

Appendix: Macroeconometric model¹

The Bank of Thailand's macroeconometric model (BOTMM) is an economic forecasting tool, consisting of 24 behavioural equations and 43 identities. The BOTMM presents to the Monetary Policy Committee (MPC) an important tool for economic forecasting. The model is used to analyze the response of the economy to various exogenous shocks and policy changes. It also assists the MPC in formulating the optimal policy to achieve the goals of price stability and sustainable economic growth in the long run.

Improving the model

In this *Report*, the BOTMM was revised by incorporating the most recent published data, particularly the quarterly GDP figures of 2006 Q4 released by the NESDB on 6 March 2007. Other notable changes made to the model since the January 2007 *Report* are as follows.

1. The exchange rate equation (equation 3.6) was revised such that the exchange rate of Japanese yen per US dollar was removed from REGIONFX due to its inconsistent movement with other currencies in the region as well as the Thai baht. Such inconsistency was due to the recent depreciation of the Japanese yen as a result of low domestic interest rates, leading to capital outflows.

2. The equation for net flows of the private financial account (equation 3.7) was adjusted to incorporate the 1-day repurchase rate (RP1D) instead of the minimum lending rate (MLR) in the calculation of the interest rate differential between domestic and the FEDFUND, which is a financial market interest rate. Moreover, FX88 which was formerly intended to capture the impact of economic fundamentals and financial returns on flow of funds, was removed from the equation since the effect of economic fundamentals was already reflected in the current account balance and that of financial returns was also captured by the interest rate differential.

¹ The Bank of Thailand's macroeconometric model was first published in the July 2000 *Report*. Revisions to the model were noted in subsequent *Reports*.

3. Two equations for commercial bank interest rates were revised. Firstly, a term representing an acceleration of the 1-day repurchase rate ($\Delta\Delta RP1D$) was added to the three-month deposit rate equation (equation 4.1) to reflect the speed of increase or decrease of the policy interest rate, which also affected the adjustments of commercial bank interest rates, on top of the direction of the policy rate. Secondly, the minimum lending rate equation (equation 4.2) was revised such that the change in the minimum lending rate is explained by the change in the three-month deposit rate and the one-quarter lag of the change in the minimum lending rate. The new equation differs from the previous one where levels of interest rates were used.

Effect of variations in the exchange rate and crude oil price on the Thai economy

The model in this *Report* was used to analyze the effect of variations in the exchange rate and the crude oil price on the Thai economy. Table A.1 shows that a one-percentage depreciation in the exchange rate (baht per US dollar) would increase core inflation, headline inflation, and economic growth by 0.03, 0.03, and 0.29 per cent, respectively.

Moreover, a one-percentage increase in the Dubai crude oil price (US dollars per barrel of Dubai crude oil) would affect core inflation, headline inflation, and economic growth by 0.01, 0.04, and -0.03 per cent respectively.

Table A.1 Summary of the effect of variations in the exchange rate and crude oil price		
	Effect on the Thai economy in the 4 th quarter ahead	
	A 1% depreciation in the exchange rate	A 1% increase in crude oil price
Core inflation	0.03	0.01
Headline inflation	0.03	0.04
Economic growth	0.29	-0.03

Source: Macroeconometric model, Bank of Thailand

Corporate and household sector models

The corporate and household sector models are tools developed by the BOT to help assess the financial conditions of the Thai corporate and household sectors. The assessment is part of the effort to ensure financial stability, which itself, in turn, is closely intertwined with monetary stability and long-term economic growth, the main objectives of monetary policy under inflation targeting. In this *Report*, the BOT has revised the corporate and household sector models using the latest released data, especially those pertaining to listed companies, household credits, and GDP.

1.8.2 Exports of services at 1988 constant prices

$$XSR = RXSR * XR$$

1.9 Imports of goods and services at 1988 constant prices

$$\Delta \ln(MRsa) = 1.112 * \Delta \ln(DDsa) + 0.613 * \Delta \ln(XRsa) - 0.237 * \Delta \ln((PM\$sa * FX88) / CPIsa) - 0.270 * ecmMR(-1)$$

(10.92) (6.53) (-3.30) (-2.98)

Adjusted R-Squared = 0.79 S.E. of regression = 0.0267 LM(2) : 0.90 (0.41)

$$ecmMR = \ln(MRsa) - (-3.690 + 1.000 * \ln(DDsa) + 0.504 * \ln(XRsa) - 0.227 * \ln((PM\$sa * FX88) / CPIsa))$$

1.9.1 Imports of goods at 1988 constant prices

$$MGR = RMGR * MR$$

1.9.2 Imports of services at 1988 constant prices

$$MSR = RMSR * MR$$

1.10 Gross domestic product at 1988 constant prices

$$GDPR = CPR + CGOVR + IPR + IPUB + (XR * MR) + OTHGDP$$

1.11 Gross domestic product at current market prices

$$GDPN = ((CPR * CPI) + (CGOVR * PGCON) + (IPR * PIP) + (IPUB * PIFX) + ((XR * PXS * FX88 / 100) - (MR * PMS * FX88 / 100)) + (OTHGDP * POTHGDP)) / 100$$

1.12 Domestic demand

$$DD = GDPR - XR + MR$$

2. Government sector

2.1 Government revenue

$$GREV = TAXREV + OTHREV$$

2.2 Tax revenue

$$TAXREV = TD + TIND$$

2.3 Direct tax

$$TD = TH + TC$$

$$TH = RH * GDPN$$

$$TC = RC * GDPN$$

2.4 Indirect tax

$$TIND = TVAT + TEXC + OTHTIND$$

$$TVAT = RVAT * (CPR * CPI / 100)$$

$$TEXC = REXC * (CPR * CPI / 100)$$

$$OTHTIND = ROTHTIND * (CPR * CPI / 100)$$

2.5 Government cash balance

$$GCB = GREV - (GCURRENT + GCAPITAL) + NONBUDGET$$

3. External sector

3.1 Current account

$$CURRENTS = (((XGR * PXG\$) - (MGR * PMG\$)) + ((XSR * PXSS) - (MSR * PMSS))) / (25.29^3 * 100)$$

$$CURRENTB = CURRENTS * FX$$

^{3/} The Baht/USD exchange rate in 1988 is 25.29.

3.2 Capital and financial account

$$\begin{aligned} \text{CAPITALS} &= \text{CAPITALSPRI} + \text{OTHCAPS} \\ \text{CAPITALB} &= \text{CAPITALS} * \text{FX} \end{aligned}$$

3.3 Balance of payments

$$\begin{aligned} \text{BPB} &= \text{CAPITALS} * \text{FX} + \text{CURRENTS} * \text{FX} + \text{OTHBP} \\ \text{BPS} &= \text{BPB} / \text{FX} \end{aligned}$$

3.4 International reserves

$$\text{RESERVE} = \text{BPS} + \text{RESERVE}(-1)$$

3.5 Net foreign assets

$$\text{NFA} = \text{NFA}(-1) + \text{BPB} + \text{OTHNFA}$$

3.6 Exchange rate

$$\begin{aligned} \ln(\text{FX88}) &= \ln(\text{FX88}(-1)) + (\ln(1 + \text{FEDFUND}/400) - \ln(1 + \text{RP14D}/400)) + \Delta \ln(\text{CPIsa}/\text{CPIUSsa}) + \text{RISK} \\ \text{RISK} &= 1.531 * \Delta \ln(\text{REGIONFX}) - 0.336 * \Delta (\text{BPB}(-1) / \text{GDPN}(-1)) \\ \text{FX} &= (\text{FX88} * 25.29^3) / 100 \\ \text{NEER} &= \text{TPFX} / \text{FX94} \\ \text{REER} &= \text{NEER} / (\text{TPCPI} / \text{CPI} * 100 / 73.43) \end{aligned}$$

3.7 Net flows of private financial account

$$\begin{aligned} \text{CAPITALSPRI} &= 0.386 * \Delta (\text{RP1D} - \text{FEDFUND}) - 0.568 * \text{CURRENTS} + 55.481 * \Delta \ln(\text{GDPNsa}) \\ &\quad (2.31) \qquad \qquad \qquad (-5.11) \qquad \qquad \qquad (3.51) \\ \text{Adjusted R-Squared} &= 0.49 \qquad \qquad \qquad \text{S.E. of regression} = 1.7369 \qquad \qquad \qquad \text{LM}(2) : 2.15 (0.13) \end{aligned}$$

4. Monetary sector

4.1 Three-month deposit rate

$$\begin{aligned} \Delta \text{RD3M} &= 0.252 * \Delta \text{RP1D} - 0.042 \Delta \text{RP1D}(-1) - 0.100 * \text{ecmRD3M}(-1) \\ &\quad (7.57) \qquad \qquad (1.537) \qquad \qquad \qquad (-3.438) \\ \text{Adjusted R-Squared} &= 0.57 \qquad \qquad \qquad \text{S.E. of regression} = 0.4941 \qquad \qquad \qquad \text{LM}(2) : 1.16 (0.32) \\ \text{ecmRD3M} &= \text{RD3M} - 0.807 * \text{RP1D} \end{aligned}$$

4.2 Minimum lending rate

$$\begin{aligned} \Delta \text{MLR} &= 0.588 * \Delta \text{RD3M} + 0.419 * \Delta \text{MLR}(-1) \\ &\quad (12.09) \qquad \qquad (7.38) \\ \text{Adjusted R-Squared} &= 0.90 \qquad \qquad \qquad \text{S.E. of regression} = 0.1955 \qquad \qquad \qquad \text{LM}(2) : 1.01 (0.38) \end{aligned}$$

4.3 Private credit

$$\begin{aligned} \Delta \ln(\text{PCREDITsa}) &= -0.014 * \Delta \text{MLR} + 0.669 * \Delta \ln(\text{GDPNsa}) - 0.002 * \ln(\text{NPL}(-2)) + 0.384 * \Delta \ln(\text{PCREDITsa}(-1)) + 0.0001 * (\text{CAPITALSPRI}(-1) * \text{FX}(-1)) \\ &\quad (-1.95) \qquad (2.78) \qquad \qquad (-2.00) \qquad (2.64) \qquad \qquad (2.29) \\ \text{Adjusted R-Squared} &= 0.46 \qquad \qquad \qquad \text{S.E. of regression} = 0.0147 \qquad \qquad \qquad \text{LM}(2) : 0.30 (0.74) \end{aligned}$$

4.4 Net claims on government

$$\begin{aligned} \Delta \text{CLAIMG} &= -0.419 * (\text{GCB} - \text{FINB}) \\ &\quad (-5.85) \\ \text{Adjusted R-Squared} &= 0.40 \qquad \qquad \qquad \text{S.E. of regression} = 40.57 \qquad \qquad \qquad \text{LM}(2) : 0.69 (0.51) \end{aligned}$$

^{3/} The Baht/USD exchange rate in 1988 is 25.29.

4.5 Money supply

$$M2A^S = NFA + CLAIMG + PCREDIT + OTHM2A$$

$$\Delta \ln(M2A^D_{sa} * 100 / CPI_{sa}) = 0.238 * \Delta \ln(GDPR_{sa}) - 0.007 * \Delta RD3M + 0.002 * CINFEX - 0.231 * ecmM2A^D(-1)$$

(2.64) (-2.24) (3.49) (-4.41)

Adjusted R-Squared = 0.43 S.E. of regression = 0.0119 LM(2) : 0.05 (0.96)

$$ecmM2A^D = \ln(M2A^D_{sa} * 100 / CPI_{sa}) - (4.349 + 0.549 * \ln(GDPR_{sa}) - 0.004 * RD3M)$$

4.6 Securities value

$$\Delta \ln(BMCAP) = 0.004 * \Delta(CAPITALS * FX) + 2.230 * \Delta \ln(GDPR_{sa}) - 0.110 * \Delta(MLR) - 0.490 * ecmBMCAP(-1)$$

(2.20) (2.16) (-2.64) (-3.11)

Adjusted R-Squared = 0.34 S.E. of regression = 0.0812 LM(2) : 0.69 (0.51)

$$ecmBMCAP = \ln(BMCAP) - (-14.695 + 0.0004 * (CAPITALS * FX) + 3.470 * \ln(GDPR_{sa}) - 0.015 * MLR)$$

5. Price index

5.1 Core consumer price index

$$\Delta \ln(CORE_{sa}) = 0.002 * (GDPR_{sa} / GDP_{HSM}) + 0.512 * \Delta \ln(CORE_{sa}(-1)) - 0.131 * ecmCORE(-1)$$

(2.95) (4.64) (-3.76)

Adjusted R-Squared = 0.72 S.E. of regression = 0.0033 LM(2) : 1.00 (0.38)

$$ecmCORE = \ln(CORE_{sa}) - (3.984 + 0.046 * \ln(PM_{sa} * FX88) + 0.036 * \ln(AVG EARN_{sa}) + 0.119 * \ln(CPIEN_{sa}(-1)))$$

5.2 Average earnings

$$\Delta \ln(AVG EARN_{sa}) = 0.296 * \Delta \ln(MINWAGE) + 0.857 * \Delta \ln(CPI_{sa}) - 0.194 * ecmAVG EARN(-1)$$

(2.96) (5.39) (-2.29)

Adjusted R-Squared = 0.32 S.E. of regression = 0.0122 LM(2) : 0.42 (0.66)

$$ecmAVG EARN = \ln(AVG EARN_{sa}) - (2.465 + 0.763 * \ln(MINWAGE(-1)) + 0.532 * \ln(CPI_{sa}))$$

5.3 Energy price index

$$\Delta \ln(CPIEN_{sa}) = 0.566 * \Delta \ln(RPPI_{sa}) - 0.211 * ecmCPIEN(-1)$$

(14.55) (-3.13)

Adjusted R-Squared = 0.74 S.E. of regression = 0.0177 LM(2) : 0.57 (0.57)

$$ecmCPIEN = \ln(CPIEN_{sa}) - (1.120 + 0.786 * \ln(RPPI_{sa}))$$

5.4 Retail petroleum price index

$$\Delta \ln(RPPI_{sa}) = 0.367 * \Delta \ln(DUBA_{sa}) + 0.467 * \Delta \ln(FX88) + 0.200 * \Delta \ln(RPPI_{sa}(-2)) - 0.364 * ecmRPPI(-1)$$

(10.01) (7.05) (3.22) (-5.25)

Adjusted R-Squared = 0.75 S.E. of regression = 0.0281 LM(2) : 0.11 (0.89)

$$ecmRPPI = \ln(RPPI_{sa}) - (-0.371 + 0.569 * \ln(DUBA_{sa}) + 0.719 * \ln(FX88))$$

5.5 Raw food price index

$$\Delta \ln(CPIRFOOD_{sa}) = 0.008 + 0.333 * \Delta \ln(FARMPRICE_{sa}) - 0.068 * ecmCPIRFOOD(-1)$$

(3.47) (5.86) (-1.78)

Adjusted R-Squared = 0.34 S.E. of regression = 0.0176 LM(2) : 0.71 (0.49)

$$ecmCPIRFOOD = \ln(CPIRFOOD_{sa}) - (0.686 + 0.893 * \ln(FARMPRICE_{sa}(-2)))$$

5.6 Farm price index (12 main products)

$$\Delta \ln(FARMPRICE_{12sa}) = 1.005 * \Delta \ln(WFP_{12sa}) + 0.616 * \Delta \ln(FX88) - 0.358 * ecmFARMPRICE_{12}(-1)$$

(9.12) (8.41) (-4.03)

Adjusted R-Squared = 0.70 S.E. of regression = 0.0306 LM(2) : 0.82 (0.45)

$$ecmFARMPRICE_{12} = \ln(FARMPRICE_{12sa}) - (-5.264 + 1.125 * \ln(WFP_{12sa}) + 1.030 * \ln(FX88))$$

5.7 Farm price index

$$\text{FARMPRICE} = (\text{WFARMPRICE}_{12} * \text{FARMPRICE}_{12}) + (\text{WFARMPRICE}_{\text{OTH}} * \text{FARMPRICE}_{\text{OTH}})$$

5.8 Headline consumer price index

$$\text{CPI} = ((1 - \text{WEN} - \text{WRFOOD}) * \text{CORE}) + (\text{WEN} * \text{CPIEN}) + (\text{WRFOOD} * \text{CPIRFOOD})$$

5.9 Private investment deflator

$$\Delta \ln(\text{PIPs}) = 1.640 * \Delta \ln(\text{CPIs}) + 0.113 * \Delta \ln(\text{FX88}(-2)) - 0.260 * \text{ecmPIP}(-1)$$

(5.24) (2.13) (-2.51)

Adjusted R-Squared = 0.45 S.E. of regression = 0.0210 LM(2) : 0.18 (0.84)

$$\text{ecmPIP} = \ln(\text{PIPs}) - (-3.842 + 1.690 * \ln(\text{CPIs}) + 0.067 * \ln(\text{FX88}(-1)))$$

5.10 Public investment deflator

$$\Delta \ln(\text{PIFXs}) = 1.192 * \Delta \ln(\text{CPIs}) - 0.129 * \text{ecmPIFX}(-1)$$

(8.05) (-2.20)

Adjusted R-Squared = 0.32 S.E. of regression = 0.0130 LM(2) : 1.23 (0.30)

$$\text{ecmPIFX} = \ln(\text{PIFXs}) - (-1.463 + 1.267 * \ln(\text{CPIs}) + 0.030 * \ln(\text{FX88}(-1)))$$

5.11 Government consumption deflator

$$\Delta \ln(\text{PGCONs}) = 0.790 * \Delta \ln(\text{CPIs}) + 0.034 * \Delta \text{SALARY} - 0.157 * \text{ecmPGCON}(-1)$$

(4.23) (4.27) (-2.17)

Adjusted R-Squared = 0.24 S.E. of regression = 0.0158 LM(2) : 0.14 (0.87)

$$\text{ecmPGCON} = \ln(\text{PGCONs}) - (0.317 + 0.974 * \ln(\text{CPIs}) + 0.065 * \text{SALARY})$$

5.12 Export price deflator

$$\Delta \ln(\text{PXSs}) = 0.205 * \Delta \ln(\text{PMSs}(-1)) + 0.629 * \Delta \ln(\text{TPGDPs}) - 0.206 * \Delta \ln(\text{FX88}) - 0.370 * \text{ecmPXS}(-1)$$

(3.26) (3.01) (-5.09) (-4.67)

Adjusted R-Squared = 0.71 S.E. of regression = 0.0158 LM(2) : 1.15 (0.33)

$$\text{ecmPXS} = \ln(\text{PXSs}) - (2.284 + 0.364 * \ln(\text{PW_NONFs}(-1)) + 0.364 * \ln(\text{MUVs}(-1)) - 0.177 * \ln(\text{FX88}))$$

5.12.1 Export price deflator for services

$$\text{PXSs} = \text{PXSs}(-4) * ((\text{CPIs}/\text{FX88}) / (\text{CPIs}(-4)/\text{FX88}(-4)))$$

5.12.2 Export price deflator for goods

$$\text{PXGs} = (\text{PXSs} - \text{WXR} * \text{PXSs}) / \text{WXR}$$

5.13 Import price deflator

$$\Delta \ln(\text{PMSs}) = 0.364 * \Delta \ln(\text{PW_NONFs}) - 0.376 * \text{ecmPMS}(-1)$$

(3.36) (-3.41)

Adjusted R-Squared = 0.27 S.E. of regression = 0.0312 LM(2) : 2.68 (0.08)

$$\text{ecmPMS} = \ln(\text{PMSs}) - (2.2396 + 0.505 * \ln(\text{PW_NONFs}) + 0.061 * \ln(\text{DUBAs}))$$

5.13.1 Import price deflator for services

$$\text{PMSs} = \text{PMSs}(-4) * ((\text{TPCPIs}/\text{TPFX}) / (\text{TPCPIs}(-4)/\text{TPFX}(-4)))$$

5.13.2 Import price deflator for goods

$$\text{PMGs} = \text{PMSs} - \text{WMR} * \text{PMSs} / \text{WMR}$$

5.14 GDP deflator

$$\text{PGDP} = \text{GDPN} / \text{GDPR} * 100$$

7. Household Model

7.1 Liabilities

7.1.1 Banks' lending to household

$$\Delta \ln(\text{LOANHHTsa}) = -0.008 * \Delta \ln(\text{MLR}(-1)) + 0.337 * \Delta \ln(\text{CPRsa}(-4)) + 0.806 * \Delta \ln(\text{LOANHHTsa}(-1))$$

(-1.93) (2.47) (11.07)

Adjusted R-Squared = 0.68

S.E. of regression = 0.0174

LM(2) : 1.74 (0.19)

7.2 Debt Repayment Capacity

7.2.1 Household Interest Payments

$$\text{INTHH} = (\text{MLR} / 100) * \text{LOANHHT}$$

7.2.2 Ratio of Interest Payments to Income after Tax

$$\text{IGEARHH} = \text{INTHH} / (\text{GDPRsa} * (1 - \text{RH})) * 100$$

List of variables

Dependent variables

AVGEARN	Average earnings (baht/month)
BMCAP	Securities value (billion baht)
BPB, BPS	Balance of payments (billion baht, billion US dollars)
CAPITALB, CAPITALS	Capital and financial account (billion baht, billion US dollars)
CAPITALSPRI	Net flows of private financial account (billion US dollars)
CGOVR	Government consumption at 1988 constant prices (billion baht)
CINFEX	Inflation expectations
CLAIMG	Net claims on government (billion baht)
CORE, CINFLAT	Core consumer price index (CPI excluding raw food and energy prices) (2002 = 100), Core inflation (per cent)
CPI	Headline consumer price index (2002 = 100)
CPIEN	Energy price index (2002 = 100)
CPIRFOOD	Raw food price index (2002 = 100)
CPR	Total private consumption at 1988 constant prices (billion baht)
CPR1	Private durable goods consumption at 1988 constant prices (including transport equipment, electrical machinery, machinery and equipment, furniture, rubber products, and glass and plastic products) (billion baht)
CPR2	Private non-durable goods consumption at 1988 constant prices (including food products, beverages, energy, and services) (billion baht)
CURRENTB, CURRENTS	Current account balance (billion baht, billion US dollars)
DD	Domestic demand at 1988 constant prices (billion baht)
FARMPRICE	Farm price index (1995 = 100)
FARMPRICE_12	Farm price index (12 main products of Thailand) (1995 = 100)
FX	Exchange rate (baht/US dollar)
FX88	Exchange rate index (1988 = 100)
FX94	Exchange rate index (1994 = 100)
GCB	Government cash balance (billion baht)
GDPN	Gross domestic product at current market prices (billion baht)
GDPR	Gross domestic product at 1988 constant prices (billion baht)
GDPR_HSM	Gross domestic product trend at 1988 constant prices, estimated from Hodrick-Prescott and exponential smoothing methods (billion baht)
GREV	Government revenue (billion baht)
IPR	Private investment at 1988 constant prices (billion baht)
IPUB	Public investment at 1988 constant prices (billion baht)
M2A ^D , M2A ^S	Money supply (M2 + finance companies' promissory notes) (billion baht)
MGR	Imports of goods at 1988 constant prices (billion baht)
MLR	Minimum lending rate (per cent per annum)
MR	Imports of goods and services at 1988 constant prices (billion baht)
MSR	Imports of services at 1988 constant prices (billion baht)
NEER	Nominal effective exchange rate (1994 = 100)
NFA	Net foreign assets (billion baht)
OTHTIND	Other indirect taxes (billion baht)
PCREDIT	Claims on private sector (including securities holdings by the private sector) (billion baht)
PGCON	Government consumption deflator (1988 = 100)
PGDP	GDP deflator (1988 = 100)
PIFX	Public investment deflator (1988 = 100)