the relative price of government market demand (PGMD), the relative price of non-rent consumption (PCNR) falls slightly and the relative price of dwelling investment (PIDW) falls significantly.

  – These responses are broadly in line with the import intensiveness of differing components of expenditure obtained from the price input-output model PRISMOD.

  – The odd equation out was real estate transfer expenses. In the long run, the relative price of real estate transfers increased more than any other price, even though we would expect it to fall in relative terms, as it has little import content. The unusually large long run elasticity obtained in the estimation may just reflect a mixture of sampling errors and the nature of the ABS data construction for this series.

3.1.3 Revised Error Correction Mechanism Specifications

In light of the issues and data limitations mentioned above, we proceeded to re-estimate the RPB equations in a form that would be suitable for inclusion in the TRYM model. The ECM specifications were altered in the following ways.

- The dependent variables in the equations are re-specified in terms of absolute rather than relative price movements. This allows the relative price of each expenditure component to adjust slowly towards a new equilibrium when the supply price changes, rather than assuming short run price homogeneity.

- This was done, however, in a manner that did not introduce steady state bias into the TRYM model. Specifically, a lagged dependent variable was introduced and constrained to ensure long run homogeneity in prices.

- As PIRET is likely to have a relatively small import component, we did not expect PIRET to change much when price of imports change. We use this judgement to solve the problem of a large long run value for PIRET. Bearing in mind the data limitations discussed earlier, the long run elasticity for PIRET, with respect to import prices (PMGS), was constrained to a value of -0.25. This is consistent with no change in PIRET when import prices increase, that is, a small fall in the relative price of PIRET, but no change in the absolute level.

- Allow for a more parsimonious lag structure without too complex dynamics, as recommended by Box and Jenkins'(1970) leaning to parsimony methodology.

As an illustration of the revised general ECM specification, the PCNR equation is given below:

Revised ECM Specification

$$\begin{aligned}\Delta\ln(PCNR)_t = {} & (1-\alpha_i-\beta_i)*\Delta\ln(PCNR)_{t-1} + \alpha_i*A(L)\Delta\ln(PCNR)_{t-2} \\ & + \beta_i*B(L)\Delta\ln(PT)_t \\ & + \delta_i*C(L)\Delta\ln[(PMGS*(1+RTMGS)/(PD*(1-RTCNR))]_t \\ & - \gamma_i*\{\ln(PCNR/PT)_{t-1} \\ & \quad - (C0 + C1*\ln[PMGS*(1+RTMGS)/(PD*(1-RTCNR))]_{t-1})\}\end{aligned}$$

where A(L), B(L) and C(L) are distributed lags, as before.

Again the general specification above was reduced to a preferred specification by omitting insignificant variables, with a mind to parsimony, and the equations exhibiting plausible dynamics. The preferred specifications and estimated parameters for each relative price equation are presented in Appendix A, and the diagnostic results are presented in Appendix B. Plots of the actual and fitted values for each equation are shown in Charts 3 to 7 in Appendix C, including the dynamic (tag 'd') and static (tag 's') simulations.

Apart from PCNR, the other four equations give good diagnostic results, suggesting no autocorrelation or heteroscedasticity problems. (Although the PGMD equation fails the Breusch-Pagan tests for heteroscedasticity at the 5% level, it passes at the 1% confidence level.) The PCNR equation exhibits some heteroscedasticity problems, and fails the Ramsey reset and Chow tests. These results suggests there are still problems with this equation and further work is required.

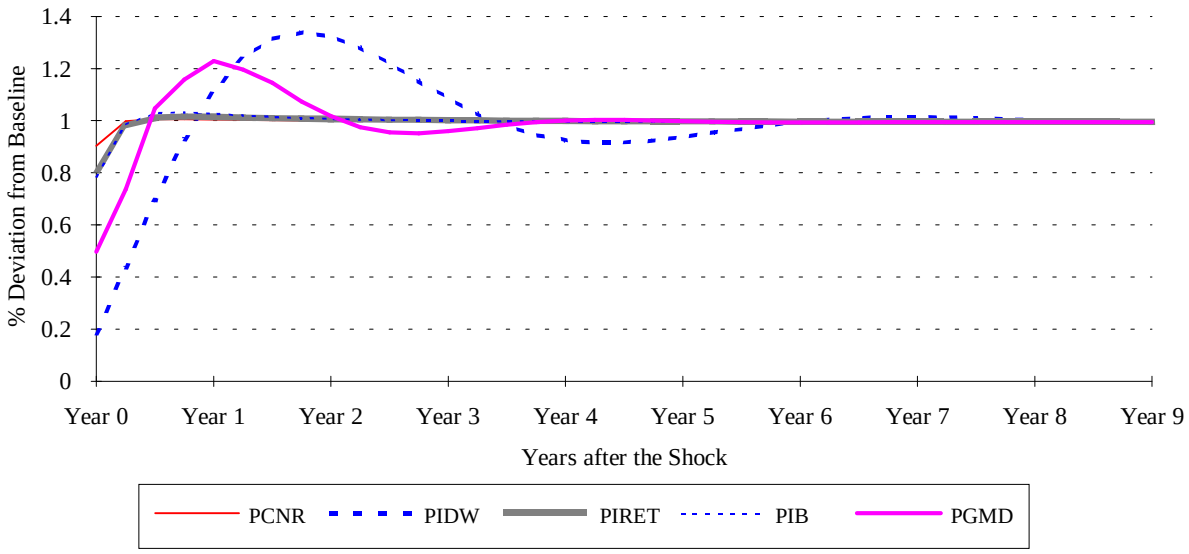
Re-estimating or re-specifying the PGMD equation is also an area for further work. At present, there is a significant but unexplained time trend in the equation. The coefficient on the $\Delta\ln(PT)_t$ term is imposed at 0.5, as the freely estimated coefficient led to highly unstable price dynamics, perhaps reflecting measurement problems. In particular, the PGMD data is currently constructed as a residual, and tends to be very volatile and noisy.

3.2 Behavioural Properties of the Re-estimated RPB (Revised ECM)

3.2.1 Increase in General Prices

Chart 1 below shows the impact of a one per cent increase in the supply price on the relative prices of each expenditure component. This could be generated by a rise in wages or any other factor that affects the cost of supply for producers. By construction, all five prices are assumed to increase by one per cent in the long run (price homogeneity). The results below are calculated as deviations from control.

Chart 1: Relative Price Dynamics for a 1% Increase in Prices (PT)



The different speed of adjustments for these prices are consistent with factors such as different contractual arrangements, the extent to which expenditure is on goods that are durable and can be stock piled or have long production lags, competition in the product market, and wage arrangements that might affect the supply price. Two prices with relatively slow adjustment are as follows:

- PIDW - jumps only slightly initially, and like PGMD, adjusts relatively slowly. This could reflect the time taken to build new houses. The overshooting observed may reflect profit margins in the PIDW data. These margins may vary with conditions of demand and supply in the dwelling sector. For example, the existence of excess demand may mean higher profit margins.

- PGMD - increases by 0.5% initially (constrained), overshoots and adjusts slowly to the long run value. The slow adjustment may reflect the existence of long lived contracts that government departments have with some suppliers. Further, PGMD also includes expenditures on military hardware. With large expenditure items and items that are constructed on order, we would expect the price to lag changes in supply prices. Thus, the price of these goods may not reflect the cost of production today, but say, the average over the last year, that is, we would not expect a rise in PT (the total supply price) to feed immediately or rapidly into the price of these goods.

A distinguishing feature of PCNR, PIB and PIRET is the large initial increase, compared to PGMD and PIDW outlined above. They also adjust quite rapidly to the long run value which suggests other factors are more important in these price adjustments.

- PCNR - The rapid adjustment of PCNR may reflect the nature of non-rent consumption goods. If they are non-durable or durable goods without long production lags, the selling price would reflect the current costs of production. Hence, any increase in PT would flow rapidly into higher non-rent consumption prices.

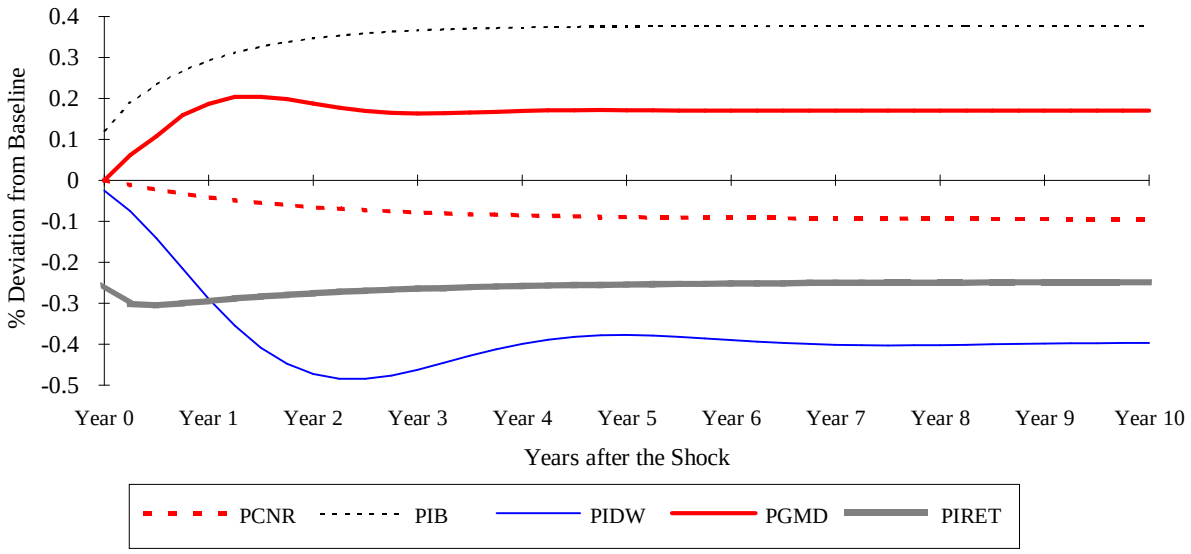
- PIB - The main linkage of domestic supply prices to PIB (price of business investment) would be through non-dwelling construction (IOB), as a large part of plant and equipment is imported. The IOB component of the business investment deflator is based on input costs (wages and raw material prices). Hence, any change to wages or supply price flows relatively quickly into the business investment deflator. Further, the quick adjustment in PIB reflects the high import component of equipment, implying a rapid exchange rate adjustment and pass through.

- PIRET - Not much economic justification could be given for this price adjustment, because of the nature of the series as noted before. Suffice to say that PIRET increases immediately and adjusts to the long run value quite quickly.

3.2.2 Increase in Import Prices

The results of a one per cent increase in import prices are shown in Chart 2 below. We would expect the relative increase/decrease in each expenditure price to reflect its dependence on imports. That is, the relative price will rise if it has a large import component and falls vice versa. Therefore, from the different import weights (penetration ratios) given by the price input-output model PRISMOD, we would expect the relative price of PGMD to increase the most, followed by PIB, PCNR, PIDW and PIRET. The results given in Chart 2 are calculated as deviations from control.

Chart 2: Relative Price Dynamics for a 1% Increase in Import Prices



The long run values and rankings of these prices are consistent with the weights given in the price input-output model PRISMOD. PGMD and PIB both increase, as expected. PIB however increases more than PGMD, but the gap between the two is not large. PCNR falls slightly, suggesting a slight fall in the price of non-rent consumption relative to other prices when import prices rise. PIDW and PIRET falls further, with PIDW falling the most. This is opposite to expected, but again, the gap between the two is not large.

There is a large immediate fall in PIRET, which is consistent with its small import component. The immediate increase in PIB is a distinguishing feature from the other prices. Finally, we note that PIDW has a more cyclical adjustment path, it over adjusts and then returns to its long run equilibrium. This cyclical nature is also observed in the PIDW series in history.

3.3 Assessment

Given the data limitations discussed and constraints imposed, the re-estimated RPB equations, in an error correction format, appear to give satisfactory behavioural properties. The constraints were imposed in order to have a version suitable for use in the TRYM model. A further adjustment was to include a lagged dependent term into the equations in order to avoid introducing steady state bias in the model. These new equations were than introduced into the model and its dynamics examined in the full model context, and to highlight any improvements to the model.

4. NEW RPB EQUATIONS IN FULL MODEL CONTEXT

This section examines the dynamics of the RPB equations in the full model context and its effects on other areas of the model. The two shocks examined are one, an increase in the general price level, and two, an increase in import prices.

4.1 Increase in General Prices via a Monetary Shock

An increase in the general price level was generated by a permanent one per cent increase in the money supply; that is, an expansionary monetary shock. A comparison of the "new version" and "old version" results, of key variables and prices, are given in Charts 8 to 25 in Appendix D. Charts 8 to 14 compares the differences in GDP, unemployment, interest rates, bond yield, exchange rate, real exchange rate, and the current account deficit (CAD) as a percentage of GDP, respectively. The price equations are examined in Charts 15 to 25.

There are no large differences in the behaviour of the key variables. GDP, interest rates, and the exchange rate behave in very much the same way as before. This is a good sign, as we did not expect the relative price equations to have a big impact on key macro variables such as GDP. Particularly as price homogeneity was enforced in the old equations, which the new equations only relaxes in the short run. A permanent one per cent increase in the money supply increases GDP in the first few years, but then unwinds and returns to control in the long run. Unemployment falls as activity picks up and returns to control in the long run. There is a permanent one per cent depreciation in the nominal exchange rate, as our price level is one per cent permanently higher, but the real exchange rate (competitiveness) is unchanged in the long run. The CAD as a percentage of GDP closely follows the path in the old version. It deteriorates in the short run as activity picks up and unwinds in the long run.

The dynamics in the levels of each expenditure price are similar to the old version. All five prices are one per cent permanently higher in the long run. The relative changes in these prices are of more interest, as they will reflect more fully the changes made to the relative price equations.

The new relative price responses are more cyclical than the old ones. This however, is expected, as we have introduced or allowed for such dynamics to exist in the adjustment process. In the old version, such dynamics were not included. This is quite apparent in the PCNR equation. The dynamics of the relative price of PCNR in the old version seems more stable as it tails off to equilibrium after three years. In the new version, the path is more cyclical because we have included a lag dependent variable in the PCNR equation. However, the magnitude of these changes, in comparison to the magnitude in other relative price changes, are not large, in the order of ± 0.01%. This seems to suggest that PCNR moves very much in line with general prices. The magnitude of the percentage deviation for the other four prices range from -0.2% to +0.2%. Hence, fluctuations in PCNR are only about $\frac{1}{10}$th of fluctuations in other prices.

PIB and PIDW closely follow the paths in the old version. The relative price of PGMD falls in the first instant, rather than rising, which seems more sensible, for reasons outlined earlier. It does however, rise and fall by a larger magnitude before stabilising in a similar fashion after 10 years. This again may simply reflect the dynamics introduced into the equation specification. The other notable difference is in an improvement in the relative change in PIRET. Rather than increasing by about 0.2% in the first quarter, PIRET falls by about 0.2% initially, relative to general prices.

Overall, the dynamics presented here are consistent with the behavioural properties and explanations presented earlier in Section 3.2.1. There is an improvement in the dynamics of the relative prices, and the behaviour of other aggregates in the model, in response to a monetary shock, appears largely unchanged. Chart 26 in Appendix D summarises the relative price changes for a permanent one per cent increase in the money supply. This is the full model equivalent of an increase in general prices examined earlier in Section 3.2.1.

4.2 Increase in Import Prices via a Fiscal Shock

An increase in import prices is generated by a permanent one per cent increase in the government debt to GDP ratio. This leads to a reduction in the tax rate in the model, via the model's fiscal policy reaction function. An expansionary fiscal shock leads to an increase in activity, which in turn increases interest rates. Consequently, the exchange rate appreciates in the short run, but depreciates in the long run as the rise in interest rates unwinds. The long run depreciation in the exchange rate leads to the desired result of an increase in import prices. All the above dynamics, for the old and new versions, are given in Charts 28 to 34 in Appendix E. A comparison in the dynamics of the relative prices are given in Charts 35 to 45.

A reduction in the tax rate stimulates economic activity, and so GDP rises and unemployment falls in the short run. There are slight improvements in the speed of adjustments to control in long run. For instance, GDP returns to control after 20 years, whereas in the old version, it is slowing returning to control. An improvement is seen in the interest rate and bond yields responses, as seen in Charts 30 and 31 respectively. In contrast to the old version, the deviations from baseline now tend to zero in the long run. This is the desired results as we would expect arbitrage activity to eliminate any interest rate differentials across markets. There is no logical reason why interest rates should not return to control as in the old version.

The exchange rate appreciates immediately due to an increase in interest rates, in both the new and old versions, and then slowly unwinds, leading to a depreciation in the long run. In the new version, the exchange rate depreciates further in the long run, and consequently, there is a larger increase in the price of imports in the long run. The CAD, as a percentage of GDP, follows a similar pattern as before.

The price responses are of particular interest, and there are a few distinct differences. Firstly, the general price level settles at a higher equilibrium value, compared to the old version. This is again due to a larger depreciation in the exchange rate in the long run. One notable difference is that the price of real estate transfers rises and returns to zero after twenty years, rather than increasing by about 0.3% in the long run.

There are definite improvements in the short run dynamics of the relative changes in these prices and in their long run values. The short run dynamics of the relative prices, as shown in Charts 41 to 45, are driven by changes in domestic demand relative to supply, and the exchange rate appreciation, which pushes up import prices. PCNR, PIDW and PIRET, being sensitive to domestic demand pressures, rise in the short run, before stabilising to their long run values. This is in contrast to PGMD and PIB. These two prices, being sensitive to imports, actually fall in the short run as import prices fall, due to an exchange rate appreciation, and rise as the exchange rate unwinds and pushes up import prices.

The long run values of these prices are determined by their import intensiveness, or the penetration ratio of imports into these prices. Therefore, we would expect the orderings of these price changes in the long run to reflect the weights given in the price input-output model PRISMOD, with PGMD increasing the most, followed by PIB, PCNR, PIDW and PIRET. This is roughly what we get, as shown more clearly in Chart 27, a summary of the relative price changes. PIB is slightly higher than PGMD, but as before, the difference is not large.

5. SUMMARY AND CONCLUSION

The relative price block (RPB) in TRYM consists of five expenditure prices, these include the price of non-rent consumption (PCNR), business investment (PIB), dwelling investment (PIDW), government market demand (PGMD) and real estate transfers (PIRET). The RPB describes how the general price level feeds into the price of these five expenditure components of demand. It gives the changes in these prices, relative to the overall change in prices in the economy. A scaling factor is applied to ensure model closure, (so that the price of demand equals the price of supply) and to obtain the levels of the above prices. Modelling these sectoral prices has its advantages and is justified as seen from the results, as prices in different sectors respond differently to shocks in the economy.

When the model was first released in June 1993, a simple set of static equations were used to model changes in the relative prices of the different components of expenditure. These equations did not capture the dynamic behaviour of these expenditure prices very well, and consequently, they performed poorly in diagnostic tests and, to some extent, affected the forecast results.

The RPB equations were therefore re-estimated by firstly, using a partial adjustment mechanism (PAM) and then in an error correction mechanism (ECM) format. ECMs were used as it introduces time dynamics into the system, allowing for the short run dynamics and long run parameters to be estimated simultaneously. The behaviour of the new set of RPB equations gave better diagnostic results and a better tracking record. There were also marked improvements in the behavioural properties of these equations. In particular, the dynamics were examined with respect to a one per cent increase in the price level (PT), and a one per cent increase in import prices. The results were consistent with our prior beliefs, and improved the dynamics of the relative price equations, compared to the 93 Conference Version of TRYM.

The new RPB equations were then introduced into the TRYM model. Some restrictions and adjustments were made to have a version suitable for use in TRYM. For example, adjustments were made to avoid steady state bias problems. Two simulation shocks were examined to replicate an increase in general prices and an increase in import prices. These were generated by a monetary shock and a fiscal shock respectively: a permanent one per cent increase in the money supply produces a permanent one per cent increase in general prices; and an increase in the government debt to GDP ratio, resulting in a reduction in the tax rate (via the model's fiscal policy reaction function) and through an exchange rate depreciation in the long run, produces an increase in import prices. The full model results from these two shocks are consistent with our prior beliefs and in many cases, an improvement in the short run dynamics and long run values.

6. ATTACHMENT A: REVIEW OF RELATIVE PRICES IN OTHER MACRO MODELS

This section gives a brief overview of how prices of different expenditure components are modelled in a number of macro models. Few models disaggregate expenditure prices as done in TRYM. Exceptions are the G-Cubed model by Warwick McKibbin and the latest version of the Murphy model with sectoral components.

A.1 Murphy Model

The Murphy model is a macroeconometric model of the Australian economy incorporating rational expectations in the financial sector. The earlier version of the model (Access Economics Murphy (AEM) model, 1992) does not disaggregate expenditure prices as done in TRYM. Although it considers the price of rental services and real estate transfer expenses, it does not compare these to the change in general prices, as in TRYM.

The latest version of the Murphy model, with sectoral components, does disaggregate a number of demand and supply prices, and considers how these prices move relative to the general price level. In this sense, it is more disaggregated than the way it is done in TRYM. Unfortunately, no detailed documentation is yet available.

A.2 NIF-88

NIF-88, the predecessor of TRYM, contained a range of price deflators. The model consisted of five broad sectors or markets, including the goods market, labour market, money or financial sector, income distribution and prices, and the government sector. NIF-88 had a total of 96 behavioural equations compared to 27 in TRYM, of which 24 were price and wage equations, compared to 10 in TRYM.

The price equations in NIF-88 could be grouped under three categories:

- the export and world price deflators, which are exogenous to the model;
- the government sector domestic expenditure deflators, for both consumption and investment expenditures, which were further disaggregated according to the level of government; and
- the private sector domestic expenditure deflators,
  - *private sector consumption deflators*, which consisted of consumption of motor vehicles (PCMV), other durables, other non-durables excluding petroleum, other non-durables excluding rent (PCRE), and
  - *private sector investment deflators*, which consisted of investment in other building and construction (PIOB), plant and equipment (PIPE), dwellings (PIDW), and non-farm inventories (PKSN).

A number of these prices were omitted and others combined to form the current price set up in TRYM. For instance:

- private sector consumption is lumped under PCNR (price of non-rent consumption);

- government sector domestic expenditure prices are lumped under PGMD (price of government expenditure;

- price of investment in other building and construction (PIOB) and price in plant and equipment (PIPE) are combined to form PIB (price of business investment);

- price of dwelling investment (PIDW) remains; and

- price of real estate transfers (PIRET) is included and price of non-farm inventories (PKSN) is omitted.

Although some of the relative prices in TRYM are originally or composites from NIF-88, the NIF-88 prices were not explicitly modelled in a relative price block as in TRYM. The relative price block in TRYM gives the absolute (levels) changes (through a scaling factor) as well as the relative changes in these prices to the overall price level.

A.3 UK Treasury Model

The 1989 Version of the UK Treasury macro model (known as SLIM), contains a few expenditure prices. These include the following.

- Retail prices excluding petrol.

- Retail price of petrol.
  - The TRYM equivalence to the above two prices is the price of non-rent consumption (PCNR).

- Price of investment excluding dwellings.
  - This is equivalent to PIB, price of investment in TRYM.

- Price of housing investment ie investment in dwellings.
  - This is equivalent to PIDW, price of dwelling investment in TRYM.

- A separate price series exits for new house prices.

Again, we note here that although there are equivalent prices in TRYM, prices in the UK Treasury model are solely the market equilibrium values, determined by demand and supply forces. There is no measure of how these prices move relative to the underlying price level. Also, neither the price of final government expenditure nor the price of real estate transfer expenses is explicitly modelled, in contrast to TRYM.

A.4 AMPS

The AMPS (Australian Medium-Term Policy Simulation) model, developed by EPAC in the mid-80s, was another macroeconometric model of the Australian economy. It used semi-annual data. It was specifically designed to serve as an analytical tool for macroeconomic policy analysis over a medium-term horizon. Although the AMPS model is no longer in use, like NIF-88, it is still useful to note what has been attempted in past macroeconomic models. Although AMPS contained a number of price series (listed below), it does not explicitly model any relative price changes.

The prices modelled in AMPS included the following:

- price of consumption goods;
- price of domestically-produced consumption good;
- price for business fixed investment;
- market price of dwellings;
- price for dwelling rental services; and
- price for multi-purpose domestically produced commodities.

A.5 MSG2 and G-Cubed

MSG2, developed by Warwick McKibbin and Jeffrey Sachs, is a multi-region (or country), dynamic general equilibrium macro model, based firmly on micro-foundations. MSG2 consists of eleven countries (or regions), with each country (region) producing one good, which is an imperfect substitute in the consumption bundle of all other regions. The model is not as disaggregated as G-Cubed and relative sectoral price changes are not modelled.

G-Cubed on the other hand, developed by Warwick McKibbon and P. Wilcoxen (1992), is a more disaggregated macro model. It is a multi-country, multi-sector dynamic model, with substantial disaggregation and sectoral detail, and the individual sectoral dynamics are fully integrated into a consistent macroeconomic framework. It consists of seven economic regions with twelve sectors in each region. It therefore has the advantage that it can analyse shocks that differ across sectors. And consequently, changes in relative prices are important in the dynamics of the model. Sectoral results are explicitly modelled and presented, including the relative change in prices for the different sectors.

In this sense, G-Cubed's sectoral price equations resemble the relative price block in TRYM. It shows how prices move in different sectors, relative to the change in the general price level. The sectoral results from G-Cubed, also highlight how the dynamics of adjustments are different when modelled at the sectoral level compared to modelling at the aggregate level.

A.6 New Zealand Model

The 'Reserve Bank Econometric Model of the New Zealand Economy: Model 12', consists of seven broad sectors, comprising 105 equations, 43 behavioural equations and 62 identities. It is specifically designed to examine monetary and exchange rate policy shocks, and for medium-term forecasting. The expenditure prices examined include the price of investment in dwellings, price of

existing dwellings, and price of business investment. There is not a relative price block as such. All these prices move in line with the general price level.

Available review information on other macroeconometric models of the Asian-Pacific countries[1] suggests that none of these models have a relative price block concept similar to that in TRYM. These include the FOCUS model of the Canadian economy, macro models of the Singapore, Malaysia, Korea and Hong Kong economies.

[1]A good overview of macro models in the Asian-Pacific region is contained in a book by S. Ichimura and Y. Matsumoto (Eds.) entitled 'Econometric Models of Asian-Pacific Countries', Springer-Verlag, 1994.

7. ATTACHMENT B: TRYM MNEMONICS

PCNR - Price of non-rent consumption

PGMD - Price of government final demand

PIB - Price of private sector business investment

PIDW - Price of dwelling investment

PIRET - Price of real estate transfer expenses

PT - Total Price of supply = Price of major items of expenditure

PD - Price of the domestic supply component of expenditure

PMGS - Price of imports

RTMGS - Rate of customs duty

RTCNR - Indirect tax rate on CNR

RTIDW - Indirect tax rate on IDW

RTIB - Indirect tax rate on IB

QTIME - Time trend

8. APPENDIX

APPENDIX A: Revised ECM: Specifications and Estimated Parameters

Equation 1: PGMD

$$\Delta \ln(PGMD)_t = \underset{(9.28)}{\mathbf{0.12}}*\log(PGMD(-1)/PGMD(-2)) + 0.38*\log(PGMD(-2)/PGMD(-3))$$

$$+ \underset{(6.00)}{\mathbf{0.5}}*\log(PT/PT(-1)) - 0.006*(QTIME-QTIME(-1))$$

$$- 0.36*\{\log[PGMD(-1)/PT(-1)]-\{\underset{(4.35)}{-0.03} - \underset{(1.64)}{0.006}*\underset{(6.00)}{QTIME(-1)}$$

$$+ \underset{(2.62)}{0.17}*\log[PMGS(-1)*[1+RTMGS(-1)]/(PD(-1)*(1-RTGMD(-1)))]\}\}$$

Equation 2: PIB

$$\Delta \ln(PIB)_t = \underset{(14.02)}{\mathbf{0.21}}*\log(PIB(-1)/PIB(-2)) + 0.79*\log(PT/PT(-1))$$

$$+ \underset{(7.10)}{0.12}*\{\log[PMGS*(1+RTMGS)/\{PD*(1-RTIB)\}]$$

$$- \log[PMGS(-1)*\{1+RTMGS(-1)\}/(PD(-1)*\{1-RTIB(-1)\})]\}$$

$$- \underset{(4.38)}{0.16}*\{\log[PIB(-1)/PT(-1)]-\{\underset{(6.02)}{-0.11}$$

$$+ \underset{(7.79)}{0.38}*\log[PMGS(-1)*[1+RTMGS(-1)]$$

$$/(PD(-1)*(1-RTIB(-1)))]\}\}$$

Equation 3: PCNR

$$\Delta \ln(PCNR)_t = \underset{(27.88)}{\mathbf{0.09}}*\log(PCNR(-1)/PCNR(-2)) + 0.91*\log(PT/PT(-1))$$

$$- \underset{(2.91)}{0.12}*\{\log[PCNR(-1)/PT(-1)] - \{\underset{(3.21)}{0.04}$$

$$- \underset{(3.07)}{0.1}*\log[PMGS(-1)*[1+RTMGS(-1)]/(PD(-1)*(1-RTCNR(-1)))]\}\}$$

Equation 4: **PIDW**

$\Delta \ln(PIDW)_t$ = **1.14***log(PIDW(-1)/PIDW(-2)) - 0.32*log(PIDW(-2)/PIDW(-3))
(3.64)

+ 0.18*log(PT/PT(-1))
(4.87)

- 0.03*{log[PMGS*(1+RTMGS)/{PD*(1-RTIDW)}]
(2.43) - log[PMGS(-1)*{1+RTMGS(-1)}/(PD(-1)*{1-RTIDW(-1)})]}

- 0.06*{log[PIDW(-1)/PT(-1)]-{0.04
(3.38) (1.78)

- 0.40*log[PMGS(-1)*[1+RTMGS(-1)]
(5.94) /(PD(-1)*(1-RTIDW(-1)))]}}

Equation 5: **PIRET**

$\Delta \ln(PIRET)_t$ = **0.18***log(PIRET(-1)/PIRET(-2)) + 0.82*log(PT/PT(-1))
(8.45)

+ 0.02*(QTIME-QTIME(-1)) - 0.26*{log[PMGS*(1+RTMGS)/PD]
(2.33) (2.23) -log[PMGS(-1)*{1+RTMGS(-1)}/PD(-1)]}

- 0.097*{log[PIRET(-1)/PT(-1)] - {-0.18 + 0.02*QTIME(-1)
(2.61) (3.55) (2.33)

- **0.25***log[PMGS(-1)*[1+RTMGS(-1)]/PD(-1)]}}

APPENDIX B: Diagnostic Tests Results:
Sample 74:4 - 94:4

ECM of the format:

$$\Delta\ln(PCNR)_t = (1-\alpha_i-\beta_i)*\Delta\ln(PCNR)_{t-1} + \alpha_i*A(L)\Delta\ln(PCNR)_{t-2}$$
$$+ \beta_i*B(L)\Delta\ln(PT)_t$$
$$+ \delta_i*C(L)\Delta\ln[(PMGS*(1+RTMGS)/(PD*(1-RTCNR))]_t$$
$$- \gamma_i*\{\ln(PCNR/PT)_{t-1}$$
$$- (C0 + C1*\ln[PMGS*(1+RTMGS)/(PD*(1-RTCNR))]_{t-1})\}$$

where A(L), B(L) and C(L) are distributed lags, as before.

The constraints here are:
- constrain long run PIRET value to be -0.25, consistent with no change in PIRET with increase in general prices, and
- allow differing pass-through of supply prices to each relative price.

	Equations				
TESTS	PGMD	PIB	PCNR	PIDW	PIRET
R^2	0.51	0.81	0.91	0.92	0.15
S.E.	2.12%	0.68%	0.33%	0.36%	4.10%
DW	2.41	2.10	2.03	2.05	2.02
Box-Pierce (8)	6.19	4.98	10.49	6.41	6.97
Jarque-Bera	0.92	1.47	1.92	1.29	3.32
Chow	**5.15****	2.16	**7.27****	1.81	1.54
Ramsey Reset	**4.39***	1.08	**22.94****	0.35	0.66
Breusch-Pagan i) Trend	**5.85***	0.005	**5.75***	0.70	0.16
ii) Y-hat	1.74	0.01	**12.79****	0.13	0.12
iii) Joint	**5.86***	0.01	**13.48****	1.75	0.18

(* indicates the test has failed at the 5% confidence level, but passes at the 1% level
** indicates the test has failed at the 1% level)

APPENDIX C: Plots of Static and Dynamic Simulations

Chart 3: PCNR - Static and Dynamic Simulations

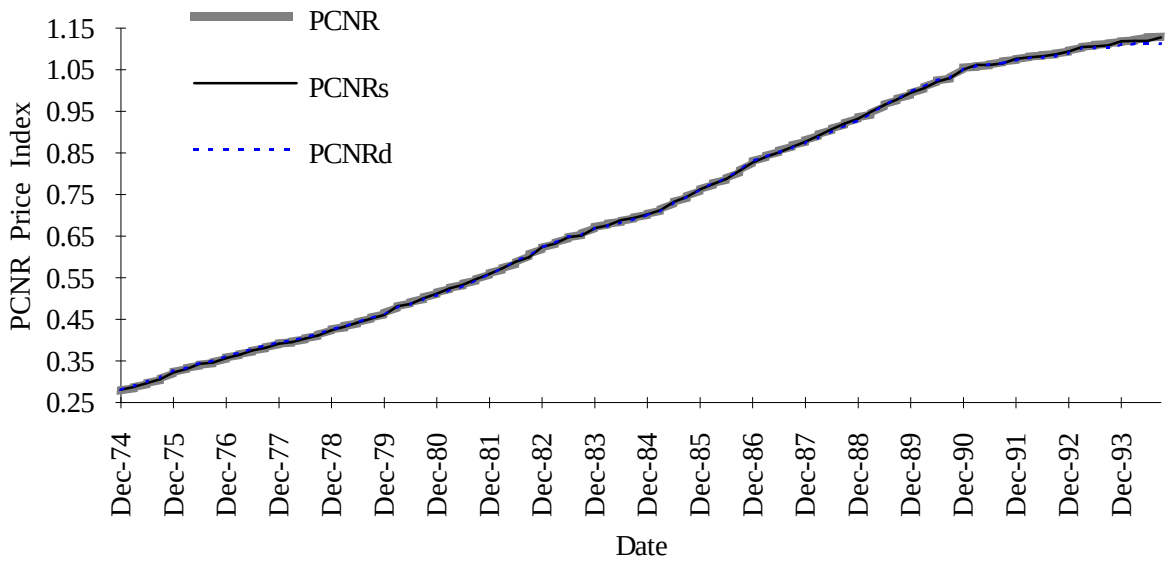


Chart 4: PIB - Static and Dynamic Simulations

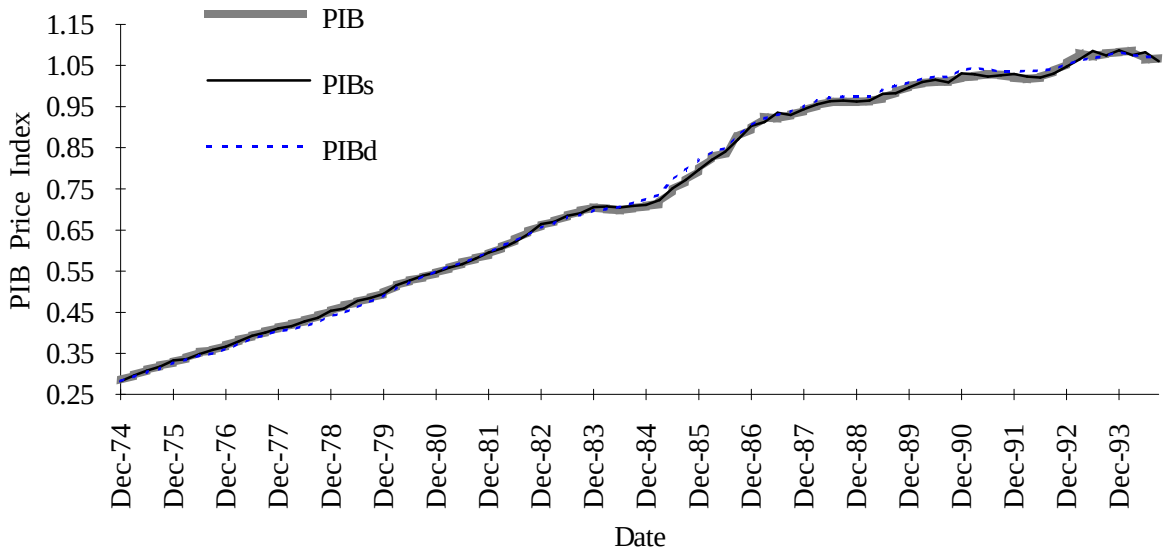


Chart 5: PIDW - Static and Dynamic Simulations

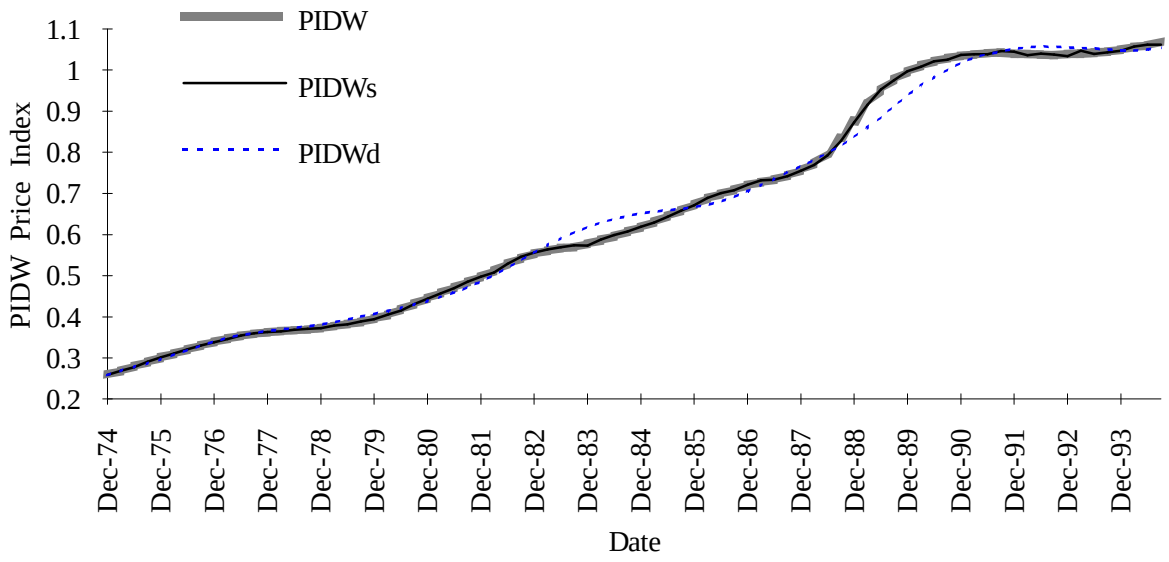


Chart 6: PGMD - Static and Dynamic Simulations

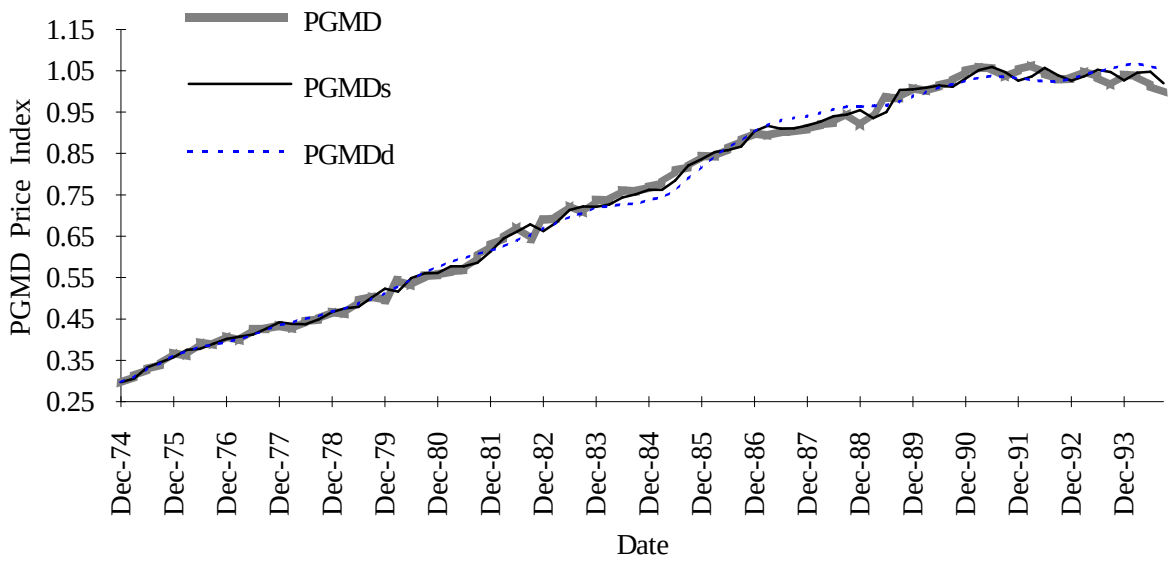
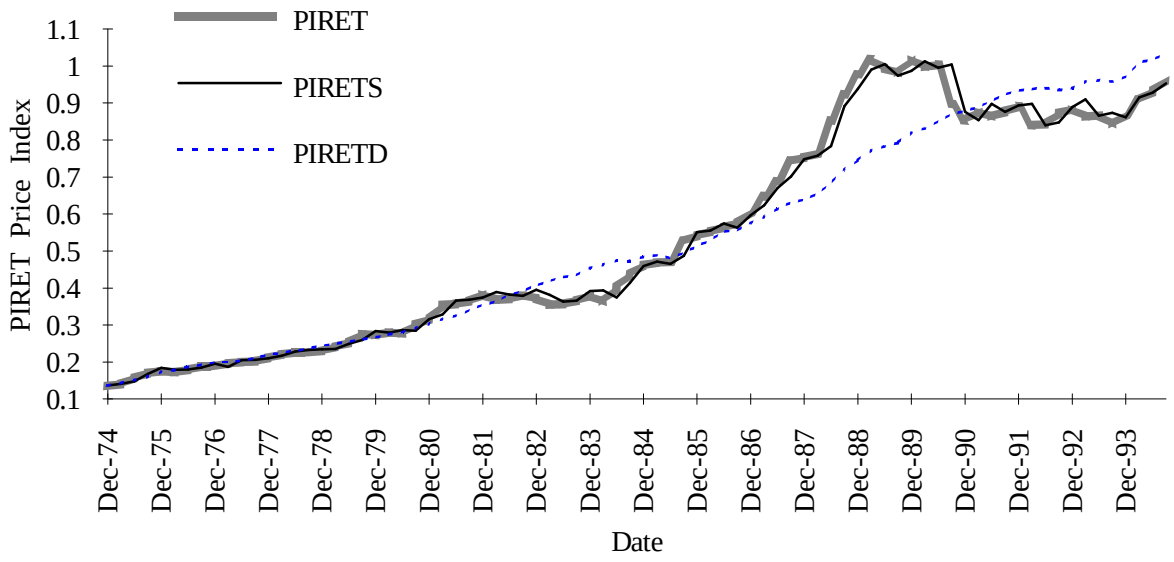


Chart 7: PIRET - Static and Dynamic Simulations



APPENDIX D: Results of an Increase in Money Supply

(Solid line = Old RPB & Shaded line = New RPB)

Chart 8: Gross Domestic Product

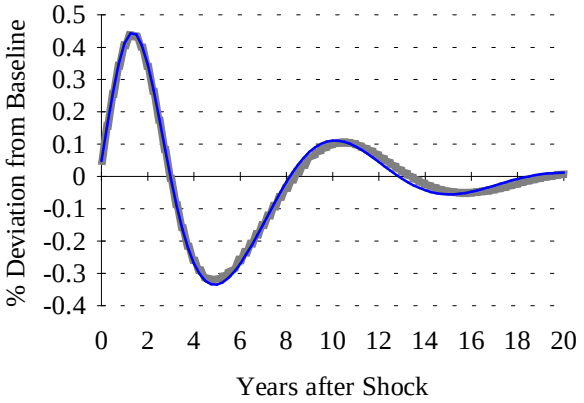


Chart 9: Unemployment

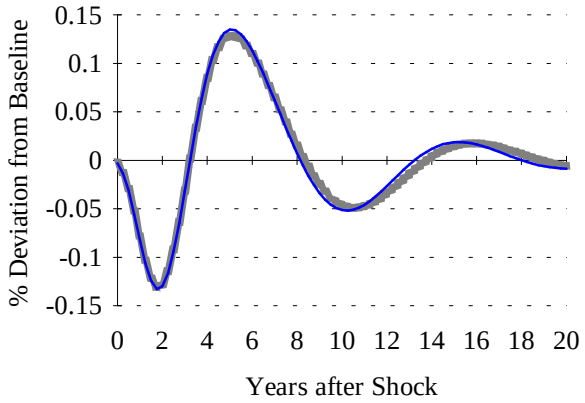


Chart 10: Interest Rates

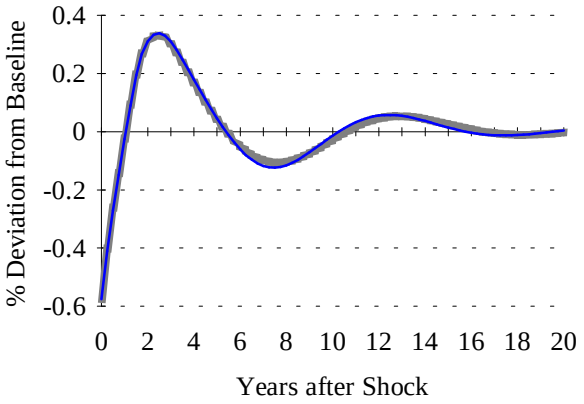


Chart 11: Bond Yields

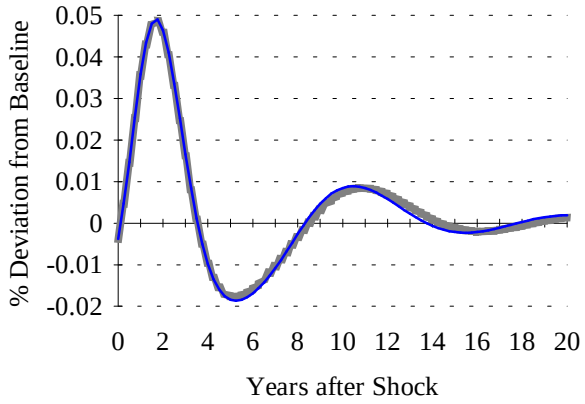


Chart 12: Exchange Rate

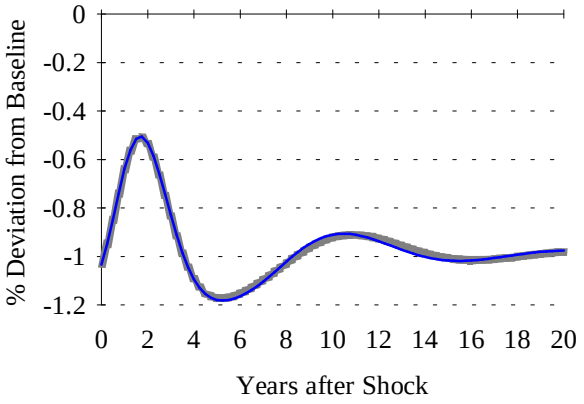


Chart 13: Real Exchange Rate

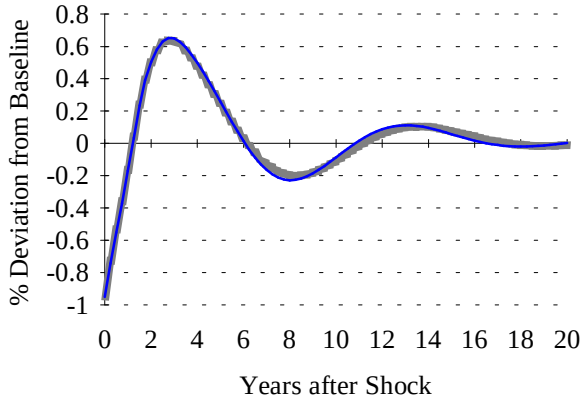


Chart 14: CAD as a % of GDP

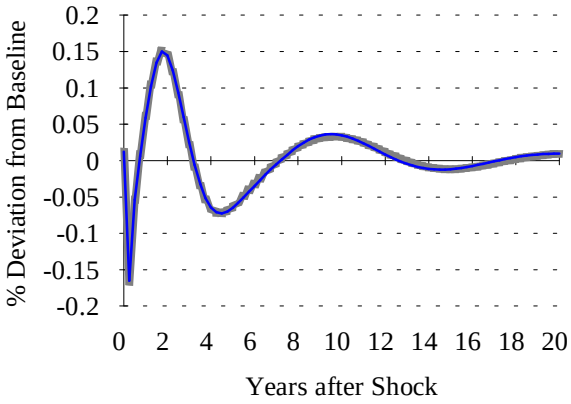


Chart 15: General Price Level

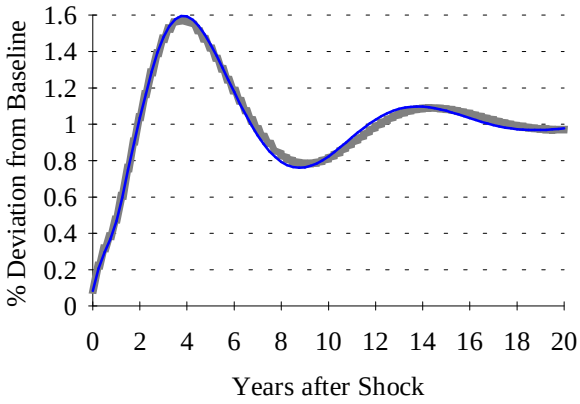


Chart 16: Price of Government Final Demand

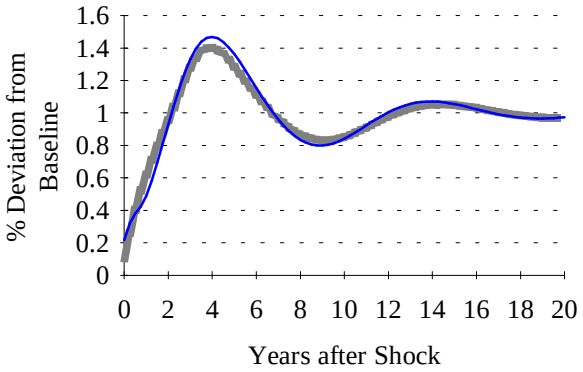


Chart 17: Price of Business Investment

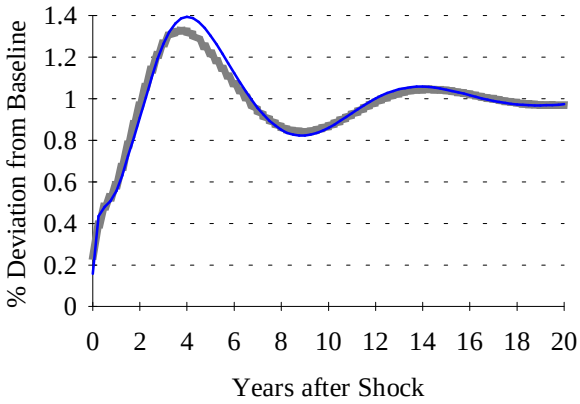


Chart 18: Price of Non-rent Concumption

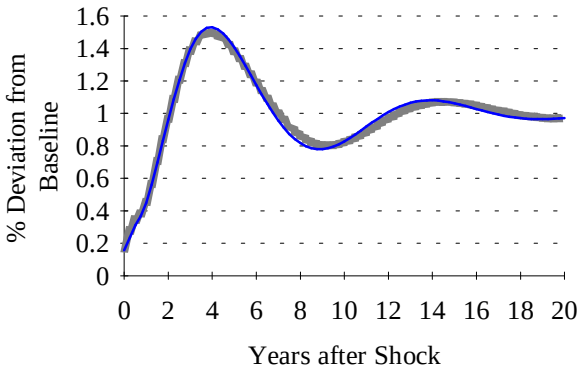


Chart 19: Price of Dwelling Investment

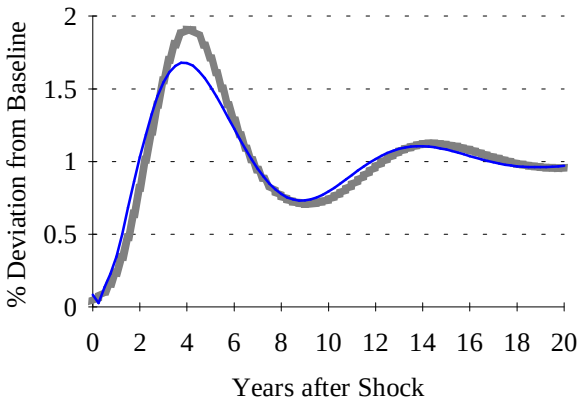


Chart 20: Price of Real Estate Transfers

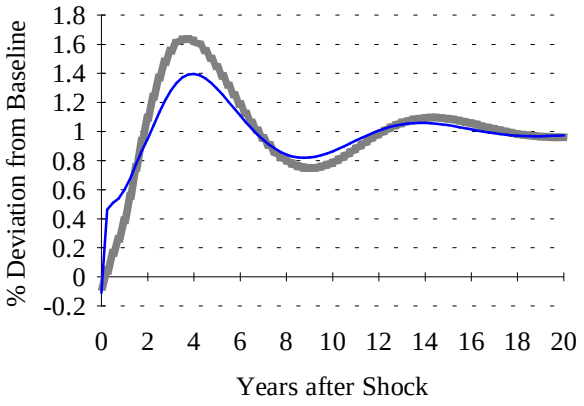


Chart 21: Relative change in PGMD

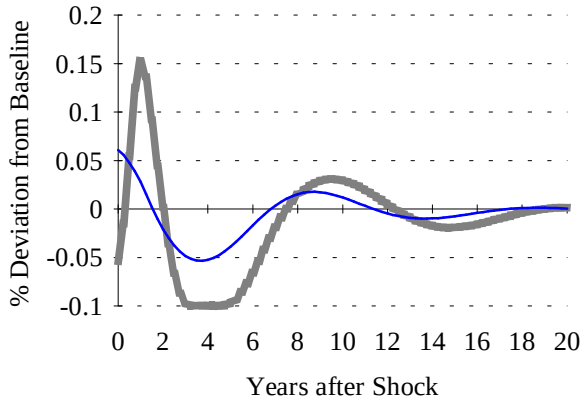


Chart 22: Relative change in PIB

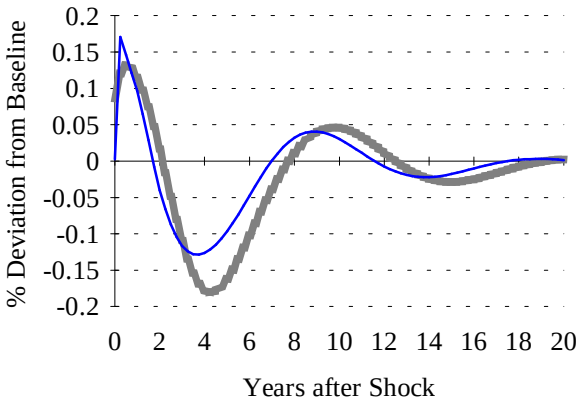


Chart 23: Relative change in PCNR

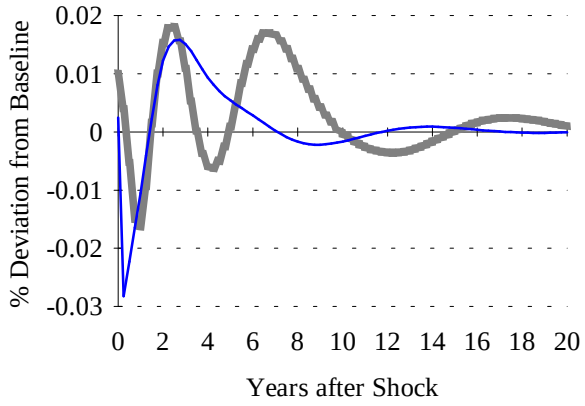


Chart 24: Relative change in PIDW

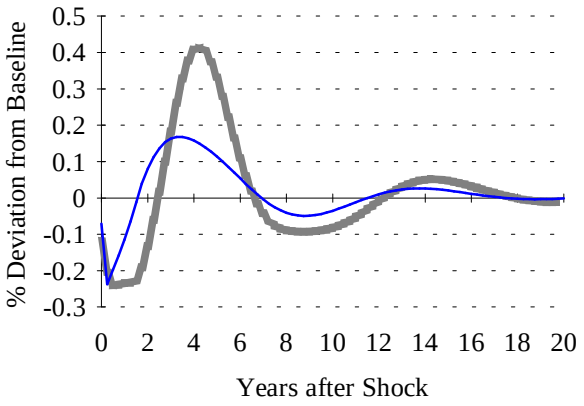


Chart 25: Relative change in PIRET

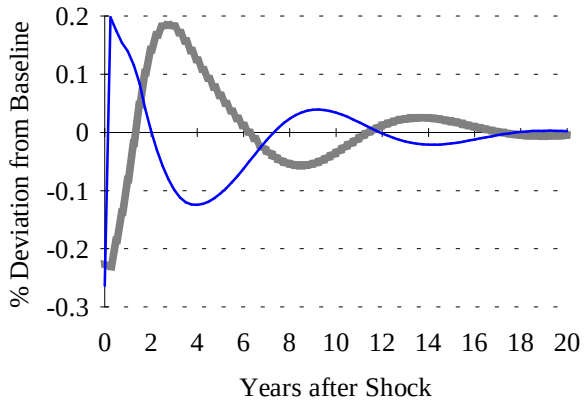


Chart 26: Summary of Relative Price Dynamics for a 1% increase in the Money Supply (Full Model Context)

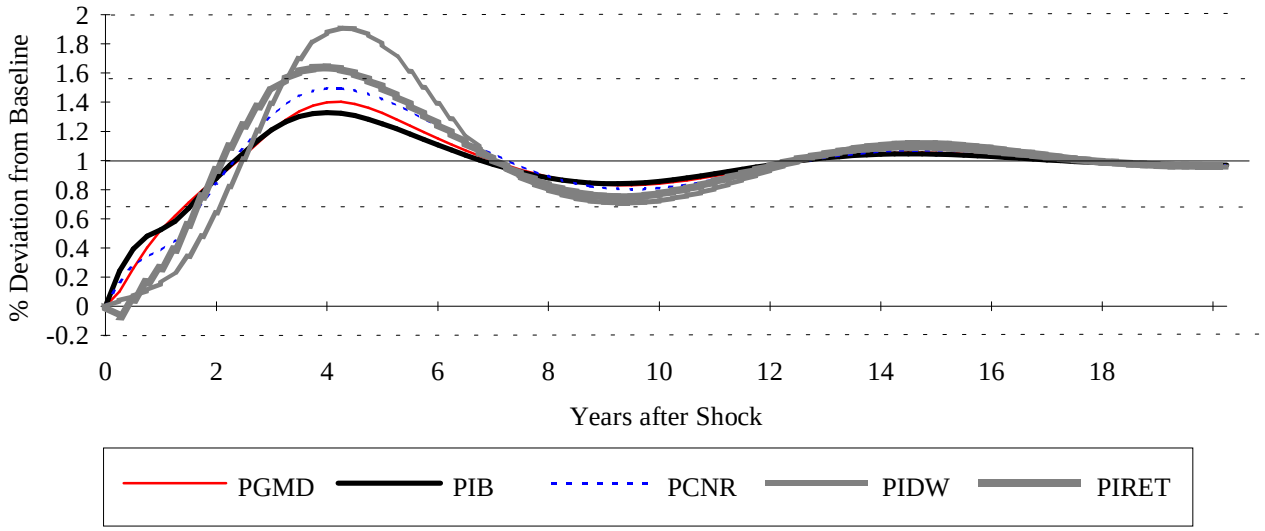


Chart 26 above is the full model equivalent of Chart 1 presented in Section 3.2.1; the response to a 1% increase in the general price level.

Chart 27: Summary of Relative Price Dynamics for a 1% Increase in Import Prices (Full Model Context)

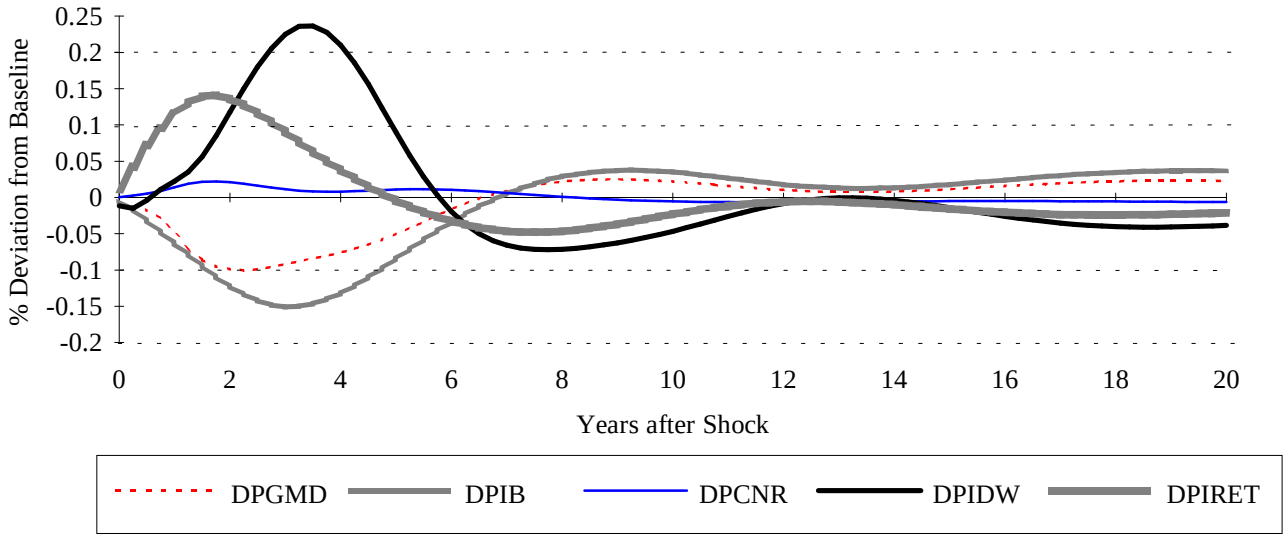


Chart 27 above is the full model equivalent of Chart 2 presented in Section 3.2.2; the response of an increase in import prices.

APPENDIX E: Results of an Increase in Government Debt to GDP

(Solid line = Old RPB & Shaded line = New RPB)

Chart 28: GDP

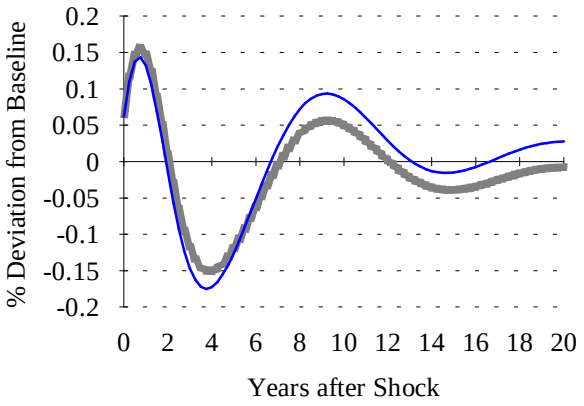


Chart 29: Unemployment

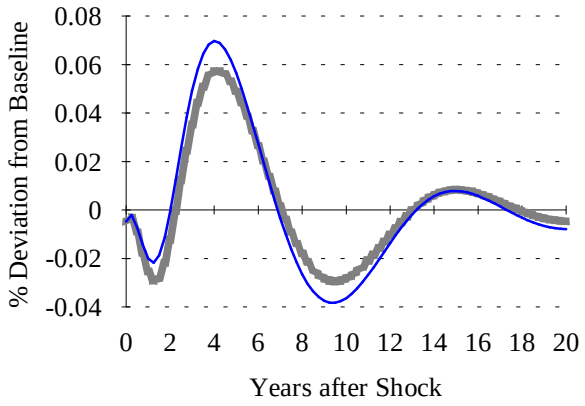


Chart 30: Interest Rates

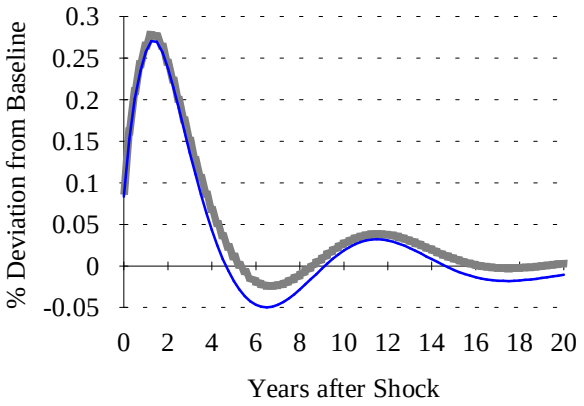


Chart 31: Bond Yields

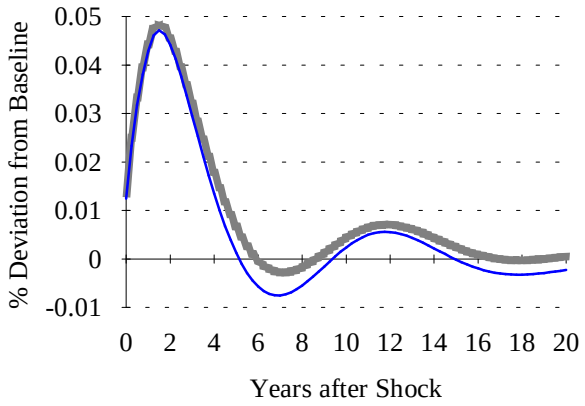


Chart 32: Exchange Rate

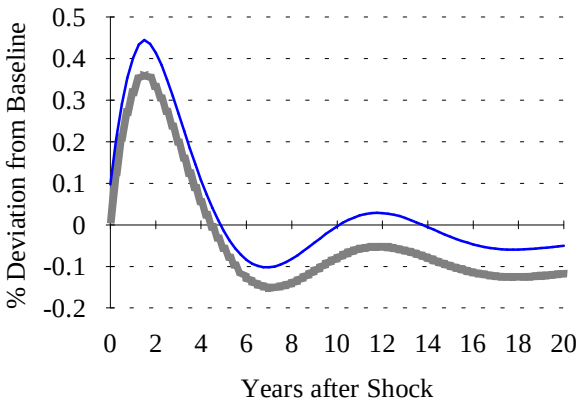


Chart 33: Price of Imports

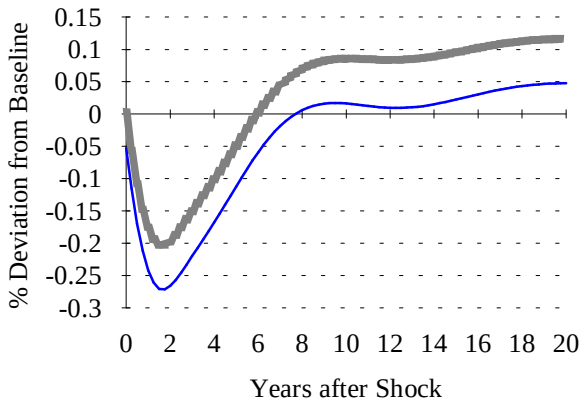


Chart 34: CAD as a % of GDP

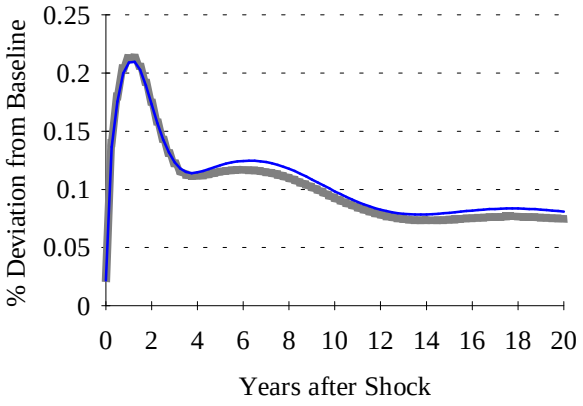


Chart 35: General Price Level

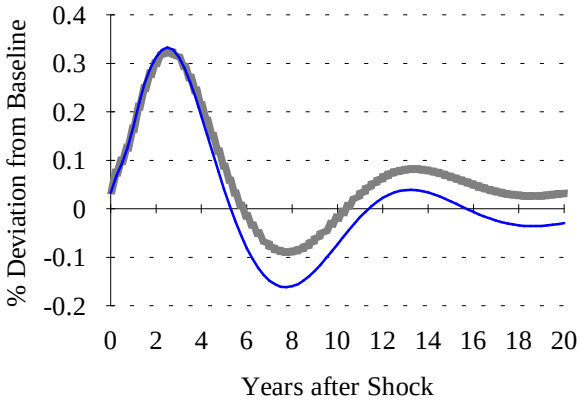


Chart 36: Price of Government Final Demand

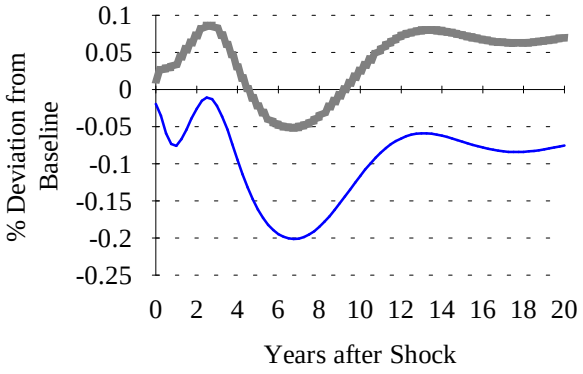


Chart 37: Price of Business Investment

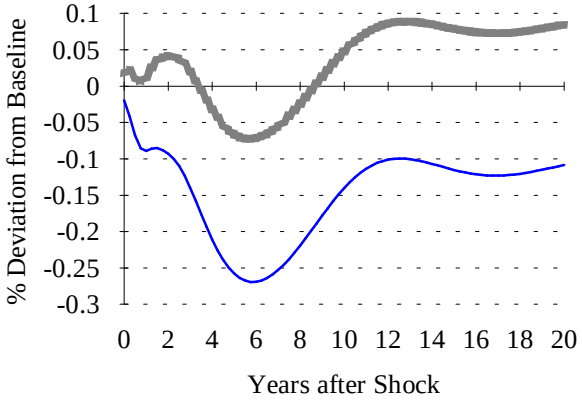


Chart 38: Price of Non-rent Consumption

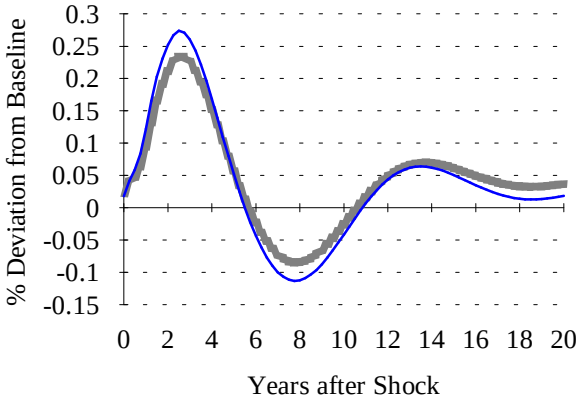


Chart 39: Price of Dwelling Investment

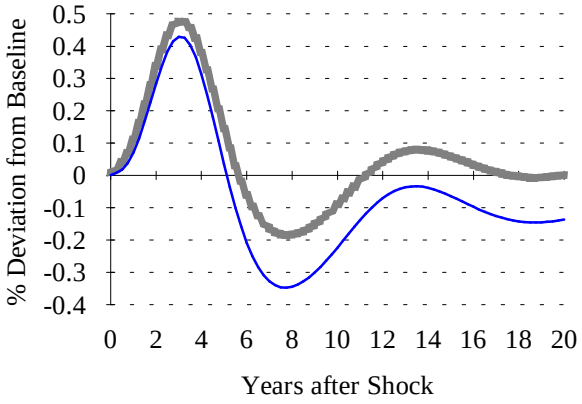


Chart 40: Price of Real Estate Transfers

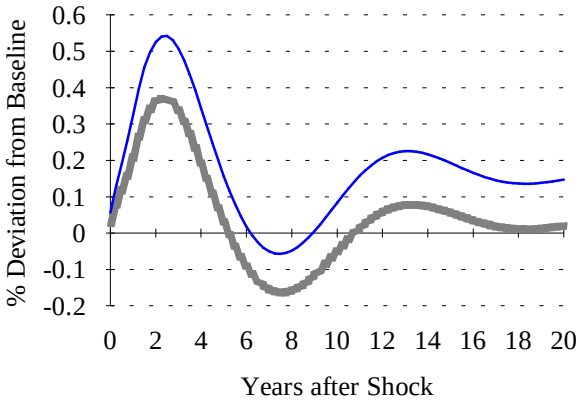


Chart 41: Relative change in PGMD

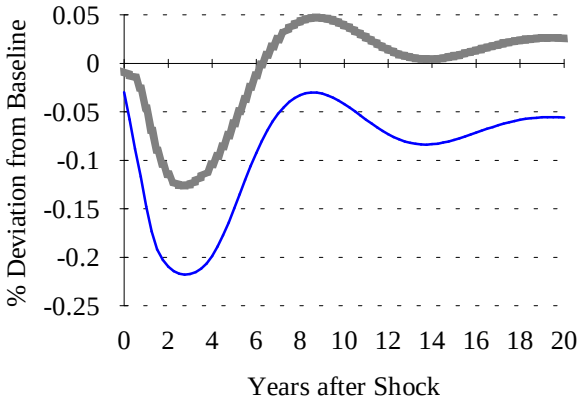


Chart 42: Relative change in PIB

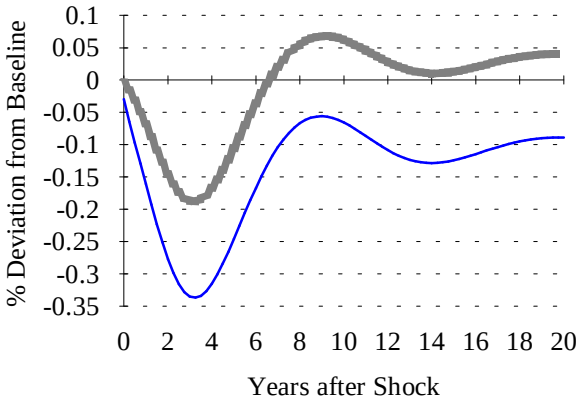


Chart 43: Relative change in PCNR

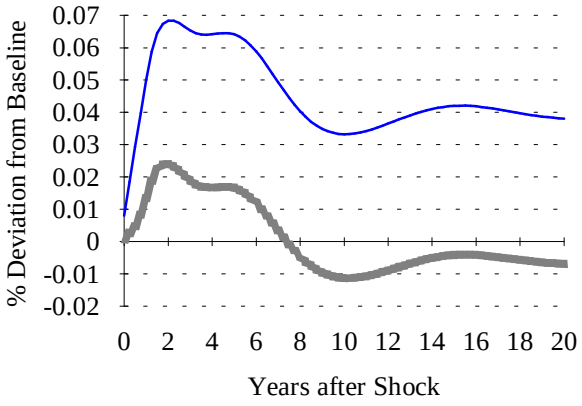


Chart 44: Relative change in PIDW

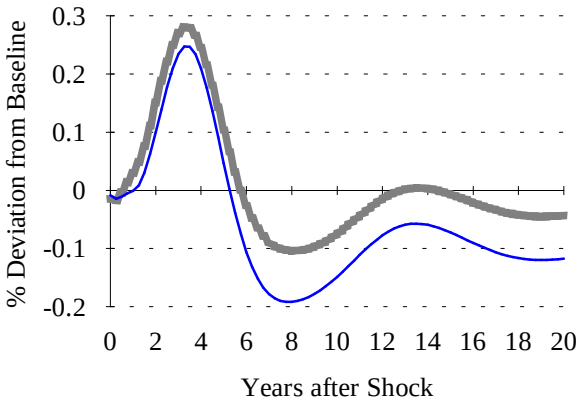
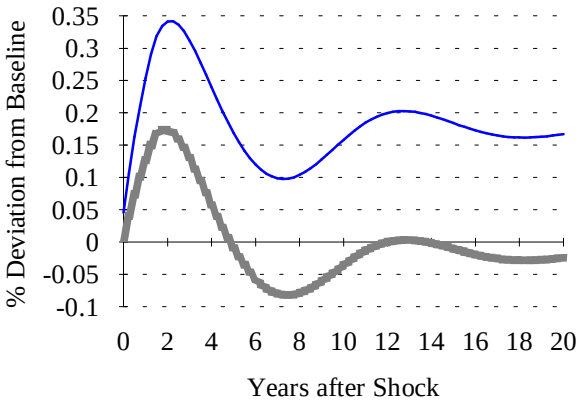


Chart 45: Relative change in PIRET



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