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The Ateneo macroeconomic and forecasting model

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Abstract

The Ateneo Macroeconomic and Forecasting Model (AMFM) is a small quarterly macroeconometric model of the Philippine economy. Designed for forecasting and policy analysis, the model generates results for key macroeconomic indicators.

The underlying structure of the AMFM is similar to the short run version of Murphy model of Australia. It incorporates Keynesian elements which capture the slow adjustment of prices and unemployment. It also integrates some of the optimizing behavior that is commonly found in Neoclassical economics and in the long run version of the Murphy model.

The stochastic equations of the model were estimated using ordinary least squares. In the specification search, each equation was evaluated on three criteria. First, the coefficient estimates must be consistent with economic theory or *a priori* expectations. Second, each equation should track actual data well. Finally, each equation must pass a series of statistical tests.

Despite being at an early stage of model development, the AMFM as a whole tracks historical data on key macroeconomic aggregates reasonably well. This is supported by the low root mean square errors and mean absolute percentage errors of the variables.

JEL classification: E17, D58
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1. Introduction

The Ateneo Macroeconomic and Forecasting Model (AMFM) is quarterly macroeconometric model of the Philippine economy. It is a small model that is composed of only 66 equations; of which, 13 are stochastic equations and 53 are identities. The model generates results for macroeconomic indicators like gross national product (GNP), gross domestic product (GDP), GDP components, GDP deflator, Consumer Price Index (CPI), 91-day T-bill rate, and the unemployment rate.

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The AMFM is designed for forecasting and policy analysis. Being a quarterly model, it is capable of making short-term forecasts. The AMFM also provides a transparent framework for a comprehensive analysis of the effects of policy changes and exogenous shocks. It is transparent in the sense that the users can readily check the equations of the model and infer its underlying assumptions and limitations. It is comprehensive in the sense that the users can immediately examine the results of a policy change on a variety of macroeconomic variables. For example, the model can simulate the effects of an increase in government spending on the government deficit, interest rate, household income, investment, general price level and a set of output indicators. The user also has a choice of examining the effects of the policy one quarter after its implementation and beyond.

The AMFM can also evaluate the effects of a mix of policies. For example, it is possible to simultaneously examine the effects of an increase in spending and a contraction/expansion in money supply. The experiments cited above are difficult to do with analytical models because of the magnitude of the problem and the need to account for the various interrelationships among economic variables. In contrast, the AMFM can execute the experiments in a matter of seconds.

Macroeconometric models of the Philippines are not new.[1] Nowadays, the most commonly used models are those of the Philippine Institute for Development Studies (PIDS), the Annual Macro Social Model (AMSM) of the National Economic and Development Authority (NEDA) (see Reyes and Buenafe [2000], Constantino et.al. [1990], Mariano and Constantino [1987]).

Most of the existing Philippine models use annual data. As such, these models are better suited for medium term analysis. Being a quarterly model, the AMFM can provide an analysis for the short term, say a quarter or so ahead. It can also be used to generate results for the medium term if simulated over a long enough period. The future version of the AMFM will also have a coherent long-run structure, which is consistent with the short-term model, that can be solved independently to generate long-run results.

Macroeconometric models that incorporate a coherent and consistent long-run structure appear to be the current trend in macroeconometric model building [Wallis 2000]. Its appeal is due, in part, to the argument that economic theory has most to say about the long-run [Powell and Murphy 1997]. It also eliminates the need to simulate a model over many periods in order to evaluate its long-run properties. Existing models of this type tend to have a long-run structure that is based on optimizing behavior and market clearing.[2] The short run version in turn incorporates price rigidities and adjustment processes.

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[1] For a review of Philippine macroeconometric models constructed prior to the 1980s, see Velasco [1980].

[2] For a review of these models, see Wallis [2000]. For examples, the reader may refer to Murphy [1998 and 1992b], Powell and Murphy [1997], Department of Treasury [1996], Malgrange [1983], and Wallis and Whitley [1987].

Like most macroeconometric models, the AMFM relies heavily on econometric techniques. These are used to determine the values of the parameters of the behavioral equations. As the theory is weak in identifying the adjustment processes that govern the behavior of economic variables, these techniques are also used to specify the dynamic relationships.

Section 2 of this paper describes the structure and key features of the AMFM. It discusses the different agents, variables and assumptions that are incorporated in the model. Section 3 explains the empirics behind the AMFM. It describes the techniques that were used to derive the parameters of the model as well as the construction of the data set. Section 4 focuses on the current model's tracking performance and Section 5 concludes by identifying future directions for the AMFM.

2. Model structure

The underlying structure of the AMFM is very similar to the short run version of Murphy model of Australia. It incorporates Keynesian elements which capture the slow adjustment of prices, unemployment, and demand determined output. It also integrates some of the optimizing behavior that is commonly found in neoclassical economics and in the long-run version of the Murphy model.

The AMFM has four major blocks. These are the real, government, financial and external sectors. The real sector determines the national output and its components, prices, employment and wages. Government represents the spending and sources of finance of the national government, while the financial sector depicts the interaction of agents in the financial markets. These sectors determine the interest rate, government deficit and government debt in the model. Finally, the external sector portrays the transactions of the Philippines with the rest of the world.

2.1 Real sector

2.1.1 Production

Borrowing heavily from the Murphy models of Australia and Fiji, the production side of the AMFM is a two-stage process. The first stage represents the optimizing behavior of firms, a feature often associated with Applied General Equilibrium (AGE) models. On the other hand, the second stage is composed of a series of equations that depict the adjustment of economic variables to equilibrium.

Stage one assumes that a production function explains the relationships between outputs and inputs. Gross output (q) is produced using labor (lt), imports (m) and capital stock (k). This output might be destined either for the domestic market (y) or for export (x). That is, $q = g(x,y) = f(lt,k_{-1},m)$.

In the short run, the representative firm's problem is to maximize profits (π) subject to given prices, capital stock and technology. In symbols, the problem is to:

$$\max \pi = px \cdot x + pnt \cdot y - w \cdot lt - pm \cdot m - pnt \cdot rr \cdot \bar{k}_{-1}$$

$$subject\ to\ q = g(x, y) = f(lt, \bar{k}_{-1}, m)$$

where *px* is the price of exports, *pm* is the price of imports, *pnt* is the price of the domestic good (net of indirect taxes), w is the wage rate, and rr is the real rate of return to capital.

Defining *lam* as the lagrange multiplier, this problem's first-order conditions are

$$px = lam \cdot \frac{\partial g(x, y)}{\partial x};$$

$$pnt = lam \cdot \frac{\partial g(x, y)}{\partial y};$$

$$w = lam \cdot \frac{\partial f(lt, m, \bar{k}_{-1})}{\partial lt};$$

$$pm = lam \cdot \frac{\partial f(lt, m, \bar{k}_{-1})}{\partial m};$$

$$q = g(x, y);\ \text{and}$$

$$q = f(x, y)$$

These represent the model's equations for export supply, gross output, labor demand, import demand, the domestic price and the lagrange multiplier, respectively.

The application of the optimizing framework to the model requires three clarifications. First, the first-order conditions specify the short run equilibrium of the model. The solution to these equations must, therefore, be distinguished from the actual values of the variables, which might deviate from their equilibrium values at a particular point in time. This is accomplished by adding the letter *e* to each variable. Second, while *y* is the choice variable in the optimization process, the first-order conditions actually provide a solution for the domestic price *pnt*. The reason is that output is determined from the demand side of the model. Assuming that the market clears in equilibrium, the supply equation (which is determined from the first-order conditions) can be thought of as providing the solution for the domestic price. Third, with the details provided in Section 3, the AMFM assumes that $g(x, y) = (A_{CET} \cdot x^2 + y^2)^{1/2}$ and $f(lt, m, k_{-1}) = A_{CB} \cdot lt^{\beta_1} \cdot m^{\beta_2} \cdot k_{-1}^{1-\beta_1-\beta_2}$. Taking cognizance of these points, the first-order conditions appear in the model as identities I01 to I06.[3]

[3] To minimize clutter in the paper, the model's equations are presented in the Appendix. All equations prefixed by the letter I, S and SS may be found under headings of Identities, Stochastic Equations, and Supplementary Equations, respectively. The Appendix also provides a complete list of variable definitions.

Stage two is composed of a series of stochastic equations that characterize the adjustment of the actual values to their equilibrium values. It recognizes, for example, that the actual value of exports (x) is not necessarily equal to its equilibrium value (xe) at a given point in time. These equations were estimated because little is known about the dynamics that govern the relationships between the two sets of variables. The result is a set of adjustment equations for export supply, import demand, domestic price and labor demand. The estimates are shown by equations S01 to S04.[4]

2.1.2 Investment and capital accumulation

The model disaggregates investment into fixed investment (*finv*) and inventory investment (*ii*). Inventory investment is treated as exogenous while fixed investment is based on the Tobin's q model (equation S05). The estimated equation postulates that fixed investment rises with the discrepancy (*arlessrr*) between the average rate of return to capital (*arr/py*) and the required rate of return to capital (*rr*).[5]

This specification links the optimizing behavior of the firms (from which *arr/py* is derived) to the interest rate (*rs)* and inflationary expectations (*exp_infyoy*). Identities I12 to I13 and equation S05 show that higher values of *rs* reduce investment through the increase in *rr*. The equations also show that higher inflationary expectations, which reduce *rr*, cause an increase in investment.

The introduction of inflationary expectations requires an explanation of how economic agents formulate expectations. On this point, the AMFM assumes adaptive expectations. That is, expected inflation rate is based on current and past values of the inflation rate (identity I14). As little is known about how past inflation rates affect expected inflation rates, an autoregressive model is used to specify this relationship. This involves regressing the current inflation rate on its past values (equation SE01). The estimated equation is then used as a proxy for expectations formation in the model.

An interesting feature of Murphy's approach to modeling investment is its careful attention to the stock-flow relationships. Identity I15 shows that positive (net) investment in the current period leads to an increase in the capital stock in the next period. Through the production function, this suggests higher productive capacity in next period. What this means is that investment tends to raise output in the current period through its effects on the demand side, and the next period through the supply side.

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[4] S04 describes the adjustment of py to pye and not the adjustment of pnt to pnte. This is of little consequence to the model because the divergence between py and pnt is explained by the indirect tax rate, an exogenous variable. Hence, the model only requires an additional equation that relates pye to pnte (identity I07).

[5] For a thorough discussion of how Tobin's q fits into the Murphy model and the AMFM, see Powell and Murphy [1997].

2.1.3 Consumption

Consumption behavior is based on the life cycle model [Ando and Modigliani, 1963]. Briefly, this is based on the notion that a household seeks to maximize its utility over the course of its lifetime. The solution posits that consumption is positively related to household income and wealth.

In the AMFM, income is captured by the private sector's real income net of income taxes (*yp*, identity I19). This income is based on the country's Gross National Product (GNP) adjusted for subsidies, transfer payments, indirect taxes, depreciation and interest payments (see identity I18). On the other hand, wealth (V) is comprised of government domestic debt, capital stock and the monetary base less the foreign debt of the private sector (identity I20).

Given the definitions of income and wealth, the consumption function was specified using econometric techniques. The estimated equation is given by S06.

2.1.4 Aggregate output and prices

The production side of the model generates the values for imports and exports. Along with the results for consumption, investment and government expenditures (the elements of which are essentially exogenous), the key ingredients for constructing measures of output and prices are now available. These are shown in identities I21 to I27.

The consumer price index (CPI) is commonly used indicator of the aggregate price level. In specifying this variable, the model adopts the approach of Murphy [1992a]. This involves a regression of the CPI on the price of the domestic good (PY). The estimated equation is shown in S07.

2.1.5 Labor market

As labor demand is specified from the production side of the economy, the labor market only needs equations that determine the labor force participation rate, labor supply, wage rate and unemployment rate.

The labor force participation rate is assumed to be a function of real wages and unemployment (equation S08). Higher real wages are specified to cause an increase in labor force participation. On the other hand, higher unemployment rates reduce labor force participation rates through the discouraged worker effect. Since plausible values for the labor force participation rate are likely to fall between zero and unity, the estimated equation uses a logistic function. Identities I30 and I31 are then used to transform the endogenous variable in S08 into labor supply.

Wage determination is specified with the aid of an expectations augmented Phillips curve. This postulates that wage rate growth is inversely related to the unemployment rate. Adaptive expectations are captured in turn by inclusion of the lagged values in the relationship. The estimated equation is shown in S09.

2.2 Government

The national government is modeled as an institution that spends on goods and services, collects taxes, receives and makes transfer payments, and acts as a borrower and lender. These activities are captured by a series of identities that depict the budget deficit and the government's sources of finance.

2.2.1 The government deficit

Government expenditures (*gspend*) are disaggregated into national government outlays for maintenance and operations, investment, interest payments, transfers and net lending (identity I33). Other expenditure items not explicitly included in the model are lumped into *gdisk1*. With the exception of interest payments, all expenditure items in identity I33 are treated as exogenous.

Government revenues (*grev*) are decomposed into tax and non-tax sources (identity I35). Tax revenues are broken down further into taxes from income and profits (*txy*), indirect taxes (*txg*), tariffs (*txg*) and other taxes (*txo*). With the exception of the last item, the components of tax revenues are endogenous in the model. These are specified as the product of an effective average tax rate (exogenous) and the relevant tax base (identities I36 to I38). For example, *txy* is the product of the exogenous tax rate (*txyr*) and *ypat*. Non-tax revenues are modeled as the sum of transfers from foreigners (*trpfg*) and households (*trphg*). The other components of government revenues, which are not explicitly modeled, are captured by *gdisk2*.

The difference between government expenditures and revenues is the budget deficit (identity I39). A deficit exists if expenditures exceed revenues.

2.2.2 Financing the government deficit

Identity I40 shows that, adjusting for *ccash*, the government deficit is financed by net borrowing from external (*gneb*) and domestic (*gndb*) sources. As *ccash* is treated as an exogenous variable, the problem reduces to specifying *gneb* and *gndb*. The AMFM treats this as a policy decision that is determined outside of the model. It is specifies *gneb* as the product of an exogenous factor (*ratfin*) and *gndb* (identity I41). If *ratfin* is greater than unity, then the government finances a larger proportion of the deficit by borrowing from foreign sources. With *gneb* and the budget deficit determined in identities I41 and I39, identity I40 solves for *gndb*.

The net borrowing variables, *gndb* and *gneb*, explain the government's debt accumulation. A positive value for *gneb* suggests that the government's foreign debt (*fdg*) is rising (identity I42). Holding the national government's net lending (*gnl*) constant, the same relationship holds for the government's domestic debt (*ddg*) and *gndb* (identity I43).

2.3 Financial

The interest rate and interest payments are determined in the financial sector. As the commercial banking sector is completely ignored in the model, the monetary base or the stock of high-powered money (HPM) serves as the money supply variable.

2.3.1 The interest rate

The AMFM assumes money market clearing; i.e., money supply equals money demand. With money supply assumed exogenous, money demand determines the interest rate (*rs*). This relationship is captured by the inverse money demand equation (equation S10). It postulates that *rs* is negatively related to changes in real money supply. The reason is that, starting from equilibrium, an increase in real money supply causes an excess supply of money. On the other hand, *rs* is positively related to gross national expenditure (adjusted for price changes) as an increase in the latter causes an increase in money demand.

2.3.2 Interest payments

Theoretically, interest payments are equal to the product of the interest rate and the stock of debt at the beginning of the period. This is unlikely to hold in practice for a number of reasons. It is possible that interest payments, which are due in a particular period, are not paid on time. Interest rates also differ across the variety debt instruments, a fact that is not currently captured by the AMFM. To address this issue, the AMFM follows a two-staged approach to modeling interest payments.

The first stage is a series of equations that take the product of the current interest rate and the debt stock at the beginning of the period. For lack of a better term, the product is referred to as *potential* interest payments. In the second stage, actual interest payments are regressed against potential interest payments.

This *ad hoc* approach is a compromise between the attempt to satisfy basic accounting identities and the problems associated with applying these identities in practice. In the current version of the AMFM, this approach is adopted for interest payments on private foreign debt and government domestic debt (I45 to I47, S11 and S12). Since satisfactory estimates were not obtained for the government's interest payments on foreign debt, this variable is (temporarily) assumed exogenous in the model.

2.4 External

The AMFM assumes that the Philippines is a small open economy with a flexible exchange rate. The small open economy assumption implies that the country is a price taker in the world markets. This simplifies the modeling process by eliminating the need to estimate the import supply and export demand functions. The domestic prices of imports and exports are therefore equal to the product of their foreign prices, the exchange rate and an adjustment for trade taxes (identities I48 and I49).

The assumption of a flexible exchange rate regime suggests the absence of changes in foreign exchange reserves. Hence, the balance of payments identity is instead used in the model to determine the level of the country's foreign debt (identity I50). With the government's foreign debt determined from the budget deficit, the difference between foreign debt and government foreign debt determines the foreign debt of the private sector (identity I51).

The exchange rate in the model is determined with the aid of an interest parity condition. This condition suggests that, holding foreign interest rates constant, an expected depreciation requires an increase in the domestic interest rate. Applying this concept to the model requires adjustments that account for the possibility of a premium on domestic assets and the formation of exchange rate expectations. To account for these aspects, the equation is estimated with the exchange rate on the left hand side. Lagged values of the exchange rate are also added to the right hand side to represent the formation of exchange rate expectations. The results are shown in equation S13.

3. Data and estimation

This section discusses the data used in the model and the various adjustments done on the data to get around certain measurement problems. The estimation procedure employed is described in the second part.

3.1 Data

The raw data set used in the model was drawn from various institutions (Table 1). In general, financial data were taken from the Bangko Sentral ng Pilipinas, employment and population from the National Statistics Office, government and external debt from the Bureau of Treasury, and the national accounts from the National Economic and Development Authority.

As in any modeling exercise similar to the AMFM, the challenge is to construct a consistent data set. This includes making adjustments so that data from the different sources satisfy the basic accounting identities and suit the specification of the model.

On the issue of missing data, for example, the actual tax structure is likely more complex than the way it is modeled. This is certainly the case for the AMFM. The Philippines has a tax structure whereby different income groups are levied different income tax rates. In contrast, the AMFM has only one tax rate. On the issue of consistency, one problem encountered is that stock and flow data on government foreign debt do not add-up.

To overcome the problems mentioned, the following broad approaches were adopted. In some instances, annual data was exploited to construct the missing quarterly variables. This was the approach used to construct quarterly values for the income side of the national accounts. In other cases, the values were constructed to suit the equations of the model without compromising the integrity of the available data. For example, the income tax rate was computed by dividing income tax revenues by the relevant income variable. This generates an estimate of the average tax rate that does not require a revision of the original values for tax revenues. In cases where consistency is the issue, the approach was to adjust the variables which require the fewest adjustments to other raw data. In the selection between stocks and flows data on the government debt, for example, the decision was to use the flows data and adjust the stock data. The reason is to avoid adjusting the budget deficit and its components.

Table 1. Sources of raw data

Variable group	*Source*
91-day T-bill	Bangko Sentral ng Pilipinas
Employment	National Statistics Office
Exchange rate	Bangko Sentral ng Pilipinas
External debt	Bureau of Treasury
Government expenditures	Bureau of Treasury
Government finance	Bureau of Treasury
Government revenues	Bureau of Treasury
High Powered Money	Bangko Sentral ng Pilipinas
Interest payments	Bureau of Treasury
National accounts	National Economic Development Authority
Population	National Statistics Office
US T-bill rates	United States Federal Reserve Website

3.2 Estimation

The estimation procedure adopted for the AMFM's stochastic equations differ from that of the parameters of the production function. The stochastic equations relied heavily on standard estimation techniques and were subjected to rigorous econometric tests. In contrast, the parameters of the production function were obtained by what may be described as a mix of calibration and standard estimation techniques. Moreover, the parameters were not subjected to diagnostic tests.

All stochastic equations were estimated using ordinary least squares. The objective was to find values for the coefficients and to specify the dynamic structure of the equations. Given the desire to make the most out of the available information, the estimation periods differ from one equation to the next. As a whole, however, the estimation process used data from fourth quarter of 1984 to the second quarter of 2001.

In the specification search, each equation was evaluated on three aspects. First, the coefficient estimates must be consistent with economic theory or *a priori* expectations. This must hold at least in the first instance in which a variable appears on the right hand side of the equation. For example, if the theory suggests that higher income leads to higher consumption spending, then the coefficient of income in the consumption function must be positive.

The second is the ability of the equation to track actual data. This involved examining the plots of the fitted values as well as the forecast values from a dynamic simulation of the equation. The idea behind this process is verify how well the equation's solutions capture turning points in the actual values.

Objective measures of tracking performance were also used. One indicator is the adjusted R^2. This measures the degree to which the explanatory variables explain the variations in the dependent variable. An adjusted R^2 that is close to unity indicates a good fit.

The adjusted R^2 is not always the best method to evaluate an equation's tracking ability. This is especially true if the equation is meant for use in a dynamic simulation. Hence, another measure used in the specification search is the mean absolute percentage error (MAPE) from a dynamic simulation of the equation. This measures the average percentage deviations, in absolute terms, of the simulated values from their actual values. A lower MAPE indicates a better fit.

The third aspect is by far the most demanding. It subjects the equations to a series of statistical tests. The aim is to minimize the risk of obtaining biased, inefficient and inconsistent estimates.[6] In doing so, each of the equations was tested for violations of: (a) first and fourth order serial correlation using the Breusch-Godfrey test; (b) heteroskedasticity using the White's test; and (c) equation misspecification using the Ramsey's RESET test.

Table 2 summarizes the results for the stochastic equations of the model.[7] It shows that adjusted R^2 has a range of 0.60 to 0.99. High estimates of the adjusted R^2 were obtained for the equations that describe consumption spending, domestic price, labor demand and the CPI. The equations with a relatively low R^2 are the ones for interest parity, interest payments, and the Phillips curve.

The MAPE for the equations range from 0.34 percent to 10.29 percent. More often than not, the equations that performed well on the basis of the adjusted R^2 are also the ones that had relatively low MAPE's. In contrast, the equations that have relatively high MAPE's are those for interest payments, exports and the inverse demand for money.

The diagnostic tests on the individual equations are satisfactory. The equations pass all the tests at the 1 and 5 percent levels of significance, and only two equations fail at the 10 percent level. The labor supply equation fails the Breusch-Godfrey test for fourth order serial correlation and the import demand equation fails the White test.

[6] A detailed discussion of the tests presented here may be found many econometrics text-books. The interested reader may consult, among others, Gujarati [1995] and Greene [1997].

Table 2. Selected Indicators for the Stochastic Equations

Equation	*Tracking performance*			*Diagnostic tests (p-values)*		
	Adj. R^2	*MAPE(%)*	*BG(1)*	*BG(4)*	*White*	*RESET*
Consumption	0.99	0.34	0.22	0.31	0.69	0.97
Exports	0.97	8.77	0.16	0.40	0.21	0.67
Imports	0.67	4.83	0.86	0.45	0.06	0.12
Labor demand	0.99	0.46	0.85	0.33	0.11	0.97
Price of domestic good	0.99	0.50	0.43	0.22	0.72	0.11
Investment	0.88	2.82	0.50	0.37	0.48	0.32
Interest payments on gov't domestic debt	0.71	9.06	0.57	0.11	0.24	0.78
Interest payments on private external debt	0.63	10.29	0.9	0.14	0.14	0.19
Inverse demand for money	0.87	8.67	0.78	0.56	0.17	0.41
Phillips curve	0.64	1.44	0.96	0.70	0.53	0.23
Labor supply	0.79	5.32	0.08	0.19	0.16	0.58
CPI	0.99	0.66	0.59	0.47	0.11	0.19
Interest parity	0.60	4.98	0.44	0.25	0.59	0.45

Note: BG(1) and BG(4) represent the Breusch-Godfrey tests for first and fourth order serial correlation, respectively.

The parameters of the production function were derived following the approach of Murphy [1992a] in his Fiji model. This assumes that gross output is a linearly homogenous Cobb-Douglas function of labor, capital and imports. Gross output, on the output side, is a Constant Elasticity of Transformation (CET) function of exports (x) and the domestic good (y).

The CET function used in the model is

$$q = (A_1 \cdot x^2 + A_2 \cdot y^2)^{1/2}.$$

Normalizing A_2 to unity reduces the equation to

$$q = (A_{CET} \cdot x^2 + y^2)^{1/2}.$$

This implies that only an estimate of A_{CET} is needed in the output side of the model.

To estimate A_{CET}, note that dividing identity I01 by identity I02 leads to

$$A_{CET} = \frac{px \cdot y}{pnt \cdot x}.$$

[7] The estimated parameters and their standard errors are reported in Appendix 1.

Since the values of *px, y, pnt,* and *x* are available, this equation can be used to generate the observed values of A_{CET} (or $A_{CET,t}$). $A_{CET,t}$ is then regressed on a constant and a time trend, and the fitted values are used as the model's estimate of A_{CET}.[8] Inserting the estimated A_{CET} into the CET function then allows the construction of q.

The input side of the production function is

$$q = A_{CB} \cdot lt^{\beta_1} \cdot m^{\beta_2} \cdot kb^{1-\beta_1-\beta_2}.$$

This specification requires parameter estimates for A_{CB}, b_1 and b_2. The last two parameters are obtained by taking the average cost shares of labor and imports in gross output from the fourth quarter of 1984 to the second quarter of 2001. Once specified, the value of $A_{CB,t}$ for each period ($A_{CB,t}$) can be derived using the following equation

$$A_{CB,t} = q / lt^{\beta_1} \cdot m^{\beta_2} \cdot kb^{1-\beta_1-\beta_2}.$$

$A_{CB,t}$ is then regressed on seasonal dummies and the fitted values are used as the model's estimate for A_{CB}. The estimating equation is shown in SE02.

4. Model evaluation

The previous section discussed tracking performance of the individual equations used in the AMFM. However, this is not enough and there exists a need to verify if the equations work well together. As with the individual equations, the objective here is to obtain solutions for the variables, based on a simulation of the entire system, that are reasonably close to their actual values.

Defining y_t as the actual observation of a variable y at time t and $\hat{y}_t$ as the model's forecast of y at time t, the forecast error is equal to the deviation of the simulated value from its actual value; i.e. $\hat{y}_t - y_t$. If the model tracks the data well, then these errors will be small.

Three commonly used measures of tracking performance are the mean error (ME), mean absolute error (MAE), and the root mean square error (RMS). These measures take the average of the forecast error, or some function thereof, over the simulation period. The formulae are [9]

$$ME = \frac{\Sigma_{t=1}^{T}(\hat{y}_t - y_t)}{T};$$

$$MAE = \frac{\Sigma_{t=1}^{T}|\hat{y}_t - y_t|}{T}; \text{ and}$$

[8] The estimation results are shown in SE03.

[9] The formulae and the discussion of the measures were drawn from Pindyck and Rubinfeld [1998], and Challen and Hagger [1983].

$$RMS = \sqrt{\frac{\Sigma_{t=1}^{T}(\hat{y}_t - y_t)^2}{T}}.$$

As these measures indicate the errors associated with the model's forecasts, values closer to zero suggest good tracking ability.

The ME is lightly regarded an indicator of tracking performance. The reason is that the ME can be close to zero even if there are large errors. This is so because large positive and negative errors can cancel each other out. Despite this shortcoming, the ME is still useful an indicator of the bias of the model results. A negative value indicates that $\hat{y}$ tends to underestimate y.

To overcome the problems associated with the ME , the MAE and the RMS may be used as alternative indicators because these transform all the errors into positive values before an average is calculated. In fact, by taking the square of the errors, the RMS tends to penalize large errors heavily.

The above indicators are not unit free. This can make interpretation a tedious task in macroeconometric models because different variables are expressed in different units. In the AMFM, for example, GDP is in millions of pesos whereas the interest rate is in percent per annum. Moreover, it is difficult to gauge how large these errors are relative to the sizes of the variables. To address this issue, this paper will also report the counterparts of the indicators where the errors are expressed in their percentage deviations, i.e., $(\hat{y}_t - y_t)/y_t$.

Table 3 presents the results from a dynamic simulation of the model from the first quarter of 1988 to the fourth quarter of 1999. These results show two patterns regarding the performance of the AMFM. First, the model seems to track aggregate prices and outputs reasonably well. Second, the model can stand improvement in its ability to track foreign debt and interest payments.

Estimates of the root mean square error (in percent) show that the aggregate variables that appear to track their historical values well are the consumer price index (CPI) and the GDP deflator (*pgdp*). These variables have errors approximately equal 1.95 and 2.00 percent of their actual values, respectively. Not far behind are the measures of aggregate economic activity. Gross domestic product at constant prices (*rgdp*) has a root mean square error (in percent) of about 2.87 percent. This is closely followed by its nominal counterpart (GDP) and gross national product at current prices (GNP).

Among the variables that still require improvements in tracking ability are foreign debt (fd) and interest payments. Foreign debt has an RMS error of about 11 percent. This is caused mainly by the large forecasting errors in private foreign debt (*fdp*). These errors carry over to interest payments because of the stock-flow relationships in the model. This can be seen in the relatively poor estimates of the *potential* interest payments (*pot_intgp* and *pot_intpf*).

5. Future work on the AMFM

While the AMFM has gone a long way since work began eight months ago, there are still a number of tasks that need to be done to enhance its usefulness as a tool for forecasting and policy analysis.

Two tasks still need to be conducted in the short term. First, is to obtain a better understanding of the model's forecasting ability by conducting outside of sample forecasts. This checks the ability of the model to track the actual data beyond the period over which the equations were estimated. To the extent that the process requires projecting the values of the exogenous variables, this also assists in decomposing the sources of the forecasting errors.

The second task is a multiplier analysis. This in a nutshell involves changing the values of some of the exogenous variables, usually the policy instruments, and evaluating the responses of the endogenous variables. Apart from providing some insights on how the model as a whole is likely to respond to changes in exogenous variables, this also helps in developing a better understanding of the channels through which the economic variables interact.

The two tasks are important in determining the degree of confidence that can be placed on the model's forecasts. To the extent that errors are found in the process, the tasks also help *debug* the model.

In the long haul, i.e., there are many features that can still be incorporated into the AMFM. Foremost of these tasks is a coherent long-run structure. Completing this task will bring the AMFM in line with recent developments in macroeconometric model building.

The model may also be disaggregated. This may involve additional production sectors, households and, perhaps, regions. Such a revision introduces a distributional dimension to the model. It will also allow the AMFM to evaluate the effects of macroeconomic policies on (relatively) small economic units.

Finally, the model may be adjusted to accommodate additional complications. For example, the financial sector might be adjusted to accommodate the money creation process, the first step is integrating the commercial banking sector. Another is a comprehensive treatment of household optimization processes.

Table 3. Results from a Dynamic Simulation of AMFM

Variable		*Levels*			*Percent*	
	ME	MAE	RMS	ME	MAE	RMS
Arlessrr	0.23	0.63	0.75	9.1	17.18	22.27
Arr	0	0.15	0.19	0.02	2.43	2.93
Bfip	18.74	251.5	2994.16	1.43	6.68	8.01
Cons	-163.12	183.56	2286.67	-1.15	1.28	1.65
Cpi	-0.11	0.31	3.65	-0.53	1.63	2
Ddg	-2906.35	2906.35	35015.69	-3.54	3.54	4.12
exp_infyoy	0	0	0.02	5.42	21.41	26.79
Exr	-0.06	0.13	1.73	-1.74	4.56	5.84
fd	-9924.53	10912.5	157205.98	-6.91	7.78	10.81
fdg	2462.1	2462.84	33216.94	2.72	2.72	3.66
fdp	-12386.63	12782.29	188972.37	-25.28	26.9	36.75
finv	18.74	251.5	2994.16	1.2	5.93	7.11
gc	0	0	0	0	0	0
gdeficit	-29.25	246.31	3152.2	15.67	75.16	139.79
gdp	40.7	956.39	12389.63	-0.19	2.3	2.87
gndp	-148.92	309.14	6058.42	-12.29	43.93	87.55
gne	-480.57	672.06	8135.13	-1.08	1.61	2.03
gneb	119.67	212.31	5505.65	-12.29	43.93	87.55
gnp	40.7	956.39	12389.63	-0.21	2.26	2.82
grev	-98.35	143.07	1786.58	-1.28	2.02	2.53
gspend	-127.61	255.53	3273.22	-1.68	3.18	4.06
infyoy	0	0.23	2.94	7.43	26.92	34.14
intf	-129.72	209.08	2621.94	-5.63	14.4	16.69
intg	-104.25	217.24	2884.51	-3.99	10.66	13.46
intgd	-104.25	217.24	2884.51	-4.82	14.43	18.14
intpf	-129.72	209.08	2621.94	-7.24	22.93	26.93
K	685	778.53	9308.92	0.3	0.35	0.42
kbp	685.00	778.53	9308.93	0.35	0.40	0.48
lame	0.00	0.01	0.13	-2.12	3.79	5.18
lfpr	0.00	0.00	0.01	-0.16	0.66	0.88
ls	0.00	0.02	0.24	-0.16	0.66	0.88
lt	0.00	0.03	0.34	-0.01	1.00	1.32
lte	-0.07	0.14	1.79	-2.42	5.33	6.77
m	-268.59	569.83	7383.44	-2.05	5.76	7.06
me	-77.69	232.70	2980.10	-0.91	2.78	3.57
pgdp	0.00	0.00	0.04	-0.32	1.59	1.95

Table 3. Results from a Dynamic Simulation of AMFM (continued)

Variable	Levels			Percent		
	ME	*MAE*	*RMS*	*ME*	*MAE*	*RMS*
pm	0.00	0.01	0.12	-1.74	4.56	5.84
pnte	0.00	0.01	0.11	-2.15	3.88	5.35
pot_intgf	35.72	35.73	465.41	2.60	2.60	3.56
pot_intgp	-258.05	375.55	4599.31	-7.72	12.93	15.35
pot_intpf	-167.55	175.56	2590.42	-23.88	25.49	35.43
pqlr	0.00	0.00	0.06	-0.80	2.13	2.54
px	0.00	0.01	0.13	-1.74	4.56	5.84
py	0.00	0.00	0.04	-0.40	1.56	1.92
pye	0.00	0.01	0.12	-2.15	3.88	5.35
qe	-170.96	266.27	3691.10	-0.62	1.06	1.41
rl	0.00	0.00	0.01	-0.36	3.27	4.04
rdif	0.00	0.00	0.01	-0.23	0.43	0.52
rgdp	39.12	445.78	5536.21	0.15	2.32	2.87
ri	-0.23	0.56	0.68	7.02	54.71	87.91
rr	-0.23	0.56	0.68	-3.46	28.41	38.39
rs	-0.10	0.18	2.17	-4.51	11.92	14.26
tdng	-444.25	652.98	7815.25	-0.27	0.39	0.45
txg	-23.56	33.02	405.49	-1.08	1.61	2.03
txm	-94.21	141.87	1872.61	-3.79	7.32	9.03
txy	19.42	68.46	982.48	0.41	2.85	3.67
u	-0.01	0.09	1.04	-1.37	9.11	11.20
v	4053.37	4611.35	60513.13	1.63	1.92	2.44
w	3.83	26.32	332.79	0.00	5.79	6.88
x	-55.82	383.35	4892.90	-0.43	4.88	5.92
xe	-45.26	202.26	2538.56	-0.24	2.78	3.36
ye	-144.38	274.16	3754.52	-0.66	1.30	1.77
yp	139.83	452.05	5789.51	0.83	2.99	3.84
ypat	290.22	1023.59	13478.34	0.41	2.85	3.67

Appendix A: Model equations

Stochastic Equations

S01 Exports

$$\log(x) = C(1) + C(2)\cdot\left[D9597^{*}\log(xe_{-8})\right] + C(3)\cdot\log(xe_{-8}) + C(4)\cdot T$$
$$+ C(5)\cdot\log(x_{-1}) + C(6)\cdot\log(x_{-4}) + C(7)\cdot\log(x_{-5}) + C(8)\cdot D9597$$

Estimation period: 1987:1-2000:4

Coefficient	*Estimate*	*Std. Error*
C(1)	6.84	1.38
C(2)	0.929	0.232
C(3)	0.144	0.075
C(4)	0.011	0.002
C(5)	0.26	0.099
C(6)	0.319	0.098
C(7)	-0.373	0.099
C(8)	-10.199	2.574

S02 Imports

$$\Delta m = C(1) + C(2)\cdot(m_{-1} - me_{-1}) + C(3)\cdot\Delta me + C(4)\cdot S2 + C(5)\cdot S3$$
$$+C(6)\cdot T + C(7)\cdot\Delta m_{-2} + C(8)\cdot\Delta m_{-4} + C(9)\cdot\Delta m_{-7}$$
$$+ C(10)\cdot\left[D9597\cdot(m_{-1} - me_{-1})\right]$$

Estimation period: 1987:1-2000:4

Coefficient	*Estimate*	*Std. Error*
C(1)	-18042.480	2752.853
C(2)	-0.602	0.076
C(3)	0.408	0.097
C(4)	7714.484	2149.845
C(5)	8960.233	1921.838
C(6)	364.134	65.767
C(7)	0.347	0.100
C(8)	0.393	0.098
C(9)	0.469	0.111
C(10)	0.466	0.081

S03 Labor demand

$$lt = C(1) + C(2) \cdot lte + C(3) \cdot lte_{-2} + C(4) \cdot lte_{-7} + C(5) \cdot S2 + C(6) \cdot T$$
$$+ C(7) \cdot lt_{-1} + C(8) \cdot lt_{-2} + C(9) \cdot lt_{-4}$$

Estimation period: 1986:4-2000:2

Coefficient	*Estimate*	*Std. Error*
C(1)	11.584	3.204
C(2)	0.089	0.032
C(3)	-0.075	0.032
C(4)	-0.061	0.033
C(5)	0.406	0.123
C(6)	0.116	0.035
C(7)	0.317	0.134
C(8)	0.312	0.134
C(9)	-0.229	0.137

S04 Price of the domestic good

$$py = C(1) + C(2) \cdot pye_{-1} + C(3) \cdot pye_{-7} + C(4) \cdot T + C(5) \cdot py_{-1}$$
$$+ C(6) \cdot py_{-6} + C(7) \cdot py_{-7}$$

Estimation period: 1986:4-2000:2

Coefficient	*Estimate*	*Std. Error*
C(1)	0.302	0.054
C(2)	0.077	0.023
C(3)	0.048	0.028
C(4)	0.022	0.005
C(5)	0.460	0.104
C(6)	-0.354	0.137
C(7)	0.257	0.113

S05 Fixed investment

$$py = C(1) + C(2) \cdot pye_{-1} + C(3) \cdot pye_{-7} + C(4) \cdot T + C(5) \cdot py_{-1}$$
$$+ C(6) \cdot py_{-6} + C(7) \cdot py_{-7}$$

Estimation period: 1987:4-2000:4

Coefficient	*Estimate*	*Std. Error*
C(1)	5258.241	3011.664
C(2)	145.722	46.791
C(3)	0.276	0.088
C(4)	0.478	0.073
C(5)	-1891.157	994.479
C(6)	-25741.42	12327.300
C(7)	636.610	266.926

S06 Consumption

$$\Delta cons = C(1) + C(2) \cdot \Delta yp_{-1} + C(3) \cdot \Delta v_{-3} + C(4) \cdot \Delta cons_{-1} + C(5) \cdot \Delta cons_{-4}$$
$$+ C(6) \cdot S3 + C(7) \cdot S4 + C(8) \cdot DUM90 + C(9) \cdot [DUM90 \cdot \Delta v_{-3}]$$

Estimation period: 1987:1-2000:1

Coefficient	*Estimate*	*Std. Error*
C(1)	-5540.135	959.701
C(2)	0.054	0.026
C(3)	0.017	0.007
C(4)	-0.598	0.098
C(5)	0.381	0.125
C(6)	11710.430	2030.935
C(7)	15230.110	3084.940
C(8)	791.048	379.390
C(9)	-0.029	0.012

S07 Consumer price index

$$cpi = C(1) + C(2) \cdot PY \cdot 100 + C(3) \cdot sl + C(4) \cdot s2 + C(5) \cdot cpi_{-1} + C(6) \cdot cpi_{-4}$$

Estimation period: 1986:1-2000:3

Coefficient	*Estimate*	*Std. Error*
C(1)	-3.88	0.73
C(2)	0.53	0.06
C(3)	2.31	0.42
C(4)	-1.24	0.41
C(5)	0.59	0.07
C(6)	-0.11	0.03

S08 Labor supply

$$loglab = C(1) + C(2) \cdot \Delta u_{-2} + C(3) \cdot \Delta u_{-3} + C(4) \cdot \left(\frac{w_{-6}}{py_{-6}} \right) + C(5) \cdot S2 + C(6) \cdot D91Q2$$

Estimation period: 1986:3-2000:2

Coefficient	*Estimate*	*Std. Error*
C(1)	0.480	0.064
C(2)	-0.545	0.294
C(3)	-1.213	0.441
C(4)	7.90E-05	3.32e-05
C(5)	0.067	0.024
C(6)	0.135	0.038

S09 Philips curve

$$\Delta_4 \log(w) = C(1) + C(2) \cdot \Delta u_{-2} + C(3) \cdot \Delta_4 \log(w_{-1}) + C(4) \cdot \Delta_4 \log(w_{-4})$$
$$+ C(5) \cdot D89Q4$$

Estimation period: 1987:1-2000:2

Coefficient	*Estimate*	*Std. Error*
C(1)	0.096	0.029
C(2)	-0.442	0.257
C(3)	0.724	0.096
C(4)	-0.245	0.086
C(5)	0.069	0.036

S10 Inverse demand for money

$$rs = C(1) + C(2) \cdot \log\left(\frac{hmp_{-5}}{py_{-5}}\right) + C(3) \cdot \log\left(\frac{hmp_{-6}}{py_{-6}}\right) + C(4) \cdot \log\left(\frac{gne_{-1}}{py_{-1}}\right)$$
$$+C(5) \cdot \log\left(\frac{gne_{-4}}{py_{-4}}\right) + C(6) \cdot \log\left(\frac{gne_{-6}}{py_{-6}}\right) + C(7) \cdot \log\left(\frac{gne_{-7}}{py_{-7}}\right)$$
$$+C(8) \cdot T + C(9) \cdot rs_{-1} + C(10) \cdot rs_{-2}$$

Estimation period: 1987:4-2000:4

Coefficient	*Estimate*	*Std. Error*
C(1)	-720.017	186.380
C(2)	-7.114	3.777
C(3)	-11.501	4.830
C(4)	18.343	6.850
C(5)	21.120	4.724
C(6)	22.486	7.641
C(7)	16.998	5.985
C(8)	-0.635	0.174
C(9)	0.678	0.140
C(10)	-0.298	0.145

S11 Interest payments on government domestic debt

$$\Delta \log(intgd) = C(1) + C(2)\cdot\left[\log(intgd_{-1}) - \log(pot\_intgp_{-3})\right]$$
$$+ C(3)\cdot T + C(4)\cdot\Delta\log(intgd_{-1}) + C(5)\cdot\Delta\log(intgd_{-3})$$
$$+ C(6)\cdot\Delta\log(intgd_{-4}) + C(7)\cdot D91Q1 + C(8)\cdot D00Q3$$
$$+ C(9)\cdot D00Q4$$

Estimation period: 1987:2-2000:4

Coefficient	*Estimate*	*Std. Error*
C(1)	-0.787	0.166
C(2)	-0.731	0.122
C(3)	0.009	0.002
C(4)	-0.375	0.097
C(5)	-0.247	0.089
C(6)	-0.244	0.087
C(7)	-0.657	0.165
C(8)	0.385	0.169
C(9)	0.494	0.169

S12 Interest payments on private external debt

$$\Delta_4 intpf = C(1) + C(2)\cdot(intpf_{-4} - pot\_intpf_{-4}) + C(3)\cdot T$$
$$+ C(4)\cdot\Delta_4 intpf_{-1} + C(5)\cdot D97Q4 + C(6)\cdot D99Q1$$

Estimation period: 1987:2-1999:4

Coefficient	*Estimate*	*Std. Error*
C(1)	-912.804	571.163
C(2)	-0.366	0.093
C(3)	61.167	19.509
C(4)	0.535	0.099
C(5)	4915.669	1532.979
C(6)	-5231.360	1579.183

S13 Interest Parity

$$\Delta\log(exr) = C(1) + C(2)\cdot rdif_{-8} + C(3)\cdot\Delta\log(exr_{-3})$$
$$+ C(4)\cdot\Delta\log(exr_{-5}) + C(5)\cdot\Delta\log(exr_{-11}) + C(6)\cdot dasia$$
$$+ C(7)\cdot dasia\cdot rdif_{-8}$$

Estimation period: 1988:1-2001:2

Coefficient	*Estimate*	*Std. Error*
C(1)	0.960844	0.477824
C(2)	-0.931207	0.465853
C(3)	-0.265238	0.101096
C(4)	-0.204367	0.098011
C(5)	0.424503	0.099032
C(6)	10.79432	4.448233
C(7)	-10.52275	4.376982

Identities

I01 First-order condition for exports

$$xe = \frac{px\cdot qe}{lame\cdot cetf}$$

I02 First-order condition for the domestic good

$$y = \frac{qe\cdot pnte}{lame}$$

I03 First-order condition for imports

$$lame = \frac{pm\cdot me}{\beta_2\cdot qe}$$

I04 First-order condition for labor

$$lte = \frac{\beta_1\cdot lame\cdot qe}{w}$$

I05 Definition of gross output – input side

$$me = \left(\frac{qe}{A_{CB} \cdot lte^{\beta_1} \cdot k_{-1}^{1-\beta_1-\beta_2}} \right)^{\frac{1}{\beta_2}}$$

I06 Definition of gross output – output side

$$qe = \left(A_{CET} \cdot xe^2 + y^2 \right)^{0.5}$$

I07 Equilibrium price of the domestic good – including taxes

$$pye = pnte \cdot (1 + txgr)$$

I08 Actual rate less required rate of return

$$arrlessrr = arr - rr$$

I09 Long-run equilibrium price of gross output

$$pqlr = \left(\frac{px^2}{A_{CET}} + pnt^2 \right)^{.05}$$

I10 Nominal rate of return to capital

$$rl = \left(pqlr \cdot A_{CB} \cdot \beta_1^{\beta_1} \cdot (1 - \beta_1 - \beta_2)^{1-\beta_1-\beta_2} \cdot \beta_2^{\beta_2} \cdot w^{-\beta_1} \cdot pm^{-\beta_2} \right)^{\frac{1}{1-\beta_1-\beta_2}}$$

I11 Actual rate of return to capital

$$arr = \frac{r1}{py}$$

I12 Required rate of return to capital

$$rr = ri + dr$$

I13 Real interest rate

$$ri = \left(\frac{1 + \frac{rs}{400}}{e^{\frac{\text{exp\_infyoy}}{4}}} \right) - 1$$

I14 Inflation expectations

$$\text{exp\_infyoy} = a_0 + a_1 \cdot \text{infyoy} + a_2 \cdot \text{infyoy}_{-3} + a_3 \cdot d90q4 + a_4 \cdot d91q1$$

I15 Aggregate capital stock

$$k = (1 - dr) \cdot k_{-1} + finv$$

I16 Private fixed investment (gross) – at constant prices

$$bfip = finv - rgko - rgeq$$

I17 Private sector capital stock

$$kbp = (1 - dr) \cdot kbp_{-1} + bfip$$

I18 Private sector income – at current prices

$$ypat = gnp + subsidies + (trpgh - trphg) + (trpfh - trphf) - txg - txm - dr \cdot py \cdot kbp_{-1} - intpf$$

I19 Private sector income net of direct taxes – constant prices

$$yp = \frac{(1 - txyr) \cdot ypat}{py}$$

I20 Private sector net wealth

$$v = \frac{ddg + py \cdot kbp - fdp}{py}$$

I21 Output of the domestic good – constant prices

$$y = cons + gc + finv + ii$$

I22 Gross national expenditure

$$gne = py \cdot (cons + gc + bfip + rgeq + rgko + ii)$$

I23 Gross Domestic Product – current prices

$$gdp = gne + px \cdot x - pm \cdot m + psd \cdot sd$$

I24 Gross National Product – current prices

$$gnp = gdp + nfia$$

I25 GDP deflator

$$gdp = w\_y \cdot py + w\_x \cdot px - w\_m \cdot pm + w\_sd \cdot psd$$

I26 Real GDP

$$rgdp = \frac{gdp}{pgdp}$$

I27 Government Consumption

$$gc = nggc + ogc$$

I28 Inflation year on year

$$infyoy = \frac{py - py_{-4}}{py_{-4}} \cdot 100$$

I29 Price of the domestic good, net of taxes

$$pnt = \frac{py}{1 + txgr}$$

I30 Labor Force Participation Rate

$$lfpr = \frac{e^{\text{loglab}}}{1 + e^{\text{loglab}}}$$

I31 Labor supply

$$ls = lfpr \cdot pop1$$

I32 Unemployment rate

$$u = \frac{ls - lt}{ls} \cdot 100$$

I33 Total government expenditures

$$gspend = ngcc \cdot py + intgd + intgf + subsidies + py \cdot (rgko + rgeq) + gnl + trpgf + trpgh + gdisk1$$

I34 Interest payments on government debt

$$intg = intgf + intgd$$

I35 Government revenues

$$grev = txy + txg + txm + txo + trpfg + trphg + gdisk2$$

I36 Government revenues from indirect taxes

$$txg = pnt \cdot y \cdot txgr$$

I37 Government revenues from import taxes

$$txm = txmr \cdot pmf \cdot exr \cdot m$$

I38 Government revenues from income taxes

$$txy = txyr \cdot ypat$$

I39 Government deficit

$$gdeficit = gspend - grev$$

I40 Financing government deficit – domestic borrowings

$$gdeficit = gndb + gneb + ccash$$

I41 Financing government deficit – external borrowings

$$gneb = ratfin \cdot gndb$$

I42 External debt of the national government - in pesos

$$\Delta fdg = gneb$$

I43 Domestic debt of the national government

$$\Delta ddg = gndb - gnl$$

I44 Total debt of the national government

$$tdng = fdg + ddg$$

I45 Potential interest payments on the government's domestic debt

$$pot\_intgp = \frac{rs}{400} \cdot ddg_{-1}$$

I46 Potential interest payments on the government's foreign debt

$$pot\_intgf = \frac{rlf10}{400} \cdot fgp_{-1}$$

I47 Potential interest payments on the private sector's foreign debt

$$pot\_intpf = \frac{rlf5}{400} \cdot fdp_{-1}$$

I48 Domestic price of imports

$$pm = pmf \cdot exr \cdot (1 + txmr)$$

I49 Domestic price of exports

$$px = pxf \cdot exr$$

I50 Balance of payments

$$\Delta fd = -[(px \cdot x - pm \cdot m) - (intpf + intgf) + (trpfh - trphf) + (trpfg - trpgf) + bal]$$

I51 External debt of the private sector

$$fdp = fd - fdg$$

I52 Total interest payments on external debt

$$intf = intpf + intgf$$

I53 Ratio of the returns from a domestic T-bill to the foreign T-bill

$$rdif = \frac{1 + \frac{rs}{400}}{1 + \frac{rsf}{400}}$$

Supplementary Equations

SE01 Equation used for I14

$$infyoy = C(1) + C(2) \cdot infyoy_{-1} + C(3) \cdot infyoy_{-4} + C(4) \cdot D91Q1 + C(5) \cdot D91Q2$$

Estimation period: 1987:1-2000:4

Coefficient	Estimate	Std. Error
C(1)	0.032	0.008
C(2)	0.743	0.082
C(3)	-0.138	0.077
C(4)	0.045	0.020
C(5)	0.068	0.020

SE02 Estimating equation for A_{CB}

$$A_{CB,t} = C(1) + C(2) \cdot S1 + C(3) \cdot S2 + C(4) \cdot S3$$

Estimation period: 1986:1-2000:2

Coefficient	Estimate	Std. Error
C(1)	2.682	0.027
C(2)	-0.283	0.038
C(3)	-0.263	0.038
C(4)	-0.259	0.038

SE03 Estimating equation for A_{CET}

$$CET = C(1) + C(2) \cdot T$$

Estimation period: 1986:1-2000:4

Coefficient	Estimate	Std. Error
C(1)	3.428286	0.163039
C(2)	-0.011461	0.004224

Appendix B: Model variables

Endogenous variables

arlessrr	*arr-rr*
arr	actual rate of return to capital
bfip	fixed investment of the private sector at constant prices
cons	consumption spending at constant prices
CPI	consumer price index (1985=100)
ddg	domestic debt of the government
exp_infyoy	expected *infyoy*
exr	exchange rate, php per usd
fd	external debt of the Philippines
fdg	foreign debt of the government
fdp	external debt of the private sector
finv	gross fixed investment at constant prices
gc	government consumption spending at constant prices
gdeficit	government deficit
gndb	government net domestic borrowing
gne	gross national expenditure
gneb	government net external borrowing
GNP	gross national product at current prices
grev	total government revenues
gspend	total government expenditures
infyoy	inflation rate, year on year
intf	net interest payments on the countrys foreign debt
intg	interest payments on government debt
intgd	government interest payments on its domestic debt
intgf	net interest payments of the government on its foreign debt
intpf	net interest payments of the private sector on its foreign debt
k	economywide stock of capital at constant prices
kbp	private sector capital stock
lame	lagrange multiplier
lfpr	labor force participation rate
loglab	$\log\left(\frac{lfpr}{1-lfpr}\right)$

ls	labor supply
lt	employment in million persons
lte	equilibrium *lt*
m	imports of goods and services at constant prices
me	equilibrium *m*
pGDP	GDP deflator (1985=100)
pm	price index for imports (1985=100)
pnt	price of the domestic good before taxes
pnte	equilibrium *pnt*
pot_intgf	potential interest payments on the government foreign debt
pot_intgp	potential interest payments on the government's domestic debt
pot_intpf	potential interest payments on the private sectors foreign debt
pqlr	long-run price of gross output
px	price index for exports (1985=100)
py	price index for the domestic output (*y*), 1985=100
pye	equilibrium *pye*
qe	equilibrium gross output
r1	nominal rate of return to capital
rdif	ratio of the return to domestic assets to foreign assets
rGDP	GDP at constant prices
ri	real interest rate
rr	required rate of return to capital
rs	short term interest rate, percent p.a.
tdng	total government debt
txg	government revenues from indirect taxes
txm	taxes on imports
txy	taxes on income and profits
u	unemployment rate
v	net wealth of the private sector, at constant prices
w	nominal wage rate
x	exports of goods and services at constant prices
xe	equilibrium *x*
y	domestic output
yp	private sector income at constant prices, after taxes
ypat	private sector income

Exogenous variables

bal	balancing item in the balance of payments
ccash	change in cash
d00q3	1 for third quarter of 2000 and 0 otherwise
d00q4	1 for fourth quarter of 2000 and 0 otherwise
d89q4	1 for fourth quarter of 1989 and 0 otherwise
d91q1	1 for first quarter of 1991 and 0 otherwise
d9597	1 for 1995-97 and 0 otherwise
d97q4	1 for fourth quarter of 1997 and 0 otherwise
d99q1	1 for first quarter of 1999 and 0 otherwise
dasia	1 for 1997:3-1998:3 and 0 otherwise
dr	rate of depreciation
dum90	1 for 1992-98 and 0 otherwise
gdisk1	adjustment item in government expenditures
gdisk2	adjustment item in government revenues
gnl	government net lending
hpm	stock of high-powered money
ii	inventory investment at constant prices
nfia	net factor income from abroad
nggc	consumption spending of the national government at constant prices
ogc	other components of government consumption, constant prices
pmf	price of imports in foreign currency
pop1	population 15 years and above
psd	price index for the *sd* (1985=100)
pxf	foreign price of exports
ratfin	ratio of *gneb* to *gneb* in the government deficit
rgeq	government investment: equity, constant prices
rgko	government investment: capital outlays, constant prices
rlf10	10-year foreign interest rate, percent p.a.
rlf5	5-year foreign interest rate, percent p.a.
rsf	short term foreign interest rate, percent p.a.
s1	s1 =1 for the first quarter, 0 otherwise
s2	s2 =1 for the second quarter, 0 otherwise
s3	s3 =1 for the third quarter, 0 otherwise
sd	statistical discrepancy at constant prices
subsidies	government subsidies
t	time trend
trpfg	transfers of foreign to government, current prices

trpfh	transfers of foreign to households, current prices
trpgf	transfers of government to foreign , current prices
trpgh	transfers of government to households , current prices
trphf	transfers of households to foreign , current prices
trphg	transfers of households to government , current prices
txgr	indirect tax rate
txmr	effective tariff rate on imports
txo	other taxes
txyr	tax rate on income and profits
w_m	ratio of imports to GDP
w_sd	ratio of *sd* to GDP
w_x	ratio of exports to GDP
w_y	ratio of the domestic output to GDP

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