Monetary Authority of Singapore

The Monetary Model of Singapore (MMS): A Technical Overview

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1. INTRODUCTION

1.1. In May 1998, the Monetary Authority of Singapore (MAS) commissioned Independent Economics[1] to work with the Economic Policy Group (EPG) to construct a quarterly macroeconometric model of Singapore taking into account the distinct institutional structures, data availability, and data properties of a small open economy.

1.2. Since its development, the Monetary Model of Singapore (MMS) has been used by the MAS to develop official economic forecasts every quarter, generate alternative scenarios, and conduct macroeconomic and industry policy analysis.

1.3. Over the decade, the MMS has seen several upgrades to the original model. The upgrades are designed to reflect the changing structure of the Singapore economy and improve the model's usability as well as robustness.

1.4. Following the introduction, we describe the modelling philosophy in Section 2. Section 3 explains in more detail the equations in the MMS. A listing of the model equations appears as Appendix A. Section 4 explores the simulation properties of MMS through a series of eight simulations. Section 5 sums up. To enhance the reader's experience, this guide could be used in conjunction with accompanying materials including an Equation Finder and an interactive slide on the Overview of MMS which are available on the MAS' website[2].

1.5. Being a technical guide, the overriding goal is to present the detailed structure of the MMS and is primarily pitched at interested readers with some knowledge of the mainstream macroeconomic theories and macroeconometric techniques. However, this guide can also be of use to other readers. Those keen in a broad non-technical overview of the MMS could proceed to Section 2. Without loss of generality, the reader can skip to the simulations in Section 4 which displays the principal mechanisms at work

[1] Independent Economics is an independent provider of economic modelling services and is the trading name adopted by Econtech Pty Ltd. Econtech Pty Ltd was founded in 1994 by Chris Murphy, a leading economic modeller, and former Director of Access Economics.

[2] The materials are available at http://www.mas.gov.sg/Monetary-Policy-and-Economics/Education-and-Research.aspx

in the model. Supplementary reading can also be found in EPG's previous papers which are more expository and narrative in nature.[3]

2. PHILOSOPHY OF THE MMS

2.1. OVERVIEW

2.1.1. The three key elements in the modelling philosophy underlying the MMS are: (1) consistency with economic theory; (2) consistency with Singapore data; and (3) usability.

2.2. CONSISTENCY WITH ECONOMIC THEORY

2.2.1. In striving for consistency with economic theory, the MMS has the following properties that hold in the long run:

(i) There is steady, balanced growth, with real variables growing at the rate given by the rate of Harrod-neutral technical progress plus the rate of growth in the labour force.

(ii) Businesses maximise profits subject to a production technology.

(iii) The unemployment rate converges to the non-accelerating inflation rate of unemployment (NAIRU).

(iv) External balance is achieved in which net foreign liabilities are stable relative to GDP as a result of the private and public sectors meeting their intertemporal budget constraints.

(v) Fiscal balance is achieved in which the budget surplus is stable relative to GDP as a result of the automatic adjustment of the income tax rate. This gives a stable ratio of public financial assets to

[3] The MMS is most recently referred in the October 2011 issue of the *Review* (Special Feature A) and in the October 2007 issue of the *Review* (Special Feature A). It is also highlighted in greater detail in MAS Staff Paper No. 39 "Two Decades of Macromodelling at the MAS" published in July 2005 and in the December 2000 issue of the *Quarterly Bulletin.*

GDP and means the public sector meets its intertemporal budget constraint.

(vi) The annual inflation rate converges to a rate determined by monetary policy operating through the exchange rate.

2.2.2. The economic theory in the MMS is not confined to long-run properties but also includes the following important dynamics:

(i) Expectations in financial markets are assumed to be rational to allow for forward-looking behaviour in financial markets. At the same time, the MMS assumes that expectations in other markets are backward looking.

(ii) Businesses attain a Neoclassical, long-run position of profit maximisation subject to a production technology constraint through a hierarchical adjustment process, which includes a Keynesian short run and a Classical medium run.

2.2.3. The economic properties of the MMS are explained in more detail in Sections 2.3-2.5.

2.3. SUPPLY SIDE

2.3.1. The MMS is a fully-integrated macro-Computable General Equilibrium (CGE) model[4] which fully accounts for the interrelationships between the supply and demand sides of the economy. It recognises that the demand side is important in influencing economic activity in the short run, but at the same time they converge to the long run of a CGE model.

2.3.2. The supply side of the MMS is just as important as its demand side. Thus Production GDP, GDP(P), is modelled in some detail, alongside the Expenditure GDP, GDP(E). In fact, the modelling of GDP(P) complements and fully integrates with the modelling of GDP(E). GDP(P) is disaggregated into five sectors, linked together through the Input-Output table:

(i) manufacturing;
(ii) construction;
(iii) ownership of dwellings;

[4] See for example Murphy, C and Powell, A (1997), *Inside a Modern Macroeconometric Model: A Guide to the Murphy Model.*

(iv) financial and business services; and
(v) other goods and services.

2.3.3. It is important to model manufacturing production because of its pivotal role in producing merchandise exports which account for a very large part of GDP(E) in Singapore. A further benefit of this is that the model produces forecasts of manufacturing production, and these can be compared directly with the detailed forecasts of manufacturing production that MAS already produces separately from an industry, “bottoms-up” perspective, as a cross-check on the MMS' forecasts.

2.3.4. The output of the construction sector broadly equates with construction investment in GDP(E). Modelling construction production means that the model takes into account that construction is relatively labour intensive, allowing it to capture the swings in construction employment that follow from swings in construction investment.

2.3.5. Modelling production by the ownership of dwellings sector involves showing the link from the capital stock of dwellings to the supply of housing services. Interaction between the supply and demand of housing services in turn affects (actual and imputed) rents. Rents affect the actual rate of return on the capital stock of dwellings which, when compared with the required rate of return, affects the level of new investment in the stock of dwellings. Thus, modelling production of the ownership of dwellings sector is a necessary part of a coherent treatment of the housing market, which also involves modelling both dwelling investment and the demand for housing services.

2.3.6. Financial and Business Services is a large sector and continues to be rapidly growing, accounting for approximately 25 per cent of GDP. The remaining "other" category of production accounts for about 40 per cent of GDP.

2.3.7. The MMS has a production function for each of its sectors, resulting in five production functions. In each sector, the production function is used to derive fully-consistent equations for employment, investment, export supply, import demand and pricing.

2.3.8. Businesses in each industry attain a long-run position of profit maximisation subject to a production technology constraint through a hierarchical adjustment process. In a Keynesian short run, businesses in maximising profits are constrained by domestic demand and the capital stocks that they have in place. Through gradual adjustment of the price of domestic demand to its marginal cost of production, the domestic demand constraint is

lifted resulting in a Classical medium run. Finally, in a Tobin-q formulation for business investment, capital stocks adjust slowly to equate the actual and required rates of return on capital, lifting the constraint on capital and giving a Neoclassical long run of profit maximisation subject only to the production technology constraint.

2.3.9. The MMS has a long-run equilibrium in which the unemployment rate converges to a NAIRU and economic growth is steady and balanced.

2.4. INTERTEMPORAL BUDGET CONSTRAINTS

2.4.1. Both the government and the private sector are subject to their respective intertemporal budget constraints. This means in both cases that the present value of future expenditures cannot exceed the combined values of existing assets plus the present value of future receipts.

2.4.2. The Singapore government is a net creditor. Thus, in the MMS, the government's intertemporal budget constraint could be enforced by requiring that public assets eventually achieve some stable ratio to GDP in the long run. However, instead it is assumed that there is a long-term stable ratio of the budget surplus to GDP, as this better accords with fiscal policy practice in Singapore.[5] Failure to enforce the government's intertemporal budget constraint would prevent the MMS from achieving a sustainable long-run equilibrium.

2.4.3. The MMS relies on the following linkages to generate a sustainable long-run equilibrium: private wealth affects consumption; private wealth is calculated net of private foreign liabilities; and foreign liabilities accumulate in response to current account deficits.

2.5. FINANCIAL MARKETS

2.5.1. In the MMS, economic agents in financial markets have rational expectations, meaning that they base their expectations for the future on the predictions of the MMS itself.

[5] It can be shown that a long-run ratio of the budget surplus to GDP, S, implies eventual stability in the ratio of public assets to GDP, A, where A=S/n and n is the equilibrium growth rate of nominal GDP.

2.5.2. This rational expectations assumption is only an approximation to reality because financial markets are susceptible to bubbles and bouts of irrationality. Further, in reality economic agents are unlikely to base their expectations on any particular economic model. Nevertheless, the assumption of rational expectations is a simple but powerful way of introducing forward-looking behaviour. It enables a model to capture the widely-recognised fact that financial markets respond virtually instantaneously to all kinds of new, relevant information. They attempt to efficiently process this information in revising daily their forecasts of the future that drive asset prices.

2.5.3. While the MMS assumes rational expectations in financial markets, it generally assumes expectations in other markets are backward-looking. In these other markets the stakes are not as high, so the costs of regularly making and acting on fully efficient forecasts are less justified.

2.5.4. To allow for forward-looking behaviour in financial markets, the MMS incorporates the Uncovered Interest Parity (UIP) condition. This sets the local 3-month interest rate equal to the foreign 3-month interest rate less the expected annualised rate of appreciation in the Singapore dollar in the coming quarter.

2.5.5. This UIP equation introduces a positive relationship between the local 3-month interest rate and the strength of the spot exchange rate. However, two equations are needed to determine these two variables. Besides the UIP equation, a second relationship reflecting the conduct of monetary policy, which involves the local 3-month interest and the spot exchange rate, is needed.

2.5.6. Singapore is a very open economy so much so that inflation depends much more on the exchange rate than it does on the 3-month interest rate. For that reason, the MAS uses the exchange rate as the instrument of monetary policy. The outcome for the exchange rate is fed into the UIP equation to determine the local 3-month interest rate.

2.5.7. To close off the financial sector, the MMS includes a term structure equation for interest rates. This equation refers to the 10-year Singapore bond yield. The terms structure equation sets the 10-year bond yield equal to the expected return from the alternative of holding a continuous sequence of three-month securities over the same 10-year term. The expected future returns on three-month securities are based on rational or model-consistent

expectations. This implies that the bond rate adjusts instantaneously to new, relevant information. The real 10-year bond rate is needed in MMS because it provides an important link from interest rates to investment decisions.

2.6. DATA

2.6.1. The second important element in the modelling philosophy of the MMS, after consistency with economic theory, is consistency with Singapore data. Just as it is important to achieve a level of consistency with economic theory so that the MMS can be used meaningfully for policy simulation, it is also important to strive for consistency with Singapore data so that the MMS can be a useful forecasting tool.

2.6.2. The pursuit of data consistency needs to be tempered by recognising the limitations of the data. These limitations include the following.

(i) Data are subject to some degree of measurement error.

(ii) Sometimes data definitions do not match theoretical concepts.

(iii) Singapore data are more volatile than data for larger countries.[6]

(iv) Singapore has been undergoing continuous structural change e.g. the economy has become less regulated and the financial sector has become more important.

2.6.3. However, these limitations do not allow us to ignore the data. Rather, the data need to be used critically, taking these limitations into account.

2.6.4. In the MMS, the behavioural equations are econometrically estimated using Singapore data. In these regression equations, most of the parameters describing dynamic adjustment and some of the parameters describing equilibrium responses are freely estimated while the values of the other parameters are calibrated. It is important for reliable forecasting that, where possible, parameters are freely estimated using Singapore data. In cases where this does not produce reasonable estimates, perhaps because of

[6] Under simple assumptions, the coefficient of variation of a data series for a country is proportional to $1/\sqrt{m}$ where m is a measure of the size of the country.

the data limitations listed above, it is equally important for plausible policy simulations that reasonable values are imposed.[7]

2.6.5. The MMS uses the Error Correction Model approach to incorporate equation dynamics. This has the advantage that it clearly distinguishes the equilibrium and dynamic parts of an equation, making it easy to inspect the economic content as this is typically confined to the equilibrium part.

2.6.6. Further, the general-to-specific approach is used to arrive at a preferred form for the dynamics. By commencing with a general specification for dynamics, this approach allows the data to guide the selection of the specific dynamic structure that is most appropriate for each equation, thus minimising the risk of imposing invalid restrictions. However, because of the data limitations listed above and concerns about the effects of multiple-testing on true significance levels, this approach is not followed in an overly slavish or mechanical way. In particular, the dynamic structures that are adopted are parsimonious, and are not allowed to conflict heavily with prior beliefs.

2.6.7. In the MMS the estimation period extends from Q2 1984 to the most recent quarter of historical data. The start date of Q2 1984 is determined by the fact that certain employment and public finance data do not commence until Q1 1983 and five quarters are lost once allowance is made for lags. Because most Singapore data are not available in seasonally adjusted form, in the MMS original data are used throughout, and seasonal dummy variables are used to account for seasonal variation.

2.6.8. The MMS applies a battery of diagnostic tests to each equation. Some tests investigate whether the error terms are well behaved in the sense of being serially independent, homoskedastic, and normally distributed. Other tests check for structural change in the parameter estimates and misspecification of functional form. Tests include the Breusch-Godfrey LM (Lagrange Multiplier) test for autocorrelation (of up to order five), the RESET test for functional form, the Bera-Jarque test for normality, and the Chow Test for structural change. In addition, two tests for heteroskedasticity are carried out, namely the Breusch-Pagan and the Goldfeld-Quandt variance ratio tests.

[7] In some cases reasonable parameter values can be obtained from estimates for similar countries such as Australia.

2.7. A COMPREHENSIBLE MODEL

2.7.1. The third and final element in the modelling philosophy of the MMS is usability. There is no point in an economic model being admired for its consistency with economic theory and data, if it is not usable. The two main aspects of this are specifying a comprehensible model and choosing an efficient computing environment. These two issues are now considered in turn.

2.7.2. The MMS has 353 equations of which 47 are behavioural (see Section 3 for details). This reduced size makes it easier to understand. However, what is even more important in making the MMS comprehensible is that it is based on a clear economic paradigm.

2.7.3. As discussed earlier, this paradigm involves a Keynesian short run, a Classical medium run, a Neoclassical long run, rational expectations in financial markets, and complete, consistent linkages between the demand and supply sides of the model as in a fully-integrated macro-CGE model.

2.7.4. In considering the size of the MMS, it is important to take into account that it is based on five production sectors. The way each of these sectors is modelled is essentially the same (except ownership of dwellings uses its own type of capital, namely the dwelling stock). Thus, once the modelling of one of these sectors is understood, it is a small step to understand the modelling of the other four sectors.

2.8. ECONOMETRIC SOFTWARE

2.8.1. The process of updating the MMS each quarter can be divided into three stages; (1) data construction; (2) estimation; and (3) simulation setup.

2.8.2. Data construction is done in Excel while estimation and simulation stages are carried out in EViews.

2.9. SUMMARY

2.9.1. There are three key elements in the modelling philosophy underlying the MMS.

2.9.2. For *consistency with economic theory*, the MMS has long-run properties of steady state growth, profit maximisation, external balance, fiscal balance, and equilibrium rates of inflation and unemployment. The theory-related dynamic properties of the MMS include rational expectations in financial markets, and a hierarchical adjustment process featuring a Keynesian short run, a Classical medium run, and a Neoclassical long run.

2.9.3. The MMS has been developed to be *consistent with Singapore data*. Equation dynamics were developed by applying the general-to-specific approach in an error correction framework. The equations were subjected to a battery of diagnostic testing.

2.9.4. The MMS' theoretical structure is comprehensible. The computer implementation in Windows (using Eviews and Excel) means that the MMS is easily updated and highly *usable*.

3. MODEL STRUCTURE

3.1. OVERVIEW

3.1.1. Table 1 summarises the structure of MMS. 133 exogenous variables feed into a system of 353 equations to determine 353 endogenous variables. The equations are of three types, with 47 behavioural (B) equations, 28 supplementary (S) equations, and 278 (I) identity equations. Each equation is denoted (Bnn), (Snn) or (Inn) depending on its type, where nn denotes the equation number. This section covers all equations, but the main focus is on the behavioural (B) equations.

Table 1
Structure of MMS

Type	Section Reference	Number
Exogenous Variables		**133**
Identity Equations	Throughout	**278**
Supplementary Equations	3.21	**28**
Behavioural Equations		**47**
Households		
Consumer Demand: (Housing Services, Finance & Business, Other)	3.2	
Labour Force (Locals)	3.3	
Wages	3.4	
Private Consumption	3.5	
Businesses		
Business Sector in Equilibrium	3.6	
Imports: (Manufacturing, Finance & Business, Other)	3.7	
Employment: (Manuf., Construction, Finance & Business, Other)	3.8	
Exports: (Manufacturing, Finance & Business, Other)	3.9	
Price of Domestic Sales: (Manuf., Construction, Finance & Business, Other)	3.10	
Business Investment: (Manuf., Construction, Fin. & Bus., Other)	3.11	
Residential Investment	3.12	
Inventory Investment	3.13	
World Trade Markets		
Export Demand	3.14	
Import Supply	3.15	

Table 1 (Continued)
Structure of MMS

Type	Section Reference	Number
Policy Reaction Equations		
TWI Exchange Rate	3.16	
Income Tax Rate	3.17	
Financial Market Behavioural Identities		
Uncovered Interest Parity (UIP)	3.18	
S$ per US Dollar	3.18	
10-year Bond Rate	3.19	
10-year Expected Inflation Rate	3.19	
Other Equations		
Price of Government Consumption	3.20	
Price of Residential Investment	3.20	
Price of Business Investment	3.20	
Consumer Price Index	3.20	

3.1.2. Descriptions of the endogenous and exogenous variables are in Appendices A.1 and A.2. In general, the mnemonics of parameters and variables used in MMS are as follows:

- Parameters/coefficients are prefixed by “C”, followed by a 4-digit number while sector-specific parameters/coefficients are prefixed by “SC”, followed by a 4-digit number;

- Residuals are prefixed with “Z_” while sector-specific residuals are prefixed by “SZ_”;

- Seasonal dummies are DUM1, DUM2 and DUM3 and time dummy variables are prefixed by “DUMyyq”;

- Time trend factors are TF or TV;

- Industry-specific variables are prefixed by “S” and are also suffixed by an industry-specific alphabet (C, E, I, L, or R).

3.1.3. In MMS, the modelling of household behaviour describes consumer demand, the labour force participation rate, wages and total consumer spending. These four areas of consumer behaviour are considered in turn in Sections 3.2-3.5, beginning with the pattern of consumer demand.

3.2. CONSUMER DEMAND

3.2.1. It is necessary to model the pattern of consumer demand in MMS as part of modelling demand facing each of the five industry sectors that appear in the model. These five sectors, which are discussed further in Section 3.5, are:

(i) manufacturing (C);
(ii) construction (E);
(iii) financial & business services (L);
(iv) housing services (R); and
(v) other services (I).

3.2.2. Each of these sectors produces consumer products, with the exception of construction. Therefore, modelling the pattern of consumer demand in MMS involves allocating total consumer spending (CONZM) across the remaining four sectors (C, I, L, R).

3.2.3. Consumers are assumed to allocate their total spending between the four products (SCONC, SCONI, SCONL, and SCONR) by maximising a Cobb-Douglas utility function (U) subject to their budget constraint.

maximise:

$$U = SCONC^{1-(\alpha_I + \alpha_L + \alpha_R)} \cdot SCONI^{\alpha_I} \cdot SCONL^{\alpha_L} \cdot SCONR^{\alpha_R}$$

subject to:

$$CONZM = SPCC \cdot SCONC + SPCI \cdot SCONI + SPCL \cdot SCONL + SPCR \cdot SCONR$$

where $\alpha_I, \alpha_L, \alpha_R$ are non-negative and SPCC, SPCI, SPCL, SPCR denote prices of the respective products.

3.2.4. This gives the following set of simple consumer demand equations, which is based on fixed budget shares.

$$\frac{SPCI \cdot SCONI}{CONZM} = \alpha_I$$
$$\frac{SPCL \cdot SCONL}{CONZM} = \alpha_L$$

$$\frac{SPCR \cdot SCONR}{CONZM} = \alpha_R$$

$$SPCC \cdot SCONC = CONZM - \left(SPCI \cdot SCONI + SPCL \cdot SCONL + SPCR \cdot SCONR\right)$$

3.2.5. It is reasonable to assume that these consumer demand equations determine the quantities consumed of SCONC, SCONI and SCONL, but in the short run this does not extend to SCONR. Rather, in the short-run in the housing market, the quantity of housing services (SCONR) is supply-determined by the stock of dwellings. The role of consumer demand for housing services is to determine the price of housing services that clears the market. This can be recognised by re-arranging the housing demand equation to make the price of housing services the dependent variable.

$$SPCR = \alpha_R \cdot \frac{CONZM}{SCONR}$$

3.2.6. Also, it is convenient to replace total consumer spending, CONZM, in the demand system with non-housing consumer spending, CONOZ, using the following identity, $CONZM = SPCR \cdot SCONR + CONOZ$, to give a system of consumer demand equations that can be expressed as follows:

$$CONOZ = CONZM - SPCR \cdot SCONR$$

$$SPCR = \frac{\alpha_R}{1-\alpha_R} \cdot \frac{CONOZ}{SCONR}$$

$$SCONI = \frac{\alpha_I}{1-\alpha_R} \cdot \frac{CONOZ}{SPCI}$$

$$SCONL = \frac{\alpha_L}{1-\alpha_R} \cdot \frac{CONOZ}{SPCL}$$

$$SCONC = \frac{\left(CONOZ - SPCI \cdot SCONI - SPCL \cdot SCONL\right)}{SPCC}$$

3.2.7. This demand system underlies the following six equations appearing in MMS.

I01 Private Consumption – Other

$$CONOZ = CONZM - SPCR \cdot SCONR$$

I02 Unscaled Equilibrium Price of Rental Services

$$SPCRD = \frac{CONOZ}{SCONR}$$

B01 Housing Services Demand (Inverted)

$$\Delta\log(SPCR) = C0100 + C0103 \cdot \log\left(\frac{SPCRD_{-1}}{SPCR_{-1}}\right) + C0101 \cdot \Delta\log(SPCRD)$$
$$+C0102 \cdot \Delta\log(SPCRD_{-2}) + (1 - C0101 - C0102) \cdot \Delta\log(SPCR_{-1})$$
$$+C0104 \cdot DUM894 + C0105 \cdot DUM1 + C0106 \cdot DUM2 + C0107 \cdot DUM3$$
$$+DUM894 \cdot (C0108 \cdot DUM1 + C0109 \cdot DUM2 + C0110 \cdot DUM3) + Z_{SPCR}$$

B02 Private Consumption – Other

$$SCONI = C6000 \cdot \frac{CONOZ}{SPCI}$$

B03 Private Consumption - Financial & Business Services

$$SCONL = C6100 \cdot \frac{CONOZ}{SPCL}$$

I03 Private Consumption – Manufacturing

$$SCONC = \frac{(CONOZ - SPCI \cdot SCONI - SPCL \cdot SCONL)}{SPCC}$$

3.2.8. The concordance between the consumer demand system and the above model equations is generally apparent with one exception. The demand equation for housing services is implemented in the model as a pair of equations, (I02) and (B01), in which the actual price of housing services adjusts to the equilibrium price in an estimated error correction model. Allowance is made for a shift in the seasonal pattern seen in the data using the dummy variable DUM894.

3.2.9. The (seasonally-adjusted) value for the underlying share of consumption devoted to housing services, α_R, can then be calculated using the following equation, where it is represented in model notation as WTCON.

I04 Housing Services' Underlying Share of Consumption

$$WTCON = \frac{\exp\left(\frac{C0100 + \left(\frac{C0105 + C0106 + C0107}{4}\right)}{C0103}\right)}{1 + \exp\left(\frac{C0100 + \left(\frac{C0105 + C0106 + C0107}{4}\right)}{C0103}\right)}$$

3.2.10. The remaining consumer demand equations are more straightforward, being based more directly on the simple set of consumer demand equations given above.

3.2.11. WTCON also figures in the construction of the logarithm of the 'ideal' price index for consumption as a weighted average of the logarithms of the prices of the four consumer products.

I05 Price of Consumption (Model Basis, Logarithm)

$$LPCON = WTCON \cdot \log(SPCR) + (1 - WTCON) \cdot \begin{pmatrix} C6000 \cdot \log(SPCI) + C6100 \cdot \log(SPCL) \\ + (1 - C6000 - C6100) \cdot \log(SPCC) \end{pmatrix}$$

3.3. LABOUR FORCE (LOCALS)

3.3.1. In the MMS, the labour force participation rate for locals is calculated as the ratio of the labour force of locals (NTS) to the sum of resident population aged 15-64 years (POP3) and resident population aged 65 years and over (POP4).

3.3.2. The equilibrium participation rate is modelled to depend on:

(i) an encouraged worker effect — higher employment is likely to encourage entry to the labour force and this is modelled using the ratio of employment to the population aged 15 years and over for locals ('employment rate');

(ii) an underlying participation rate (PRT) that allows for demographic shifts and a time trend to take into account social trends.

(iii) changes in purchasing power, as indicated by after-tax nominal wages (POL1 is the rate of labour income tax; WL is the nominal wages for locals) deflated by the private consumption deflator (PCON).

B04 Participation Rate (Locals)

$$\log\left(\frac{\left(\frac{NTS}{POP3+POP4}\right)}{\frac{PRT}{100}}\right) = C0200 + C0201\cdot DUM1 + C0202\cdot DUM2$$

$$+C0203\cdot DUM3 + C0210\cdot DUM061 + C0204\cdot TF$$

$$+C0205\cdot\log\left(\frac{\left(\frac{NTS_{-1}}{POP3_{-1}+POP4_{-1}}\right)}{\frac{PRT_{-1}}{100}}\right) + C0206\cdot\log\left(\frac{\left(\frac{NTS_{-2}}{POP3_{-2}+POP4_{-2}}\right)}{\frac{PRT_{-2}}{100}}\right)$$

$$+C0207\cdot\left(\log\left(\frac{(1-POL1_{-2})\cdot WL_{-2}}{PCON_{-2}}\right) - 4\cdot\log(C8005)\cdot TV_{-2}\right)$$

$$+C0208\cdot\log\left(\frac{\left(\frac{NL}{POP3+POP4}\right)}{\frac{PRT}{100}}\right) + C0209\cdot\log\left(\frac{\left(\frac{NL_{-1}}{POP3_{-1}+POP4_{-1}}\right)}{\frac{PRT_{-1}}{100}}\right) + Z_{NTS}$$

3.3.3. Similar to other estimated equations in MMS, the participation rate equation has included adjustment dynamics (where NL denotes local employment), seasonal and structural dummies such as a dummy for the historical period to the first quarter of 2006 (DUM061). This is to take into account the introduction of government policies to encourage the labour force participation of older workers.

3.3.4. This model-based definition of the participation rate (PART) is constructed in a separate equation.

I06 Participation Rate - Model Basis

$$PART = 100 \cdot \frac{NTS}{POP3 + POP4}$$

3.3.5. A further equation appears for the smoothed growth rate of the labour force, POPGR. It is based on growth in the working-age population, modified for movements in the underlying labour force participation rate. In the long run, growth in the labour force is part of the sustainable growth rate of real output, GR. Thus POPGR appears later in an equation for GR.

I07 Labour Force Smoothed Growth Rate

$$POPGR = 0.125 \cdot \left(\Delta\log\left(POP3 + POP4\right) + \Delta\log\left(PRT\right)\right) + 0.875 \cdot POPGR_{-1}$$

3.4. WAGES

3.4.1. The wage equation for locals is an inflation expectations augmented Phillips curve.

B05 Local Wages

$$\Delta\log\left(WL\right) = AA0SLGR + C0300 + C0305 \cdot \left(\frac{INFE_{-1}}{400}\right) + \left(1 - C0305\right) \cdot \Delta\log\left(PCON_{-1}\right)$$
$$+ C0301 \cdot DUM1 + C0302 \cdot DUM2 + C0303 \cdot DUM3 + 0.6 \cdot \Delta\log\left(1 + RCPF\right)$$
$$+ C0304 \cdot URL_{-1} + Z_{WL}$$

3.4.2. The benchmark growth rate of nominal wages for locals (WL) equals trend growth in local labour efficiency (AA0SLGR) plus expected inflation, calculated as a weighted average of forward- and backward-looking inflation expectations. The trend in labour efficiency is taken from the model's

production sector that is discussed later. Forward-looking expected inflation (INFE) is defined as the average inflation rate expected for the next 10 years.

3.4.3. Growth in nominal wages departs from its benchmark rate depending on the unemployment rate for locals, URL. This is seen when the wage equation is re-expressed using the NAIRU (after removing effects from seasonality and changes in the rate of employer CPF (RCPF)).

$$\Delta\log(WL) = benchmark\ rate + C0304 \cdot (URL_{-1} - NAIRU)$$

where $NAIRU = \dfrac{-\left(C0300 + \dfrac{C0301 + C0302 + C0303}{4} + Z_{WL}\right)}{C0304}$

3.4.4. From the above, an estimate of the NAIRU can be constructed from the estimation results. This estimate refers to the model-based measure of the URL, which is defined below.

3.4.5. In MMS, it is assumed that unemployment is confined to locals, so it can be calculated as the difference between the local labour force and local employment. The labour force of locals (NTS) was modelled in Section 3.3, while total employment of locals (NL) is modelled in Section 3.7.

I08 Unemployment - Survey Basis

$$NUN = NTS - NL$$

I09 Unemployment Rate - Locals - Model Basis

$$URL = 100 \cdot \frac{NUN}{NTS}$$

3.4.6. The model-based measure differs from the headline measure in assuming that unemployment among foreign workers is zero. On that basis, it calculates an estimate of the unemployment rate for local workers as total unemployment, NUN, relative to the labour force of locals, NTS.

3.4.7. If wage growth stabilises at the benchmark rate, local unemployment stabilises at the NAIRU. The C0304 term is the feedback effect of unemployment on wage growth that is essential in ensuring that this long-run equilibrium is obtained. If unemployment is below the NAIRU, wages rise faster than the benchmark rate, which raises real unit labour costs, which

in turn increases unemployment. This process continues until unemployment is restored to the NAIRU.

3.4.8. The wage of foreign workers in foreign currency is exogenous to MMS. In other words, it is assumed that foreign workers are willing to work in Singapore at the reservation wage. The foreign worker wage (FWFNT) is multiplied by the exchange rate (E) to convert it to Singapore dollars. A foreign worker levy (POLFWL) is then applied to the foreign worker wage in domestic currency. The foreign worker wage with the levy applied (WF) represents the cost of hiring foreign workers to firms.

I84A Wages for Foreign Labour – Without Levy

$WFNT_i = FWFNT_i \cdot E$ *for industry i*

I84B Wages for Foreign – With Levy

$WF_i = WFNT_i \cdot (1 + POLFWL_i)$ *for industry i*

3.5. PRIVATE CONSUMPTION

3.5.1. The final area of household behaviour that is modelled in the MMS is aggregate private consumption.

3.5.2. MMS includes an Ando-Modigliani consumption function in which equilibrium consumption is determined by current labour income and (non-human wealth. This is a hybrid specification because in choosing between income flow and the value of the asset that income is generated from, it uses the income flow for human wealth, but the asset value for non-human wealth.

3.5.3. On conceptual grounds it might be appealing to use asset values throughout i.e. to capitalise labour income into human wealth in modelling consumption. However, human wealth fluctuates greatly with fluctuations in the real interest rate, which is at odds with the relatively modest fluctuations observed in consumption.

3.5.4. It might then be argued that, for consistency, if labour income is used in preference to human wealth, property income should be used instead of non-human wealth. However, property income is positively related to real interest rates, and when this is carried through to equilibrium consumption it

could de-stabilise the MMS. Thus, non-human wealth is used. It is measured at replacement cost (not market value) to reduce measurement error.

3.5.5. The estimated aggregate consumption equation is coded in the model as a pair of equations set out below.

I10 Equilibrium Private Consumption

$$\log(COND) =$$
$$\frac{(C0400 + C0401 \cdot DUM1 + C0402 \cdot DUM2 + C0403 \cdot DUM3 + C0404 \cdot TF)}{C0406}$$
$$+0.5 \cdot Labour\ Income + 0.5 \cdot Non\ Human\ Wealth$$
$$= \frac{(C0400 + C0401 \cdot DUM1 + C0402 \cdot DUM2 + C0403 \cdot DUM3 + C0404 \cdot TF)}{C0406}$$
$$+0.5 \cdot \log\begin{pmatrix} WB + TRFOPR + TRPUPR + (RGEC + RGEK) \cdot GDPZ + NETLEN \\ -TAXITP - REVOTH - TAXITS - INTSB \end{pmatrix}$$
$$+0.5 \cdot \log(PIH \cdot KH + PEX \cdot KI + PIFT \cdot (K - FK) - ZP \cdot E) - \log(PCON)$$

B06 Private Consumption

$$\log(CONZM) - LPCONM = C0405 \cdot (400 \cdot \Delta LPCON - INFE_{-1}) + C0406 \cdot \log(COND)$$
$$+(1 - C0406) \cdot (\log(CONZM_{-1} \cdot GR) - LPCONM_{-1}) + C0407 \cdot (\Delta URL)$$
$$+C0408 \cdot (\Delta URL_{-1}) + Z_{CON}$$

3.5.6. The first equation (I10) encapsulates the Ando-Modigliani theory. It defines equilibrium consumption (COND) as a weighted average of labour income, adjusted for taxes and transfers, and non-human wealth, which includes both financial and real assets. Both are converted to real terms by deflating by the price index for consumption, PCON. The equal weights attached to the logarithms of labour income and non-human wealth broadly reflect the shares of labour and property in national income.

3.5.7. The second equation (B06) models the dynamic adjustment of actual consumption to this equilibrium level. It includes a Deaton (1977) effect in which real consumption is reduced if inflation exceeds its long run rate determined by relative PPP. Hence, this effect is transitory.

3.6. BUSINESS SECTOR IN EQUILIBRIUM

3.6.1. The MMS distinguishes five industries, which are identified by the suffix "*s*" taking the five values shown below.

(i) C = manufacturing
(ii) E = construction
(iii) I = other industries
(iv) L = other financial and business services
(v) R = ownership of dwellings

3.6.2. The modelling of equilibrium in each industry in MMS has two key features:

(i) firms are assumed to maximise profit subject to a production technology; and
(ii) this production technology is explicitly for an open economy.

3.6.3. This open economy approach not only provides equilibrium relationships for employment, investment and pricing, it also provides equilibrium relationships for export supply and import demand.

3.6.4. In developing MMS for Singapore, it was necessary to take into account special aspects of the openess of the Singapore economy. The production technology in MMS is illustrated in Figure1.

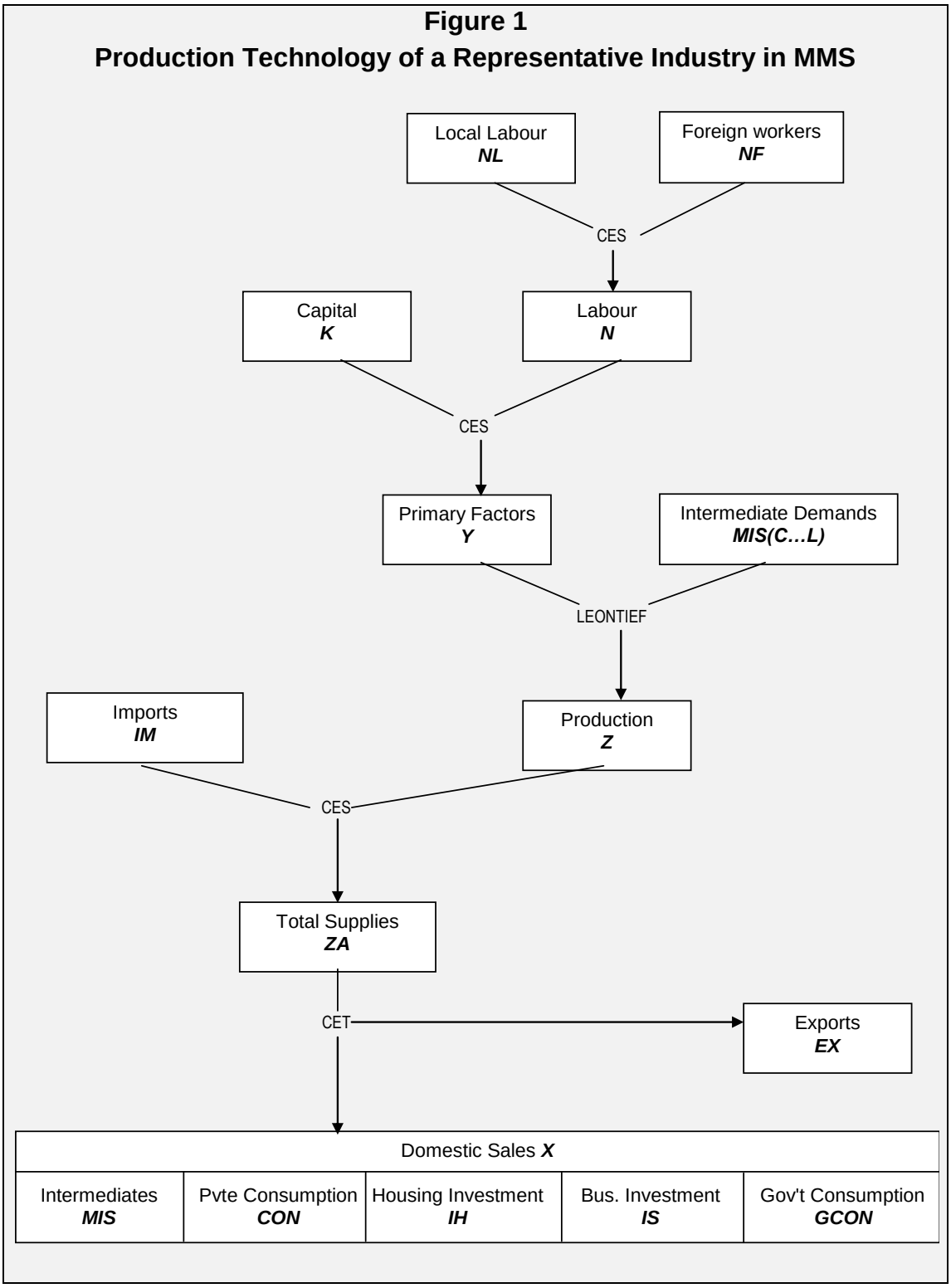
3.6.5. Inputs include capital (K), labour (N), intermediates (MIS) and imports (IM), while outputs include domestic sales (X) and exports (EX). Two types of labour are identified, local labour (NL) and foreign workers (NF).

3.6.6. In MMS, imports are treated as an input to producing exports. This is because in Singapore, especially in manufacturing, it is common for imports to be re-exported after the addition of local value added.

3.6.7. In Singapore, foreign workers are an important source of labour and have different characteristics from locals. Foreign and local workers have different productivities. There are also specific taxes that apply to the employment of foreign workers, such as the foreign worker levy. More importantly, while there are a limited number of local workers, there are alternative sources of foreign workers from around the region. Given their importance and significant differences relative to local workers, foreign workers are separately identified as an input into production in MMS. It is

assumed that foreign workers are willing to work in Singapore for a given reservation wage.

Figure 1
Production Technology of a Representative Industry in MMS



3.6.8. Having decided on the choice of production technology, the next step is to set up a short-run profit maximisation problem. Specifically, it is assumed that, in each industry, firms choose their inputs of local labour, foreign workers, intermediates and imports to maximise profit from domestic sales and exports, while taking their stocks of capital as given. This can be formalised taking the "other" sector (I) as an example. Note that industry-specific variable names are prefixed with an "S". Most variables described in this section follow the "prefix-variable-suffix" convention (e.g. SXI refers to domestic sales for sector I). The additional alphabet "P" refers to prices (e.g. SPXI refers to price of domestic sales for sector I). For intermediates, the term SMISiI refers to the intermediate inputs supplied by industry "i" to the "other" sector (I).

choose:

$$SXI, SEXI, SZAI, SNLI, SNFI, SIMI, SYI, SZI, SMISCI, ..., SMISLI$$

to maximise:

$$profit = SPXI \cdot SXI + PEX \cdot SEXI - \left(\begin{array}{l} WL \cdot SNLI + WFI \cdot SNFI + PIM \cdot SIMI + \\ \sum_i SPMIi \cdot SMISiI \end{array} \right)$$

subject to:

$$g\left(SEXI, SXI\right) = SZAI$$
$$SNI = k\left(SNLI, SNFI\right)$$
$$SYI = f\left(SNI, SKI\right)$$
$$SZI = i\left(SYI, SMISCI, ...SMISLI\right)$$
$$SZAI = h\left(SIMI, SZI\right)$$

3.6.9. The traditional closed economy production function relates output to inputs of capital and labour. The above open economy production function is extended to include exports and imports. In the above k(.), f(.) and h(.) are CES functions, while g(.) is a CET function, and i(.) is a Leontief function. Comparing the CES functions, the function h(.) may appear to take a different form than the function f(.), but this only reflects a re-parameterisation in terms of the elasticity of substitution, not any underlying difference in functional form.

$$k\left(SNLI, SNFI\right) = \left(\left(ALI \cdot NLI\right)^{SCI9920} + \left(AFI \cdot SNFI\right)^{SCI9920} \right)^{\frac{1}{SCI9920}}$$

$$f(SNI,SKI)=\left((SAA0I\cdot SNI)^{SCI9020}+(SAA1I\cdot SKI)^{SCI9020}\right)^{\frac{1}{SCI9020}}$$

$$h(SIMI,SZI)=\left((SCI9002\cdot SIMI)^{\frac{SCI9021-1}{SCI9021}}+(SCI9003\cdot SZI)^{\frac{SCI9021-1}{SCI9021}}\right)^{\frac{SCI9021}{1-SCI9021}}$$

$$g(SEXI,SXI)=\left((SCI9004\cdot SEXI)^{SCI9022}+(SCI9005\cdot SXI)^{SCI9022}\right)^{\frac{-1}{SCI9022}}$$

$$SZI=i(SYI,SMICI...SMILI)$$

becomes $SYI=\dfrac{SZI}{SCI9007}$

3.6.10. From Figure 1, it can be seen that domestic sales for the "other" sector (SXI) are directed to up to five categories of end users, as reflected in model equation (I11I).

I11I Domestic Sales of Composite Commodity I

$$SXI=SCONI+GCON+SIHI+SISI+SMISI$$

3.6.11. In maximising profit subject to the open economy production technology, firms are assumed to take their capital stock, K, and all prices (PX, PEX, WL, WF, PIM, PMIC…L) as given.

3.6.12. Using the Leontief technology for intermediate inputs shown in the above equations, demand for intermediates (MIS) takes the following form, which uses intermediate demand for products of the "other" sector (SMISI) as an example. The parameters, in this instance, (SMCIC, SMCIE, SMCII, SMCIL and SMCIR) measure the sectoral shares of intermediate demand for I across the five industries.

I12I Intermediate Demand for I

$$SMISI=SMCIC\cdot SCC9007\cdot SYC+SMCIE\cdot SCE9007\cdot SYE+SMCII\cdot SCI9007\cdot SYI$$
$$+SMCIL\cdot SCL9007\cdot SYL+SMCIR\cdot SCR9007\cdot SYR$$

3.6.13. This makes the realistic assumption that demand for intermediates depends on actual rather than equilibrium use of primary factors i.e. on SYs rather than SYSRs, which is explained below.

3.6.14. The remaining first-order conditions from the profit-maximising problem are a set of 14 non-linear equations in the choice variables of X, EX,

ZA, N, NL, NF, IM, Y, Z and five Lagrange multipliers. Two of these Lagrange multipliers are interpreted as the shadow price of ZA and are thus the same. This leaves nine equations involving the choice variables and four Lagrange multipliers that are interpreted as the shadow prices of ZA, Y, Z and N.

3.6.15. Thus, in the 13 equations, the solved variables are X, EX, ZA, N, NL, NF, IM, Y, Z, PZ, PY, PZA and WSR and the given variables are PX, PEX, WL, WF, PIM, PMIC…L and K.

3.6.16. In the short-run, the Keynesian assumption that domestic sales, X, are demand-determined is more plausible than the classical assumption made above that X is chosen by firms. This is taken into account by assuming that X is demand-determined in the short-run, but that firms gradually adjust PX until all the classical first-order conditions are satisfied. The representative firm's target for PX, which is interpreted as the marginal cost of producing X, is obtained as part of the solution of the first-order conditions by swapping X and PX between the lists of solved and given variables.

3.6.17. Thus the first order conditions are solved for PX, EX, ZA, N, NL, NF, IM, Y, Z, PZ, PY, PZA and WSR as functions of the given variables X, PEX, WL, WF, PIM, PMIC…L and K.

3.6.18. These optimising solutions are distinguished from the actual values of these variables by appending the suffix 'SR', which stand for the short-run equilibrium solution.

$$EXSR = j_1(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$NLSR = j_2(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$NFSR = j_3(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$IMSR = j_4(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$PXSR = j_5(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$ZASR = j_6(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$YSR = j_7(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$ZSR = j_8(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$PZASR = j_9(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$PYSR = j_{10}(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$
$$PZSR = j_{11}(PEX, WL, WF, PIM, PMIC...PMIL, X, K)$$

$$NSR = j_{12}\left(PEX, WL, WF, PIM, PMIC...PMIL, X, K\right)$$
$$WSR = j_{13}\left(PEX, WL, WF, PIM, PMIC...PMIL, X, K\right)$$

3.6.19. One complication is that analytical forms for the functions $j_1...j_{13}$ are not easy to derive because the first order conditions are non-linear.

3.6.20. Instead, for model simulation, the first order conditions are inserted directly into the model to be solved numerically.

I13I Shadow Price of Primary Factors for I

$$SPYSRI = \left(\frac{WSRI}{SAA0I}\right)\cdot\left(1+\left(\frac{SAA0I\cdot SNSRI}{SAA1I\cdot SKI}\right)^{-SCI9020}\right)^{\left(\frac{SCI9020-1}{SCI9020}\right)}$$

I14I Shadow Price of Production of I

$$SPZSRI = \left(1+POLOIT\cdot SCI9015\right)\cdot\left(\begin{array}{l}\frac{SPYSRI}{SCI9007}+SMCCI\cdot\left(1+POLCT\cdot SMBCI\right)\cdot SPXC+\\ SMCEI\cdot\left(1+POLCT\cdot SMBEI\right)\cdot SPXE+\\ SMCII\cdot\left(1+POLCT\cdot SMBII\right)\cdot SPXI+\\ SMCLI\cdot\left(1+POLCT\cdot SMBLI\right)\cdot SPXL\end{array}\right)$$

I15I Shadow Price of Total Supply of I

$$SPZASRI = \left(\left(\frac{PIM}{SCI9002}\right)^{(1-SCI9021)}+\left(\frac{SPZSRI}{SCI9003}\right)^{(1-SCI9021)}\right)^{\left(\frac{1}{1-SCI9021}\right)}$$

I16I Shadow Price of Domestic Sales of I

$$SPXSRI = SCI9005\cdot\left(SPZASRI^{\left(\frac{SCI9022}{SCI9022-1}\right)}-\left(\frac{PEX}{SCI9004}\right)^{\left(\frac{SCI9022}{SCI9022-1}\right)}\right)^{\left(\frac{SCI9022-1}{SCI9022}\right)}$$

I17I Short-run Equilibrium Exports of I

$$SEXSRI = \left(\frac{SCI9005}{SCI9004}\right)\cdot SXI\cdot\left(\left(\frac{\left(\frac{PEX}{SCI9004}\right)}{SPZASRI}\right)^{\left(\frac{SCI9022}{1-SCI9022}\right)}-1\right)^{\left(\frac{-1}{SCI9022}\right)}$$

I18I Short-run Equilibrium Total Supply of I

$$SZASRI = \left(\left(SCI9004 \cdot SEXSRI \right)^{SCI9022} + \left(SCI9005 \cdot SXI \right)^{SCI9022} \right)^{\left(\frac{1}{SCI9022} \right)}$$

I19I Short-run Equilibrium Imports of I

$$SIMSRI = \left(\frac{1}{SCI9002} \right) \cdot SZASRI \cdot \left(1 + \left(\frac{\left(\frac{SPZSRI}{SCI9003} \right)}{\left(\frac{PIM}{SCI9002} \right)} \right)^{(1-SCI9021)} \right)^{\left(\frac{SCI9021}{1-SCI9021} \right)}$$

I20I Short-run Equilibrium Production of I

$$SZSRI = \left(\frac{1}{SCI9003} \right) \cdot SZASRI \cdot \left(1 + \left(\frac{\left(\frac{PIM}{SCI9002} \right)}{\left(\frac{SPZSRI}{SCI9003} \right)} \right)^{(1-SCI9021)} \right)^{\left(\frac{SCI9021}{1-SCI9021} \right)}$$

I21I Short-run Equilibrium Primary Factors for I

$$SYSRI = \frac{SZSRI}{SCI9007}$$

I22I Short-run Equilibrium Employment for I

$$SNSRI = \left(\frac{1}{SAA0I} \right) \cdot \left(SYSRI^{SCI9020} - \left(SAA1I \cdot SKI \right)^{SCI9020} \right)^{\left(\frac{1}{SCI9020} \right)}$$

I22IA Short-run Equilibrium Local Employment for I

$$SNLSRI = \left(\frac{\left(\frac{WL}{ALI} \right)}{WSRI} \right)^{\left(\frac{1}{SCI9920-1} \right)} \cdot \frac{SNSRI}{ALI}$$

I22IB Short-run Equilibrium Foreign Employment for I

$$SNFSRI = \left(\frac{1}{AFI} \right) \cdot \left(SNSRI^{SCI9920} - \left(ALI \cdot SNLSRI \right)^{SCI9920} \right)^{\left(\frac{1}{SCI9920} \right)}$$

I22IC CES-weighted Wage for I

$$WSRI = \left(\left(\frac{WFI}{AFI} \right)^{\left(\frac{SCI9920}{SCI9920-1} \right)} + \left(\frac{WL}{ALI} \right)^{\left(\frac{SCI9920}{SCI9920-1} \right)} \right)^{\left(\frac{SCI9920-1}{SCI9920} \right)}$$

3.6.21. To obtain historical data for the 13 variables, these 13 first-order conditions are solved numerically. First, values are selected for the elasticities of substitution/transformation governing the various economic choices portrayed in Figure 1. They involve:

(i) local labour and foreign workers (NL and NF) in producing the labour bundle;
(ii) capital and labour (K and N) in producing primary factors (Y);
(iii) imports and production (IM and Z) in producing total supplies (ZA); and
(iv) the allocation of total supplies (ZA) between exports and domestic sales (EX and X).

3.6.22. The selection of the values for these elasticities is guided by the consequences for the statistical fit of equations, the model's simulation properties and academic research guidance from the empirical literature.

3.6.23. Next, the scale parameters AL, AF, SAA1s and SCs9002…5 are obtained by calibration using the assumed elasticities together with historical shares for imports and exports in total supplies, local labour and foreign workers in value added. The level and rate of growth of labour efficiency for each industry also need to be specified in constructing ALs and AFs, and this is done using regression-based methods. The ALs and AFs can be freely varied in the forecast period.

3.6.24. The sustainable growth rate in real output, LOG(GR), is calculated as the sum of smoothed growth in the labour force (POPGR) plus smoothed growth in labour efficiency (AA0SGR). The smoothing, which was applied to the labour force in calculating POPGR in equation (I07), and adopted in the growth of AA0SGR below, is used to ensure that the sustainable real growth rate does not change abruptly. GR plays a role in a number of areas, most importantly in determining the benchmark rates of investment.

I23B Smoothed Growth in Labour Efficiency

$$AA0SGR = \frac{\sum_i \left(WL_{-1} \cdot SNLi_{-1} \cdot \Delta \log \left(ALi \right) + WFi_{-1} \cdot SNFi_{-1} \cdot \Delta \log \left(AFi \right) \right)}{\sum_i \left(WL_{-1} \cdot SNLi_{-1} + WFi_{-1} \cdot SNFi_{-1} \right)}$$

I24 Equilibrium Real Growth Factor

$$\log(GR) = POPGR + 0.125 \cdot AA0SGR + 0.875 \cdot \left(\log(GR_{-1}) - POPGR_{-1}\right)$$

3.6.25. A separate smoothed labour efficiency growth in local labour is also calculated (AA0SLGR). This is used in determining the sustainable growth in local wages.

I23A Smoothed Growth in Local Labour Efficiency

$$AA0SLGR = \frac{\left(\begin{array}{l} SNLC_{-1} \cdot \Delta\log(ALC) + SNLE_{-1} \cdot \Delta\log(ALE) + \\ SNLI_{-1} \cdot \Delta\log(ALI) + SNLL_{-1} \cdot \Delta\log(ALL) \end{array}\right)}{NL_{-1}}$$

3.6.26. The short-run equilibrium elasticities are solved numerically in MMS. Some results follow from the estimations:

(i) the own-price effects all have the expected signs, with higher export prices leading to higher export supply, higher import prices leading to reduced import demand;

(ii) higher local wages leading to reduced demand for aggregate labour and local labour demand, but higher demand for foreign workers (for C, I and L);

(iii) higher foreign wages leading to reduced demand for foreign workers and but higher demand for local labour, with very little change to overall labour demand for E, this is because E is a non-tradable industry;

(iv) demand elasticities for foreign workers are more elastic than for locals because locals account for more of labour income and so there is less scope for substitution, whereas there is greater flexibility in the number of foreign workers because in aggregate, they have a smaller share of labour income (demand elasticities are smaller the higher is the share of income that go to that factor);

(v) higher local sales always leads to higher employment and (where applicable) higher imports; and

(vi) homogeneity conditions are satisfied. The export supply, local labour demand, foreign worker demand, aggregate labour demand and import demand equations are homogenous of degree zero in prices and homogenous of degree one in X and K, while the local sales price equation is homogenous of degree one in prices and homogeneous of degree zero in X and K.

3.6.27. The MMS does not assume that firms are always in short-run equilibrium. Rather, it allows for dynamic adjustment of IM, NF, NL, EX and PX towards equilibrium, as shown in the next four sections. However, the determination of these equilibrium values makes up the economic content of the modelling of production, and is more important than the adjustment to equilibrium described below.

3.6.28. MMS also contains a series of equations to model real GDP by industry, as defined in the national accounts. These equations are shown below, using the "other" sector as an example. The parameters (SMBIC, SMBIE, SMBII, SMBIL and SMBIR), shown in equation I26I, represent the different commodity tax rates across the five industries.

I25I Primary Factors for I

$$SYI = \frac{\left(SXI - SIMI + SEXI\right)}{SCI9007}$$

I26I Commodity Taxes in Constant Prices for I

$$SCTI = SCI9012 \cdot SCONI + SCI9013 \cdot SISI + \begin{bmatrix} SMBIC \cdot SMCIC \cdot SCC9007 \cdot SYC + SMBIE \cdot SMCIE \cdot SCE9007 \cdot SYE + \\ SMBII \cdot SMCII \cdot SCI9007 \cdot SYI + SMBIL \cdot SMCIL \cdot SCL9007 \cdot SYL + \\ SMBIR \cdot SMCIR \cdot SCR9007 \cdot SYR \end{bmatrix}$$

I27I GDP for I

$$GDPPI = SYI \cdot \left(1 + SCI9007 \cdot \frac{SCI9015}{1 + SCI9015}\right)$$

Total product taxes (GDPPD), is then:

A13 Product Taxes in Constant Prices

$$GDPPD = RGDPPD \cdot \begin{bmatrix} \left(1 + SCC9012\right) \cdot SCONC + \left(1 + SCI9012\right) \cdot SCONI + \\ \left(1 + SCL9012\right) \cdot SCONL \end{bmatrix} + SCTC + SCTE + SCTI + SCTL + SCTR + SCM9012 \cdot SIMC$$

3.6.29. The first equation, (I25I), calculates primary factor demand, SYI, (or value added) for I as production net of intermediate inputs. From Figure 1, production is simply calculated by taking domestic sales (SXI) and adding exports (SEXI) net of imports (SIMI). Under the Leontief technology depicted in Figure 1, primary factor demand can be calculated from production by dividing by the appropriate scaling factor. This is equivalent to subtracting intermediate inputs. Besides being used in modelling GDP by industry in equation (I27I), primary factor demand is also used to model demand for intermediate inputs in equation (I12I) above.

3.6.30. To obtain real GDP by industry as defined in the national accounts, it is only necessary to adjust primary factors or value added to include indirect taxes. Following the Input-Output table, indirect taxes are divided between commodity taxes and production taxes in the MMS.

3.6.31. Commodity taxes, SCTI, are calculated for the "other" sector (industry I) in equation (I26I) and include taxes on consumption, investment and intermediate usage of I, where the intermediate usage portion is enclosed in square brackets [.].

3.6.32. GDP for industry I is then calculated in equation (I27I). This involves adjusting value added (SYI) to include production taxes.

3.6.33. Commodity taxes are then added to other product taxes, namely the Goods and Services Tax and Manufacturing import duty to obtain total product taxes. Summing GDP by industry across the industries and adding product taxes gives GDP by production as defined in the national accounts.

3.6.34. The modelling of the business sector in MMS draws on the Input-Output table. Specifically, Table 2 shows the 2007 Singapore Input-Output Table for the five sectors identified in the MMS. This table was obtained by aggregating from the 136 industries in the published tables. The original version of MMS used the 1990 Input-Output Table, but MMS has been updated each time a new input-output table has been released.

3.6.35. Input-Output tables provide a more detailed and complete picture of the economy than is available from any other source. For example, the inter-industry flows of goods and services shown in the top-left corner of Table 2 can only be obtained from the Input-Output table. More up-to-date information is available for some items in the input-output table. For example, the components of GDP(E) and GDP(I), which have been re-produced in the

bottom panel of Table 2, are also available on a quarterly, up-to-date basis as part of the quarterly national accounts. This up-to-date information has been used to derive updated estimates of the other entries in the Input-Output table.

Table 2
Singapore 2007 Input-Output Table Aggregated to the Five Industry Sectors Used in the MMS

	Mfg	Cons	HS	F&B	Others	Int. Use	C	G	IB	IH	EX	FD Use	Tot. Sup.	IM
Manufacturing	154,720	9,904	3	5,927	27,261	197,815	21,826	-	24,397	-	200,523	246,747	444,563	181,449
Construction	387	15,729	514	619	1,613	18,862	71	-	11,335	7,548	-	18,953	37,816	0
Housing Services	-	-	-	-	-	-	7,965	-	-	-	-	7,965	7,965	0
Fin. & Bus.	21,802	1,694	1,351	36,208	36,480	97,535	13,950	-	3,692	2,458	34,464	54,564	152,099	36,306
Others	23,544	2,512	191	12,895	88,507	127,650	47,154	25,598	4,656	1,994	113,513	192,916	320,566	49,352
Total Int. Sales	200,453	29,840	2,058	55,650	153,861	441,862	90,966	25,598	44,081	12,000	348,501	521,147	963,009	267,106
Taxes on Products	125	3	-	168	360	656	8,600	-	4,954		-	13,554	14,210	-
Other Taxes on Production	236	17	290	1,171	1,239	2,954	-	-	-	-	-	-	2,954	-
Compensation of Employees	19,313	6,734	-	22,184	56,644	104,875	-	-	-	-	-	-	104,875	-
Gross Operating Surplus	41,677	1,221	5,616	36,620	59,110	144,245	-	-	-	-	-	-	144,245	-
Value Added at Basic Values	61,226	7,973	5,907	59,975	116,994	252,074	-	-	-	-	-	-	252,074	-
Singapore Production	261,805	37,816	7,965	115,793	271,215	694,593	-	-	-	-	-	-	1,229,293	-
Imports of Goods and Services	181,449	-	-	36,306	49,352	267,107	-	-	-	-	-	-	267,107	-
Import Duties	1,310	-	-	-	-	1,310	-	-	-	-	-	-	1,310	-
Total Usage	444,564	37,816	7,965	152,099	320,567	963,010	99,567	25,598	49,035	12,000	348,501	534,701	1,229,293	-

Table 2 (Continued)

Singapore 2007 Input-Output Table Aggregated to the Five Industry Sectors Used in the MMS

	Mfg	Cons	HS	F&B	Others	Int. Use	C	G	IB	IH	EX	FD Use	Tot. Sup.	IM
GDP(I)	61,226	7,973	5,907	59,975	116,994	-	-	-	-	-	-	-	15,520	267,594
GDPI(I) (% of Total)	23%	3%	2%	22%	44%	-	-	-	-	-	-	-	6%	-
SYC	60,990	7,955	5,616	58,804	115,755	-	-	-	-	-	-	-	-	-
GDP(E)	-	-	-	-	-	-	**99,567**	**25,598**	**49,035**	**12,000**	**348,501**	**-267,107**	**267,594**	-
National Accounts (Adjusted)	65,246	7,974	5,908	60,966	117,976	259,379	37%	10%	18%	4%	130%	-100%	100%	-
SCTC	4,020	1	1	991	982	5,995	-	-	-	-	-	-	-	-
National Accounts + SCTC	**65,122**	**7,874**	**9,945**	**60,068**	**115,527**	**268,062**	**99,291**	**25,551**	**49,288**	**12,000**	**581,082**	-	-	**499,149**

3.7. IMPORTS

3.7.1. In each sector, actual imports (SIM) adjust to equilibrium imports (SIMSR) in a partial adjustment model. (See Section 3.6 for explanation of how IMSR is determined.)

3.7.2. Taking the manufacturing sector (C) as an example, this gives the following equation.

B07C Manufacturing Imports

$$\log(SIMC) = SCC5800 + SCC5801 \cdot DUM1 + SCC5802 \cdot DUM2$$
$$+ SCC5803 \cdot DUM3 + SCC5804 \cdot TF + SCC5805 \cdot \log(GR \cdot SIMSRC_{-1})$$
$$+ (1 - SCC5805) \cdot \log(GR \cdot SIMC_{-1})$$
$$+ SCC5806 \cdot \left[\log\left(\frac{SEXC}{GR \cdot SEXSRC_{-1}} \right) - (1 - SCC5805) \cdot \log\left(\frac{SEXC_{-1}}{GR_{-1} \cdot SEXSRC_{-2}} \right) \right]$$
$$+ SZ_{IMC}$$

3.7.3. For manufacturing, the imports equation also takes into account the close connection in Singapore between manufacturing exports (SEXC) and manufacturing imports (SIMC). In particular, when manufacturing exports exceed their equilibrium level, manufacturing imports are likely to follow suit.

3.8. EMPLOYMENT

3.8.1. In each sector, actual employment for locals (SNL) and foreign workers (SNF) adjusts to equilibrium employment (SNSRL and SNSRF) in a generalised adjustment model, extended to include the ratio of marginal cost to price. (See Section 3.6 for explanation of the more important issue of how SNSRL and SNSRF are determined.)

3.8.2. The dynamics in the employment equations for each industry is shown in the following equation:

$$N_t - N_{t-1} = (0.1) \cdot \left(N_t^* - N_{t-1} \right) + \rho \cdot \left\{ N_{t-1} - N_{t-2} - (0.1) \cdot \left(N_{t-1}^* - N_{t-2} \right) \right\} + other\ terms$$

3.8.3. The second term is equivalent to an adjustment for a first-order autoregressive error term, with one exception. The AR(1) transformation has

been applied to actual and equilibrium employment, but not the other terms in the equation. The symbol of ρ is used for the new parameter, because of its similarity to an AR(1) parameter.

3.8.4. Again taking the manufacturing sector (C) as an example, this gives the following equation:

B08CA Local Manufacturing Employment

$$\log(SNLC) = SCC5600 + SCC5601 \cdot DUM1 + SCC5602 \cdot DUM2 + SCC5603 \cdot DUM3$$
$$+ SCC5604 \cdot TF + SCC5605 \cdot \log(SNLSRC) + (1 - SCC5605) \cdot \log(\exp(POPGR) \cdot SNLC_{-1})$$
$$+ SCC5607 \cdot \begin{bmatrix} \log(SNLC_{-1}) - SCC5605 \cdot \log(SNLSRC_{-1}) \\ -(1 - SCC5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNLC_{-2}) \end{bmatrix}$$
$$+ SCC5606 \cdot \log\left(\frac{SPXSRC}{SPXC}\right) + SZ_{NLC}$$

3.8.5. The employment of foreign workers in each industry is endogenous. Thus, there is a corresponding adjustment equation for the actual level of foreign worker employment to equilibrium. The POPGR variable is included in the regression equation so that the long-term relationship between actual and equilibrium foreign worker employment (SNF, SNFSR) is dependent on the population growth.

B08CB Foreign Manufacturing Employment

$$\log(SNFC) = SCCF5600 + SCCF5601 \cdot DUM1 + SCCF5602 \cdot DUM2$$
$$+ SCCF5603 \cdot DUM3 + SCCF5604 \cdot TF + SCCF5605 \cdot \log(SNFSRC)$$
$$+ (1 - SCCF5605) \cdot \log(\exp(POPGR) \cdot SNFC_{-1})$$
$$+ SCCF5607 \cdot \begin{bmatrix} \log(SNFC_{-1}) - SCCF5605 \cdot \log(SNFSRC_{-1}) \\ -(1 - SCCF5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNFC_{-2}) \end{bmatrix}$$
$$+ SCCF5606 \cdot \log\left(\frac{SPXSRC}{SPXC}\right) + SZ_{NFC}$$

3.8.6. Total employment in each industry is the sum of locals and foreign workers employed in that industry.

I29C Total Employment for C

$$SNC = SNLC + SNFC$$

3.8.7. Total employment of locals and foreign workers (N) is obtained by adding the employment in each industry.

I30 Total Employment – Locals

$$NL = SNLC + SNLE + SNLI + SNLL$$

I31 Total Employment - Foreign

$$NF = SNFC + SNFE + SNFI + SNFL$$

I32 Total Employment

$$N = SNC + SNE + SNI + SNL$$

3.9. EXPORT SUPPLY

3.9.1. In each sector, actual export supply (SEX) adjusts to equilibrium export supply (SEXSR) in a simple partial adjustment model. (See Section 3.6 for explanation of the more important issue of how EXSR is determined.)

3.9.2. Again taking the manufacturing sector (C) as an example, this gives the following equation:

B09C Manufacturing Exports Supply

$$\begin{aligned}
&\log(SEXC) = SCC5700 + SCC5701 \cdot DUM1 + SCC5702 \cdot DUM2 + SCC5703 \cdot DUM3 \\
&+ SCC5704 \cdot TF + SCC5705 \cdot \log(GR \cdot SEXSRC_{-1}) + (1 - SCC5705) \cdot \log(GR \cdot SEXC_{-1}) \\
&+ SCC5706 \cdot \left(\log\left(\frac{GDPF}{GDPF_{-1}} \right) - \log(GR) \right) + SCC5707 \cdot \left(\log\left(\frac{GDPF_{-1}}{GDPF_{-2}} \right) - \log(GR_{-1}) \right) \\
&+ SCC5708 \cdot \left(\log\left(\frac{GDPF_{-2}}{GDPF_{-3}} \right) - \log(GR_{-2}) \right) + SCC5709 \cdot \left(\log\left(\frac{GDPF_{-3}}{GDPF_{-4}} \right) - \log(GR_{-3}) \right) \\
&+ SCC5710 \cdot \log(RBB) + SCC5711 \cdot \log(RBB_{-1}) + SZ_{EXC}
\end{aligned}$$

3.9.3. This equation also includes six additional terms designed to pick up the short-term effect of the world economic cycle on the volume of manufacturing exports. The first of these is the rate of growth of foreign real GDP (GDPF), while the second is the US book-to-bill ratio for electronics (RBB).

3.10. PRICE OF DOMESTIC SALES

3.10.1. The price of the domestic sales (SPX) adjusts to equilibrium or marginal cost (SPXSR) in a relatively complicated error correction model of dynamics, as seen in the following example for the "other" sector (I). (See Section 3.6 for explanation of the more important issue of how SPXSR is determined.)

B10I Other Sales Price of Industry I

$$\Delta\log(SPXI) = SCI5900 + SCI5901\cdot DUM1 + SCI5902\cdot DUM2 + SCI5903\cdot DUM3$$
$$+SCI5904\cdot\Delta\log(SPXSRI_{-2}) + SCI5905\cdot\Delta\log(SPXSRI_{-3})$$
$$+(1-SCI5904-SCI5905)\cdot\Delta\log(SPXSRI_{-1}) + SCI5906\cdot\log\left(\frac{SPXSRI_{-4}}{SPXI_{-4}}\right) + SZ_{PXI}$$

3.10.2. The key coefficient is SCI5906, which is attached to the error correction term.

3.10.3. SPX is the key price in the model. After adjustments for indirect taxes where needed, it determines the prices for the supply by each sector of the components of domestic sales: materials, private consumption, housing investment, business investment and government consumption. These tax-adjusting price equations are shown below, taking the "other" sector (I) as an example.

I34I Price of Private Consumption of I

$$SPCI = (1+POLGST)\cdot SPXI\cdot(1+SCI9012\cdot POLCT)$$

I35I Price of Business Investment in I

$$SPISI = SPXI\cdot(1+SCI9013\cdot POLCT)$$

3.10.4. There are no separate price equations for prices of materials and housing investment supplied by each sector, because wherever these prices are used in the model, they are expressed directly in terms of SPxs. There are no separate price equations for prices of government consumption supplied by each sector because taxes do not apply.

3.11. BUSINESS INVESTMENT

3.11.1. A Tobin-q framework is used to model business investment in the four industries sector as well as housing investment. Thus the rate of investment is above or below a benchmark rate, according to whether the actual rate of return on business investment is above or below a required rate of return.

3.11.2. This incorporates the main factors commonly believed to influence business investment. In this approach, higher real wages reduce business investment by reducing the actual rate of return, while higher real interest rates reduce business investment by increasing the required rate of return.

3.11.3. Tobin-q also completes the neoclassical profit maximisation used in Section 3.6. In that short-run optimisation, firms in each sector chose variable outputs and inputs to maximise profit, taking the capital stock (K) as given. This incorporates all of the conditions required for profit maximisation except that, with a fixed capital stock, the marginal product of capital condition was not introduced. Tobin-q postulates that the capital stock gradually adjusts to eliminate differences between the actual and required rates of return. This is equivalent to the zero pure profit condition, which is based on the marginal product of capital condition and the first order conditions already embedded in the model in Section 3.6. Thus, one effect of using a Tobin-q theory of investment is to incorporate the remaining first order condition for profit maximisation, the marginal product of capital condition, into the MMS.

3.11.4. To use a Tobin-q style model of business investment, measures are needed for the benchmark rate of business investment and of the actual and required rates of return on business investment.

3.11.5. In the long run, the stock of business capital in each sector will increase in line with the natural rate of growth of the economy, GR-1. Thus the benchmark rate of investment (SIBFTI) in the “other” sector (I) needs to cover both natural growth in the stock of business capital (SKI) and depreciation of 2.5 per cent per quarter.

$$SIBFTI = \left(GR - 1 + 0.025\right) \cdot SKI$$

3.11.6. The actual rate of return on capital is calculated in two steps. The first step calculates the market price of capital services as the price of primary

factors net of payments to labour. The second step expresses the price of capital services relative to the replacement price of capital (PIFTM).

I36I Price of Capital Services for I

$$SPKI = SAA1I \cdot \left[SPYSRI^{\left(\frac{SCI9020}{SCI9020-1}\right)} - \left(\frac{WSRI}{SAA0I}\right)^{\left(\frac{SCI9020}{SCI9020-1}\right)} \right]^{\left(\frac{SCI9020-1}{SCI9020}\right)}$$

I37I Actual Rate of Return on Capital for I

$$SARI = 400 \cdot \frac{SPKI}{PIFTM}$$

3.11.7. The required rate of return on business investment includes depreciation, the real interest rate, RI, and a risk premium, γ, where each is expressed as a proportionate rate per quarter.

$$0.025 + RI + \gamma$$

3.11.8. In the above, RI is defined as the real 10-year bond rate, which is modelled in Section 3.19.

3.11.9. In the final equation, business investment adjusts partially to the benchmark rate, and is influenced by the q-effect (the difference between the actual and required rates of return) lagged two quarters.

B11I Investment Demand by Industry I

$$\frac{SIFI}{SKI} = SCI6000 + SCI6001 \cdot DUM1 + SCI6002 \cdot DUM2 + SCI6003 \cdot DUM3 +$$
$$SCI6004 \cdot TF + SCI6005 \cdot \left(\frac{SARI_{-2}}{400} - \left(0.025 + RI_{-2}\right) \right) + \left(1 - SCI6006\right) \cdot \left(GR + 0.025 - 1\right)$$
$$+ SCI6006 \cdot \frac{SIFI_{-1}}{SKI_{-1}} + SZ_{IFI}$$

3.11.10. Business investment, net of depreciation, adds to the business capital stock each quarter.

I39I Business Fixed Capital of I

$$SKI = \left(1 - 0.025\right) \cdot SKI_{-1} + SIFI_{-1}$$

3.11.11. Equation (B11I) determines business investment by the "other" sector. Adding together business investment demand by all sectors gives total business investment (IFB), known in MMS as private non-residential investment.

I40 Private Non-Residential Investment

$$IFB = SIFC + SIFE + SIFI + SIFL$$

3.11.12. Adding in public non-residential investment, GIF, gives total non-residential investment, IFT.

I41 Non-Residential Investment

$$IFT = IFB + GIF$$

3.11.13. While the above equations model non-residential investment by the industry of demand, it is also necessary to model non-residential investment by the industry of supply. This is because the supply of investment goods is one of the destinations for domestic sales for each sector, as shown in Figure 1 and equation (I11I).

3.11.14. The supply of investment by industry is modelled in two levels. In the first level, an exogenous proportion of investment (RSISE) is assumed to be supplied by the construction sector (industry E). This is seen in equation (I42E) for the supply of construction investment, which also includes an adjustment for commodity taxes.

I42E Investment Supply by Industry E

$$SISE = RSISE \cdot \frac{IFT}{(1 + SCE9013)}$$

3.11.15. The remaining proportion of investment, 1-RSISE, is supplied by other industries in fixed proportions. Taking manufacturing (industry C) as an example, equation (I42C) represents the proportion of non-construction investment supplied by industry C as SCC9030.

I42C Investment Supply by Industry C

$$SISC = SCC9030 \cdot (1 - RSISE) \cdot \frac{IFT}{(1 + SCC9013)}$$

3.12. RESIDENTIAL INVESTMENT

3.12.1. A Tobin-q model is also applied to housing investment.

3.12.2. The rate of investment is above or below a benchmark rate, according to whether the actual rate of return on housing investment is above or below a required rate of return. This requires measures of the benchmark rate of housing investment and of the actual and required rates of return on housing investment.

3.12.3. In the long run, the stock of housing will increase in line with the natural rate of growth of the economy, GR-1. Thus the benchmark rate of housing investment (IH) needs to cover both the natural growth in the stock of housing (KH) and an assumed rate of depreciation of 1% per quarter.

$$IH = (GR - 1 + 0.01) \cdot KH$$

3.12.4. The stock of housing will grow faster or slower than this benchmark rate according to whether the actual rate of return on housing is higher or lower than the required rate of return.

3.12.5. The actual rate of return on housing is calculated in two steps. The first step calculates the market price of housing services as proportional to the price of primary factors in the housing market. The second step expresses the price of housing services relative to the replacement price of housing.

I36R Price of Capital Services for R

$$SPKR = SAA1R \cdot SPYSRR$$

I37R Actual Rate of Return on Capital for R

$$SARR = 400 \cdot \frac{SPKR}{PIHM}$$

$$0.01 + RI + \beta$$

3.12.6. The required rate of return on housing above includes depreciation, the real interest rate, RI, and a risk premium, β, where each of these is expressed as a proportionate rate per quarter.

3.12.7. In the equation below, the rate of housing investment adjusts partially to the benchmark rate, and is influenced by the q-effect (the difference between the actual and required rates of return) lagged four quarters.

B11R Residential Investment

$$\frac{IH}{KH} = SCR6000 + SCR6001 \cdot DUM1 + SCR6002 \cdot DUM2 + SCR6003 \cdot DUM3 + SCR6004 \cdot \left(\frac{SARR_{-4}}{400} - \left(0.01 + RI_{-4}\right) \right) + \left(1 - SCR6005\right) \cdot \left(GR + 0.01 - 1\right) + SCR6005 \cdot \frac{IH_{-1}}{KH_{-1}} + SZ_{IH}$$

3.12.8. Housing investment, net of depreciation, adds to the housing stock that is carried over to the next quarter.

I39R Housing Stock

$$KH = \left(1 - 0.01\right) \cdot KH_{-1} + IH_{-1}$$

3.12.9. While the above models housing or residential investment by the industry of demand, namely the housing services (industry R), it is also necessary to model residential investment by the industry of supply, chiefly the construction industry (industry E). This is because the supply of housing investment is one of the destinations for domestic sales, as shown in Figure 1 and equation (I11I).

3.12.10. Most housing investment is supplied by the construction industry. There are analogous equations for industries I and L, which make small contributions to the supply of housing investment.

I43E Housing Investment Supply by Industry E

$$SIHE = SCE9031 \cdot IH$$

3.13. INVENTORY INVESTMENT

3.13.1. Inventories are assumed to meet demand for manufactured goods.

3.13.2. Official statistics implies that inventory investment (II) has been fairly small on average over the last 14 years. However, sales have roughly doubled over the same period implying falling stock levels.

3.13.3. To allow for a reasonable stock-to-sales ratio, the measurement issue is taken into account by using bridging equations. This is done by distinguishing true inventory investment, IIT, from measured inventory investment, II. Suppose that IIT in II is proportional to the true stock of inventories, KI.

$$IIT = II + \beta \cdot KI$$

3.13.4. The existing inventory investment equation is based on economic principles and so should refer to the true level of inventory investment. So it should be re-interpreted to refer to true inventory investment, IIT, rather than measured inventory investment, II.

$$IIT = (GR - 1) \cdot KI + a \cdot KI + \upsilon \cdot SEXC$$

(where a < 0)

3.13.5. The same re-interpretation is appropriate for the existing equation for the accumulation of the stock of inventories.

$$KI = KI_{-1} + IIT_{-1}$$

3.13.6. We then use the first equation, linking true and measured inventory investment, to substitute out for the unobservable true inventory investment with the observable measured inventory investment. This gives the following final pair of equations:

$$KI = (1 + \beta) \cdot KI_{-1} + II_{-1}$$
$$II = (GR - 1 - \beta) \cdot KI + a \cdot KI + \upsilon \cdot SEXC$$

or using MMS notation and expanding more fully:

I44 Stock of Inventories - Beginning of Period

$$KI = (1 + C0806) \cdot KI_{-1} + II_{-1}$$

B12 Inventory Investment

$$II = (C0800 + C0801 \cdot DUM1 + C0802 \cdot DUM2 + C0803 \cdot DUM3 + C0804 \cdot TF) \cdot SEXC + (GR - 1 - C0806) \cdot KI + C0805 \cdot KI + Z_{II} \cdot SEXC$$

3.13.7. Inventories increase if desired stock levels, which are assumed to be proportional to manufacturing exports (SEXC), exceed actual stock levels (KI). Inventory investment adds to the stock of inventories that is carried over to the next quarter.

3.14. EXPORT DEMAND

3.14.1. Singapore is assumed to be a price taker in world trade markets. This leads to equations for export demand and import supply.

3.14.2. The equation for the demand for exports sets the price of exports in S$, PEX, equal to an exogenous foreign price, PEXF, converted to S$ using the exchange rate, E.

B13 Demand for Exports (Price)

$$PEX = PEXF \cdot E$$

3.15. IMPORT SUPPLY

3.15.1. Similarly, the equation for the supply of imports sets the price of imports in S$, PIM, equal to an exogenous foreign price, PIMF, converted to S$ using the exchange rate, E.

B14 Supply of Imports (Price)

$$PIM = PIMF \cdot E$$

3.15.2. Users of imports also need to pay customs duty at the rate POLCD.

I46 Price of Imports Including Import Duty

$$PIMAT = PIM \cdot (1 + POLCD)$$

3.16. MONETARY POLICY

3.16.1. The MMS includes policy specifications for monetary and fiscal policy.

3.16.2. These specifications are flexible enough to deal with the requirements of both forecasting and simulation experiments. In forecasting situations, macro policy settings can be fed directly into the model, while in simulation experiments the policy specifications can be used to allow for plausible macro policy responses to economic shocks.

3.16.3. In deciding on a monetary policy specification, the first step is to identify the instrument of monetary policy which is the exchange rate used by the MAS.

3.16.4. In considering exchange rate policy in Singapore, it is useful to begin by considering a linear approximation to the uncovered interest parity (UIP) condition. The UIP condition itself appears in MMS as explained in Section 3.18.

$$RS = RSF - 400 \cdot \left[XLE - LE \right]$$

3.16.5. This approximation to UIP states that the 3-month interest rate in Singapore, RS, will equal the foreign 3-month interest rate, RSF, less the expected annualised rate of appreciation in the S$, where LE is the logarithm of the foreign currency/S$ exchange rate, and XLE is the rational expectation for LE one-quarter-ahead. That is, ex-ante rates of return are equated between a Singapore 3-month security and a foreign 3-month security.

3.16.6. This approximation to UIP provides a useful point of departure in developing a flexible monetary policy specification. This involves two different formulations of monetary policy, a forecasting formulation and a simulation formulation.

3.16.7. The forecasting formulation sets the local interest rate to achieve a target path LET for LE.

$$RS = RSF - 400 \cdot \left[LET_1 - LET \right] + d \cdot 100 \cdot \left[LET - LE \right]$$

3.16.8. This formulation raises the local interest rate relative to the foreign interest rate if the exchange rate, LE, is below its target path, LET. The equation also adjusts for the annualised rate of appreciation in the target exchange rate, to allow for ongoing adjustments in the exchange rate and to ensure that this form is consistent with the UIP condition in the steady state.

3.16.9. The simulation formulation of monetary policy sets the local interest rate to respond to inflation.

$$RS = RSF - 400 \cdot \left[LET_1 - LET \right] + g \cdot 100 \cdot \left[LP + LET - LPF \right]$$

3.16.10. This formulation raises the local interest rate in response to a rise in the logarithm of the local price level, LP, that is not matched in the corresponding foreign price level, LPF, converted using the target exchange rate. Like the forecasting form, the policy simulation form adjusts for the annualised rate of appreciation in the target exchange rate so that it does not conflict with the UIP condition in the steady state.

3.16.11. In deriving the flexible monetary policy specification, the forecasting and policy simulation formulations of monetary policy are combined.

$$RS = RSF - 400 \cdot \left[LET_1 - LET \right] + d \cdot 100 \cdot \left[LET - LE \right] + g \cdot 100 \cdot \left[LP + LET - LPF \right]$$

This can be compared with the approximation to the UIP condition given earlier.

$$RS = RSF - 400 \cdot \left[XLE - LE \right]$$

3.16.12. Using the UIP condition to eliminate the local interest rate from the monetary policy specification and simplifying, gives an exchange rate specification:

$$LE = LET + \frac{4}{4+d} \cdot \left[XLE - LET_1 \right] + \frac{g}{4+d} \cdot \left[LP + LET - LPF \right]$$

3.16.13. Re-expressing this specification using MMS notation, gives equation (B15) of the model. PCPI is the Consumer Price Index.

B15 TWI Exchange Rate Specification

$$\log(ETWI) = \log(ETWIT) + \left(\frac{4}{4+C1601}\right)\cdot\left(\log(XETWI) - \log(ETWIT_1)\right) +$$

$$\left(\frac{C1602}{4+C1601}\right)\cdot\left(\log\left(\frac{PCPI\cdot ETWIT}{PEXF}\right) - C1600\right) + Z_{ETWI}$$

where $\log(XETWI) = \log(C48SC) - \frac{XER}{100}$

3.16.14. This exchange rate specification is flexible because the user of MMS has the ability to vary the values of the parameters **d** and **g** (or C1601 and C1602 in MMS notation). In forecasting situations, g = 0 and the exchange rate becomes exogenous. In effect, the actual exchange rate, ETWI, matches the target exchange rate, ETWIT.

3.16.15. Results for a monetary policy tightening in the forecasting case are shown below. Monetary policy was tightened by permanently lifting the exchange rate target, ETWIT, one per cent above its baseline path.

3.16.16. As seen in Chart 1, under the exogenous exchange rate closure the lift of one per cent in the target exchange rate is matched in the actual exchange rate, there being no variation in interest rates. This succeeds in ultimately reducing the local price level one per cent below its baseline path. This monetary tightening reduces real GDP by up to 0.8 per cent, but it then converges to baseline in damped cycles.

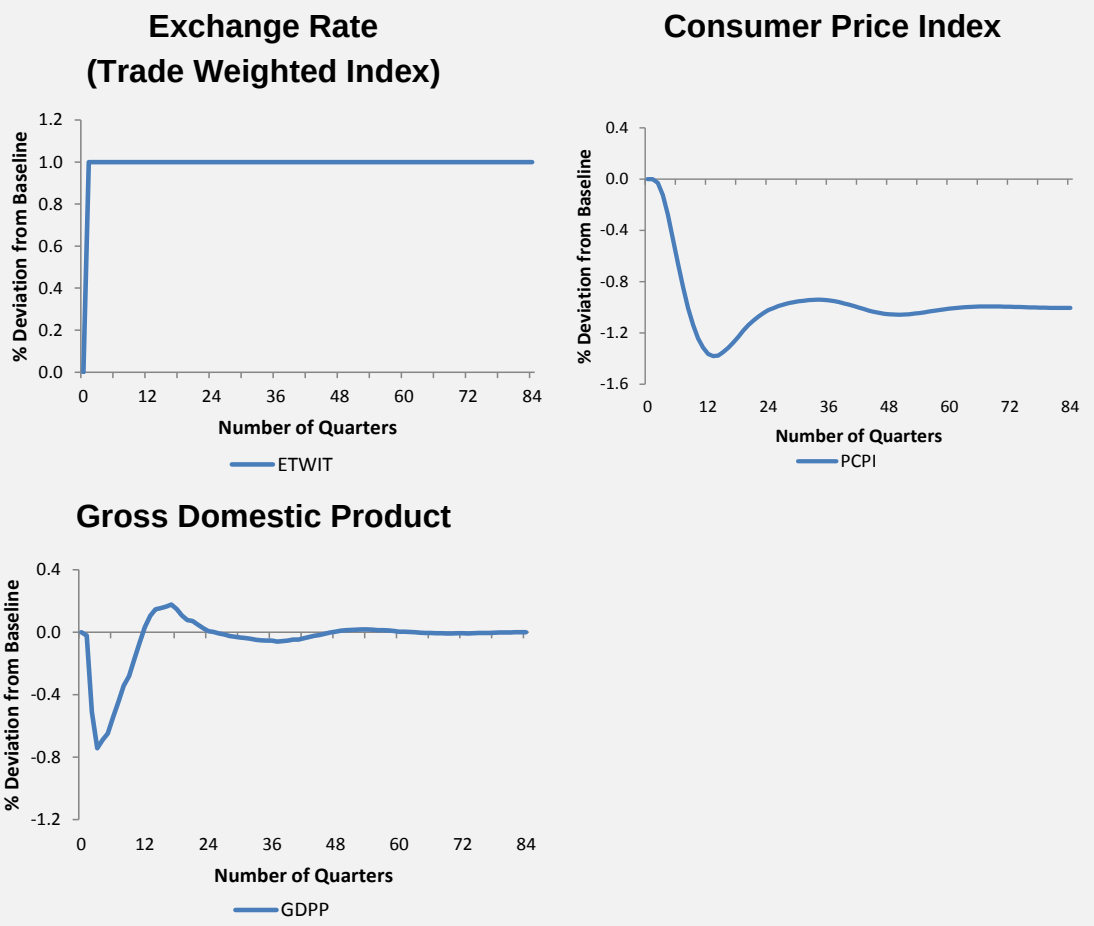
3.16.17. Finally, the equilibrium rate of growth in nominal spending (POL13) is equal to the sum of equilibrium real growth (GR), and the equilibrium domestic inflation rate, which in turn will equal the foreign inflation rate (PEXF) less the target rate of appreciation of the Singapore dollar (ETWIT). POL13 plays a role only in the steady state version of the MMS.

I47 Equilibrium Rate of Growth in Nominal Spending

$$POL13 = 4\cdot\log(GR) + 4\cdot\log\left(\frac{PEXF}{PEXF_{-1}}\right) - 4\cdot\log\left(\frac{ETWIT}{ETWIT_{-1}}\right)$$

Chart 1

Monetary Policy Tightening under Exogenous Exchange Rate Closure



3.17. FISCAL POLICY

3.17.1. Model development was undertaken progressively in recent years to improve the fiscal section of MMS to allow for robust fiscal policy analysis. Specifically, the following extensions were implemented:

(i) A mapping was introduced between model-based definition of fiscal aggregates to official definitions of fiscal aggregates. In this way, the internal consistency of the model could be maintained by retaining model-based fiscal aggregates;

(ii) Disaggregating fiscal aggregates even further for greater detail and accuracy; and

(iii) Allowing for the delay between the accrual of personal and company tax liabilities and their payment.

3.17.2. As noted above, the extensions implemented were designed so that the MMS is able to provide analyses of budget aggregates. Thus, the formulation of the fiscal policy specification remains broadly unchanged. Like the monetary policy specification, the fiscal policy specification needs to be flexible enough to deal with the requirements of simulation experiments.

3.17.3. In specifying a fiscal policy specification for use in simulation experiments, the first step is to identify the swing instrument of fiscal policy. For most countries the choice is not clear-cut and Singapore is no exception. However, a swing instrument must be chosen so that public debt/assets follow a sustainable path. Given its large size in the government budget, labour income tax was taken to be the swing instrument of fiscal policy.

3.17.4. In simulation experiments, the authorities are assumed to have a long-term value for the public surplus relative to nominal GDP, GDPZ, which is pursued through adjustments in the rate of labour income tax. Thus an endogenous component of the rate of labour income tax, POL1N, is adjusted until the one-year lagged public surplus ratio, PUBS/GDPZ, achieves the given ratio, RPUBS.

B16 Income Tax Rate Rule

$$\Delta POL1N = -C8009 \cdot \left(\frac{PUBS_{-4}}{GDPZ_{-4}} - RPUBS \right)$$

3.17.5. It can be shown that the ratio of the budget surplus to GDP, RPUBS, implies eventual stability in the ratio of public assets to GDP, A=RPUBS/n. Specifically, A converges where n is the equilibrium growth rate of nominal GDP.

3.17.6. In forecasting situations, model users will usually want to make their own assumptions about the near-term path of the rate of labour income tax. This is achieved by varying POL1X, which is the exogenous component of POL1. Thus the actual rate of tax, POL1, is determined as the sum of the endogenous component produced by the rule, POL1N, and the exogenously specified shift factor, POL1X. Alternatively, the path for POL1 can be influenced by changing the public sector surplus target, RPUBS.

I48 Rate of Tax on Labour Income

$$POL1 = POL1N + POL1X$$

3.17.7. The rate of labour income tax, POL1, is more conveniently expressed as a percentage, POL1T.

I49 Rate of Tax on Labour Income

$$POL1T = 100 \cdot POL1$$

3.17.8. The stock of public financial assets, AG, is assumed to be denominated in foreign currency. It increases with new public lending to the foreign sector net of capital transfers (TRCAP) from the Consolidated Revenue Account (CRA) and Development Fund Account (DFA), converted to foreign currency. The current value of the stock of public financial assets also allows for a capital gain at the exogenous rate PREM2 on last period's stock.

I50 Stock of Public Financial Assets Expressed in Foreign Currency

$$\Delta AG = \frac{PUBS_{-1} - TRCAP_{-1}}{E_{-1}} + \frac{PREM2_{-1}}{400} \cdot AG_{-1}$$

3.17.9. Capital gains in Singapore dollars on public investment in foreign assets are calculated as INVADJ1. It reflects both the overseas capital gains and the capital gains from depreciation of the Singapore dollar.

I50A Investment Adjustment

$$INVADJ1 = E \cdot AG - E_{-1} \cdot AG_{-1} - \left(PUBS_{-1} - TRCAP_{-1}\right)$$

3.17.10. Public financial assets are also expressed as a percentage of annual nominal GDP, PUASST.

I51 Public Financial Assets (% of Nominal GDP)

$$PUASST = \frac{100 \cdot AG \cdot E}{\left(GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4}\right)}$$

3.17.11. The MMS computes revenue from income and corporate tax separately. Corporate income tax is computed as the corporate tax rate (POLCOT) applied to the base after allowing for a coverage factor (RCIT). The tax base for property income tax is divided into property income earned by locals, YPT, and property income earned in Singapore by foreigners:

$$\frac{FK}{K} \cdot \left(GOS - 0.025 \cdot PIFT \cdot K\right).$$

3.17.12. In the above, property income earned by foreigners is estimated by applying the foreign-owned share of the business capital stock, FK/K, to the net operating surplus of the business sector (which is gross operating surplus GOS less capital depreciation). The modelling of property income earned by locals can be found in equation I64.

I52A Income Tax – Corporate

$$TAXITC = RCIT \cdot POLCOT \cdot \left(\begin{array}{l} \left(1 - WTITC\right) \cdot \left(YPT_{-4} + \frac{FK_{-4}}{K_{-4}} \cdot \left(GOS_{-4} - 0.025 \cdot PIFT_{-4} \cdot K_{-4}\right) \right) + \\ WTITC \cdot \left(YPT_{-1} + \frac{FK_{-1}}{K_{-1}} \cdot \left(GOS_{-1} - 0.025 \cdot PIFT_{-1} \cdot K_{-1}\right) \right) \end{array} \right)$$

3.17.13. Under the existing tax system in Singapore, income tax liabilities are assessed and paid in arrears. This is reflected in the above equation for corporate income tax receipts in the 4-quarter lag applied to the tax base, when WTITC=0. The equation also allows for a possible future shift to a provisional tax system by setting WTITC=1, reducing the lag applied to the tax base to one quarter.

3.17.14. Personal income tax revenue (TAXITP) is forecast based on the personal income tax rate, POL1, applied to the wage bill (WB). The lagged wage bill is used to account for the gap between the accrual of personal income tax liability and their payment.

I52B Income Tax – Personal

$$TAXITP = POL1 \cdot \left(WTITP \cdot WB + \left(1 - WTITP\right) \cdot WB_{-5} \right)$$

3.17.15. Again, under the existing tax system in Singapore, income tax liabilities are assessed and paid in arrears. This is reflected in the above equation for personal income tax receipts in the 5-quarter lag applied to the tax base, when WTITP=0. The equation also allows for a possible future shift to a pay-as-you-go tax system by setting WTITP=1, which removes the lag applied to the tax base.

3.17.16. Model development in recent years expanded the indirect tax details contained in MMS. Assets tax is modelled as an exogenous ratio of assets tax to indirect taxes on production, TAXOIT.

I52C Direct Tax – Assets Tax

$$TAXASS = RTAXASS \cdot TAXOIT$$

3.17.17. Motor vehicle revenue, TAXCA, comes from sources including Certificates of Entitlement (COE) and Additional Registration Fees (ARF). It is modelled as an exogenous share, RTAXCA, of commodity tax revenue, TAXCT.

I52D Indirect Tax – COE and ARF on National Accounts (Accrual) Basis

$$TAXCA = RTAXCA \cdot TAXCT$$

3.17.18. TAXCA is measured on an accrual or national accounts basis. It is converted to a cash basis by adding an adjustment, Z_{CA}. It is then split between COE and ARF in a pair of equations, using an exogenous share for ARF revenue, RATARF.

I52E Non-Tax Revenue – COE

$$TAXCOE = TAXCA + Z_{CA} - TAXARF$$

I52F Indirect Tax – ARF

$$TAXARF = RATARF \cdot \left(TAXCA + Z_{CA} \right)$$

3.17.19. Other indirect taxes (TAXOTI) is calculated as indirect taxes on production (TAXOIT) plus commodity taxes less asset taxes and COE and ARF revenue. An allowance is once again made between revenue collected on a cash basis (which is the definition used by the Ministry of Finance) and an accrual basis (which is the definition used in the national accounts).

I52G Indirect Tax – Other indirect taxes

$$TAXOTI = TAXOIT + TAXCT + Z_{ITLS} - TAXASS - TAXCA$$

3.17.20. Income from statutory boards (TAXITS) is modelled as an exogenous share of nominal GDP. The interest earned on loans made to statutory boards (INTSB) is also modelled in a similar fashion.

I52H Income Tax – Stat Boards

$$TAXITS = RTAXITS \cdot GDPZ$$

I52I Interest on Loans to Stat Boards

$$INTSB = RINTSB \cdot GDPZ$$

3.17.21. Government operating expenditure (GEC) is proxied as nominal government consumption (GCONZ) plus transfers from the public to the foreign sector (TRPUFO), plus the residuals introduced above to convert from an accrual basis to a cash basis. The remaining discrepancy is modelled as a share, RGEC, of nominal GDP (GDPZ).

I52J Government Operating Expenditure

$$GEC = \left(GCONZ + TRPUFO + Z_{ITLS} + Z_{CA}\right) + RGEC \cdot GDPZ$$

3.17.22. Similarly, Government development expenditure (GEK) is proxied as nominal government investment, plus a discrepancy modelled as a proportion, RGEK, of nominal GDP.

I52K Government Development Expenditure

$$GEK = GIFZ + RGEK \cdot GDPZ$$

3.17.23. Transfers from public to private are based on the proportion of transfers (that is an implied rate of transfers) to nominal GDP. Other non-tax government revenue (REVOTH), net government lending (NETLEN) and net capital receipts (NETCAP) are modelled in a similar way.

I52L Special Transfers: Government to Private

$$TRPUPR = POL11 \cdot GDPZ$$

I52M Other Non-tax Government Revenue

$$REVOTH = POL15 \cdot GDPZ$$

I52N Net Lending

$$NETLEN = POL16 \cdot GDPZ$$

I52O Net Capital Receipts

$$NETCAP = POL17 \cdot GDPZ$$

3.17.24. The public sector surplus (PUBS) is equal to total tax revenue less government outlays (GSPEND). Tax revenue consists of the following categories: personal income tax (TAXITP), corporate income tax (TAXITC), income from statutory boards (TAXITS), indirect taxes net of subsidies (ITLS), interest earned on loans to statutory boards (INTSB), other non-tax government revenue (REVOTH), net investment income (NETINV) and net capital receipts (NETCAP minus GSPEND).

I52 Public Sector Surplus

$$PUBS = TAXITP + TAXITC + TAXITS + ITLS + INTSB + REVOTH + NETINV + NETCAP - GSPEND$$

3.17.25. The public sector surplus (PUBSSH) is also expressed as a percentage of GDP.

I53 Public Surplus (% of GDPZ)

$$PUBSSH = 100 \cdot \frac{PUBS}{GDPZ}$$

3.17.26. The components affecting the budget balance in equation (I52) above are modelled in some detail in MMS. This is set out below, beginning with government outlays (GSPEND).

3.17.27. Government outlays include government operating expenditure, government development expenditure, net transfers to the private sector (TRPUPR) and net lending ($POL16 \cdot GDPZ$).

I54 Government Outlays

$$GSPEND = GCONZ + TRPUFO + RGEC \cdot GDPZ + GIFZ + RGEK \cdot GDPZ + TRPUPR + POL16 \cdot GDPZ$$

3.17.28. Net transfers to the foreign sector are modelled as a proportion, POL12, of GDP.

I55 Net Transfers from Public Sector to Foreign Sector

$$TRPUFO = POL12 \cdot GDPZ$$

3.17.29. Government Consumption (GCON) is purchased entirely from industry I. Nominal Government Consumption is just the volume multiplied by the price (PGCON).

I57 Nominal Government Consumption

$$GCONZ = PGCON \cdot GCON$$

3.17.30. Indirect taxes net of subsidies (ITLS) are another component of the budget balance in equation (I52) above. In MMS, ITLS is made up of five categories: TAXFWL, TAXCT, TAXCD, TAXGST and TAXOIT. The equations for each category are given below:

I58 Indirect Taxes Net of Subsidies

$$ITLS = TAXFWL + TAXCT + TAXCD + TAXGST + TAXOIT$$

3.17.31. Revenue from the foreign workers levy (TAXFWL) depends on the implied rate of levy in each industry and the foreign worker wage bill.

I59 Foreign Workers Levy

$$TAXFWL = \sum_i WFNTi \cdot POLFWLi \cdot SNFi \text{ where i denotes industry i}$$

3.17.32. Commodity taxes depend on real commodity taxes collected from each industry, modelled in equation (I26s) above, and the price of each commodity, SPXs. An adjustment factor, POLCT, is applied to allow for any changes in rates of commodity taxes over time.

I60 Commodity Taxes

$$TAXCT = POLCT \cdot \begin{pmatrix} SPXC \cdot SCTC + SPXE \cdot SCTE + SPXI \cdot SCTI \\ + SPXL \cdot SCTL + SPXR \cdot SCTR \end{pmatrix}$$

3.17.33. Customs duty (TAXCD) is calculated as the implied average rate of duty, POLCD, applied to the value of manufacturing imports, PIM*SIMC.

I61 Customs Duty

$$TAXCD = POLCD \cdot PIM \cdot SIMC$$

3.17.34. GST revenue (TAXGST) is calculated by applying the implied rate of GST, POLGST, to the model proxy for the GST base, non-housing private consumption before GST (CONOZ).

I62 GST Revenue

$$TAXGST = \left(\frac{POLGST}{1 + POLGST} \right) \cdot CONOZ$$

3.17.35. Indirect taxes on production of, say, industry I, are calculated by applying the implied rate of production tax, SCI9015, to the value of production of industry I before production tax,

$$\frac{\left(SPXI \cdot SXI + PEX \cdot SEXI - PIM \cdot SIMI \right)}{1 + SCI9015}$$

3.17.36. Production tax revenue (TAXOIT) is then summed over industries. In addition, equation (I63) applies an adjustment factor, POLOIT, to each production tax rate, SCs9015, to allow for changes in rates of production taxes over time.

I63 Indirect Taxes on Production

$$\begin{aligned} TAXOIT = & \\ & \left(\frac{POLOIT \cdot SCC9015}{1 + POLOIT \cdot SCC9015} \right) \cdot \left(SPXC \cdot SXC + PEX \cdot SEXC - PIMAT \cdot SIMC \right) \\ & + \left(\frac{POLOIT \cdot SCE9015}{1 + POLOIT \cdot SCE9015} \right) \cdot SPXE \cdot SXE \\ & + \left(\frac{POLOIT \cdot SCI9015}{1 + POLOIT \cdot SCI9015} \right) \cdot \left(SPXI \cdot SXI + PEX \cdot SEXI - PIM \cdot SIMI \right) \\ & + \left(\frac{POLOIT \cdot SCL9015}{1 + POLOIT \cdot SCL9015} \right) \cdot \left(SPXL \cdot SXL + PEX \cdot SEXL - PIM \cdot SIML \right) \\ & + \left(\frac{POLOIT \cdot SCR9015}{1 + POLOIT \cdot SCR9015} \right) \cdot SPXR \cdot SXR \end{aligned}$$

3.17.37. A component of the base for corporate income tax (equation I52A) is property income of locals (YPT), which is calculated in equation (I64). It includes the locally-owned share of the net operating surplus of the business sector (GOS), plus the net operating surplus from housing services, less service payments on private foreign debt (ZP).

I64 Property Income of Locals

$$YPT = \frac{(K - FK)}{K} \cdot (GOS - 0.025 \cdot PIFT \cdot K) + SPYSRR \cdot SYSRR$$
$$-0.01 \cdot PIH \cdot KH - \frac{RSF}{400} \cdot ZP \cdot E$$

3.17.38. Finally, the major components of the public sector's budget are calculated as percentages of nominal GDP. These are public consumption, public investment, and net revenue.

I65 Government Consumption / GDP

$$GCSH = 100 \cdot \frac{GCONZ}{GDPZ}$$

I66 Public Investment: Non-Residential / GDP

$$PUBINV = 100 \cdot \frac{GIFZ}{GDPZ}$$

I67 Net Revenue

$$NRSH = GCSH + PUBINV + PUBSSH$$

3.18. FOREIGN EXCHANGE MARKET

3.18.1. The assumption of uncovered interest parity sets the return from investing S$1 in a Singapore 3-month bill equal to the expected return from investing the same amount in a foreign 3-month bill.

$$1+\frac{RS}{400}=\left(1+\frac{RSF}{400}\right)\cdot\frac{E_{1|0}}{E}$$

3.18.2. The expected return from the foreign three month bill depends on the expected rate of depreciation of S$ from its value at the start of the quarter, E, to its expected value at the end of the quarter, $E_{1|0}$.

3.18.3. New information causes the foreign exchange market to change its forecast $E_{1|0}$, and E or RS must adjust instantaneously to ensure that uncovered interest parity continues to hold.

3.18.4. In Singapore, the exchange rate is the instrument of monetary policy, as modelled in Section 3.16, leaving RS to adjust to maintain uncovered interest parity.

3.18.5. Re-arranging the uncovered interest parity condition gives the following equation for the 3-month bill rate. In this equation, ER is defined as 100 times the logarithm of the exchange rate, and XER is the MMS's one-quarter-ahead forecast for ER.

B17 Uncovered Interest Parity

$$RS=400\cdot\left[\left(1+\frac{RSF}{400}\right)\cdot\exp\left(\frac{XER-ER+ZRER}{100}\right)-1\right]$$

I68 Transformation of Exchange Rate

$$ER=100\cdot\log(E)$$

I69 Model Exchange Rate

$$E=\frac{C48SC}{ETWI}$$

3.18.6. To apply the uncovered interest parity equation, it is necessary to construct a short-term foreign interest rate, RSF. This raises the general issue of constructing foreign sector variables from foreign country data in MMS.

3.18.7. For simplicity, for most purposes the foreign sector is modelled as a weighted average of several foreign countries.

3.19. BOND AND EQUITY MARKETS

3.19.1. Under the expectations theory of the term structure, the return from holding a 10-year bond should equal the expected return for holding a continuous sequence of 3-month securities over the same period, and this can be approximated as follows:

$$RL = \frac{1}{40}\sum_{i=0}^{39} RS_{i|0} \tag{1}$$

3.19.2. It is convenient to further approximate by replacing the unweighted average of expected short-term interest rates with an average based on geometrically declining weights:

$$RL = (1-\lambda)\cdot\sum_{i=0}^{\infty}\lambda^{i}\cdot RS_{i|0} \tag{2}$$

3.19.3. Leading this equation by one quarter, multiplying by λ, and taking expectations based in the current quarter gives the following:

$$\lambda\cdot RL_{1|0} = (1-\lambda)\cdot\sum_{i=1}^{\infty}\lambda^{i}\cdot RS_{i|0} \tag{3}$$

Subtracting equation (3) from equation (2), re-arranging and using the fact that, $RS_{0|0} = RS$, results in the following equation for the 10-year bond rate:

$$RL = (1-\lambda)\cdot RS + \lambda\cdot RL_{i|0}$$

3.19.4. This relates the 10-year bond rate to the short-term interest rate and the rational expectation for the 10-year bond rate in the next quarter.

Setting $\lambda = 0.95$ and switching to model notation gives the following, where ZRRL is the equation residual.

B19 10-Year Government Bond Yield

$$RL = (1-0.95)\cdot RS + 0.95\cdot XRL + ZRRL$$

3.19.5. The value of 0.95 was chosen for the geometric weighting factor of λ because it implies a mean lead on expected future short-term interest rates of,

$$\frac{\lambda}{1-\lambda} = \frac{0.95}{1-0.95} = 19 \text{ quarters}$$

which is very similar to the mean lead in the original formulation of equation (1), based on the unweighted average, of 19.5 quarters.

3.19.6. The 10-year expected inflation rate in Singapore, INFE, is modelled as a forward-looking variable depending on the steady-state growth rates of foreign prices PEXF and target exchange rate appreciation ETWIT.

3.19.7. The real 10-year bond rate, used in modelling business investment, is defined in equation (I75) where it is expressed as a proportion per quarter.

I75 Real 10-Year Bond Rate (Proportion Per Quarter)

$$RI = \left[\frac{\left(1+\frac{RL}{400}\right)}{\exp\left(\frac{INFE}{400}\right)}\right] - 1$$

3.19.8. The above equation is simply the exact version of the usual approximation to the real interest rate, which would be as follows:

$$RI = \frac{(RL - INFE)}{400}$$

The advantage of using the exact version given by equation (I75) is that it is consistent with super-neutrality.

3.20. OTHER EQUATIONS

3.20.1. The remaining equations in the core of MMS are set out in this sub-section, while the next sub-section sets out the non-core or supplementary equations.

3.20.2. The remaining equations in the core of MMS are grouped under three headings:

(i) other national accounts equations;
(ii) other price equations; and
(iii) other balance of payments equations.

Other National Accounts Equations

3.20.3. Of the remaining national accounts equations, those that appear in the core of MMS are set out in this sub-section, while the next sub-section includes national accounts equations that appear in MMS as supplementary equations.

3.20.4. Nominal investment for each category of investment is calculated as the product of price and volume.

I76 Nominal Residential Investment

$$IHZ = PIH \cdot IH$$

I77 Nominal Private Non-Residential Investment

$$IFZ = PIFT \cdot IFB$$

I78 Nominal Public Non-Residential Investment

$$GIFZ = PIFT \cdot GIF$$

I79 Nominal Non-Residential Investment

$$IFTZ = PIFT \cdot IFT$$

3.20.5. Nominal final demand (FDZ) is calculated by summing the products of price and volume for each component — private consumption, government consumption, residential investment, and non-residential investment. The price of government consumption is represented by the price of local sales in the "other" sector because all of government consumption comes from this industry.

I80 Nominal Final Demand

$$FDZ = PCONM \cdot CONS + SPXI \cdot GCON + PIHM \cdot IH + PIFTM \cdot IFT$$

3.20.6. Nominal exports (EXZ) are calculated as production for export less inventory investment in exports plus re-exports.

I81 Nominal Exports of Goods and Services

$$EXZ = PEX \cdot (SEXC + SEXI + SEXL) - PEX \cdot (II + SD + Z_{GDP} - Z_{EX}) + C58NO \cdot RIMREZ \cdot IMZ$$

3.20.7. Nominal imports, IMZ, are calculated as the sum of imports by industry, $PIM \cdot (SIMC + SIMI + SIML)$ plus imports that are re-exported, $C58N0 \cdot RIMREZ \cdot IMZ$.

Solving for IMZ gives the following:

I82 Nominal Imports of Goods and Services

$$IMZ = PIM \cdot \frac{(SIMC + SIMI + SIML)}{(1 - C58N0 \cdot RIMREZ)}$$

3.20.8. Nominal GDP (GDPZ) is calculated as final demand plus inventory investment plus a statistical discrepancy plus exports net of imports.

I83 Nominal GDP (Model Basis)

$$GDPZ = FDZ + PEX \cdot (II + SD + Z_{GDP}) + EXZ - IMZ$$

3.20.9. Labour costs (WBBT) are calculated by applying the wage rate for locals to employment for locals and adding this to the wage rate for foreign workers in each industry multiplied by the number of foreign workers in each industry.

I84 Labour Costs

$$WBBT = \sum_i \left(WL \cdot NL_i + WF_i \cdot SNF_i \right)$$

3.20.10. Labour income, WB, is calculated by excluding the foreign worker levy, which is paid by business to government, from labour costs.

I85 Labour Income

$$WB = WBBT - TAXFWL$$

3.20.11. To calculate the gross operating surplus of the business sector (GOS), the first step is to exclude housing services from GDP to obtain business sector GDP, $GDPZ - SPYSRR \cdot SYSRR$.

3.20.12. The next step is to subtract labour income and indirect taxes, to obtain equation (I86).

I86 Business Gross Operating Surplus

$$GOS = GDPZ - WB - ITLS - SPYSRR \cdot SYSRR$$

3.20.13. Net transfers from the foreign sector to the private sector (TRFOPR) are negative. This is because they mainly reflect transfers from foreign workers in Singapore to their home countries. Because of this, they are modelled as a proportion, POL14, of the labour income earned by foreign workers in Singapore before foreign worker levies are applied.

I87 Net Transfers from Foreign Sector to Private Sector

$$TRFOPR = POL14 \cdot \left(WFNTC \cdot SNFC + WFNTE \cdot SNFE + WFNTI \cdot SNFI + WFNTL \cdot SNFL \right)$$

3.20.14. The total stock of business capital (K) is obtained by adding together the capital stocks of each business sector.

I88 Stock of Business Capital

$$K = SKC + SKE + SKI + SKL$$

Other Price Equations

3.20.15. The key price equations in MMS have already been given. Specifically, for each industry, the price of domestic sales was modelled in Section 3.10, while the prices of imports and exports were modelled in Sections 3.14 and 3.15.

3.20.16. However, it remains to use the industry-level prices for domestic sales to calculate the aggregate prices for each component of domestic sales or final demand — private consumption, government consumption, business investment and residential investment. These aggregate prices are different from each other because the industry composition varies from one component of final demand to the next. For example, government consumption is supplied entirely by industry I ("other") while residential investment is supplied mainly by industry E (construction).

3.20.17. To obtain the model-based estimate for the price of private consumption, the first step is to calculate private consumption in constant prices (CONS) by summing private consumption of each industry's product, after allowing for commodity taxes.

I89 Private Consumption

$$CONS = (1+RGDPPD)\cdot\begin{pmatrix}(1+SCC9012)\cdot SCONC+(1+SCI9012)\cdot SCONI+\\(1+SCL9012)\cdot SCONL\end{pmatrix}$$
$$+(1+SCR9012)\cdot SCONR$$

3.20.18. The price of private consumption (PCONM) is then calculated as private consumption in current prices, CONZM, divided by private consumption in constant prices, CONS.

I90 Price of Private Consumption - Model Basis

$$PCONM = \frac{CONZM}{CONS}$$

3.20.19. Government consumption is supplied entirely by the "other" industry (industry I), so the price of government consumption (PGCONM) equals the price of domestic sales by industry I, SPXI.

I91 Price of Government Consumption - Model Basis

$$PGCONM = SPXI$$

3.20.20. Business investment and residential investment rely on supplies from a range of industries, so the price of business investment (PIFTM) and the price of residential investment (PIHM) are both obtained as weighted averages of various industry prices of investment supply (SPISs).

I92 Price of Business Investment - Model Basis

$$PIFTM = RSISE \cdot \frac{SPISE}{1+SCE9013} + (1-RSISE) \cdot \left[\begin{array}{l} \left(\frac{SCC9030}{1+SCC9013} \right) \cdot SPISC + \left(\frac{SCI9030}{1+SCI9013} \right) \cdot SPISI + \\ \left(\frac{SCL9030}{1+SCL9013} \right) \cdot SPISL \end{array} \right]$$

I93 Price of Residential Investment - Model Basis

$$PIHM = SCE9031 \cdot SPXE + SCI9031 \cdot SPXI + SCL9031 \cdot SPXL$$

3.20.21. The above aggregate prices for each component of final demand are consistent with the industry compositions of each component.

3.20.22. At the same time, the national accounts contain separate estimates for the price of each component of final demand, and it is important for the MMS to forecast these national accounts prices. The national accounts prices for three components of final demand are estimated from the following equations:

B21 Price of Government Consumption

$$(PGCON - SPXI) \cdot \frac{GCON}{FDZ} = C2700 + C2701 \cdot TF + C2702 \cdot DUM1 + C2703 \cdot DUM2 + C2704 \cdot DUM3 + C2705 \cdot (PIH_{-1} - PIHM_{-1}) \cdot \frac{IH_{-1}}{FDZ_{-1}} + C2706 \cdot (PIFT_{-1} - PIFTM_{-1}) \cdot \frac{IFT_{-1}}{FDZ_{-1}} + Z_{PGCON}$$

B22 Price of Residential Investment

$$(PIH - PIHM) \cdot \frac{IH}{FDZ} = C2800 + C2801 \cdot TF + C2802 \cdot DUM1 + C2803 \cdot DUM2 + C2804 \cdot DUM3 + C2805 \cdot (PIH_{-1} - PIHM_{-1}) \cdot \frac{IH_{-1}}{FDZ_{-1}} + C2806 \cdot (PIFT_{-1} - PIFTM_{-1}) \cdot \frac{IFT_{-1}}{FDZ_{-1}} + Z_{PIH}$$

B23 Price of Business Investment

$$(PIFT - PIFTM)\cdot\frac{IFT}{FDZ} =$$
$$C2900 + C2901\cdot TF + C2902\cdot DUM1 + C2903\cdot DUM2 + C2904\cdot DUM3$$
$$+C2905\cdot(PIH_{-1} - PIHM_{-1})\cdot\frac{IH_{-1}}{FDZ_{-1}} + C2906\cdot(PIFT_{-1} - PIFTM_{-1})\cdot\frac{IFT_{-1}}{FDZ_{-1}} + Z_{PIFT}$$

3.20.23. For example, in equation (B21) the national accounts price of government consumption, PGCON, is modelled using the model-based price for the same variable, PGCONM. Differences between the two prices are modelled using a time trend, seasonal dummies and lagged price differences.

3.20.24. The dependent variable of each equation is expressed as a share of nominal final demand, FDZ, and the same explanatory variables appear in each equation. This is to ensure that the following identity for nominal final demand is binding.

$$FDZ = PCONM\cdot CONS + PGCONM\cdot GCON + PIHM\cdot IH + PIFTM\cdot IFT$$
$$= PCON\cdot CONS + PGCON\cdot GCON + PIH\cdot IH + PIFT\cdot IFT$$

3.20.25. The first part of this condition appears as equation (I80), while the second part is implied, and is used to calculate national accounts nominal private consumption in equation (I94). This in turn is used to obtain the national accounts price for the fourth component of final demand, private consumption.

I94 Nominal Private Consumption

$$CONZ = FDZ - GCONZ - IHZ - IFTZ$$

I95 Price of Private Consumption

$$PCON = \frac{CONZ}{CONS}$$

3.20.26. In another supplementary equation, the price of private consumption is used in turn in modelling the Consumer Price Index, PCPI.

B24 Consumer Price Index

$$\log\left(\frac{PCPI}{PCON}\right) = C3800 + C3801\cdot DUM1 + C3802\cdot DUM2 + C3803\cdot DUM3$$
$$+C3804\cdot\log\left(\frac{PCPI_{-1}}{PCON_{-1}}\right) + Z_{PCPI}$$

Other Balance of Payments Equations

3.20.27. Of the remaining balance of payments equations, those that appear in the core of MMS are set out in this sub-section, while the next sub-section includes balance of payments equations that appear in MMS as supplementary equations.

3.20.28. In MMS, the balance on current account is modelled as a share of GDP, and is built up from its components.

3.20.29. The trade balance as a share of GDP (TGSB) is constructed as nominal exports, EXZ, net of nominal imports, IMZ, expressed as a percentage of nominal GDP, GDPZ.

I96 Balance on Goods and Services (Value)

$$TGSB = 100 \cdot \frac{(EXZ - IMZ)}{GDPZ}$$

3.20.30. The balance on net transfers (TRB) is calculated as net transfers from the foreign sector to the private sector (TRFOPR) less net transfers from the public sector to the foreign sector (TRPUFO).

I97 Balance on Net Transfers

$$TRB = 100 \cdot \frac{(TRFOPR - TRPUFO)}{GDPZ}$$

3.20.31. The MMS models the Government's net investment income (NETINV) as a risk-adjusted return on the stock of public foreign assets, AG. Since AG is denominated in foreign dollars, this income flow is multiplied by the exchange rate to convert it into Singapore dollars.

I97A Government Net Investment Income

$$NETINV = \frac{(RSF + PREM1)}{400} \cdot AG \cdot E$$

3.20.32. The balance on net factor income (NFIB) is calculated as investment income on government foreign assets less interest payments on private foreign borrowing (both of which are taken to be denominated in foreign currency). The return to foreign-owned capital (net of company tax income paid, after allowing for the lag from the accrual of income tax liabilities to tax collection) is also subtracted. An adjustment, Z_{NFIB}, is included to reconcile this model-based estimate of the balance on net factor income with the headline data for NFIB.

I98 Balance on Net Factor Income

$$NFIB = 100 \cdot \frac{\left(\begin{array}{l} NETINV - \frac{RSF}{400} \cdot ZP \cdot E - \frac{FK}{K} \cdot \left(GOS - 0.025 \cdot PIFT \cdot K \right) + \\ RCIT \cdot POLCOT \cdot \frac{FK_{-4}}{K_{-4}} \cdot \left(GOS_{-4} - 0.025 \cdot PIFT_{-4} \cdot K_{-4} \right) \end{array} \right)}{GDPZ} + Z_{NFIB}$$

3.20.33. The balance on current account (CURB) is obtained by adding the trade, transfer (TRB) and net factor income balances, where all balances are expressed as percentages of GDPZ.

I99 Balance on Current Account

$$CURB = TGSB + TRB + NFIB$$

3.20.34. The current account balance or surplus must be matched by an equal capital outflow or deficit. Therefore in modelling capital inflow, the first step is to take the negative of CURB, and convert it from a percentage of GDP to millions of Singapore dollars,

$$-GDPZ \cdot \frac{CURB}{100}$$

3.20.35. To identify private capital inflow, public capital inflow must be subtracted from total capital inflow. In fact, there is usually a public capital outflow, so public capital outflow must be added to total capital inflow to give, $-GDPZ \cdot \frac{CURB}{100} + PUBS$ where as a simplifying assumption, the budget surplus, PUBS, is invested abroad.

3.20.36. The equation for net private capital inflow (DOS) also contains adjustments for a balancing item, BOPCAP, and depreciation on foreign equity investment.

I100 Net Private Capital Inflow

$$DOS = 0.025 \cdot PIFT \cdot FK + PUBS - \left(BOPCAP + GDPZ \cdot \frac{CURB}{100} \right)$$

3.20.37. Net foreign equity investment (FIF) is modelled as an exogenous proportion, RFIF, of total business investment.

I101 Net Foreign Equity Investment

$$FIF = RFIF \cdot IFB$$

3.20.38. Such new investment adds to the stock of foreign equity capital (FK), which is also affected by depreciation.

I102 Net Foreign Equity Capital - Beginning of Period

$$FK = (1 - 0.025) \cdot FK_{-1} + FIF_{-1}$$

3.20.39. Net private capital inflow (DOS) can now be split between an increase in foreign debt and an increase in foreign equity. Subtracting foreign equity investment from private capital inflow gives the increase in foreign debt, ZP, which is assumed to be denominated in foreign currency.

I104 Net Foreign Private Debt

$$\Delta ZP = \frac{\left(DOS_{-1} - PIFT_{-1} \cdot FIF_{-1} \right)}{E_{-1}}$$

3.21. SUPPLEMENTARY EQUATIONS

3.21.1. The "headline" versions of some economic variables do not appear in the core of the model because they have been replaced by "model-based" versions that are measured in a more consistent way. However, it is important that the model can produce forecasts of the major headline economic variables.

3.21.2. To meet this need, a series of bridging or supplementary equations have been added, with each using the "model-based" version of a variable to forecast the "headline" version of the same variable. In addition, the supplementary model uses the variables from the core model to calculate predictions for a range of other economic variables that are of forecasting interest.

3.21.3. The supplementary equations are grouped under four headings:

(i) other national accounts equations;
(ii) other labour market equations;
(iii) other balance of payments equations; and
(iv) miscellaneous equations.

Other National Accounts Equations

3.21.4. Some national accounts equations appear in the core of MMS and have been set out earlier, especially in sub-section 3.20. Only the supplementary national accounts equations are presented here.

3.21.5. The first equation calculates real final demand (FD) by summing its components.

S01 Final Demand

$$FD = CONS + GCON + IH + IFT$$

3.21.6. Gross National Expenditure (GNE) is obtained by adding inventory investment to final demand.

S02 Gross National Expenditure

$$GNE = FD + II$$

3.21.7. Exports (EX) are calculated as production for export less inventory investment in exports plus re-exports.

S03 Exports of Goods and Services

$$EX = SEXC + SEXI + SEXL - SD - II + C58RE \cdot RIMREZ \cdot IM + Z_{EX}$$

3.21.8. Real imports, IM, are calculated as the sum of imports by industry, $SIMC + SIMI + SIML$ plus imports that are re-exported, $C58RE \cdot RIMREZ \cdot IM$. Solving for IM gives the following equation (S04).

S04 Imports of Goods and Services

$$IM = \frac{SIMC + SIMI + SIML}{\left(1 - C58RE \cdot RIMREZ\right)}$$

3.21.9. The next two equations calculate the expenditure-based and production-based definitions of real GDP respectively.

S05 GDP (Expenditure-based Estimate)

$$GDPE = GNE + EX - IM$$

S06 GDP (Production-based Estimate)

$$GDPP = GDPPC + GDPPE + GDPPI + GDPPL + GDPPR + GDPPD$$

3.21.10. The price of GDP is calculated by dividing nominal GDP (GDPZ), which was defined in equation (I83), by real GDP (GDPP), which is defined in equation (S06).

S07 Price of GDP

$$PGDPT = \frac{GDPZ}{GDPP}$$

3.21.11. The following supplementary equations calculate key investment and saving aggregates as shares of nominal GDP:

S08 Private Non-Residential Investment Share

$$PRINV = 100 \cdot \frac{\left(IFZ + PEX \cdot II\right)}{GDPZ}$$

S09 Residential Investment Share

$$IHINV = 100 \cdot \frac{IHZ}{GDPZ}$$

S10 National Investment Share

$$NATINV = PUBINV + PRINV + IHINV$$

S11 National Saving Share

$$NATSAV = NATINV + CURB + 100 \cdot \frac{BOPCAP}{GDPZ}$$

S12 Public Saving Share

$$PUBSAV = +PUBSSH + PUBINV + 100 \cdot POL3$$

S13 Private Saving Share

$$PRSAV = NATSAV - PUBSAV$$

Other Labour Market Equations

3.21.12. Employment data by industry for local and foreign workers are from a different source from headline labour market data which is based on the Labour Force Survey (LFS). A supplementary equation for survey employment is included to account for the differences in these data sets.

S14 Survey Employment

$$NSUR = C1800 \cdot NL + C1801 \cdot NF + Z_{NSUR}$$

3.21.13. This is then used to calculate the unemployment rate on a survey basis (URT).

S15 Unemployment Rate - Survey Basis

$$URT = 100 \cdot \frac{NUN}{NUN + NSUR}$$

3.21.14. In Singapore, wage forecasts are traditionally presented in original rather than seasonally adjusted form. For modelling wages in MMS, a seasonally adjusted resident wage series (WL), has been constructed. For forecasting purposes, a bridging equation has been included that reverses the seasonal adjustment process to obtain wages in the more commonly used original form, WO.

S16 Wages - Original Terms

$$\log\left(\frac{WO}{WL}\right) = (1 - DUM011) \cdot \begin{pmatrix} C39MA \cdot DUM1 + C39JU \cdot DUM2 + C39SE \cdot DUM3 \\ + C39DE \cdot (1 - DUM1 - DUM2 - DUM3) \end{pmatrix}$$
$$+ DUM011 \cdot \begin{pmatrix} C390MA \cdot DUM1 + C390JU \cdot DUM2 + C390SE \cdot DUM3 \\ + C390DE \cdot (1 - DUM1 - DUM2 - DUM3) \end{pmatrix}$$

3.21.15. This wage is then converted from thousands of dollars per quarter to dollars per month and employer CPF contributions are excluded, to give the headline measure of average monthly earnings, WHL.

S17 Headline Average Monthly Earnings

$$WHL = \frac{1000}{3} \cdot \left(\frac{WO}{1 + RCPF}\right)$$

Other Balance of Payments Equations

3.21.16. Some balance of payments equations appear in the core of MMS and have been set out earlier, especially in sub-section 3.20. Only the supplementary balance of payments equations are presented here.

3.21.17. Traditionally, non-oil domestic exports, EXNOD, are an important focus when forecasting exports. This is not the case in MMS because it forecasts exports by industry. However, there is a large overlap between manufacturing exports, SEXC, and EXNOD, providing a basis for a supplementary equation for EXNOD.

S18 Non-Oil Domestic Exports

$$\log\left(\frac{EXNOD}{SEXC}\right) = C3000 + C3001 \cdot DUM1 + C3002 \cdot DUM2 + C3003 \cdot DUM3$$
$$+ C3004 \cdot TF + C3005 \cdot \log\left(\frac{EXNOD_{-1}}{SEXC_{-1}}\right) + Z_{EXNOD}$$

3.21.18. Nominal non-oil domestic exports, EXNODZ, can then be modelled in a supplementary equation that applies the price index for total exports, PEX, to real non-oil domestic exports.

S19 Nominal Non-Oil Domestic Exports

$$\log\left(\frac{EXNODZ}{PEX \cdot EXNOD}\right) = C3100 + C3101 \cdot DUM1 + C3102 \cdot DUM2 + C3103 \cdot DUM3$$
$$+ C3104 \cdot TF + C3105 \cdot \log\left(\frac{EXNODZ_{-1}}{PEX_{-1} \cdot EXNOD_{-1}}\right) + Z_{EXNODZ}$$

3.21.19. The next equation calculates the balance of trade in volume terms (TGSBQ) as a percentage of real GDP.

S20 Balance on Goods & Services (Volume)

$$TGSBQ = 100 \cdot \frac{(EX - IM)}{GDPP}$$

3.21.20. The terms of trade (TOT) is calculated as the ratio of the price of exports (EXZ/EX) to the price of imports (IMZ/IM).

S21 Terms of Trade

$$TOT = 100 \cdot \frac{\left(\frac{EXZ}{EX}\right)}{\left(\frac{IMZ}{IM}\right)}$$

3.21.21. Net foreign assets as a percentage of GDP (FOASST) include government investment abroad, AG, net of foreign private debt, ZP, and equity, FK.

A40 Net Foreign Assets

$$FOASST = 100 \cdot \frac{(AG - ZP) \cdot E - PIFT \cdot FK}{GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4}}$$

3.21.22. Public financial assets (PUASST) are assumed to take the form of public investment abroad, AG, and are converted from foreign currency to Singapore dollars before being expressed as a percentage of GDPZ.

S23 Public Financial Assets

$$PUASST = 100 \cdot \frac{AG \cdot E}{(GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4})}$$

Miscellaneous

3.21.23. The remaining equations are supplementary.

3.21.24. Equation (S27) defines the average product of labour (PROD) as real GDP (GDPP) relative to total employment including both local (NL) and foreign (NF) workers.

S27 Labour Productivity

$$PROD = \frac{GDPP}{NF + NL}$$

3.21.25. Equation (S28) defines nominal unit labour costs (ULC) as the wage bill (WBBT), relative to real GDP (GDPP). That is, it measures the nominal cost of labour per unit of real output.

S28 Nominal Unit Labour Costs

$$ULC = \frac{WBBT}{GDPP}$$

4. SIMULATION PROPERTIES

4.1. OVERVIEW

4.1.1. This section explores the simulation properties of MMS through a series of eight simulations. They show how the policies of the MAS, and other developments both domestic and international, affect economic outcomes in MMS. They also demonstrate various ways in which MMS is consistent with economic theory. All eight simulations were conducted under the Exogenous Exchange Rate Closure, which was explained in Section 3.16.

4.1.2. To explore the simulation properties of a model, the first step is to establish a baseline simulation. For this documentation, the baseline simulation is a balanced growth path generated using synthetic data for model inputs. In practice, the simulation properties of MMS and most macroeconometric models are only mildly sensitive to the choice of baseline simulation. This is because simulation properties are invariant to the choice of baseline for a linear model, and most macroeconometric models are only mildly non-linear.

4.1.3. Each of the simulations involves varying one or more model inputs from their baseline paths and re-simulating the model. The reported results of a simulation are then calculated as the difference between model outputs in the simulation itself and the baseline simulation. Thus these results reflect the effects on the model outputs of the specified changes to model inputs.

4.2. EXCHANGE RATE

4.2.1. The first two simulations vary the exchange rate from its baseline path. This is important because, as explained in Section 3.16, the exchange rate is the tool of monetary policy used by the MAS. Thus exchange rate simulations are really monetary policy simulations. Furthermore, because Singapore is an ultra-open economy, exchange rate changes have very important effects.

4.2.2. Simulation 1 is a “textbook” simulation in which the value of the Singapore dollar is raised two per cent above its baseline path indefinitely, as shown in the path for ETWIT in Chart 2.

4.2.3. This flows through to a similar two per cent reduction in prices for both imports and exports when expressed in Singapore dollars. Through a number of channels this gradually flows through to prices generally. Thus Chart 2 shows that after nine quarters both the CPI and wages are two per cent below their baseline paths.

4.2.4. Chart 3 shows that the tightening in exchange rate or monetary policy reduces domestic demand, with real GNE reaching a trough of 1.0 per cent below baseline after six quarters. The temporarily higher real exchange rate also significantly reduces real net exports. The fall in GNE combines with the fall in net exports so that real GDP reaches a trough of 1.5 per cent below baseline after two quarters.

4.2.5. In a dampened response to the loss in GDP, unemployment peaks at 0.5 percentage point above baseline after five quarters. As in most countries, the dampened nature of this response is explained by pro-cyclical fluctuations in productivity and the discouraged worker effect on the labour force participation rate.

4.2.6. Charts 2 and 3 confirm the long-run neutrality of monetary policy in MMS. Appreciating the nominal exchange rate by two per cent ultimately reduces domestic prices by the same percentage, leaving the real exchange rate unchanged. Similarly, while economic activity is weaker in the short term, it is unaffected in the long-term.

Chart 2
Simulation 1: Appreciation of 2 per cent
Price Effects

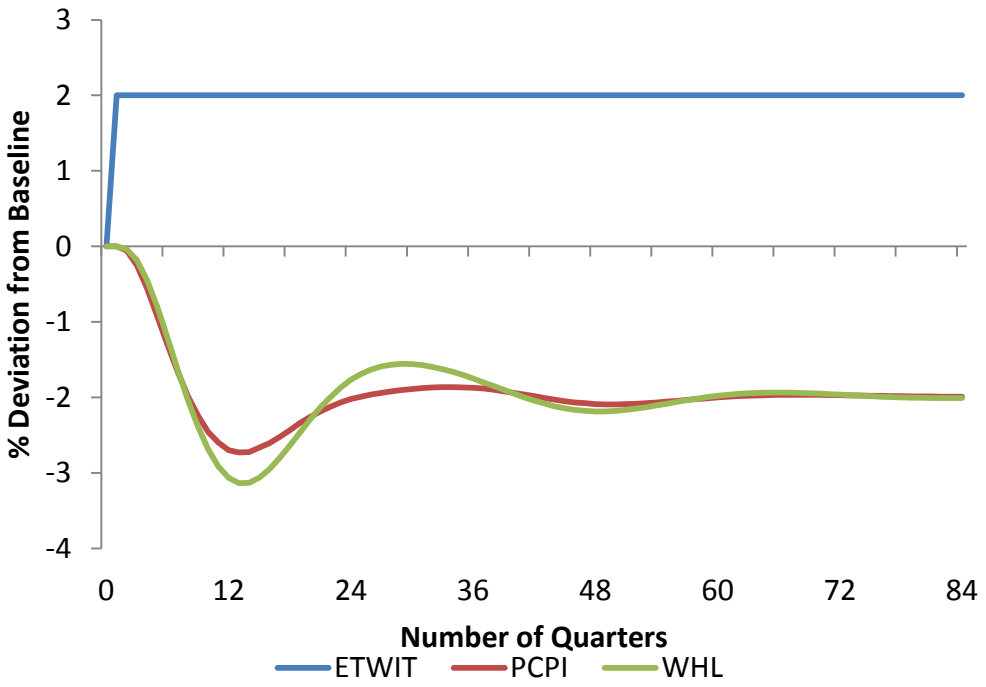
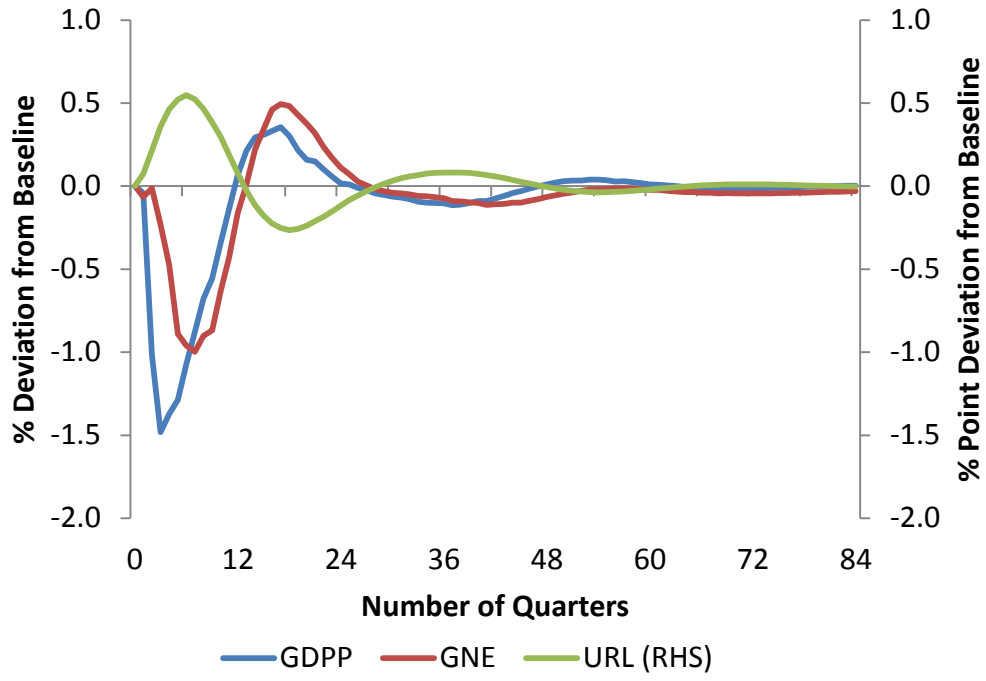


Chart 3
Simulation 1: Appreciation of 2 per cent
Activity Effects



4.2.7. Simulation 2 examines the effects in MMS of a permanent increase of one percentage point in the annual rate of appreciation of the Singapore dollar. This simulation also provides a test of whether there is long-run superneutrality of monetary policy in MMS.

4.2.8. Under a higher annual rate of appreciation in the exchange rate, there is an ever-widening gap between the simulated path of the exchange rate and the baseline path, as shown by the results for ETWIT in Chart 4, which can be compared with Chart 2 for Simulation 1.

4.2.9. Since Simulation 2 adjusts the rate of change in the exchange rate rather than its level, it is more natural to examine its effect on the rate of change of prices (or inflation) as in Chart 5, than its effect on the level of prices as in Chart 4.

4.2.10. Chart 5 shows the effects on the annualised quarterly rate of change in the CPI. Ultimately, adding one percentage point to the annual rate of increase in the exchange rate reduces inflation by the same amount. Indeed, Chart 5 shows that it takes only six quarters for this effect to be realised. Adding one percentage point to the annual rate of appreciation of the exchange rate potentially adds the same amount to the return to international investors from holding Singapore dollars. However, under uncovered interest parity, this will eventually be offset by a reduction of one percentage point in the short-term Singapore interest rate, RS, leaving unchanged the total expected return to international investors from holding Singapore dollars.

Chart 4
Simulation 2: Annual Appreciation of 1 percentage point
Price Effects

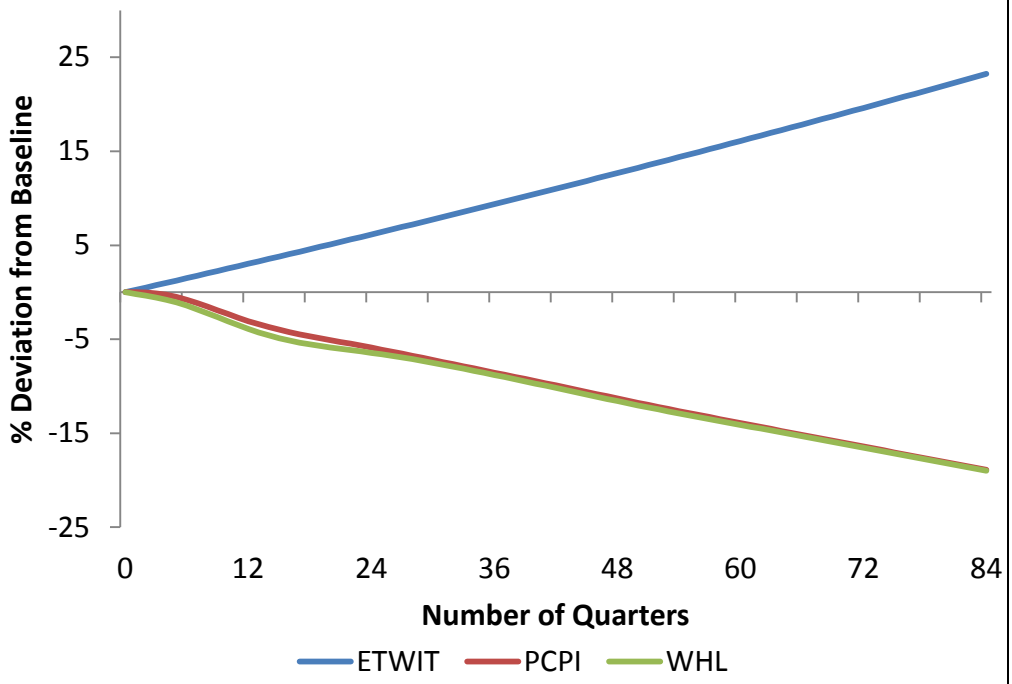
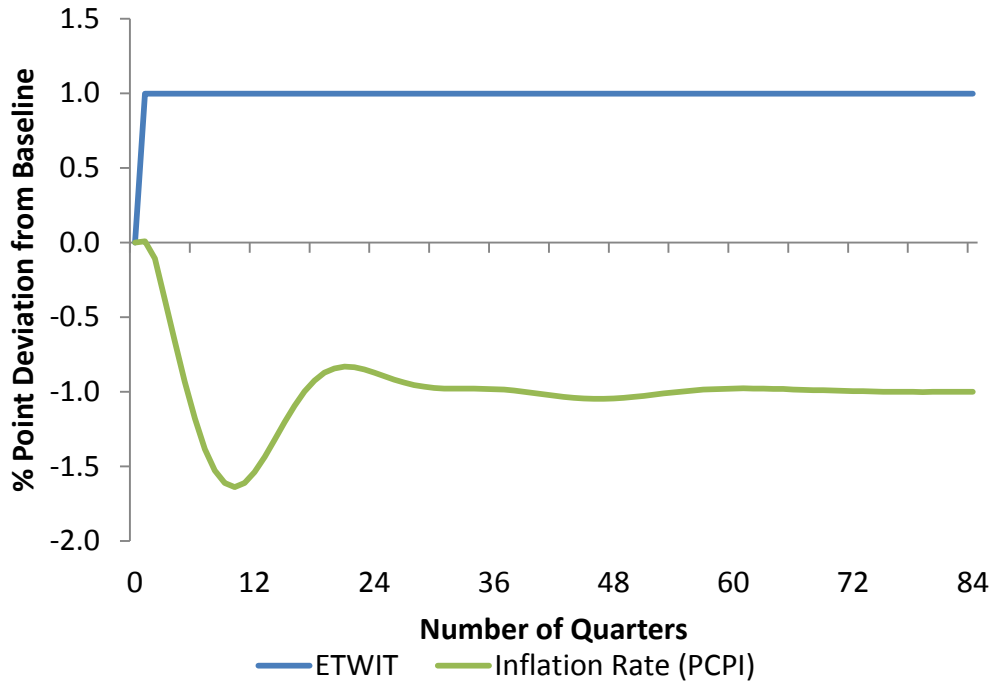
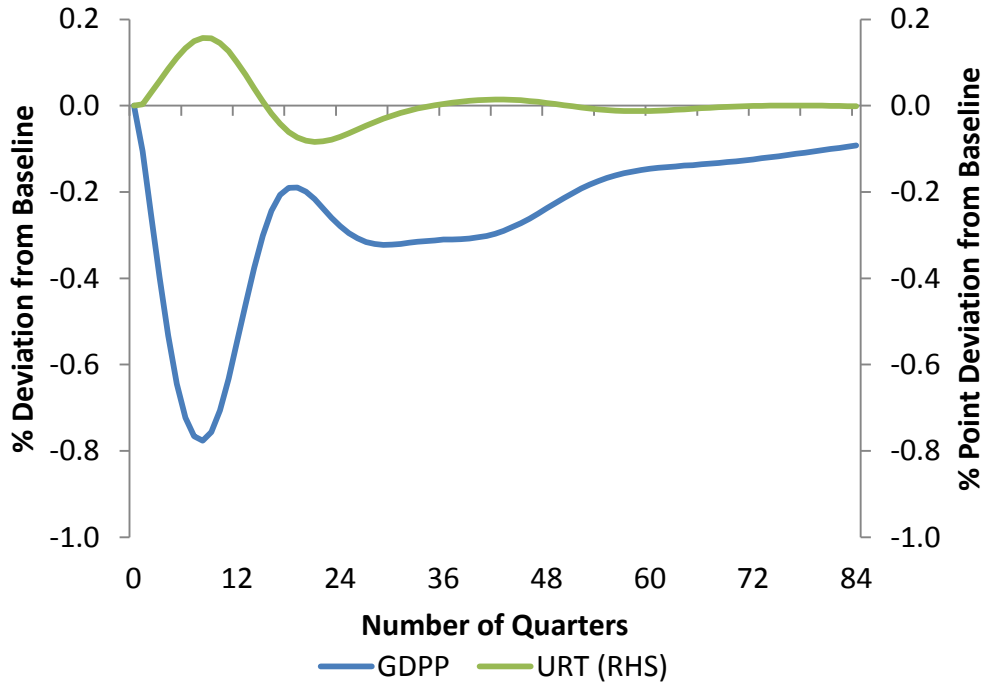


Chart 5
Simulation 2: Annual Appreciation of 1 percentage point
Inflation Effects



4.2.11. Chart 6 shows that the tightening in exchange rate or monetary policy reduces real GDP by about 0.8 per cent below baseline after eight quarters, with an associated dampened rise in the unemployment rate. It also shows the superneutrality of monetary policy in MMS. The permanent fall in the inflation rate brought about by the permanent increase in the rate of appreciation of the Singapore dollar has no effect in the long run on real variables such as GDP and unemployment rate. While this superneutrality property in MMS reflects its design features, it also points to the absence of some real world non-neutralities in the effects of inflation on taxation.

Chart 6
Simulation 2: Annual Appreciation of 1 percentage point
Activity Effects



4.3. FOREIGN SHOCKS

4.3.1. The ultra-open nature of the Singapore economy means that foreign shocks can have major domestic effects. This section simulates the effects of shocks to foreign prices and export demand.

4.3.2. In simulation 3, foreign prices are permanently reduced by two per cent. This is similar in effect to Simulation 1, which appreciated the exchange rate by two per cent. Both simulations have the effect of reducing foreign prices expressed in Singapore dollars by two per cent.

4.3.3. Chart 7 shows that, as expected, the effects on the CPI are similar in the two simulations. The two per cent fall in prices of imports and exports expressed in Singapore dollars leads to a two per cent fall in the CPI, irrespective of whether the fall in import and export prices originates in the exchange rate or in foreign prices.

4.3.4. Equally, while Chart 7 shows that the CPI effects are similar between the two simulations, they are not identical. This is because the appreciation of the exchange rate, but not the fall in foreign prices, leads to wealth effects in MMS. The main wealth effect is that a higher Singapore dollar reduces the earnings of the Singapore government on its foreign financial investments, when those earnings are converted to Singapore dollars. In MMS, this reduction in the wealth of the Singapore government leads to higher labour income tax to re-build that wealth. This in turn reduces consumer spending and domestic demand, leading to a larger peak reduction in the CPI in Simulation 1 than in Simulation 3.

4.3.5. The next foreign shock, Simulation 4, involves weaker foreign export demand reflecting a decline in global chip sales. Specifically, the US book-to-bill ratio for electronics (RBB) is assumed to gradually fall by 0.01 below baseline for four quarters, before recovering to baseline levels. In MMS, RBB affects demand for manufacturing exports. This fall in manufacturing exports directly affects manufacturing GDP, GDPPC. As shown in Chart 8, the peak loss in GDPPC is around 0.6 per cent. In turn, this reduces domestic GDP with a peak loss of around 0.25 per cent.

Chart 7
Simulation 1 vs Simulation 3:
Trade Prices up 2 per cent – Price Effects

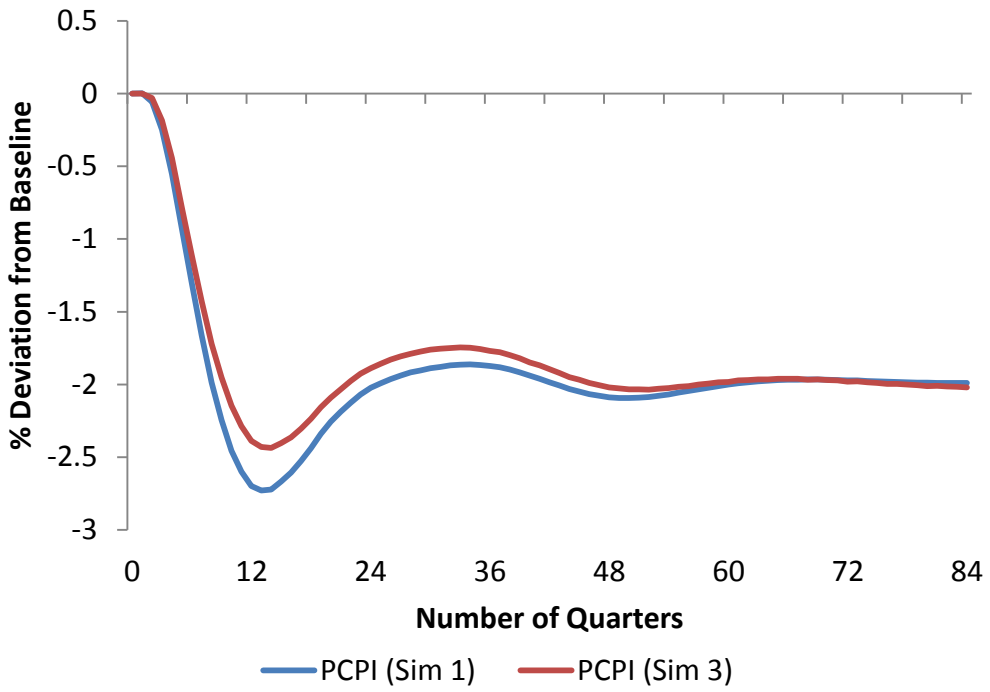
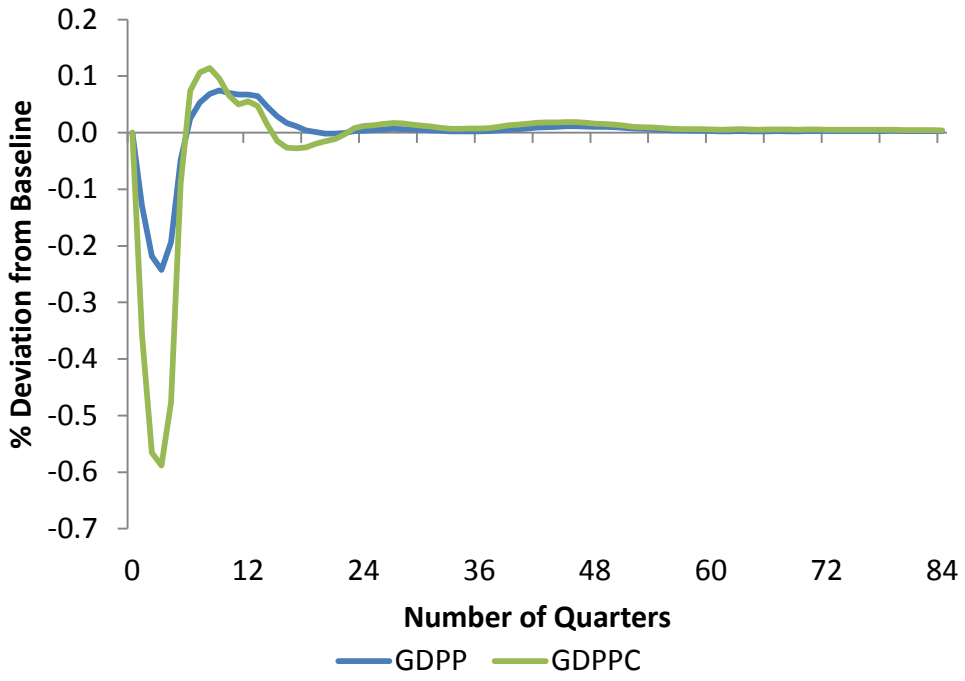


Chart 8
Simulation 4: Weaker Foreign Export Demand
Activity Effects



4.4. DOMESTIC SHOCKS

4.4.1. The remaining four simulations are domestic shocks designed to illustrate various simulation properties of MMS.

4.4.2. Simulations 5 and 6, which alter labour productivity and the NAIRU, illustrate the important role of the supply side in long-run equilibrium in MMS.

4.4.3. Simulation 5 involves an increase in labour efficiency in each employing industry (C,E,I,L) of two per cent phased in over four quarters. Broadly, this is expected to ultimately boost production by two per cent. So that government demand can expand broadly in line with private demand, the simulation also includes a phased expansion of two per cent in government consumption, GCON, and government fixed investment, GIF.

4.4.4. Chart 9 confirms that a two per cent across-the-board gain in labour efficiency leads to about a two per cent gain in production in all sectors. The gain in production in each industry takes time to develop for three reasons:

(i) the gain in efficiency is phased in over four quarters;
(ii) in MMS, production is driven by demand factors in the short term, with supply factors such as productivity prevailing in the long term;
(iii) the full expansion of two per cent in production requires a similar expansion in industry capital stocks, and this takes time to develop.

4.4.5. In the long term, the two per cent gain in labour efficiency generates a similar gain in real wages. Overall, Simulation 5 confirms the central role of the supply side in the long run equilibrium of MMS.

Chart 9
Simulation 5: 2 per cent Labour Efficiency Gain
GDP by Industry Effects

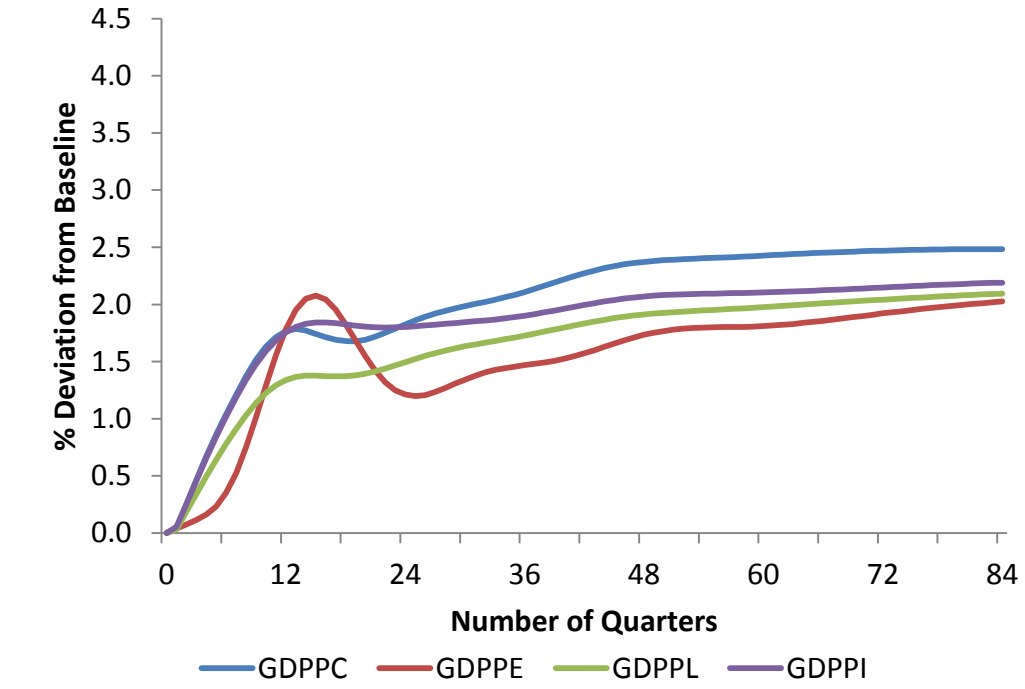
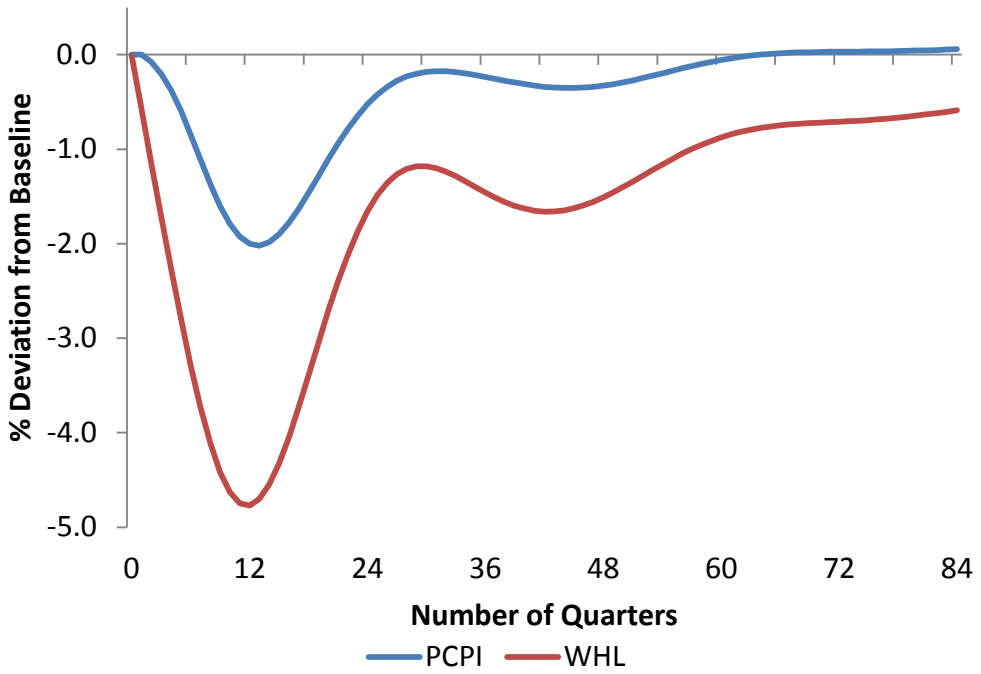


Chart 10
Simulation 6: 1 percentage point Reduction in NAIRU
Price Effects



4.4.6. Simulation 6 is designed to show how the NAIRU, which is implied by the MMS wage equation, determines the unemployment rate in long-run equilibrium. This simulation reduces the NAIRU by one percentage point through the appropriate negative adjustment to the wage equation residual.

4.4.7. Lowering the NAIRU below the baseline unemployment rate generates an excess supply of labour, putting downward pressure on wages. Chart 10 shows that wages reach a trough of 4.8 per cent below baseline after ten quarters. While this reduces prices, with the CPI reaching a trough of 2.0 per cent below baseline after 12 quarters, this still implies a significant, but temporary, net reduction in real wages.

4.4.8. Lower real wages stimulate employment and production. Chart 11 shows that the fall in the NAIRU of one percentage point has fully flowed through to the unemployment rate after 16 quarters, which is associated with a gain in real GDP of 2.7 per cent.

4.4.9. Industry capital stocks gradually expand, catching up with gains in industry employment. Ultimately the effect of reducing the NAIRU is to expand industry employment, capital and production in about equal proportions. Nominal and real wages then converge back to baseline, as seen in Chart 10.

4.4.10. In the long run, the economy has expanded by about three per cent relative to baseline. Reflecting the encouraged worker effect on labour force participation, about two-thirds of the expansion in employment is absorbed by a rise in labour force participation, with the other one-third reflected in the reduction in the unemployment rate of one percentage point, matching the reduction in the NAIRU.

Chart 10
Simulation 6: 1 percentage point Reduction in NAIRU
Price Effects

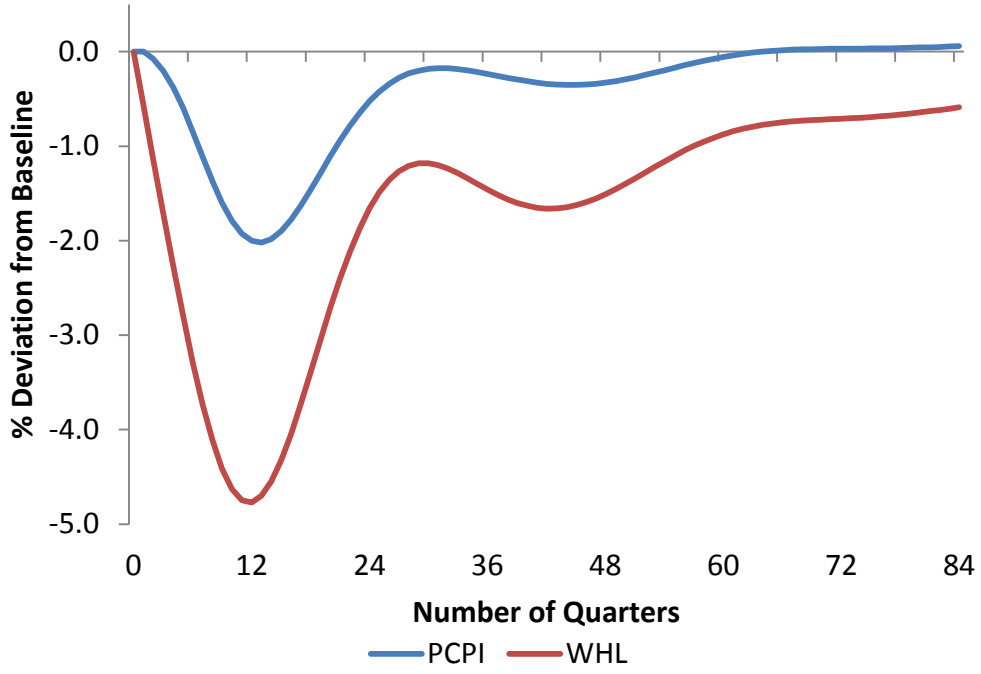
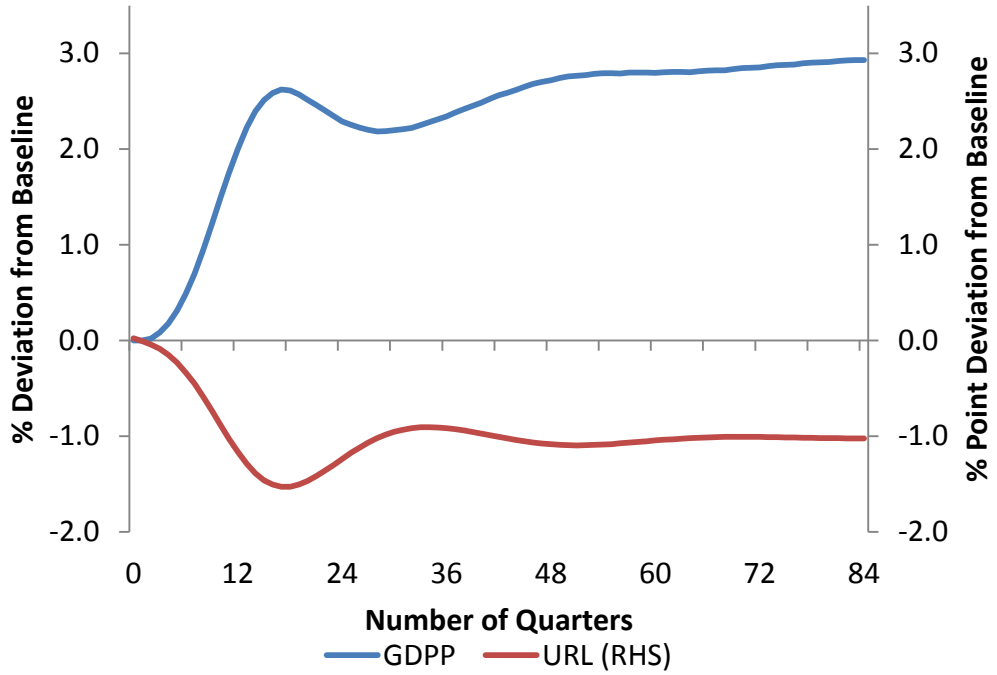


Chart 11
Simulation 6: 1 percentage point Reduction in NAIRU
Activity Effects



4.4.11. Simulation 7 highlights the fiscal closure in MMS. MMS ensures that fiscal policy is sustainable by using the labour income tax rate as a swing fiscal policy instrument that adjusts gradually to achieve a long-run ratio of the budget surplus to GDPZ. This simulation illustrates this mechanism by raising the long-run ratio for the budget surplus by the equivalent of one per cent of GDPZ.

4.4.12. Raising the long-run ratio of the budget surplus by one percentage point of GDPZ places the actual budget surplus below its target. In the income tax rate rule outlined in Section 3.17, this induces gradual increases in the rate of labour income tax to raise the budget surplus. Chart 12 shows the labour income tax rate reaching a peak after 24 quarters.

4.4.13. Chart 13 shows the associated rise in the budget surplus expressed as a percentage of GDPZ. While the budget surplus is increased directly by the higher rate of labour income tax, it is also increased indirectly as higher surpluses build up government financial assets, leading to increased earnings on those assets. Indeed, eventually the income tax rate decreases, and the gain in the budget surplus is sustained as a legacy of the build-up of government financial assets. The targeted gain in the budget surplus of one per cent of GDPZ is achieved after 24 quarters, as shown in Chart 13.

4.4.14. The slow nature of the convergence of the budget surplus to its long-run ratio is deliberate. The income tax rate rule is included in MMS only so that the model has the necessary long-run property that fiscal policy is sustainable.

4.4.15. A more aggressive income tax rate rule would have an undue influence on the short-term properties of the model. It would tend to undermine the impact of automatic stabilisers on the budget, making fiscal policy pro-cyclical. It would also make it more difficult in a forecasting context to ensure that near-term income tax rates are consistent with announced policy, with the model user having to offset the influence of the income tax rate rule.

4.4.16. Chart 13 also shows the "twin surpluses" hypothesis in MMS. The gain of one per cent of GDPZ in the budget balance gradually flows through to a similar gain in the current account balance. In this simulation both the budget balance and the current account balance benefit from the accumulation of government foreign financial assets.

Chart 12

Simulation 7: Budget Surplus Long-run Ratio up 1% of GDPZ

Income Tax Rate Adjustment

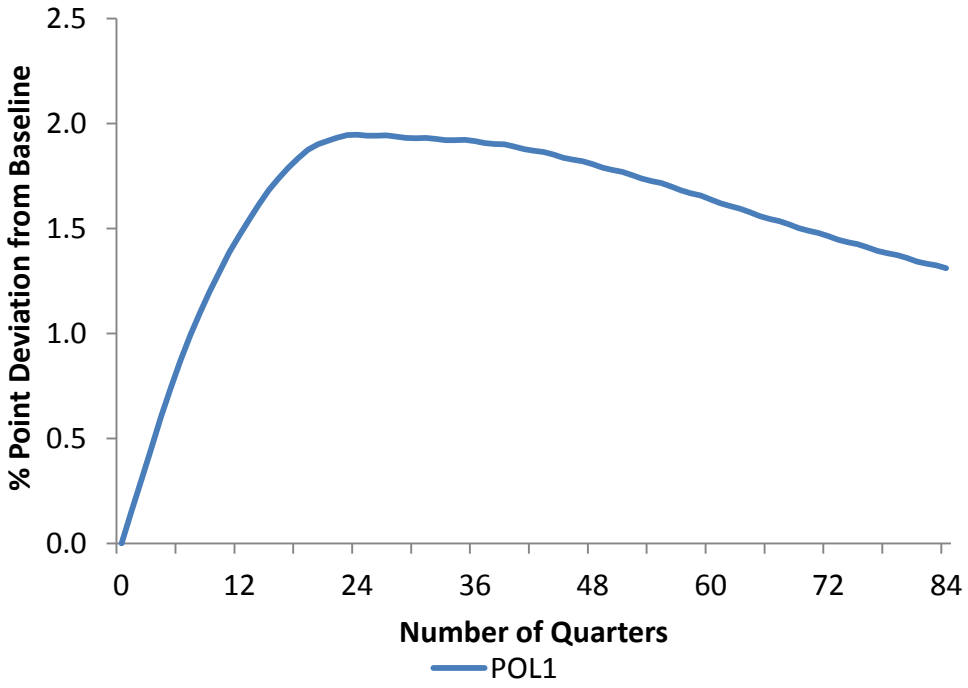
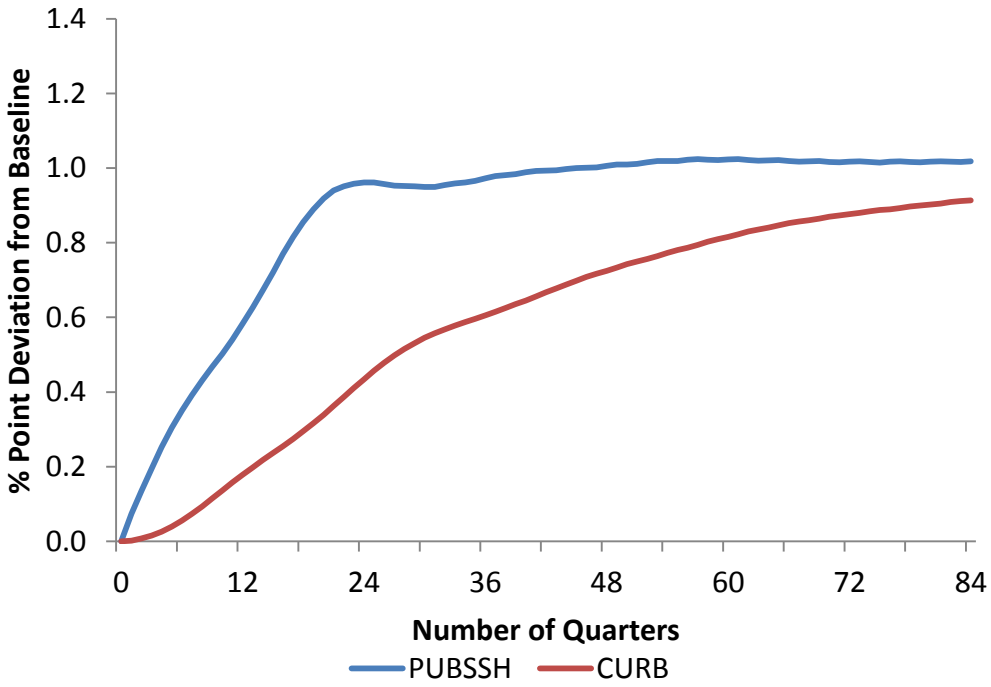


Chart 13

Simulation 7: Budget Surplus Long-run Ratio up 1% of GDPZ

Budget & Current Account Balance Effects



4.4.17. Simulation 8 highlights the industry structure in MMS. It raises the required rate of return on investment in manufacturing by one percentage point per annum, through the appropriate adjustment to the residual of the manufacturing investment equation. The required rates of return on investment in the other four industries in MMS are unaltered.

4.4.18. Raising the required rate of return on manufacturing investment places the actual rate of return, SARC, below the required rate, discouraging manufacturing investment. Chart 14 shows the cumulative loss of manufacturing capital, SKC, from this reduced flow of manufacturing investment.

4.4.19. As the manufacturing capital stock erodes, the marginal product of manufacturing capital increases, pushing up the actual rate of return, SARC, as seen in Chart 14. Eventually the actual rate of return rises by 1 percentage point per annum, closing the gap with the required rate of return. The rate of manufacturing investment then returns to normal, and the loss of manufacturing capital levels out.

4.4.20. The reduction in the manufacturing capital stock reduces manufacturing productivity, leading to lower manufacturing production, GDPPC, as shown in Chart 15. This reduces demand for inputs to manufacturing from other industries. It also lowers incomes, leading to reduced consumer demand across-the-board. Both of these effects combine to reduce production in other industries, (GDPPE, GDPPI, GDPPL), as seen in Chart 15.

4.4.21. This highlights the neoclassical basis for production decisions in each industry in long-run equilibrium in MMS.

Chart 14
Simulation 8: Mfg Risk Premium up 1% p.a.
Return and Capital Effects

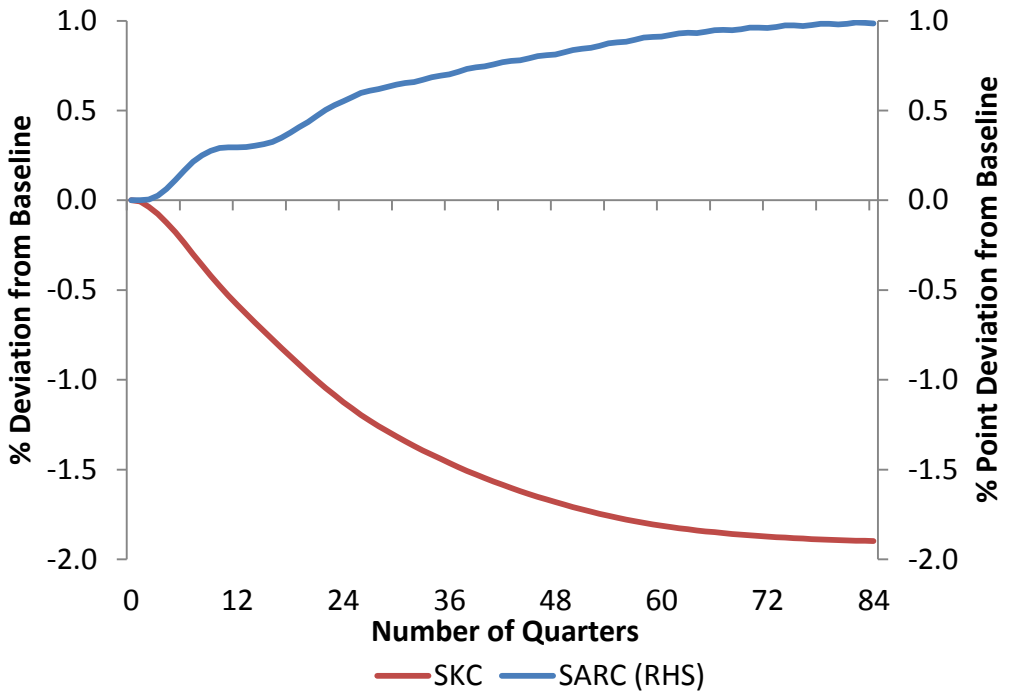
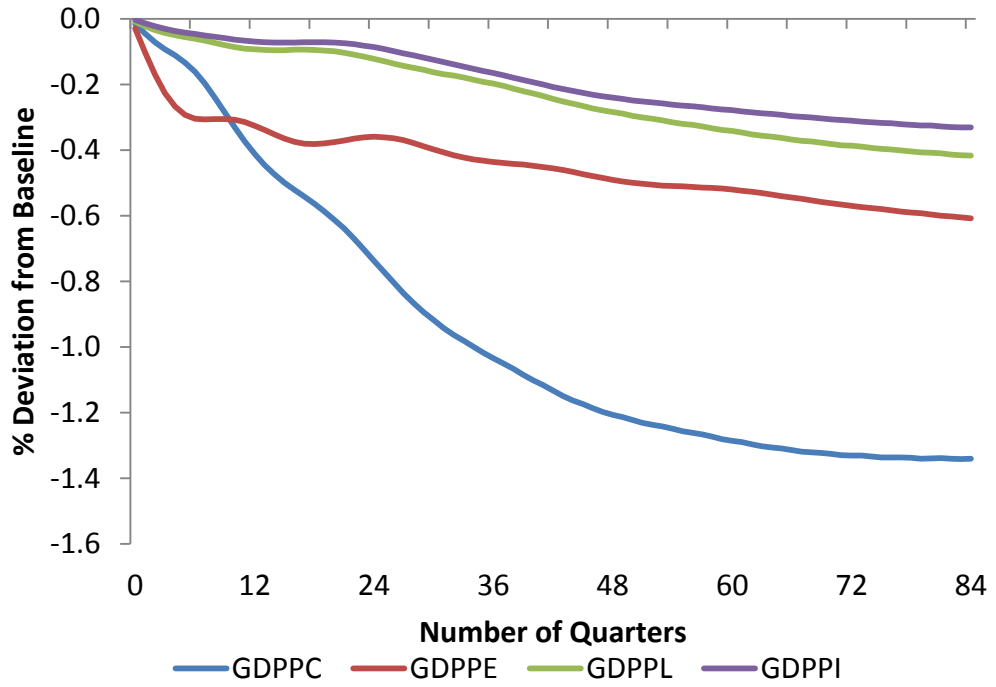


Chart 15
Simulation 8: Mfg Risk Premium up 1% p.a.
GDP by Industry Effects



5. CONCLUSION

5.1.1. With the introduction of MMS, quantitative work in EPG has become more rigorous. MMS is continuously being updated with the latest set of data and augmented as necessary to reflect the need of policymakers for more information on particular aspects of the structure of the economy.

5.1.2. At EPG, we believe that macromodelling should adopt a **pluralistic** approach. It is rare for one model to be superior for all possible purposes: forecasting, policy making, conditional forecasts, testing hypotheses or investigating the effects of a previous policy change. EPG recognises that different models or modelling styles can be best suited for different purposes. As such, we do not rely on one flagship model, but rather we use different models as the purpose dictates. We also rely on spreadsheet models for the different sectors of the economy.

5.1.3. EPG also believes in **pragmatism**, which is the practice of supplementing model output with sectoral analyses, survey data, market trends as well as value judgements. Although a model is a very useful tool for developing the forecasts, it does not replace the need for skilled economic judgements. Modellers need to be aware of the limitations of their models. The complexities of the economy cannot be fully captured by a macroeconometric model, no matter how comprehensive its specifications. In particular, macroeconomic models cannot quantify variables such as panic, greed or the herd psychology of investors. As a result, even the predictions of the most sophisticated model have been thrown off by unexpected developments in the environment. Hence, in EPG, the assumptions entering our models are continually re-assessed, and the output of the model adjusted where we have such additional sources of information to complement the raw forecast results.

5.1.4. To sum up, MMS will continue to play an integral role in the economic analysis work of EPG as we continue to upgrade our suite of models to ensure that they reflect the latest technical developments in the discipline, and the ongoing structural changes in the economy.

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APPENDIX A

VARIABLE DEFINITIONS

A.1 EXOGENOUS (INPUT) VARIABLES

#	Code	Description	Units
1	BOPCAP	NET CAPITAL TRANSFERS FROM ABROAD	$m
2	DUM1	DUMMY - SEASONAL - MARCH QTR	0/1 dummy
3	DUM2	DUMMY - SEASONAL - JUNE QTR	0/1 dummy
4	DUM3	DUMMY - SEASONAL - SEPT QTR	0/1 dummy
5	DUM061	DUMMY - UP TO 2006Q1	0/1 dummy
6	DUM894	DUMMY - UP TO 1989Q4	0/1 dummy
7	ETWIT	EXCHANGE RATE - TWI - BEG. - TARGET PATH	Feb73=100
8	EUSCH	EXCHANGE RATE - US$ PER CHINA YUAN - BEG.	US$/yuan
9	EUSEU	EXCHANGE RATE - US$ PER EURO - BEG.	US$/euro
10	EUSIN	EXCHANGE RATE - US$ PER INDONESIAN RUPIAH - BEG.	US$/rup
11	EUSJA	EXCHANGE RATE - US$ PER JAPANESE YEN - BEG.	US$/¥
12	EUSMA	EXCHANGE RATE - US$ PER MALAYSIAN RINGGIT - BEG.	US$/rggt
13	EUSTH	EXCHANGE RATE - US$ PER THAILAND BAHT - BEG.	US$/baht
14	GCON	GOVERNMENT CONSUMPTION	2010$m
15	GDPF	FOREIGN REAL GDP - NODX WEIGHTS	1985=100
16	GIF	PUBLIC NON-RESIDENTIAL INVESTMENT	2010$m
17	PEXF	PRICE - EXPORTS - FOREIGN CURRENCY	2010=1
18	PIMF	PRICE - IMPORTS - FOREIGN CURRENCY	2010=1
19	POL11	SPECIAL TRANSFERS - GOV'T TO PRIVATE - PROP. OF GDP	prop. gdp
20	POL12	TRANSFERS FROM GOV'T TO ABROAD - PROP. OF GDP	prop. gdp
21	POL14	TRANSFERS TO PRIVATE FROM ABROAD - PROP. OF FWI	prop. gdp
22	POL15	GOV'T OTHER NON-TAX REVENUE - PROP. OF GDP	prop. gdp
23	POL16	NET LENDING - PROP. OF GDP	prop. gdp
24	POL17	NET CAPITAL RECEIPTS - PROP. OF GDP	prop. gdp
25	POL1X	RATE OF TAX - LABOUR INCOME - SHIFTER	prop.
26	POL3	RESIDUAL GOV'T REVENUE - PROP. OF GDP	prop. gdp
27	POLCD	RATE OF CUSTOMS DUTY - MANUFACTURING IMPORTS	prop.
28	POLCOT	RATE OF TAX - CORPORATE	prop.
29	POLCT	RATE OF TAX - COMMODITIES - SHIFT FACTOR	2010=1
30	POLFWLC	RATE OF FOREIGN WORKER LEVY - PROP. OF WAGES - MFG	prop.
31	POLFWLE	RATE OF FOREIGN WORKER LEVY - PROP. OF WAGES - CTN	prop.
32	POLFWLI	RATE OF FOREIGN WORKER LEVY - PROP. OF WAGES - OTH	prop.

#	Code	Description	Units
33	POLFWLL	RATE OF FOREIGN WORKER LEVY - PROP. OF WAGES – F&B	prop.
34	POLGST	RATE OF TAX - GST	prop.
35	POLOIT	RATE OF TAX - PRODUCTION - SHIFT FACTOR	2010=1
36	POP3	RESIDENT POPULATION - AGED 15-64	000 pers.
37	POP4	RESIDENT POPULATION - AGED 65 AND OVER	000 pers.
38	PREM1	GOVT INVESTMENT DIVIDENDS PREMIUM	% p.a.
39	PREM2	GOVT INVESTMENT RE-VALUATION PREMIUM	% p.a.
40	PRT	UNDERLYING PARTICIPATION RATE, RESIDENT - PER CENT	per cent
41	RATARF	SHARE - ARF / (ARF + COE)	prop.
42	RBB	RATIO - BOOK-TO-BILL	prop.
43	RCIT	RATIO - COMPANY TAX COVERAGE - PROP.	prop.
44	RCPF	RATE OF CONTRIBUTION - EMPLOYER CPF - PROP.	prop.
45	RFIF	RATIO - FOREIGN TO TOTAL BUSINESS INVESTMENT	prop.
46	RGDPPD	RATIO - GST TO BASE - 2010 PRICES	prop.
47	RGEC	RATIO - GOVT OPEX TO GCONZ+TRPUFO	prop.
48	RGEK	RATIO - GOVT DEVEL. EXP TO GFIZ	prop.
49	RIMREZ	RATIO - ENTREPOT TO TOTAL IMPORTS	prop.
50	RINTSB	RATIO - INTSB/GDPZ	prop.
51	ROWNO	RATIO - OWNER-OCUPATION RATE (ADJUSTED)	prop.
52	RPUBS	RATIO - PUBLIC SECTOR SURPLUS TO GDP	prop.
53	RSCH	INTEREST RATE - SAME AS US - BEG.	% p.a.
54	RSEU	INTEREST RATE - 3-MONTH INTERBANK - EURO - BEG.	% p.a.
55	RSIN	INTEREST RATE - 1-90 CALL - INDONESIA - BEG.	% p.a.
56	RSJA	INTEREST RATE - OVERNIGHT CALL - JAPAN - BEG.	% p.a.
57	RSMA	INTEREST RATE - 3-MONTH I/BANK - MALAYSIA - BEG.	% p.a.
58	RSTH	INTEREST RATE - BANK THAILAND CALL - INDONESIA - BEG.	% p.a.
59	RSUS	INTEREST RATE - 3-MONTH INTERBANK - US - BEG.	% p.a.
60	RSISE	RATIO - CONSTRUCTION TO TOTAL FIXED INVESTMENT	prop.
61	RTAXASS	SHARE - ASSETS TAX / OTHER INDIRECT TAXES	prop.
62	RTAXITS	RATIO - TAXITS/GDPZ	prop.
63	RTAXCA	SHARE - COE+ARF / OTHER PRODUCT TAXES	prop.
64	ALC	LOCAL LABOUR EFFICIENCY INDEX - MFG	index
65	ALE	LOCAL LABOUR EFFICIENCY INDEX - CTN	index
66	ALI	LOCAL LABOUR EFFICIENCY INDEX - OTHER	index
67	ALL	LOCAL LABOUR EFFICIENCY INDEX - F&B	index
68	AFC	FOREIGN LABOUR EFFICIENCY INDEX - MFG	index
69	AFE	FOREIGN LABOUR EFFICIENCY INDEX - CTN	index
70	AFI	FOREIGN LABOUR EFFICIENCY INDEX - OTHER	index
71	AFL	FOREIGN LABOUR EFFICIENCY INDEX - F&B	index
72	SAA0C	LABOUR EFFICIENCY INDEX - MFG	index
73	SAA0E	LABOUR EFFICIENCY INDEX - CTN	index
74	SAA0I	LABOUR EFFICIENCY INDEX - OTHER	index
75	SAA0L	LABOUR EFFICIENCY INDEX - F&B	index

#	Code	Description	Units
76	SAA1C	CAPITAL EFFICIENCY INDEX - MFG	index
77	SAA1E	CAPITAL EFFICIENCY INDEX - CTN	index
78	SAA1I	CAPITAL EFFICIENCY INDEX - OTHER	index
79	SAA1L	CAPITAL EFFICIENCY INDEX - F&B	index
80	SAA1R	CAPITAL EFFICIENCY INDEX - HOUSING	index
81	SD	STATISTICAL DISCREPANCY	2010$m
82	FWFNTC	FOREIGN WAGE - FOREIGN CURRENCY - MFG	$F '000
83	FWFNTE	FOREIGN WAGE - FOREIGN CURRENCY - CTN	$F '000
84	FWFNTI	FOREIGN WAGE - FOREIGN CURRENCY - OTHER	$F '000
85	FWFNTL	FOREIGN WAGE - FOREIGN CURRENCY - F&B	$F '000
86	SZ_EXC	RESIDUAL - EXPORTS - MFG	prop.
87	SZ_EXI	RESIDUAL - EXPORTS - OTHER	prop.
88	SZ_EXL	RESIDUAL - EXPORTS - F&B	prop.
89	SZ_IFC	RESIDUAL - FIXED INVESTMENT - MFG	prop. SKC
90	SZ_IFE	RESIDUAL - FIXED INVESTMENT - CTN	prop. SKE
91	SZ_IFI	RESIDUAL - FIXED INVESTMENT - OTHER	prop. SKI
92	SZ_IFL	RESIDUAL - FIXED INVESTMENT - F&B	prop. SKL
93	SZ_IH	RESIDUAL - RESIDENTIAL INVESTMENT	prop. KH
94	SZ_IMC	RESIDUAL - IMPORTS - MFG	prop.
95	SZ_IMI	RESIDUAL - IMPORTS - OTHER	prop.
96	SZ_IML	RESIDUAL - IMPORTS - F&B	prop.
97	SZ_NFC	RESIDUAL – FOREIGN EMPLOYMENT - MFG	prop.
98	SZ_NFE	RESIDUAL – FOREIGN EMPLOYMENT – CTN	prop.
99	SZ_NFI	RESIDUAL – FOREIGN EMPLOYMENT – OTHER	prop.
100	SZ_NFL	RESIDUAL – FOREIGN EMPLOYMENT – F&B	prop.
101	SZ_NLC	RESIDUAL – LOCAL EMPLOYMENT - MFG	prop.
102	SZ_NLE	RESIDUAL – LOCAL EMPLOYMENT – CTN	prop.
103	SZ_NLI	RESIDUAL – LOCAL EMPLOYMENT – OTHER	prop.
104	SZ_NLL	RESIDUAL – LOCAL EMPLOYMENT – F&B	prop.
105	SZ_PXC	RESIDUAL - PRICE OF LOCAL SALES - MFG	prop.
106	SZ_PXE	RESIDUAL - PRICE OF LOCAL SALES - CTN	prop.
107	SZ_PXI	RESIDUAL - PRICE OF LOCAL SALES - OTHER	prop.
108	SZ_PXL	RESIDUAL - PRICE OF LOCAL SALES - F&B	prop.
109	TF	TIME TREND - FIXED IN FORECAST	2010=0
110	TRCAP	CAPITAL TRANSFERS FROM CRA AND DFA	$m
111	TV	TIME TREND - EXTENDED IN FORECAST	2010=0
112	WTITC	WEIGHT ON CONTEMPORANEOUS CORPORATE TAX	0/1 dummy
113	WTITP	WEIGHT ON CONTEMPORANEOUS PERSONAL TAX	0/1 dummy
114	ZRER	RESIDUAL - ER	prop.
115	ZRINFE	RESIDUAL - INFE	prop.
116	ZRRL	RESIDUAL - RL	prop.
117	Z_CA	RESIDUAL - ARF+COE: CASH-ACCRUAL	$m
118	Z_CON	RESIDUAL - PRIVATE CONSUMPTION	prop.
119	Z_ETWI	RESIDUAL - TWI EXCHANGE RATE	prop.
120	Z_EUS	RESIDUAL - US DOLLAR EXCHANGE RATE	prop.

#	Code	Description	Units
121	Z_EXNOD	RESIDUAL - EXPORTS - NON-OIL DOMESTIC	prop.
122	Z_EXNODZ	RESIDUAL - EXPORTS - NOMINAL - NON-OIL DOMESTIC	prop.
123	Z_GDP	RESIDUAL - GDP	prop.
124	Z_II	RESIDUAL - INVENTORY INVESTMENT	prop. SEXC
125	Z_ITLS	RESIDUAL - ITLS_mof-ITLS_nac	$m
126	Z_NFIB	RESIDUAL - NET FOREIGN INCOME BALANCE - % OF GDPZ	% of gdp
127	Z_NSUR	RESIDUAL - EMPLOYMENT - SURVEY	000 pers.
128	Z_NTS	RESIDUAL - LABOUR FORCE - LOCAL	prop.
129	Z_PCPI	RESIDUAL - CPI	prop.
130	Z_PGCON	RESIDUAL - PRICE - GOVERNMENT CONSUMPTION	prop. FDZ
131	Z_PIFT	RESIDUAL - PRICE - NON-RESIDENTIAL INVESTMENT	prop. FDZ
132	Z_PIH	RESIDUAL - PRICE - RESIDENTIAL INVESTMENT	prop. FDZ
133	Z_SPCR	RESIDUAL - PRICE - HOUSING RENT	prop.

A.2 ENDOGENOUS (OUTPUT) VARIABLES

#	Code	Description	Units
1	AA0SGR	LABOUR EFFICIENCY - WEIGHTED GROWTH RATE	prop. p.q.
2	AA0SLGR	LOCAL LABOUR EFFICIENCY - WEIGHTED GROWTH RATE	prop. p.q.
3	AG	ASSETS - PUBLIC - FOREIGN CURRENCY - BEG.	for$m
4	COND	PRIVATE CONSUMPTION - EQUILIBRIUM	2010$m
5	CONOZ	PRIVATE CONSUMPTION - NON-HOUSING - NOMINAL	$m
6	CONS	PRIVATE CONSUMPTION	2010$m
7	CONZ	PRIVATE CONSUMPTION - NOMINAL	$m
8	CONZM	PRIVATE CONSUMPTION - NOMINAL - MODEL BASIS	$m
9	CURB	CURRENT A/C BALANCE - % OF GDPZ	% of gdp
10	DOS	PRIVATE CAPITAL INFLOW	$m
11	E	EXCHANGE RATE - S$ PER FOREIGN CURRENCY - BEG.	2010=1
12	ECH	EXCHANGE RATE - S$ PER CHINA YUAN - BEG.	S$/yuan
13	EEU	EXCHANGE RATE - S$ PER EURO - BEG.	S$/euro
14	EIN	EXCHANGE RATE - S$ PER INDONESIAN RUPIAH - BEG.	S$/rup
15	EJA	EXCHANGE RATE - S$ PER JAPANESE YEN - BEG.	S$/¥
16	EMA	EXCHANGE RATE - S$ PER MALAYSIAN RINGGIT - BEG.	S$/rggt
17	ER	EXCHANGE RATE - 100 x LOG(E) - BEG.	2010=0
18	ETH	EXCHANGE RATE - S$ PER THAILAND BAHT - BEG.	S$/baht
19	ETWI	EXCHANGE RATE - TRADE-WEIGHTED INDEX - BEG.	Feb73=100
20	EUS	EXCHANGE RATE - S$ PER US DOLLAR - BEG.	S$/US$
21	EX	EXPORTS	2010$m
22	EXZ	EXPORTS - NOMINAL	$m
23	EXNOD	EXPORTS - NON-OIL DOMESTIC	2012$m
24	EXNODZ	EXPORTS - NOMINAL - NON-OIL DOMESTIC	$m
25	FD	FINAL DEMAND	2010$m
26	FDZ	FINAL DEMAND - NOMINAL	$m
27	FIF	PRIVATE CAPITAL INFLOW - REAL	2010$m
28	FK	FOREIGN-OWNED CAPITAL - BEG.	2010$m
29	FOASST	NET FOREIGN ASSETS - % OF GDPZ	% of gdp
30	GCONZ	GOVERNMENT CONSUMPTION - NOMINAL	$m
31	GCSH	GOVERNMENT CONSUMPTION - % OF GDPZ	% of gdp
32	GDPE	GDP - EXPENDITURE-BASED ESTIMATE	2010$m
33	GDPP	GROSS DOMESTIC PRODUCT	2010$m
34	GDPPC	GDP - MFG	2010$m
35	GDPPD	GDP - PRODUCT TAXES	2010$m
36	GDPPE	GDP - CTN	2010$m
37	GDPPI	GDP - OTHER	2010$m
38	GDPPL	GDP - F&B - EXCL. GDPPR	2010$m
39	GDPPR	GDP - HOUSING - OWNER-OCCUPIED	2010$m
40	GDPZ	GDP - NOMINAL	$m
41	GEC	GOVERNMENT OPERATING EXPENDITURE	$m

#	Code	Description	Units
42	GEK	GOVERNMENT DEVELOPMENT EXPENDITURE	$m
43	GIFZ	PUBLIC FIXED INVESTMENT - NON-RESIDENTIAL - NOMINAL	$m
44	GNE	GROSS NATIONAL EXPENDITURE	2010$m
45	GOS	GROSS OPERATING SURPLUS - MODEL BASIS	$m
46	GR	NATURAL GROWTH FACTOR	qtr fact.
47	GSPEND	GOVERNMENT SPENDING - NOMINAL	$m
48	IFB	PRIVATE NON-RESIDENTIAL INVESTMENT	2010$m
49	IFT	NON-RESIDENTIAL INVESTMENT	2010$m
50	IFTZ	NON-RESIDENTIAL INVESTMENT - NOMINAL	$m
51	IFZ	PRIVATE NON-RESIDENTIAL INVESTMENT - NOMINAL	$m
52	IH	RESIDENTIAL INVESTMENT	2010$m
53	IHINV	RESIDENTIAL INVESTMENT - % OF GDPZ	% of gdp
54	IHZ	RESIDENTIAL INVESTMENT - NOMINAL	$m
55	II	INVENTORY INVESTMENT	2010$m
56	IM	IMPORTS	2010$m
57	IMZ	IMPORTS - NOMINAL	$m
58	INF	ANNUALISED INFLATION RATE	% p.a.
59	INFE	INFLATION RATE - 10-YEAR EXPECTED	% p.a.
60	INTSB	NON-TAX REVENUE - INTEREST ON STAT BOARD LOANS	$m
61	INVADJ1	INVESTMENT ADJUSTMENT (BEG. OF QUARTER)	$m
62	ITLS	INDIRECT TAXES LESS SUBSIDIES	$m
63	K	NON-RESIDENTIAL CAPITAL STOCK - BEG.	2010$m
64	KH	RESIDENTIAL CAPITAL STOCK - BEG.	2010$m
65	KI	INVENTORY STOCK - BEG.	2010$m
66	LPCON	PRICE - PRIVATE CONSUMPTION - LOGARITHM	2010=0
67	N	EMPLOYMENT	000 pers.
68	NATINV	NATIONAL INVESTMENT - % OF GDPZ	% of gdp
69	NATSAV	NATIONAL SAVING - % OF GDPZ	% of gdp
70	NETLEN	NET LENDING	$m
71	NETCAP	NET CAPITAL RECEIPTS	$m
72	NETINV	NET INVESTMENT INCOME	$m
73	NF	EMPLOYMENT - FOREIGNERS	000 pers.
74	NFIB	NET FOREIGN INCOME BALANCE - % OF GDPZ	% of gdp
75	NL	EMPLOYMENT - LOCALS	000 pers.
76	NRSH	NET REVENUE - % OF GDPZ	% of gdp
77	NSUR	EMPLOYMENT - SURVEY	000 pers.
78	NTS	LABOUR FORCE - LOCALS	000 pers.
79	NUN	UNEMPLOYMENT - SURVEY	000 pers.
80	PART	PARTICIPATION RATE - PER CENT	per cent
81	PCON	PRICE - PRIVATE CONSUMPTION	2010=1
82	PCONM	PRICE - PRIVATE CONSUMPTION - MODEL-BASIS	2010=1
83	PCPI	CONSUMER PRICE INDEX	2009=100
84	PEX	PRICE - EXPORTS	2010=1
85	PGCON	PRICE - GOVERNMENT CONSUMPTION	2010=1

#	Code	Description	Units
86	PGDPT	PRICE - GROSS DOMESTIC PRODUCT	2010=1
87	PIFT	PRICE - NON-RESIDENTIAL INVESTMENT	2010=1
88	PIFTM	PRICE - NON-RESIDENTIAL INVESTMENT - MODEL-BASIS	2010=1
89	PIH	PRICE - RESIDENTIAL INVESTMENT	2010=1
90	PIHM	PRICE - RESIDENTIAL INVESTMENT - MODEL-BASIS	2010=1
91	PIM	PRICE - IMPORTS	2010=1
92	PIMAT	PRICE - IMPORTS - MFG - AFTER CUSTOMS DUTY	index
93	POL1	RATE OF TAX - LABOUR INCOME - PROPORTION	prop.
94	POL13	NATURAL GROWTH RATE - NOMINAL	prop. p.a.
95	POL1N	RATE OF TAX - LABOUR INCOME - ENDOGENOUS	prop.
96	POL1T	RATE OF TAX - LABOUR INCOME - PER CENT	per cent
97	POPGR	WORKING-AGE POPULATION GROWTH RATE - SMOOTHED	prop. p.q.
98	PRINV	PRIVATE INVESTMENT - % OF GDPZ	% of gdp
99	PROD	LABOUR PRODUCTIVITY	index
100	PRSAV	PRIVATE SAVING - % OF GDPZ	% of gdp
101	PUASST	ASSETS - PUBLIC - % OF GDPZ	% of gdp
102	PUBINV	PUBLIC INVESTMENT - % OF GDPZ	% of gdp
103	PUBS	PUBLIC SECTOR SURPLUS	$m
104	PUBSAV	PUBLIC SAVING - % OF GDPZ	% of gdp
105	PUBSSH	PUBLIC SECTOR SURPLUS - % OF GDPZ	% of gdp
106	REVOTH	NON-TAX REVENUE - OTHER	$m
107	RI	INTEREST RATE - REAL - PROP. PER QTR - BEG.	prop. p.q.
108	RL	INTEREST RATE - 10-YEAR - BEG.	% p.a.
109	RS	INTEREST RATE - 3-MONTH - BEG.	% p.a.
110	RSF	INTEREST RATE - 3-MONTH - FOREIGN - BEG.	% p.a.
111	SARC	ACTUAL RATE OF RETURN - MFG	% p.a.
112	SARE	ACTUAL RATE OF RETURN - CTN	% p.a.
113	SARI	ACTUAL RATE OF RETURN - OTHER	% p.a.
114	SARL	ACTUAL RATE OF RETURN - F&B	% p.a.
115	SARR	ACTUAL RATE OF RETURN - HOUSING	% p.a.
116	SCONC	PRIVATE CONSUMPTION - MFG	2010$m
117	SCONI	PRIVATE CONSUMPTION - OTHER	2010$m
118	SCONL	PRIVATE CONSUMPTION - F&B	2010$m
119	SCONR	PRIVATE CONSUMPTION - RENT	2010$m
120	SCTC	COMMODITY TAXES - 2010 PRICES - MFG	2010$m
121	SCTE	COMMODITY TAXES - 2010 PRICES - CTN	2010$m
122	SCTI	COMMODITY TAXES - 2010 PRICES - OTHER	2010$m
123	SCTL	COMMODITY TAXES - 2010 PRICES - F&B	2010$m
124	SCTR	COMMODITY TAXES - 2010 PRICES - HOUSING	2010$m
125	SEXC	EXPORTS - MFG	2010$m
126	SEXI	EXPORTS - OTHER	2010$m
127	SEXL	EXPORTS - F&B	2010$m
128	SEXSRC	EXPORTS - EQUILIBRIUM - MFG	2010$m
129	SEXSRI	EXPORTS - EQUILIBRIUM - OTHER	2010$m

#	Code	Description	Units
130	SEXSRL	EXPORTS - EQUILIBRIUM - F&B	2010$m
131	SIFC	NON-RESIDENTIAL INVESTMENT DEMAND - MFG	2010$m
132	SIFE	NON-RESIDENTIAL INVESTMENT DEMAND - CTN	2010$m
133	SIFI	NON-RESIDENTIAL INVESTMENT DEMAND - OTHER	2010$m
134	SIFL	NON-RESIDENTIAL INVESTMENT DEMAND - F&B	2010$m
135	SIHE	RESIDENTIAL INVESTMENT SUPPLY - MFG	2010$m
136	SIHI	RESIDENTIAL INVESTMENT SUPPLY - CTN	2010$m
137	SIHL	RESIDENTIAL INVESTMENT SUPPLY - F&B	2010$m
138	SIMC	IMPORTS - MFG	2010$m
139	SIMI	IMPORTS - OTHER	2010$m
140	SIML	IMPORTS - F&B	2010$m
141	SIMSRC	IMPORTS - EQUILIBRIUM - MFG	2010$m
142	SIMSRI	IMPORTS - EQUILIBRIUM - OTHER	2010$m
143	SIMSRL	IMPORTS - EQUILIBRIUM - F&B	2010$m
144	SISC	NON-RESIDENTIAL INVESTMENT SUPPLY - MFG	2010$m
145	SISE	NON-RESIDENTIAL INVESTMENT SUPPLY - CTN	2010$m
146	SISI	NON-RESIDENTIAL INVESTMENT SUPPLY - OTHER	2010$m
147	SISL	NON-RESIDENTIAL INVESTMENT SUPPLY - F&B	2010$m
148	SKC	CAPITAL STOCK DEMAND - MFG	2010$m
149	SKE	CAPITAL STOCK DEMAND - CTN	2010$m
150	SKI	CAPITAL STOCK DEMAND - OTHER	2010$m
151	SKL	CAPITAL STOCK DEMAND - F&B	2010$m
152	SMISC	INTERMEDIATE SUPPLY - MFG	2010$m
153	SMISE	INTERMEDIATE SUPPLY - CTN	2010$m
154	SMISI	INTERMEDIATE SUPPLY - OTHER	2010$m
155	SMISL	INTERMEDIATE SUPPLY - F&B	2010$m
156	SNFC	EMPLOYMENT - FOREIGN - MFG	000 pers.
157	SNFE	EMPLOYMENT - FOREIGN - CTN	000 pers.
158	SNFI	EMPLOYMENT - FOREIGN - OTHER	000 pers.
159	SNFL	EMPLOYMENT - FOREIGN - F&B	000 pers.
160	SNC	EMPLOYMENT – LOCAL - MFG	000 pers.
161	SNE	EMPLOYMENT – LOCAL - CTN	000 pers.
162	SNI	EMPLOYMENT - LOCAL - OTHER	000 pers.
163	SNL	EMPLOYMENT - LOCAL - F&B	000 pers.
164	SNLC	EMPLOYMENT - LOCALS - MFG	000 pers.
165	SNLE	EMPLOYMENT - LOCALS - CTN	000 pers.
166	SNLI	EMPLOYMENT - LOCALS - OTHER	000 pers.
167	SNLL	EMPLOYMENT - LOCALS - F&B	000 pers.
168	SNLSRC	EMPLOYMENT - LOCALS- EQ'M - MFG	000 pers.
169	SNLSRE	EMPLOYMENT - LOCALS- EQ'M - CTN	000 pers.
170	SNLSRI	EMPLOYMENT - LOCALS- EQ'M - OTHER	000 pers.
171	SNLSRL	EMPLOYMENT - LOCALS- EQ'M - F&B	000 pers.
172	SNFSRC	EMPLOYMENT - FOREIGN- EQ'M - MFG	000 pers.
173	SNFSRE	EMPLOYMENT - FOREIGN - EQ'M - CTN	000 pers.
174	SNFSRI	EMPLOYMENT - FOREIGN - EQ'M - OTHER	000 pers.

#	Code	Description	Units
175	SNFSRL	EMPLOYMENT - FOREIGN - EQ'M - F&B	000 pers.
176	SNSRC	EMPLOYMENT - EQ'M - MFG	000 pers.
177	SNSRE	EMPLOYMENT - EQ'M - CTN	000 pers.
178	SNSRI	EMPLOYMENT - EQ'M - OTHER	000 pers.
179	SNSRL	EMPLOYMENT - EQ'M - MFG	000 pers.
180	SPCC	PRICE - PRIVATE CONSUMPTION - MFG	2010=1
181	SPCI	PRICE - PRIVATE CONSUMPTION - OTHER	2010=1
182	SPCL	PRICE - PRIVATE CONSUMPTION - F&B	2010=1
183	SPCR	PRICE - PRIVATE CONSUMPTION - RENT	2010=1
184	SPCRD	PRICE - PRIVATE CONSUMPTION - EQUILIBRIUM - RENT	index
185	SPISC	PRICE - NON-RESID. INVESTMENT SUPPLY - MFG	2010=1
186	SPISE	PRICE - NON-RESID. INVESTMENT SUPPLY - CTN	2010=1
187	SPISI	PRICE - NON-RESID. INVESTMENT SUPPLY - OTHER	2010=1
188	SPISL	PRICE - NON-RESID. INVESTMENT SUPPLY - F&B	2010=1
189	SPKC	PRICE - CAPITAL STOCK SERVICES DEMAND - MFG	index
190	SPKE	PRICE - CAPITAL STOCK SERVICES DEMAND - CTN	index
191	SPKI	PRICE - CAPITAL STOCK SERVICES DEMAND - OTHER	index
192	SPKL	PRICE - CAPITAL STOCK SERVICES DEMAND - F&B	index
193	SPKR	PRICE - CAPITAL STOCK SERVICES DEMAND - HOUSING	index
194	SPXC	PRICE - LOCAL SALES - MFG	2010=1
195	SPXE	PRICE - LOCAL SALES - CTN	2010=1
196	SPXI	PRICE - LOCAL SALES - OTHER	2010=1
197	SPXL	PRICE - LOCAL SALES - F&B	2010=1
198	SPXR	PRICE - LOCAL SALES - RENT	2010=1
199	SPXSRC	PRICE - LOCAL SALES - EQUILIBRIUM - MFG	2010=1
200	SPXSRE	PRICE - LOCAL SALES - EQUILIBRIUM - CTN	2010=1
201	SPXSRI	PRICE - LOCAL SALES - EQUILIBRIUM - OTHER	2010=1
202	SPXSRL	PRICE - LOCAL SALES - EQUILIBRIUM - F&B	2010=1
203	SPYSRC	PRICE - PRIMARY FACTORS - EQUILIBRIUM - MFG	2010=1
204	SPYSRE	PRICE - PRIMARY FACTORS - EQUILIBRIUM - CTN	2010=1
205	SPYSRI	PRICE - PRIMARY FACTORS - EQUILIBRIUM - OTHER	2010=1
206	SPYSRL	PRICE - PRIMARY FACTORS - EQUILIBRIUM - F&B	2010=1
207	SPYSRR	PRICE - PRIMARY FACTORS - EQUILIBRIUM - RENT	2010=1
208	SPZASRC	PRICE - TOTAL SUPPLY - EQUILIBRIUM - MFG	2010=1
209	SPZASRI	PRICE - TOTAL SUPPLY - EQUILIBRIUM - OTHER	2010=1
210	SPZASRL	PRICE - TOTAL SUPPLY - EQUILIBRIUM - F&B	2010=1
211	SPZSRC	PRICE - LOCAL SUPPLY - EQUILIBRIUM - MFG	2010=1
212	SPZSRI	PRICE - LOCAL SUPPLY - EQUILIBRIUM - OTHER	2010=1
213	SPZSRL	PRICE - LOCAL SUPPLY - EQUILIBRIUM - F&B	2010=1
214	SXC	LOCAL SALES - MFG	2010$m
215	SXE	LOCAL SALES - CTN	2010$m
216	SXI	LOCAL SALES - OTHER	2010$m
217	SXL	LOCAL SALES - F&B	2010$m
218	SXR	LOCAL SALES - RENT	2010$m

#	Code	Description	Units
219	SY	PRIMARY FACTORS	2010$m
220	SYC	PRIMARY FACTORS - MFG	2010$m
221	SYE	PRIMARY FACTORS - CTN	2010$m
222	SYI	PRIMARY FACTORS - OTHER	2010$m
223	SYL	PRIMARY FACTORS - F&B	2010$m
224	SYR	PRIMARY FACTORS - RENT	2010$m
225	SYSRC	PRIMARY FACTORS - EQUILIBRIUM - MFG	2010$m
226	SYSRE	PRIMARY FACTORS - EQUILIBRIUM - CTN	2010$m
227	SYSRI	PRIMARY FACTORS - EQUILIBRIUM - OTHER	2010$m
228	SYSRL	PRIMARY FACTORS - EQUILIBRIUM - F&B	2010$m
229	SYSRR	PRIMARY FACTORS - EQUILIBRIUM - RENT	2010$m
230	SZASRC	TOTAL SUPPLY - EQUILIBRIUM - MFG	2010$m
231	SZASRI	TOTAL SUPPLY - EQUILIBRIUM - OTHER	2010$m
232	SZASRL	TOTAL SUPPLY - EQUILIBRIUM - F&B	2010$m
233	SZSRC	LOCAL SUPPLY - EQUILIBRIUM - MFG	2010$m
234	SZSRI	LOCAL SUPPLY - EQUILIBRIUM - OTHER	2010$m
235	SZSRL	LOCAL SUPPLY - EQUILIBRIUM - F&B	2010$m
236	TAXASS	DIRECT TAX - ASSETS	$m
237	TAXCD	INDIRECT TAX - IMPORT DUTIES	$m
238	TAXCOE	NON-TAX REVENUE - COE	$m
239	TAXCT	COMMODITY TAXES REVENUE	$m
240	TAXOTI	INDIRECT TAX - OTHER INDIRECT TAXES	$m
241	TAXFWL	FOREIGN WORKER LEVY	$m
242	TAXGST	INDIRECT TAX - GST	$m
243	TAXITC	DIRECT TAX - INCOME - CORPORATE	$m
244	TAXITP	DIRECT TAX - INCOME - PERSONAL	$m
245	TAXITS	DIRECT TAX - INCOME - STAT BOARDS	$m
246	TAXARF	INDIRECT TAX - ARF	$m
247	TAXOIT	PRODUCTION TAXES REVENUE	$m
248	TAXCA	INDIRECT TAX - COE+ARF (accrual / nat. acc. basis)	$m
249	TGSB	BALANCE OF TRADE - NOMINAL - % OF GDPZ	% of gdp
250	TGSBQ	BALANCE OF TRADE - 2010 PRICES - % OF GDPZ	% of gdp
251	TOT	TERMS-OF-TRADE	2010=100
252	TRB	BALANCE ON TRANSFERS	% of gdp
253	TRFOPR	NET TRANSFERS TO PRIVATE SECTOR FROM ABROAD	$m
254	TRPUFO	NET TRANSFERS FROM GOV'T TO ABROAD	$m
255	TRPUPR	SPECIAL TRANSFERS: FROM GOV'T TO PRIVATE	$m
256	ULC	NOMINAL UNIT LABOUR COSTS	index
257	URL	UNEMPLOYMENT RATE - LOCALS - MODEL BASIS	per cent
258	URT	UNEMPLOYMENT RATE - SURVEY	per cent
259	WL	LOCAL AVERAGE QRTLY EARNINGS (INCL. CPF) - sa	$'000
260	WB	WAGE BILL (EXCL. FWL)	$m
261	WBBT	WAGE BILL	$m
262	WHL	AVERAGE MONTHLY EARNINGS (EXCL. CPF) - $	$/month
263	WO	AVERAGE QRTLY EARNINGS (INCL. CPF) - orig	$'000

#	Code	Description	Units
264	WFNTC	QTRLY FOREIGN WAGE BEFORE LEVY - MFG	$'000
265	WFNTE	QTRLY FOREIGN WAGE BEFORE LEVY - CTN	$'000
266	WFNTI	QTRLY FOREIGN WAGE BEFORE LEVY - OTHER	$'000
267	WFNTL	QTRLY FOREIGN WAGE BEFORE LEVY - F&B	$'000
268	WFC	QTRLY FOREIGN WAGE WITH LEVY - MFG	$'000
269	WFE	QTRLY FOREIGN WAGE WITH LEVY - CTN	$'000
270	WFI	QTRLY FOREIGN WAGE WITH LEVY - OTHER	$'000
271	WFL	QTRLY FOREIGN WAGE WITH LEVY - F&B	$'000
272	WSRC	CES-WEIGHTED WAGE - MFG	$'000
273	WSRE	CES-WEIGHTED WAGE - CTN	$'000
274	WSRI	CES-WEIGHTED WAGE - OTHER	$'000
275	WSRL	CES-WEIGHTED WAGE – F&B	$'000
276	WTCON	RENTAL SHARE OF PRIVATE CONSUMPTION - EQ'M	prop.
277	YPT	INCOME - PRIVATE PROPERTY	$m
278	ZP	DEBT - PRIVATE - FOREIGN CURRENCY - BEG.	for$m

APPENDIX B

EQUATION LISTING

B.1 Consumer Demand

I01 Private Consumption - Other

$$CONOZ = CONZM - SPCR \cdot SCONR$$

I02 Unscaled Equilibrium Price of Rental Services

$$SPCRD = \frac{CONOZ}{SCONR}$$

B01 Housing Services Demand (Inverted)

$$\Delta\log(SPCR) = C0100 + C0103 \cdot \log\left(\frac{SPCRD_{-1}}{SPCR_{-1}}\right) + C0101 \cdot \Delta\log(SPCRD)$$
$$+C0102 \cdot \Delta\log(SPCRD_{-2}) + (1 - C0101 - C0102) \cdot \Delta\log(SPCR_{-1})$$
$$+C0104 \cdot DUM894 + C0105 \cdot DUM1 + C0106 \cdot DUM2 + C0107 \cdot DUM3$$
$$+DUM894 \cdot (C0108 \cdot DUM1 + C0109 \cdot DUM2 + C0110 \cdot DUM3) + Z_{SPCR}$$

B02 Private Consumption – Other

$$SCONI = C6000 \cdot \frac{CONOZ}{SPCI}$$

B03 Private Consumption - Financial & Business Services

$$SCONL = C6100 \cdot \frac{CONOZ}{SPCL}$$

I03 Private Consumption – Manufacturing

$$SCONC = \frac{(CONOZ - SPCI \cdot SCONI - SPCL \cdot SCONL)}{SPCC}$$

I04 Housing Services Underlying Share of Consumption

$$WTCON = \frac{\exp\left(\frac{C0100 + \left(\frac{C0105 + C0106 + C0107}{4}\right)}{C0103}\right)}{1 + \exp\left(\frac{C0100 + \left(\frac{C0105 + C0106 + C0107}{4}\right)}{C0103}\right)}$$

I05 Price of Consumption (Model Basis, Logarithm)

$$LPCON = WTCON \cdot \log(SPCR) + (1 - WTCON) \cdot \begin{pmatrix} C6000 \cdot \log(SPCI) + C6100 \cdot \log(SPCL) \\ + (1 - C6000 - C6100) \cdot \log(SPCC) \end{pmatrix}$$

B.2 Participation Rate

B04 Participation Rate (Locals)

$$\log\left(\frac{\left(\frac{NTS}{POP3 + POP4}\right)}{\frac{PRT}{100}}\right) = C0200 + C0201 \cdot DUM1 + C0202 \cdot DUM2$$
$$+ C0203 \cdot DUM3 + C0210 \cdot DUM061 + C0204 \cdot TF$$
$$+ C0205 \cdot \log\left(\frac{\left(\frac{NTS_{-1}}{POP3_{-1} + POP4_{-1}}\right)}{\frac{PRT_{-1}}{100}}\right) + C0206 \cdot \log\left(\frac{\left(\frac{NTS_{-2}}{POP3_{-2} + POP4_{-2}}\right)}{\frac{PRT_{-2}}{100}}\right)$$
$$+ C0207 \cdot \left(\log\left(\frac{(1 - POL1_{-2}) \cdot WL_{-2}}{PCON_{-2}}\right) - 4 \cdot \log(C8005) \cdot TV_{-2}\right)$$
$$+ C0208 \cdot \log\left(\frac{\left(\frac{NL}{POP3 + POP4}\right)}{\frac{PRT}{100}}\right) + C0209 \cdot \log\left(\frac{\left(\frac{NL_{-1}}{POP3_{-1} + POP4_{-1}}\right)}{\frac{PRT_{-1}}{100}}\right) + Z_{NTS}$$

I06 Participation Rate - Model Basis

$$PART = 100 \cdot \frac{NTS}{POP3 + POP4}$$

I07 Labour Force Smoothed Growth Rate

$$POPGR = 0.125 \cdot \left(\Delta \log(POP3 + POP4) + \log\left(\frac{PRT}{PRT_{-1}} \right) \right) + 0.875 \cdot POPGR_{-1}$$

B.3 Wages

B05 Local Wages

$$\Delta \log(WL) = AA0SLGR + C0300 + C0305 \cdot \left(\frac{INFE_{-1}}{400} \right) + (1 - C0305) \cdot \Delta \log(PCON_{-1})$$
$$+ C0301 \cdot DUM1 + C0302 \cdot DUM2 + C0303 \cdot DUM3 + 0.6 \cdot \Delta \log(1 + RCPF)$$
$$+ C0304 \cdot URL_{-1} + Z_W$$

I08 Unemployment - Survey Basis

$$NUN = NTS - NL$$

I09 Unemployment Rate - Locals - Model Basis

$$URL = 100 \cdot \frac{NUN}{NTS}$$

I84A Wages for Foreign – Without Levy

$$WFNT_i = FWFNT_i \cdot E$$

I84B Wages for Foreign – with Levy

$$WF_i = WFNT_i \cdot (1 + POLFWL_i)$$

B.4 Private Consumption

I10 Equilibrium Private Consumption

$$\log(COND) = \frac{(C0400 + C0401 \cdot DUM1 + C0402 \cdot DUM2 + C0403 \cdot DUM3 + C0404 \cdot TF)}{C0406}$$
$$+ \frac{5}{10} \cdot \log \begin{pmatrix} WB + TRFOPR + TRPUPR + (RGEC + RGEK) \cdot GDPZ \\ + NETLEN - TAXITP - REVOTH - TAXITS - INTSB \end{pmatrix}$$
$$+ \frac{5}{10} \cdot \log(PIH \cdot KH + PEX \cdot KI + PIFT \cdot (K - FK) - ZP \cdot E) - LPCON$$

B06 Private Consumption

$$\log(CONZM) - LPCONM = C0405 \cdot (400 \cdot \Delta LPCON - INFE_{-1}) + C0406 \cdot \log(COND)$$
$$+ (1 - C0406) \cdot (\log(CONZM_{-1} \cdot GR) - LPCONM_{-1}) + C0407 \cdot (\Delta URL)$$
$$+ C0408 \cdot (\Delta URL_{-1}) + Z_{CON}$$

B.5 Business Sector in Equilibrium

Industry C

I11C Domestic Sales of Composite Commodity C

$$SXC = SCONC + SISC + SMISC$$

I12C Intermediate Demand for C

$$SMISC = SMCCC \cdot SCC9007 \cdot SYC + SMCCE \cdot SCE9007 \cdot SYE + SMCCI \cdot SCI9007 \cdot SYI$$
$$+ SMCCL \cdot SCL9007 \cdot SYL + SMCCR \cdot SCR9007 \cdot SYR$$

I13C Shadow Price of Primary Factors for C

$$SPYSRC = \left(\frac{WSRC}{SAA0C}\right) \cdot \left(\left(1 + \left(\frac{SAA0C \cdot SNSRC}{SAA1C \cdot SKC} \right)^{-SCC9020} \right)^{\frac{SCC9020-1}{SCC9020}} \right)$$

1I4C Shadow Price of Production of C

$$SPZSRC =$$

$$\left(1+POLOIT\cdot SCC9015\right)\cdot\left(\begin{array}{l}\dfrac{SPYSRC}{SCC9007}+SMCCC\cdot\left(1+POLCT\cdot SMBCC\right)\cdot SPXC\\ +SMCEC\cdot\left(1+POLCT\cdot SMBEC\right)\cdot SPXE\\ +SMCIC\cdot\left(1+POLCT\cdot SMBIC\right)\cdot SPXI\\ +SMCLC\cdot\left(1+POLCT\cdot SMBLC\right)\cdot SPXL\end{array}\right)$$

I15C Shadow Price of Total Supply of C

$$SPZASRC=\left[\left(\frac{PIMAT}{SCC9002}\right)^{(1-SCC9021)}+\left(\frac{SPZSRC}{SCC9003}\right)^{(1-SCC9021)}\right]^{\left(\frac{1}{1-SCC9021}\right)}$$

I16C Shadow Price of Domestic Sales of C

$$SPXSRC=SCC9005\cdot\left(SPZASRC^{\left(\frac{SCC9022}{SCC9022-1}\right)}-\left(\frac{PEX}{SCC9004}\right)^{\left(\frac{SCC9022}{SCC9022-1}\right)}\right)^{\left(\frac{SCC9022-1}{SCC9022}\right)}$$

I17C Short-run Equilibrium Exports of C

$$SEXSRC=\left(\frac{SCC9005}{SCC9004}\right)\cdot SXC\cdot\left(\left(\frac{\left(\frac{PEX}{SCC9004}\right)}{SPZASRC}\right)^{\left(\frac{SCC9022}{1-SCC9022}\right)}-1\right)^{\left(\frac{-1}{SCC9022}\right)}$$

I18C Short-run Equilibrium Total Supply of C

$$SZASRC=\left(\left(SCC9004\cdot SEXSRC\right)^{SCC9022}+\left(SCC9005\cdot SXC\right)^{SCC9022}\right)^{\left(\frac{1}{SCC9022}\right)}$$

19C Short-run Equilibrium Imports of C

$$SIMSRC=\left(\frac{1}{SCC9002}\right)\cdot SZASRC\cdot\left(1+\left(\frac{\left(\frac{SPZSRC}{SCC9003}\right)}{\left(\frac{PIMAT}{SCC9002}\right)}\right)^{(1-SCC9021)}\right)^{\left(\frac{SCC9021}{1-SCC9021}\right)}$$

I20C Short-run Equilibrium Production of C

$$SZSRC = \left(\frac{1}{SCC9003}\right) \cdot SZASRC \cdot \left(1 + \frac{\left(\frac{PIMAT}{SCC9002}\right)^{(1-SCC9021)}}{\left(\frac{SPZSRC}{SCC9003}\right)}\right)^{\left(\frac{SCC9021}{1-SCC9021}\right)}$$

I21C Short-run Equilibrium Primary Factors for C

$$SYSRC = \frac{SZSRC}{SCC9007}$$

I22C Short-run Equilibrium l Employment for C

$$SNSRC = \left(\frac{1}{SAA0C}\right) \cdot \left(SYSRC^{SCC9020} - \left(SAA1C \cdot SKC\right)^{SCC9020}\right)^{\left(\frac{1}{SCC9020}\right)}$$

I22CA Short-run Equilibrium Local Employment for C

$$SNLSRC = \left(\frac{\left(\frac{WL}{ALC}\right)}{WSRC}\right)^{\left(\frac{1}{SCC9920-1}\right)} \cdot \frac{SNSRC}{ALC}$$

I22CB Short-run Equilibrium Foreign Employment for C

$$SNFSRC = \left(\frac{1}{AFC}\right) \cdot \left(SNSRC^{SCC9920} - \left(ALC \cdot SNLSRC\right)^{SCC9920}\right)^{\left(\frac{1}{SCC9920}\right)}$$

I22CC CES-weighted Wage for C

$$WSRC = \left(\left(\frac{WFC}{AFC}\right)^{\left(\frac{SCC9920}{SCC9920-1}\right)} + \left(\frac{WL}{ALC}\right)^{\left(\frac{SCC9920}{SCC9920-1}\right)}\right)^{\left(\frac{SCC9920-1}{SCC9920}\right)}$$

Industry E

I11E Domestic Sales of Composite Commodity E

$$SXE = SIHE + SISE + SMISE$$

I12E Intermediate Demand for E

$$SMISE = SMCEC \cdot SCC9007 \cdot SYC + SMCEE \cdot SCE9007 \cdot SYE + SMCEI \cdot SCI9007 \cdot SYI + SMCEL \cdot SCL9007 \cdot SYL + SMCER \cdot SCR9007 \cdot SYR$$

I13E Shadow Price of Primary Factors for E

$$SPYSRE = \left(\frac{WSRE}{SAA0E}\right) \cdot \left(1 + \left(\frac{SAA0E \cdot SNSRE}{SAA1E \cdot SKE}\right)^{-SCE9020}\right)^{\left(\frac{SCE9020-1}{SCE9020}\right)}$$

1I4E Shadow Price of Production of E

$$SPZSRE = \left(1 + POLOIT \cdot SCE9015\right) \cdot \left(\begin{array}{l} \frac{SPYSRE}{SCE9007} \\ +SMCCE \cdot \left(1 + POLCT \cdot SMBCE\right) \cdot SPXC \\ +SMCEE \cdot \left(1 + POLCT \cdot SMBEE\right) \cdot SPXE \\ +SMCIE \cdot \left(1 + POLCT \cdot SMBIE\right) \cdot SPXI \\ +SMCLE \cdot \left(1 + POLCT \cdot SMCLE\right) \cdot SPXL \end{array}\right)$$

I16E Shadow Price of Domestic Sales of E

$$SPXSRE = SPZSRE$$

I20E Short-run Equilibrium Production of E

$$SZSRE = SXE$$

I21E Short-run Equilibrium Primary Factors for E

$$SYSRE = \frac{SXE}{SCE9007}$$

I22E Short-run Equilibrium Employment for E

$$SNSRE = \left(\frac{1}{SAA0E}\right) \cdot \left(SYSRE^{SCE9020} - \left(SAA1E \cdot SKE\right)^{SCE9020}\right)^{\left(\frac{1}{SCE9020}\right)}$$

I22EA Short-run Equilibrium Local Employment for E

$$SNLSRE = \left(\frac{\left(\frac{WL}{ALE} \right)}{WSRE} \right)^{\left(\frac{1}{SCE9920-1} \right)} \cdot \frac{SNSRE}{ALE}$$

I22EB Short-run Equilibrium Foreign Employment for E

$$SNFSRE = \left(\frac{1}{AFE} \right) \cdot \left(SNSRE^{SCE9920} - \left(ALE \cdot SNLSRE \right)^{SCE9920} \right)^{\left(\frac{1}{SCE9920} \right)}$$

I22EC CES-weighted Wage for E

$$WSRE = \left(\left(\frac{WFE}{AFE} \right)^{\left(\frac{SCE9920}{SCE9920-1} \right)} + \left(\frac{WL}{ALE} \right)^{\left(\frac{SCE9920}{SCE9920-1} \right)} \right)^{\left(\frac{SCE9920-1}{SCE9920} \right)}$$

Industry I

I11I Domestic Sales of Composite Commodity I

$$SXI = SCONI + GCON + SIHI + SISI + SMISI$$

I12I Intermediate Demand for I

$$SMISI = SMCIC \cdot SCC9007 \cdot SYC + SMCIE \cdot SCE9007 \cdot SYE + SMCII \cdot SCI9007 \cdot SYI + SMCIL \cdot SCL9007 \cdot SYL + SMCIR \cdot SCR9007 \cdot SYR$$

I13I Shadow Price of Primary Factors for I

$$SPYSRI = \left(\frac{WSRI}{SAA0I} \right) \cdot \left(1 + \left(\frac{SAA0I \cdot SNSRI}{SAA1I \cdot SKI} \right)^{-SCI9020} \right)^{\left(\frac{SCI9020-1}{SCI9020} \right)}$$

I14I Shadow Price of Production of I

$$SPZSRI = \left(1 + POLOIT \cdot SCI9015 \right) \cdot \left(\begin{array}{l} \frac{SPYSRI}{SCI9007} \\ + SMCCI \cdot \left(1 + POLCT \cdot SMBCI \right) \cdot SPXC \\ + SMCEI \cdot \left(1 + POLCT \cdot SMBEI \right) \cdot SPXE \\ + SMCII \cdot \left(1 + POLCT \cdot SMBII \right) \cdot SPXI \\ + SMCLI \cdot \left(1 + POLCT \cdot SMBLI \right) \cdot SPXL \end{array} \right)$$

I15I Shadow Price of Total Supply of I

$$SPZASRI = \left(\left(\frac{PIM}{SCI9002} \right)^{(1-SCI9021)} + \left(\frac{SPZSRI}{SCI9003} \right)^{(1-SCI9021)} \right)^{\left(\frac{1}{1-SCI9021} \right)}$$

I16I Shadow Price of Domestic Sales of I

$$SPXSRI = SCI9005 \cdot \left(SPZASRI^{\left(\frac{SCI9022}{SCI9022-1} \right)} - \left(\frac{PEX}{SCI9004} \right)^{\left(\frac{SCI9022}{SCI9022-1} \right)} \right)^{\left(\frac{SCI9022-1}{SCI9022} \right)}$$

I17I Short-run Equilibrium Exports of I

$$SEXSRI = \left(\frac{SCI9005}{SCI9004} \right) \cdot SXI \cdot \left(\left(\frac{\left(\frac{PEX}{SCI9004} \right)}{SPZASRI} \right)^{\left(\frac{SCI9022}{1-SCI9022} \right)} - 1 \right)^{\left(\frac{-1}{SCI9022} \right)}$$

I18I Short-run Equilibrium Total Supply of I

$$SZASRI = \left(\left(SCI9004 \cdot SEXSRI \right)^{SCI9022} + \left(SCI9005 \cdot SXI \right)^{SCI9022} \right)^{\left(\frac{1}{SCI9022} \right)}$$

I19I Short-run Equilibrium Imports of I

$$SIMSRI = \left(\frac{1}{SCI9002} \right) \cdot SZASRI \cdot \left(1 + \left(\frac{\left(\frac{SPZSRI}{SCI9003} \right)}{\left(\frac{PIM}{SCI9002} \right)} \right)^{(1-SCI9021)} \right)^{\left(\frac{SCI9021}{1-SCI9021} \right)}$$

I20I Short-run Equilibrium Production of I

$$SZSRI = \left(\frac{1}{SCI9003} \right) \cdot SZASRI \cdot \left(1 + \left(\frac{\left(\frac{PIM}{SCI9002} \right)}{\left(\frac{SPZSRI}{SCI9003} \right)} \right)^{(1-SCI9021)} \right)^{\left(\frac{SCI9021}{1-SCI9021} \right)}$$

I21I Short-run Equilibrium Primary Factors for I

$$SYSRI = \frac{SZSRI}{SCI9007}$$

I22I Short-run Equilibrium Employment for I

$$SNSRI = \left(\frac{1}{SAA0I}\right) \cdot \left(SYSRI^{SCI9020} - \left(SAA1I \cdot SKI\right)^{SCI9020}\right)^{\left(\frac{1}{SCI9020}\right)}$$

I22IA Short-run Equilibrium Local Employment for I

$$SNLSRI = \left(\frac{\left(\frac{WL}{ALI}\right)}{WSRI}\right)^{\left(\frac{1}{SCI9920-1}\right)} \cdot \frac{SNSRI}{ALI}$$

I22IB Short-run Equilibrium Foreign Employment for I

$$SNFSRI = \left(\frac{1}{AFI}\right) \cdot \left(SNSRI^{SCI9920} - \left(ALI \cdot SNLSRI\right)^{SCI9920}\right)^{\left(\frac{1}{SCI9920}\right)}$$

I22IC CES-weighted Wage for I

$$WSRI = \left(\left(\frac{WFI}{AFI}\right)^{\left(\frac{SCI9920}{SCI9920-1}\right)} + \left(\frac{WL}{ALI}\right)^{\left(\frac{SCI9920}{SCI9920-1}\right)}\right)^{\left(\frac{SCI9920-1}{SCI9920}\right)}$$

Industry L

I11L Domestic Sales of Composite Commodity L

$$SXL = SCONL + SIHL + SISL + SMISL$$

I12L Intermediate Demand for L

$$SMISL = SMCLC \cdot SCC9007 \cdot SYC + SMCLE \cdot SCE9007 \cdot SYE$$
$$+SMCLI \cdot SCI9007 \cdot SYI + SMCLL \cdot SCL9007 \cdot SYL$$
$$+SMCLR \cdot SCR9007 \cdot SYR$$

I13L Shadow Price of Primary Factors for L

$$SPYSRL = \left(\frac{WSRL}{SAA0L}\right) \cdot \left(1 + \left(\frac{SAA0L \cdot SNSRL}{SAA1L \cdot SKL}\right)^{(-SCL9020)}\right)^{\left(\frac{SCL9020-1}{SCL9020}\right)}$$

1I4L Shadow Price of Production of L

$$SPZSRL = \left(1 + POLOIT \cdot SCL9015\right) \cdot \left(\begin{array}{l} \dfrac{SPYSRL}{SCL9007} \\ +SMCCL \cdot \left(1 + POLCT \cdot SMBCL\right) \cdot SPXC \\ +SMCEL \cdot \left(1 + POLCT \cdot SMBEL\right) \cdot SPXE \\ +SMCIL \cdot \left(1 + POLCT \cdot SMBIL\right) \cdot SPXI \\ +SMCLL \cdot \left(1 + POLCT \cdot SMBLL\right) \cdot SPXL \end{array} \right)$$

I15L Shadow Price of Total Supply of L

$$SPZASRL = \left(\left(\frac{PIM}{SCL9002} \right)^{(1-SCL9021)} + \left(\frac{SPZSRL}{SCL9003} \right)^{(1-SCL9021)} \right)^{\left(\frac{1}{1-SCL9021} \right)}$$

I16L Shadow Price of Domestic Sales of L

$$SPXSRL = SCL9005 \cdot \left(SPZASRL^{\left(\frac{SCL9022}{SCL9022-1} \right)} - \left(\frac{PEX}{SCL9004} \right)^{\left(\frac{SCL9022}{SCL9022-1} \right)} \right)^{\left(\frac{SCL9022-1}{SCL9022} \right)}$$

I17L Short-run Equilibrium Exports of L

$$SEXSRL = \left(\frac{SCL9005}{SCL9004} \right) \cdot SXL \cdot \left(\left(\frac{\left(\frac{PEX}{SCL9004} \right)}{SPZASRL} \right)^{\left(\frac{SCL9022}{1-SCL9022} \right)} - 1 \right)^{\left(\frac{-1}{SCL9022} \right)}$$

I18L Short-run Equilibrium Total Supply of L

$$SZASRL = \left(\left(SCL9004 \cdot SEXSRL \right)^{SCL9022} + \left(SCL9005 \cdot SXL \right)^{SCL9022} \right)^{\left(\frac{1}{SCL9022} \right)}$$

19L Short-run Equilibrium Imports of L

$$SIMSRL = \left(\frac{1}{SCL9002} \right) \cdot SZASRL \cdot \left(1 + \left(\frac{\left(\frac{SPZSRL}{SCL9003} \right)}{\left(\frac{PIM}{SCL9002} \right)} \right)^{(1-SCL9021)} \right)^{\left(\frac{SCL9021}{1-SCL9021} \right)}$$

I20L Short-run Equilibrium Production of L

$$SZSRL = \left(\frac{1}{SCL9003}\right) \cdot SZASRL \cdot \left(1 + \frac{\left(\frac{PIM}{SCL9002}\right)^{(1-SCL9021)}}{\left(\frac{SPZSRL}{SCL9003}\right)}\right)^{\left(\frac{SCL9021}{1-SCL9021}\right)}$$

I21L Short-run Equilibrium Primary Factors for L

$$SYSRL = \frac{SZSRL}{SCL9007}$$

I22L Short-run Equilibrium Employment for L

$$SNSRL = \left(\frac{1}{SAA0L}\right) \cdot \left(SYSRL^{SCL9020} - \left(SAA1L \cdot SKL\right)^{SCL9020}\right)^{\left(\frac{1}{SCL9020}\right)}$$

I22LA Short-run Equilibrium Local Employment for L

$$SNLSRL = \left(\frac{\left(\frac{WL}{ALL}\right)}{WSRL}\right)^{\left(\frac{1}{SCL9920-1}\right)} \cdot \frac{SNSRL}{ALL}$$

I22LB Short-run Equilibrium Foreign Employment for L

$$SNFSRL = \left(\frac{1}{AFL}\right) \cdot \left(SNSRL^{SCL9920} - \left(ALL \cdot SNLSRL\right)^{SCL9920}\right)^{\left(\frac{1}{SCL9920}\right)}$$

I22LC CES-weighted Wage for L

$$WSRL = \left(\left(\frac{WFL}{AFL}\right)^{\left(\frac{SCL9920}{SCL9920-1}\right)} + \left(\frac{WL}{ALL}\right)^{\left(\frac{SCL9920}{SCL9920-1}\right)}\right)^{\left(\frac{SCL9920-1}{SCL9920}\right)}$$

Industry R

I11R Domestic Sales of Composite Commodity R

$$SCONR = SXR$$

I13R Shadow Price of Primary Factors for R

$$SPYSRR = \left[\frac{SPXR}{(1+POLOIT \cdot SCR9015)} - \begin{pmatrix} SMCCR \cdot (1+POLCT \cdot SMBCR) \cdot SPXC \\ +SMCER \cdot (1+POLCT \cdot SMBER) \cdot SPXE \\ +SMCIR \cdot (1+POLCT \cdot SMBIR) \cdot SPXI \\ +SMCLR \cdot (1+POLCT \cdot SMBLR) \cdot SPXL \end{pmatrix} \right] \cdot SCR9007$$

I21R Short-run Equilibrium Production of R

$$SXR = SCR9007 \cdot SYSRR$$

I22R Short-run Equilibrium Primary Factors for R

$$SYSRR = SAA1R \cdot KH$$

Equilibrium Growth

I23A Smoothed Growth in Local Labour Efficiency

$$AA0SLGR = \frac{\begin{pmatrix} SNLC_{-1} \cdot \Delta\log(ALC) + SNLE_{-1} \cdot \Delta\log(ALE) \\ +SNLI_{-1} \cdot \Delta\log(ALI) + SNLL_{-1} \cdot \Delta\log(ALL) \end{pmatrix}}{NL_{-1}}$$

I23B Smoothed Growth in Labour Efficiency

$$AA0SGR = \frac{\sum_i \left(WL_{-1} \cdot SNLi_{-1} \cdot \Delta\log(ALi) + WFi_{-1} \cdot SNFi_{-1} \cdot \Delta\log(AFi) \right)}{\sum_i \left(WL_{-1} \cdot SNLi_{-1} + WFi_{-1} \cdot SNFi_{-1} \right)}$$

I24 Equilibrium Real Growth Factor

$$\log(GR) = POPGR + 0.125 \cdot AA0SGR + 0.875 \cdot \left(\log(GR_{-1}) - POPGR_{-1} \right)$$

Industry C

I25C Primary Factors for C

$$SYC = \frac{(SXC - SIMC - SCM9012 \cdot SIMC + SEXC)}{SCC9007}$$

I26C Commodity Taxes in Constant Prices for C

$$SCTC = SCC9012 \cdot SCONC + SCC9013 \cdot SISC + \begin{bmatrix} SMBCC \cdot SMCCC \cdot SCC9007 \cdot SYC \\ +SMBCE \cdot SMCCE \cdot SCE9007 \cdot SYE \\ +SMBCI \cdot SMCCI \cdot SCI9007 \cdot SYI \\ +SMBCL \cdot SMCCL \cdot SCL9007 \cdot SYL \\ +SMBCR \cdot SMCCR \cdot SCR9007 \cdot SYR \end{bmatrix}$$

I27C GDP for C

$$GDPPC = SYC \cdot \left(1 + SCC9007 \cdot \frac{SCC9015}{1 + SCC9015}\right)$$

Industry E

I25E Primary Factors for E

$$SYE = \frac{SXE}{SCE9007}$$

I26E Commodity Taxes in Constant Prices for E

$$SCTE = SCE9013 \cdot SISE + \begin{bmatrix} SMBEC \cdot SMCEC \cdot SCC9007 \cdot SYC \\ +SMBEE \cdot SMCEE \cdot SCE9007 \cdot SYE \\ +SMBEI \cdot SMCEI \cdot SCI9007 \cdot SYI \\ +SMBEL \cdot SMCEL \cdot SCL9007 \cdot SYL \\ +SMBER \cdot SMCER \cdot SCR9007 \cdot SYR \end{bmatrix}$$

I27E GDP for E

$$GDPPE = SYE \cdot \left(1 + SCE9007 \cdot \frac{SCE9015}{1 + SCE9015}\right)$$

Industry I

I25I Primary Factors for I

$$SYI = \frac{\left(SXI - SIMI + SEXI\right)}{SCI9007}$$

I26I Commodity Taxes in Constant Prices for I

$$SCTI = SCI9012 \cdot SCONI + SCI9013 \cdot SISI + \begin{bmatrix} SMBIC \cdot SMCIC \cdot SCC9007 \cdot SYC \\ +SMBIE \cdot SMCIE \cdot SCE9007 \cdot SYE \\ +SMBII \cdot SMCII \cdot SCI9007 \cdot SYI \\ +SMBIL \cdot SMCIL \cdot SCL9007 \cdot SYL \\ +SMBIR \cdot SMCIR \cdot SCR9007 \cdot SYR \end{bmatrix}$$

I27I GDP for I

$$GDPPI = SYI \cdot \left(1 + SCI9007 \cdot \frac{SCI9015}{1 + SCI9015} \right)$$

Industry L

I25L Primary Factors for L

$$SYL = \frac{\left(SXL - SIML + SEXL \right)}{SCL9007}$$

I26L Commodity Taxes in Constant Prices for L

$$SCTL = SCL9012 \cdot SCONL + SCL9013 \cdot SISL + \begin{bmatrix} SMBLC \cdot SMCLC \cdot SCC9007 \cdot SYC \\ +SMBLE \cdot SMCLE \cdot SCE9007 \cdot SYE \\ +SMBLI \cdot SMCLI \cdot SCI9007 \cdot SYI \\ +SMBLL \cdot SMCLL \cdot SCL9007 \cdot SYL \\ +SMBLR \cdot SMCLR \cdot SCR9007 \cdot SYR \end{bmatrix}$$

I27L GDP for L

$$GDPPL = SYL \cdot \left(1 + SCL9007 \cdot \frac{SCL9015}{1 + SCL9015} \right) + \frac{\left(1 - ROWNO \right)}{ROWNO} \cdot GDPPR$$

Industry R

I25R Primary Factors for R

$$SYR = \frac{SXR}{SCR9007}$$

I26R Commodity Taxes in Constant Prices for R

$$SCTR = SCR9012 \cdot SCONR + SMBRC \cdot SMCRC \cdot SCC9007 \cdot SYC$$
$$+SMBRE \cdot SMCRE \cdot SCE9007 \cdot SYE + SMBRI \cdot SMCRI \cdot SCI9007 \cdot SYI$$
$$+SMBRL \cdot SMCRL \cdot SCL9007 \cdot SYL + SMBRR \cdot SMCRR \cdot SCR9007 \cdot SYR$$

I27R GDP for R

$$GDPPR = ROWNO \cdot SYR \cdot \left(1 + SCR9007 \cdot \frac{SCR9015}{1 + SCR9015} \right)$$

B.6 Imports

B07C Manufacturing Imports

$$\log(SIMC) =$$
$$SCC5800 + SCC5801 \cdot DUM1 + SCC5802 \cdot DUM2 + SCC5803 \cdot DUM3 + SCC5804 \cdot TF$$
$$+SCC5805 \cdot \log(GR \cdot SIMSRC_{-1}) + (1 - SCC5805) \cdot \log(GR \cdot SIMC_{-1})$$
$$+SCC5806 \cdot \left[\log\left(\frac{SEXC}{GR \cdot SEXSRC_{-1}} \right) - (1 - SCC5805) \cdot \log\left(\frac{SEXC_{-1}}{GR_{-1} \cdot SEXSRC_{-2}} \right) \right] + SZ_{IMC}$$

B07I Other Imports

$$\log(SIMI) = SCI5800 + SCI5801 \cdot DUM1 + SCI5802 \cdot DUM2 + SCI5803 \cdot DUM3 + SCI5804 \cdot TF$$
$$+SCI5805 \cdot \log(GR \cdot SIMSRI_{-1}) + (1 - SCI5805) \cdot \log(GR \cdot SIMI_{-1}) + SZ_{IMI}$$

B07L Finance & Business Imports

$$\log(SIML) = SCL5800 + SCL5801 \cdot DUM1 + SCL5802 \cdot DUM2 + SCL5803 \cdot DUM3 + SCL5804 \cdot TF$$
$$+SCL5805 \cdot \log(GR \cdot SIMSRL_{-1}) + (1 - SCL5805) \cdot \log(GR \cdot SIML_{-1}) + SZ_{IML}$$

I28 Product Taxes in Constant Prices

$$GDPPD = RGDPPD \cdot \begin{pmatrix} (1 + SCC9012) \cdot SCONC + (1 + SCI9012) \cdot SCONI \\ +(1 + SCL9012) \cdot SCONL \end{pmatrix}$$
$$+SCTC + SCTE + SCTI + SCTL + SCTR + SCM9012 \cdot SIMC$$

B.7 Employment

Industry C

B08CA Local Manufacturing Employment

$$\log(SNLC) = SCC5600 + SCC5601 \cdot DUM1 + SCC5602 \cdot DUM2 + SCC5603 \cdot DUM3$$
$$+SCC5604 \cdot TF + SCC5605 \cdot \log(SNLSRC) + (1 - SCC5605) \cdot \log(\exp(POPGR) \cdot SNLC_{-1})$$
$$+SCC5607 \cdot \begin{bmatrix} \log(SNLC_{-1}) - SCC5605 \cdot \log(SNLSRC_{-1}) \\ -(1 - SCC5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNLC_{-2}) \end{bmatrix}$$
$$+SCC5606 \cdot \log\left(\frac{SPXSRC}{SPXC}\right) + SZ_{NLC}$$

B08CB Foreign Manufacturing Employment

$$\log(SNFC) = SCCF5600 + SCCF5601 \cdot DUM1 + SCCF5602 \cdot DUM2 + SCCF5603 \cdot DUM3$$
$$+SCCF5604 \cdot TF + SCCF5605 \cdot \log(SNFSRC) + (1 - SCCF5605) \cdot \log(\exp(POPGR) \cdot SNFC_{-1})$$
$$+SCCF5607 \cdot \begin{bmatrix} \log(SNFC_{-1}) - SCCF5605 \cdot \log(SNFSRC_{-1}) \\ -(1 - SCCF5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNFC_{-2}) \end{bmatrix}$$
$$+SCCF5606 \cdot \log\left(\frac{SPXSRC}{SPXC}\right) + SZ_{NFC}$$

I29C Total Employment for C

$$SNC = SNLC + SNFC$$

Industry E

B08EA Local Construction Employment

$$\log(SNLE) = SCE5600 + SCE5601 \cdot DUM1 + SCE5602 \cdot DUM2 + SCE5603 \cdot DUM3$$
$$+SCE5604 \cdot TF + SCE5605 \cdot \log(SNLSRE) + (1 - SCE5605) \cdot \log(\exp(POPGR) \cdot SNLE_{-1})$$
$$+SCE5607 \cdot \begin{bmatrix} \log(SNLE_{-1}) - SCE5605 \cdot \log(SNLSRE_{-1}) \\ -(1 - SCE5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNLE_{-2}) \end{bmatrix}$$
$$+SCE5606 \cdot \log\left(\frac{SPXSRE}{SPXE}\right) + SZ_{NLE}$$

B08EB Foreign Construction Employment

$$\log(SNFE) = SCEF5600 + SCEF5601 \cdot DUM1 + SCEF5602 \cdot DUM2 + SCEF5603 \cdot DUM3$$
$$+SCEF5604 \cdot TF + SCEF5605 \cdot \log(SNFSRE) + (1 - SCEF5605) \cdot \log(\exp(POPGR) \cdot SNFE_{-1})$$
$$+SCEF5607 \cdot \begin{bmatrix} \log(SNFE_{-1}) - SCEF5605 \cdot \log(SNFSRE_{-1}) \\ -(1 - SCEF5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNFE_{-2}) \end{bmatrix}$$
$$+SCEF5606 \cdot \log\left(\frac{SPXSRE}{SPXE}\right) + SZ_{NFE}$$

I29E Total Employment for E

$$SNE = SNLE + SNFE$$

Industry I

B08IA Local Other Employment

$$\log(SNLI) = SCI5600 + SCI5601 \cdot DUM1 + SCI5602 \cdot DUM2 + SCI5603 \cdot DUM3$$
$$+SCI5604 \cdot TF + SCI5605 \cdot \log(SNLSRI) + (1 - SCI5605) \cdot \log(\exp(POPGR) \cdot SNLI_{-1})$$
$$+SCI5607 \cdot \begin{bmatrix} \log(SNLI_{-1}) - SCI5605 \cdot \log(SNLSRI_{-1}) - \\ (1 - SCI5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNLI_{-2}) \end{bmatrix}$$
$$+SCI5606 \cdot \log\left(\frac{SPXSRI}{SPXI}\right) + SZ_{NLI}$$

B08IB Foreign Other Employment

$$\log(SNFI) = SCIF5600 + SCIF5601 \cdot DUM1 + SCIF5602 \cdot DUM2 + SCIF5603 \cdot DUM3$$
$$+SCIF5604 \cdot TF + SCIF5605 \cdot \log(SNFSRI) + (1 - SCIF5605) \cdot \log(\exp(POPGR) \cdot SNFI_{-1})$$
$$+SCIF5607 \cdot \begin{bmatrix} \log(SNFI_{-1}) - SCIF5605 \cdot \log(SNFSRI_{-1}) \\ -(1 - SCIF5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNFI_{-2}) \end{bmatrix}$$
$$+SCIF5606 \cdot \log\left(\frac{SPXSRI}{SPXI}\right) + SZ_{NFI}$$

I29I Total Employment for I

$$SNI = SNLI + SNFI$$

Industry L

B08LA Local Finance & Business Employment

$$\log(SNLL) = SCL5600 + SCL5601 \cdot DUM1 + SCL5602 \cdot DUM2 + SCL5603 \cdot DUM3$$
$$+SCL5604 \cdot TF + SCL5605 \cdot \log(SNLSRL) + (1 - SCL5605) \cdot \log(\exp(POPGR) \cdot SNLL_{-1})$$
$$+SCL5607 \cdot \begin{bmatrix} \log(SNLL_{-1}) - SCL5605 \cdot \log(SNLSRL_{-1}) - \\ (1 - SCL5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNLL_{-2}) \end{bmatrix}$$
$$+SCL5606 \cdot \log\left(\frac{SPXSRL}{SPXL}\right) + SZ_{NLL}$$

B08LB Foreign Finance & Business Employment

$$\log(SNFL) = SCLF5600 + SCLF5601 \cdot DUM1 + SCLF5602 \cdot DUM2 + SCLF5603 \cdot DUM3$$
$$+SCLF5604 \cdot TF + SCLF5605 \cdot \log(SNFSRL) + (1 - SCLF5605) \cdot \log(\exp(POPGR) \cdot SNFL_{-1})$$
$$+SCLF5607 \cdot \begin{bmatrix} \log(SNFL_{-1}) - SCLF5605 \cdot \log(SNFSRL_{-1}) - \\ (1 - SCLF5605) \cdot \log(\exp(POPGR_{-1}) \cdot SNFL_{-2}) \end{bmatrix}$$
$$+SCLF5606 \cdot \log\left(\frac{SPXSRL}{SPXL}\right) + SZ_{NFL}$$

I29L Total Employment for L

$$SNL = SNLL + SNFL$$

Total Employment

I30 Total Employment - Locals

$$NL = SNLC + SNLE + SNLI + SNLL$$

I31 Total Employment - Foreign Workers

$$NF = SNFC + SNFE + SNFI + SNFL$$

I32 Total Employment

$$N = SNC + SNE + SNI + SNL$$

B.8 Export Supply

B09C Manufacturing Exports Supply

$$\log(SEXC) = SCC5700 + SCC5701 \cdot DUM1 + SCC5702 \cdot DUM2 + SCC5703 \cdot DUM3$$
$$+SCC5704 \cdot TF + SCC5705 \cdot \log(GR \cdot SEXSRC_{-1}) + (1 - SCC5705) \cdot \log(GR \cdot SEXC_{-1})$$
$$+SCC5706 \cdot \left(\log\left(\frac{GDPF}{GDPF_{-1}} \right) - \log(GR) \right) + SCC5707 \cdot \left(\log\left(\frac{GDPF_{-1}}{GDPF_{-2}} \right) - \log(GR_{-1}) \right)$$
$$+SCC5708 \cdot \left(\log\left(\frac{GDPF_{-2}}{GDPF_{-3}} \right) - \log(GR_{-2}) \right) + SCC5709 \cdot \left(\log\left(\frac{GDPF_{-3}}{GDPF_{-4}} \right) - \log(GR_{-3}) \right)$$
$$+SCC5710 \cdot \log(RBB) + SCC5711 \cdot \log(RBB_{-1}) + SZ_{EXC}$$

B09I Other Exports Supply

$$\log(SEXI) = SCI5700 + SCI5701 \cdot DUM1 + SCI5702 \cdot DUM2 + SCI5703 \cdot DUM3$$
$$+SCI5704 \cdot TF + SCI5705 \cdot \log(GR \cdot SEXSRI_{-1}) + (1 - SCI5705) \cdot \log(GR \cdot SEXI_{-1}) + SZ_{EXI}$$

B09L Finance & Business Exports Supply

$$\log(SEXL) = SCL5700 + SCL5701 \cdot DUM1 + SCL5702 \cdot DUM2 + SCL5703 \cdot DUM3$$
$$+SCL5704 \cdot TF + SCL5705 \cdot \log(GR \cdot SEXSRL_{-1}) + (1 - SCL5705) \cdot \log(GR \cdot SEXL_{-1}) + SZ_{EXL}$$

B.9 Price of Domestic Sales

Industry C

B10C Manufacturing Sales Price

$$\Delta \log(SPXC) = SCC5900 + SCC5901 \cdot DUM1 + SCC5902 \cdot DUM2 + SCC5903 \cdot DUM3$$
$$+SCC5904 \cdot \Delta \log(SPXSRC_{-2}) + SCC5905 \cdot \Delta \log(SPXSRC_{-3})$$
$$+(1 - SCC5904 - SCC5905) \cdot \Delta \log(SPXSRC_{-1}) + SCC5906 \cdot \log\left(\frac{SPXSRC_{-4}}{SPXC_{-4}} \right) + SZ_{PXC}$$

I34C Price of Private Consumption of C

$$SPCC = (1 + POLGST) \cdot SPXC \cdot (1 + SCC9012 \cdot POLCT)$$

I35C Price of Business Investment in C

$$SPISC = SPXC \cdot (1 + SCC9013 \cdot POLCT)$$

Industry E

B10E Other Sales Price

$$\Delta\log(SPXE) = SCE5900 + SCE5901\cdot DUM1 + SCE5902\cdot DUM2 + SCE5903\cdot DUM3$$
$$+SCE5904\cdot\Delta\log(SPXSRE_{-2}) + SCE5905\cdot\Delta\log(SPXSRE_{-3})$$
$$+(1-SCE5904-SCE5905)\cdot\Delta\log(SPXSRE_{-1}) + SCE5906\cdot\log\left(\frac{SPXSRE_{-4}}{SPXE_{-4}}\right) + SZ_{PXE}$$

I35E Price of Business Investment in E

$$SPISE = SPXE\cdot(1+SCE9013\cdot POLCT)$$

Industry I

B10I Other Sales Price

$$\Delta\log(SPXI) = SCI5900 + SCI5901\cdot DUM1 + SCI5902\cdot DUM2 + SCI5903\cdot DUM3$$
$$+SCI5904\cdot\Delta\log(SPXSRI_{-2}) + SCI5905\cdot\Delta\log(SPXSRI_{-3})$$
$$+(1-SCI5904-SCI5905)\cdot\Delta\log(SPXSRI_{-1}) + SCI5906\cdot\log\left(\frac{SPXSRI_{-4}}{SPXI_{-4}}\right) + SZ_{PXI}$$

I34I Price of Private Consumption of I

$$SPCI = (1+POLGST)\cdot SPXI\cdot(1+SCI9012\cdot POLCT)$$

I35I Price of Business Investment in I

$$SPISI = SPXI\cdot(1+SCI9013\cdot POLCT)$$

Industry L

B10L Finance & Business Sales Price

$$\Delta\log(SPXL) = SCL5900 + SCL5901\cdot DUM1 + SCL5902\cdot DUM2 + SCL5903\cdot DUM3$$
$$+SCL5904\cdot\Delta\log(SPXSRL_{-2}) + SCL5905\cdot\Delta\log(SPXSRL_{-3})$$
$$+(1-SCL5904-SCL5905)\cdot\Delta\log(SPXSRL_{-1}) + SCL5906\cdot\log\left(\frac{SPXSRL_{-4}}{SPXL_{-4}}\right) + SZ_{PXL}$$

I34L Price of Private Consumption of L

$$SPCL = (1+POLGST)\cdot SPXL\cdot(1+SCL9012\cdot POLCT)$$

I35L Price of Business Investment in L

$$SPISL = SPXL \cdot \left(1 + SCL9013 \cdot POLCT\right)$$

Industry R

I34R Price of Private Consumption of R

$$SPXR = \frac{SPCR}{\left(1 + SCR9012 \cdot POLCT\right)}$$

B.10 Business Investment

Industry C

I36C Price of Capital Services for C

$$SPKC = SAA1C \cdot \left[SPYSRC^{\left(\frac{SCC9020}{SCC9020_{-1}}\right)} - \left(\frac{WSRC}{SAA0C}\right)^{\left(\frac{SCC9020}{SCC9020_{-1}}\right)} \right]^{\left(\frac{SCC9020_{-1}}{SCC9020}\right)}$$

I37C Actual Rate of Return on Capital for C

$$SARC = 400 \cdot \frac{SPKC}{PIFTM}$$

B11C Investment Demand by Industry C

$$\frac{SIFC}{SKC} = SCC6000 + SCC6001 \cdot DUM1 + SCC6002 \cdot DUM2 + SCC6003 \cdot DUM3$$
$$+ SCC6004 \cdot TF + SCC6005 \cdot \left(\frac{SARC_{-1}}{400} - \left(0.025 + RI_{-1}\right)\right) + \left(1 - SCC6006\right) \cdot \left(GR + 0.025 - 1\right)$$
$$+ SCC6006 \cdot \frac{SIFC_{-1}}{SKC_{-1}} + SZ_{IFC}$$

I39C Business Fixed Capital of C

$$SKC = \left(1 - 0.025\right) \cdot SKC_{-1} + SIFC_{-1}$$

Industry E

I36E Price of Capital Services for E

$$SPKE = SAA1E \cdot \left[SPYSRE^{\left(\frac{SCE9020}{SCE9020_{-1}}\right)} - \left(\frac{W}{SAA0E}\right)^{\left(\frac{SCE9020}{SCE9020_{-1}}\right)} \right]^{\left(\frac{SCE9020_{-1}}{SCE9020}\right)}$$

I37E Actual Rate of Return on Capital for E

$$SARE = 400 \cdot \frac{SPKE}{PIFTM}$$

B11E Investment Demand by Industry E

$$\frac{SIFE}{SKE} = SCE6000 + SCE6001 \cdot DUM1 + SCE6002 \cdot DUM2 + SCE6003 \cdot DUM3$$
$$+SCE6004 \cdot TF + SCE6005 \cdot \left(\frac{SARE_{-1}}{400} - \left(0.025 + RI_{-1}\right) \right) + \left(1 - SCE6006\right) \cdot \left(GR + 0.025 - 1\right)$$
$$+SCE6006 \cdot \frac{SIFE_{-1}}{SKE_{-1}} + SZ_{IFE}$$

I39E Business Fixed Capital of E

$$SKE = \left(1 - 0.025\right) \cdot SKE_{-1} + SIFE_{-1}$$

Industry I

I36I Price of Capital Services for I

$$SPKI = SAA1I \cdot \left[SPYSRI^{\left(\frac{SCI9020}{SCI9020_{-1}}\right)} - \left(\frac{WSRI}{SAA0I}\right)^{\left(\frac{SCI9020}{SCI9020_{-1}}\right)} \right]^{\left(\frac{SCI9020_{-1}}{SCI9020}\right)}$$

I37I Actual Rate of Return on Capital for I

$$SARI = 400 \cdot \frac{SPKI}{PIFTM}$$

B11I Investment Demand by Industry I

$$\frac{SIFI}{SKI} = SCI6000 + SCI6001 \cdot DUM1 + SCI6002 \cdot DUM2 + SCI6003 \cdot DUM3$$
$$+SCI6004 \cdot TF + SCI6005 \cdot \left(\frac{SARI_{-2}}{400} - \left(0.025 + RI_{-2}\right) \right) + \left(1 - SCI6006\right) \cdot \left(GR + 0.025 - 1\right)$$
$$+SCI6006 \cdot \frac{SIFI_{-1}}{SKI_{-1}} + SZ_{IFI}$$

I39I Business Fixed Capital of I

$$SKI = \left(1 - 0.025\right) \cdot SKI_{-1} + SIFI_{-1}$$

Industry L

I36L Price of Capital Services for L

$$SPKL = SAA1L \cdot \left[SPYSRL^{\left(\frac{SCL9020}{SCL9020-1}\right)} - \left(\frac{WSRL}{SAA0L} \right)^{\left(\frac{SCL9020}{SCL9020-1}\right)} \right]^{\left(\frac{SCL9020-1}{SCL9020}\right)}$$

I37L Actual Rate of Return on Capital for L

$$SARL = 400 \cdot \frac{SPKL}{PIFTM}$$

B11L Investment Demand by Industry L

$$\frac{SIFL}{SKL} = SCL6000 + SCL6001 \cdot DUM1 + SCL6002 \cdot DUM2 + SCL6003 \cdot DUM3$$
$$+SCL6004 \cdot TF + SCL6005 \cdot \left(\frac{SARL_{-2}}{400} - \left(0.025 + RI_{-2}\right) \right) + \left(1 - SCL6006\right) \cdot \left(GR + 0.025 - 1\right)$$
$$+SCL6006 \cdot \frac{SIFL_{-1}}{SKL_{-1}} + SZ_{IFL}$$

I39L Business Fixed Capital of L

$$SKL = \left(1 - 0.025\right) \cdot SKL_{-1} + SIFL_{-1}$$

Total Investment

I40 Private Non-Residential Investment

$$IFB = SIFC + SIFE + SIFI + SIFL$$

I41 Non-Residential Investment

$$IFT = IFB + GIF$$

I42C Investment Supply by Industry C

$$SISC = SCC9030 \cdot (1 - RSISE) \cdot \frac{IFT}{(1 + SCC9013)}$$

I42E Investment Supply by Industry E

$$SISE = RSISE \cdot \frac{IFT}{(1 + SCE9013)}$$

I42I Investment Supply by Industry I

$$SISI = SCI9030 \cdot (1 - RSISE) \cdot \frac{IFT}{(1 + SCI9013)}$$

I42L Investment Supply by Industry L

$$SISL = SCL9030 \cdot (1 - RSISE) \cdot \frac{IFT}{(1 + SCL9013)}$$

B.11 Residential Investment

I36R Price of Capital Services for R

$$SPKR = SAA1R \cdot SPYSRR$$

I37R Actual Rate of Return on Capital for R

$$SARR = 400 \cdot \frac{SPKR}{PIHM}$$

B11R Residential Investment

$$\frac{IH}{KH} = SCR6000 + SCR6001 \cdot DUM1 + SCR6002 \cdot DUM2 + SCR6003 \cdot DUM3$$
$$+ SCR6004 \cdot \left(\frac{SARR_{-4}}{400} - \left(0.01 + RI_{-4}\right) \right) + \left(1 - SCR6005\right) \cdot \left(GR + 0.01 - 1\right)$$
$$+ SCR6005 \cdot \frac{IH_{-1}}{KH_{-1}} + SZ_{IH}$$

I39R Housing Stock

$$KH = \left(1 - 0.01\right) \cdot KH_{-1} + IH_{-1}$$

I43E Housing Investment Supply by Industry E

$$SIHE = SCE9031 \cdot IH$$

I43I Housing Investment Supply by Industry I

$$SIHI = SCI9031 \cdot IH$$

I43L Housing Investment Supply by Industry L

$$SIHL = SCL9031 \cdot IH$$

B.12 Inventory Investment

B12 Inventory Investment

$$II = \left(C0800 + C0801 \cdot DUM1 + C0802 \cdot DUM2 + C0803 \cdot DUM3 + C0804 \cdot TF\right) \cdot SEXC$$
$$+ \left(GR - 1 - C0806\right) \cdot KI + C0805 \cdot KI + Z_{II} \cdot SEXC$$

I44 Stock of Inventories - Beginning of Period

$$KI = \left(1 + C0806\right) \cdot KI_{-1} + II_{-1}$$

B.13 Export Demand

B13 Demand for Exports (Price)

$$PEX = PEXF \cdot E$$

B.14 Import Supply

B14 Supply of Imports (Price)

$$PIM = PIMF \cdot E$$

I46 Price of Imports Including Import Duty

$$PIMAT = PIM \cdot (1 + POLCD)$$

B.15 Monetary Policy

B15 TWI Exchange Rate Rule

$$\log(ETWI) = \log(ETWIT) + \left(\frac{4}{4 + C1601}\right) \cdot \left(\log(XETWI) - \log(ETWIT_{1})\right)$$

$$+ \left(\frac{C1602}{4 + C1601}\right) \cdot \left(\log\left(\frac{PCPI \cdot ETWIT}{PEXF}\right) - C1600\right) + Z_{ETWI}$$

where $\log(XETWI) = \log(C48SC) - \frac{XER}{100}$

I47 Equilibrium Rate of Growth in Nominal Spending

$$POL13 = 4 \cdot \log(GR) + 4 \cdot \log\left(\frac{PEXF}{PEXF_{-1}}\right) - 4 \cdot \log\left(\frac{ETWIT}{ETWIT_{-1}}\right)$$

B.16 Fiscal Policy

B16 Income Tax Rate Rule

$$\Delta POL1N = -C8009 \cdot \left(\frac{PUBS_{-4}}{GDPZ_{-4}} - RPUBS\right)$$

I48 Rate of Tax on Labour Income (Proportion)

$$POL1 = POL1N + POL1X$$

I49 Rate of Tax on Labour Income (percentage)

$$POL1T = 100 \cdot POL1$$

I50 Stock of Public Financial Assets Expressed in Foreign Currency

$$\Delta AG = \frac{PUBS_{-1} - TRCAP_{-1}}{E_{-1}} + \frac{PREM2_{-1}}{400} \cdot AG_{-1}$$

I50A Investment Adjustment

$$INVADJ1 = E \cdot AG - E_{-1} \cdot AG_{-1} - \left(PUBS_{-1} - TRCAP_{-1}\right)$$

I51 Public Financial Assets (% of GDPZ)

$$PUASST = \frac{100 \cdot AG \cdot E}{\left(GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4}\right)}$$

I52A Income Tax – Corporate

$$TAXITC = RCIT \cdot POLCOT \cdot \left(\begin{array}{l} \left(1 - WTITC\right) \cdot \left(YPT_{-4} + \frac{FK_{-4}}{K_{-4}} \cdot \left(GOS_{-4} - 0.025 \cdot PIFT_{-4} \cdot K_{-4}\right) \right) \\ + WTITC \cdot \left(YPT_{-1} + \frac{FK_{-1}}{K_{-1}} \cdot \left(GOS_{-1} - 0.025 \cdot PIFT_{-1} \cdot K_{-1}\right) \right) \end{array} \right)$$

I52B Income Tax – Personal

$$TAXITP = POL1 \cdot \left(WTITP \cdot WB + \left(1 - WTITP\right) \cdot WB_{-5}\right)$$

I52C Indirect Tax – Assets Tax

$$TAXASS = RTAXASS \cdot TAXOIT$$

I52D Indirect Tax – COE and ARF on National Accounts (accrual) Basis

$$TAXCA = RTAXCA \cdot TAXCT$$

I52E Indirect Tax – COE

$$TAXCOE = TAXCA + Z_{CA} - TAXARF$$

I52F Indirect Tax – ARF

$$TAXARF = RATARF \cdot \left(TAXCA + Z_{CA}\right)$$

I52G Indirect Tax – Other indirect taxes

$$TAXOTI = TAXOIT + TAXCT + Z_{ITLS} - TAXASS - TAXCA$$

I52H Income Tax – Stat Boards

$$TAXITS = RTAXITS \cdot GDPZ$$

I52I Interest on Loans to Stat Boards

$$INTSB = RINTSB \cdot GDPZ$$

I52J Government Operating Expenditure

$$GEC = \left(GCONZ + TRPUFO + Z_{ITLS} + Z_{CA}\right) + RGEC \cdot GDPZ$$

I52K Government Development Expenditure

$$GEK = GIFZ + RGEK \cdot GDPZ$$

I52L Special Transfers: Government to Private

$$TRPUPR = POL11 \cdot GDPZ$$

I52M Other Non-tax Government Revenue

$$REVOTH = POL15 \cdot GDPZ$$

I52N Net Lending

$$NETLEN = POL16 \cdot GDPZ$$

I52O Net Capital Receipts

$$NETCAP = POL17 \cdot GDPZ$$

I52 Public Sector Surplus

$$PUBS = TAXITP + TAXITC + TAXITS + ITLS + INTSB + REVOTH + NETINV + NETCAP - GSPEND$$

I53 Public Surplus (% of GDPZ)

$$PUBSSH = 100 \cdot \frac{PUBS}{GDPZ}$$

I54 Government Outlays

$$GSPEND = GCONZ + TRPUFO + RGEC \cdot GDPZ + GIFZ + RGEK \cdot GDPZ + TRPUPR + POL16 \cdot GDPZ$$

I55 Net Transfers from Public Sector to Foreign Sector

$$TRPUFO = POL12 \cdot GDPZ$$

I57 Nominal Government Consumption

$$GCONZ = PGCON \cdot GCON$$

I58 Indirect Taxes Net of Subsidies

$$ITLS = TAXFWL + TAXCT + TAXCD + TAXGST + TAXOIT$$

I59 Foreign Workers Levy

$$TAXFWL = \sum_i WFNTi \cdot POLFWLi \cdot SNFi$$

I60 Commodity Taxes

$$TAXCT = POLCT \cdot \begin{pmatrix} SPXC \cdot SCTC + SPXE \cdot SCTE \\ +SPXI \cdot SCTI + SPXL \cdot SCTL + SPXR \cdot SCTR \end{pmatrix}$$

I61 Customs Duty

$$TAXCD = POLCD \cdot PIM \cdot SIMC$$

I62 GST Revenue

$$TAXGST = \left(\frac{POLGST}{1 + POLGST} \right) \cdot CONOZ$$

I63 Indirect Taxes on Production

$$\begin{aligned} TAXOIT = & \\ & \left(\frac{POLOIT \cdot SCC9015}{1 + POLOIT \cdot SCC9015} \right) \cdot \left(SPXC \cdot SXC + PEX \cdot SEXC - PIMAT \cdot SIMC \right) \\ & + \left(\frac{POLOIT \cdot SCE9015}{1 + POLOIT \cdot SCE9015} \right) \cdot SPXE \cdot SXE \\ & + \left(\frac{POLOIT \cdot SCI9015}{1 + POLOIT \cdot SCI9015} \right) \cdot \left(SPXI \cdot SXI + PEX \cdot SEXI - PIM \cdot SIMI \right) \\ & + \left(\frac{POLOIT \cdot SCL9015}{1 + POLOIT \cdot SCL9015} \right) \cdot \left(SPXL \cdot SXL + PEX \cdot SEXL - PIM \cdot SIML \right) \\ & + \left(\frac{POLOIT \cdot SCR9015}{1 + POLOIT \cdot SCR9015} \right) \cdot SPXR \cdot SXR \end{aligned}$$

I64 Property Income of Locals

$$\begin{aligned} YPT = & \frac{\left(K - FK \right)}{K} \cdot \left(GOS - 0.025 \cdot PIFT \cdot K \right) + SPYSRR \cdot SYSRR \\ & - 0.01 \cdot PIH \cdot KH - \frac{RSF}{400} \cdot ZP \cdot E \end{aligned}$$

I65 Government Consumption / GDP

$$GCSH = 100 \cdot \frac{GCONZ}{GDPZ}$$

I66 Public Investment: Non-Residential / GDP

$$PUBINV = 100 \cdot \frac{GIFZ}{GDPZ}$$

I67 Net Revenue / GDP

$$NRSH = GCSH + PUBINV + PUBSSH$$

B.17 Foreign Exchange Market

B17 Uncovered Interest Parity

$$RS = 400 \cdot \left[\left(1 + \frac{RSF}{400} \right) \cdot \exp\left(\frac{XER - ER + ZRER}{100} \right) - 1 \right]$$

I68 Transformation of Exchange Rate

$$ER = 100 \cdot \log(E)$$

I69 Model Exchange Rate

$$E = \frac{C48SC}{ETWI}$$

B.18 Bond and Equity Markets

B19 10-Year Government Bond Yield

$$RL = (1 - 0.95) \cdot RS + 0.95 \cdot XRL + ZRRL$$

I75 Real 10-Year Bond Rate (Proportion per Quarter)

$$RI = \left[\frac{\left(1 + \frac{RL}{400} \right)}{\exp\left(\frac{INFE}{400} \right)} \right] - 1$$

B.19 Other Equations

I76 Nominal Residential Investment

$$IHZ = PIH \cdot IH$$

I77 Nominal Private Non-residential Investment

$$IFZ = PIFT \cdot IFB$$

I78 Nominal Public Non-residential Investment

$$GIFZ = PIFT \cdot GIF$$

I79 Nominal Non-Residential Investment

$$IFTZ = PIFT \cdot IFT$$

I80 Nominal Final Demand

$$FDZ = PCONM \cdot CONS + SPXI \cdot GCON + PIHM \cdot IH + PIFTM \cdot IFT - PEX \cdot Z_{EX}$$

I81 Nominal Exports of Goods and Services

$$EXZ = PEX \cdot (SEXC + SEXI + SEXL) - PEX \cdot (II + SD + Z_{GDP} - Z_{EX})$$
$$+C58NO \cdot RIMREZ \cdot IMZ$$

I82 Nominal Imports of Goods and Services

$$IMZ = PIM \cdot \frac{(SIMC + SIMI + SIML)}{(1 - C58N0 \cdot RIMREZ)}$$

I83 Nominal GDP (Model Basis)

$$GDPZ = FDZ + PEX \cdot (II + SD + Z_{GDP}) + EXZ - IMZ$$

I84 Labour Costs

$$WBBT = \sum_i WL \cdot NL + WF_i \cdot SNF_i$$

I85 Labour Income

$$WB = WBBT - TAXFWL$$

I86 Business Gross Operating Surplus

$$GOS = GDPZ - WB - ITLS - SPYSRR \cdot SYSRR$$

I87 Net Transfers from Foreign Sector to Private Sector

$$TRFOPR = POL14 \cdot \begin{pmatrix} WFNTC \cdot SNFC + WFNTE \cdot SNFE \\ +WFNTI \cdot SNFI + WFNTL \cdot SNFL \end{pmatrix}$$

I88 Stock of Business Capital

$$K = SKC + SKE + SKI + SKL$$

I89 Private Consumption

$$CONS = (1+RGDPPD)\cdot\begin{pmatrix}(1+SCC9012)\cdot SCONC\\ +(1+SCI9012)\cdot SCONI+(1+SCL9012)\cdot SCONL\end{pmatrix}$$
$$+(1+SCR9012)\cdot SCONR$$

I90 Price of Private Consumption - Model Basis

$$PCONM = \frac{CONZM}{CONS}$$

I92 Price of Business Investment - Model Basis

$$PIFTM = RSISE\cdot\frac{SPISE}{1+SCE9013}$$
$$+(1-RSISE)\cdot\left[\left(\frac{SCC9030}{1+SCC9013}\right)\cdot SPISC+\left(\frac{SCI9030}{1+SCI9013}\right)\cdot SPISI+\left(\frac{SCL9030}{1+SCL9013}\right)\cdot SPISL\right]$$

I93 Price of Residential Investment - Model Basis

$$PIHM = SCE9031\cdot SPXE+SCI9031\cdot SPXI+SCL9031\cdot SPXL$$

B21 Price of Government Consumption

$$(PGCON-SPXI)\cdot\frac{GCON}{FDZ}=C2700+C2701\cdot TF+C2702\cdot DUM1+C2703\cdot DUM2$$
$$+C2704\cdot DUM3+C2705\cdot(PIH_{-1}-PIHM_{-1})\cdot\frac{IH_{-1}}{FDZ_{-1}}$$
$$+C2706\cdot(PIFT_{-1}-PIFTM_{-1})\cdot\frac{IFT_{-1}}{FDZ_{-1}}+Z_{PGCON}$$

B22 Price of Residential Investment

$$(PIH-PIHM)\cdot\frac{IH}{FDZ}=C2800+C2801\cdot TF+C2802\cdot DUM1+C2803\cdot DUM2$$
$$+C2804\cdot DUM3+C2805\cdot(PIH_{-1}-PIHM_{-1})\cdot\frac{IH_{-1}}{FDZ_{-1}}$$
$$+C2806\cdot(PIFT_{-1}-PIFTM_{-1})\cdot\frac{IFT_{-1}}{FDZ_{-1}}+Z_{PIH}$$

B23 Price of Business Investment

$$(PIFT-PIFTM)\cdot\frac{IFT}{FDZ}=C2900+C2901\cdot TF+C2902\cdot DUM1+C2903\cdot DUM2$$
$$+C2904\cdot DUM3+C2905\cdot(PIH_{-1}-PIHM_{-1})\cdot\frac{IH_{-1}}{FDZ_{-1}}$$
$$+C2906\cdot(PIFT_{-1}-PIFTM_{-1})\cdot\frac{IFT_{-1}}{FDZ_{-1}}+Z_{PIFT}$$

I94 Nominal Private Consumption

$$CONZ = FDZ - GCONZ - IHZ - IFTZ$$

I95 Price of Private Consumption

$$PCON = \frac{CONZ}{CONS}$$

B24 Consumer Price Index

$$\log\left(\frac{PCPI}{PCON}\right) = C3800 + C3801 \cdot DUM1 + C3802 \cdot DUM2 + C3803 \cdot DUM3$$
$$+C3804 \cdot \log\left(\frac{PCPI_{-1}}{PCON_{-1}}\right) + Z_{PCPI}$$

I96 Balance on Goods and Services (Value)

$$TGSB = 100 \cdot \frac{(EXZ - IMZ)}{GDPZ}$$

I97 Balance on Net Transfers

$$TRB = 100 \cdot \frac{(TRFOPR - TRPUFO)}{GDPZ}$$

I97A Government Net Investment Income

$$NETINV = \frac{(RSF + PREM1)}{400} \cdot AG \cdot E$$

I98 Balance on Net Factor Income (% of GDPZ)

$$NFIB = 100 \cdot \frac{\left(\begin{array}{l} NETINV - \frac{RSF}{400} \cdot ZP \cdot E - \frac{FK}{K} \cdot (GOS - 0.025 \cdot PIFT \cdot K) \\ +RCIT \cdot POLCOT \cdot \frac{FK_{-4}}{K_{-4}} \cdot (GOS_{-4} - 0.025 \cdot PIFT_{-4} \cdot K_{-4}) \end{array}\right)}{GDPZ} + Z_{NFIB}$$

I99 Balance on Current Account (% of GDPZ)

$$CURB = TGSB + TRB + NFIB$$

I100 Net Private Capital Inflow

$$DOS = 0.025 \cdot PIFT \cdot FK + PUBS - \left(BOPCAP + GDPZ \cdot \frac{CURB}{100} \right)$$

I101 Net Foreign Equity Investment

$$FIF = RFIF \cdot IFB$$

I102 Net Foreign Equity Capital - Beginning of Period

$$FK = (1 - 0.025) \cdot FK_{-1} + FIF_{-1}$$

I104 Net Foreign Private Debt

$$\Delta ZP = \frac{(DOS_{-1} - PIFT_{-1} \cdot FIF_{-1})}{E_{-1}}$$

A40 Net Foreign Assets (% of GDPZ)

$$FOASST = 100 \cdot \frac{(AG - ZP) \cdot E - PIFT \cdot FK}{GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4}}$$

B.20 Supplementary Equations

S01 Final Demand

$$FD = CONS + GCON + IH + IFT$$

S02 Gross National Expenditure

$$GNE = FD + II$$

S03 Exports of Goods and Services

$$EX = SEXC + SEXI + SEXL - SD - II + C58RE \cdot RIMREZ \cdot IM + Z_{EX}$$

S04 Imports of Goods and Services

$$IM = \frac{SIMC + SIMI + SIML}{(1 - C58RE \cdot RIMREZ)}$$

S05 GDP (Expenditure-based Estimate)

$$GDPE = GNE + EX - IM$$

S06 GDP: Production-based Estimate

$$GDPP = GDPPC + GDPPE + GDPPI + GDPPL + GDPPR + GDPPD + Z_{EX}$$

S07 Price of GDP

$$PGDPT = \frac{GDPZ}{GDPP}$$

S08 Private Non-Residential Investment Share

$$PRINV = 100 \cdot \frac{\left(IFZ + PEX \cdot II\right)}{GDPZ}$$

S09 Residential Investment Share

$$IHINV = 100 \cdot \frac{IHZ}{GDPZ}$$

S10 National Investment Share

$$NATINV = PUBINV + PRINV + IHINV$$

S11 National Saving Share

$$NATSAV = NATINV + CURB + 100 \cdot \frac{BOPCAP}{GDPZ}$$

S12 Public Saving Share

$$PUBSAV = +PUBSSH + PUBINV + 100 \cdot POL3$$

S13 Private Saving Share

$$PRSAV = NATSAV - PUBSAV$$

S14 Survey Employment

$$NSUR = C1800 \cdot NL + C1801 \cdot NF + Z_{NSUR}$$

S15 Unemployment Rate - Survey Basis

$$URT = 100 \cdot \frac{NUN}{NUN + NSUR}$$

S16 Wages - Original Terms

$$\log\left(\frac{WO}{WL}\right) = \left(1 - DUM011\right) \cdot \begin{pmatrix} C39MA \cdot DUM1 + C39JU \cdot DUM2 + C39SE \cdot DUM3 \\ +C39DE \cdot \left(1 - DUM1 - DUM2 - DUM3\right) \end{pmatrix}$$

$$+DUM011 \cdot \begin{pmatrix} C390MA \cdot DUM1 + C390JU \cdot DUM2 + C390SE \cdot DUM3 \\ +C390DE \cdot \left(1 - DUM1 - DUM2 - DUM3\right) \end{pmatrix}$$

S17 Headline Average Monthly Earnings

$$WHL = \frac{1000}{3} \cdot \left(\frac{WO}{1 + RCPF} \right)$$

S18 Non-Oil Domestic Exports

$$\log\left(\frac{EXNOD}{SEXC} \right) = C3000 + C3001 \cdot DUM1 + C3002 \cdot DUM2 + C3003 \cdot DUM3$$
$$+ C3004 \cdot TF + C3005 \cdot \log\left(\frac{EXNOD_{-1}}{SEXC_{-1}} \right) + Z_{EXNOD}$$

S19 Nominal Non-Oil Domestic Exports

$$\log\left(\frac{EXNODZ}{PEX \cdot EXNOD} \right) = C3100 + C3101 \cdot DUM1 + C3102 \cdot DUM2 + C3103 \cdot DUM3$$
$$+ C3104 \cdot TF + C3105 \cdot \log\left(\frac{EXNODZ_{-1}}{PEX_{-1} \cdot EXNOD_{-1}} \right) + Z_{EXNODZ}$$

S20 Balance on Goods & Services (Volume)

$$TGSBQ = 100 \cdot \frac{(EX - IM)}{GDPP}$$

S21 Terms-of-Trade

$$TOT = 100 \cdot \frac{\left(\frac{EXZ}{EX} \right)}{\left(\frac{IMZ}{IM} \right)}$$

S23 Public Financial Assets

$$PUASST = 100 \cdot \frac{AG \cdot E}{(GDPZ_{-1} + GDPZ_{-2} + GDPZ_{-3} + GDPZ_{-4})}$$

S27 Labour Productivity

$$PROD = \frac{GDPP}{NF + NL}$$

S28 Nominal Unit Labour Costs

$$ULC = \frac{WBBT}{GDPP}$$

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