Inflation Targeting

(Class Notes)

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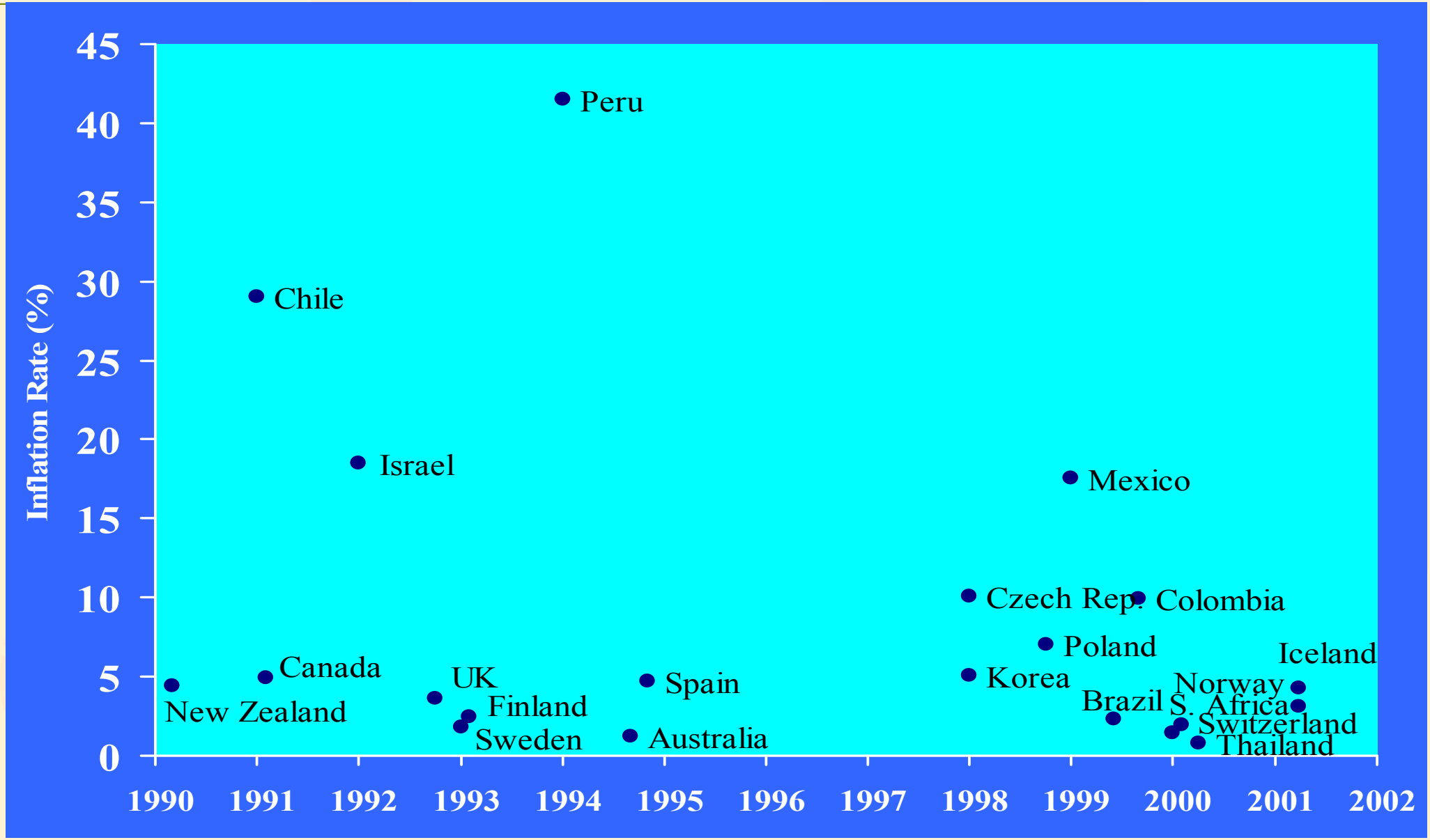
Monetary Policy and Inflation Targeting

- The main task of the IMF-World Bank models on macroeconomic stabilization is the design of a consistent set of policies intended to move an economy toward internal and external balance. They give central importance to fiscal policies: the control of the fiscal deficit (public sector borrowings) to deliver the dual objectives of GDP growth and controlled inflation.
- The monetary sector enters through the monetary aggregates and the identity of money supply and money demand.
- A main monetary policy tool – the level of interest rates- enters only through its effect on money velocity and money demand. It effects on aggregate demand are ignored. Thus, a major ingredient in monetary policy is not used.
- When there is a need to reduce an excessive rate of inflation to "normal" levels, more direct action may be needed. The Central Bank has three possible routes:
  1. The CB can use a "nominal foreign exchange anchor": monetary policy aims at pegging the exchange rate to a country with low inflation to bring inflation to this level. This option however has made countries more vulnerable to balance of payments crises: As the peg is introduced when inflation is high, the currency becomes overvalued, depressing exports and encouraging imports. If the B/P deficits are covered by inflows of FDIs, these inflows also lead to inflationary pressures as the Central Bank buys foreign exchange to maintain the peg.

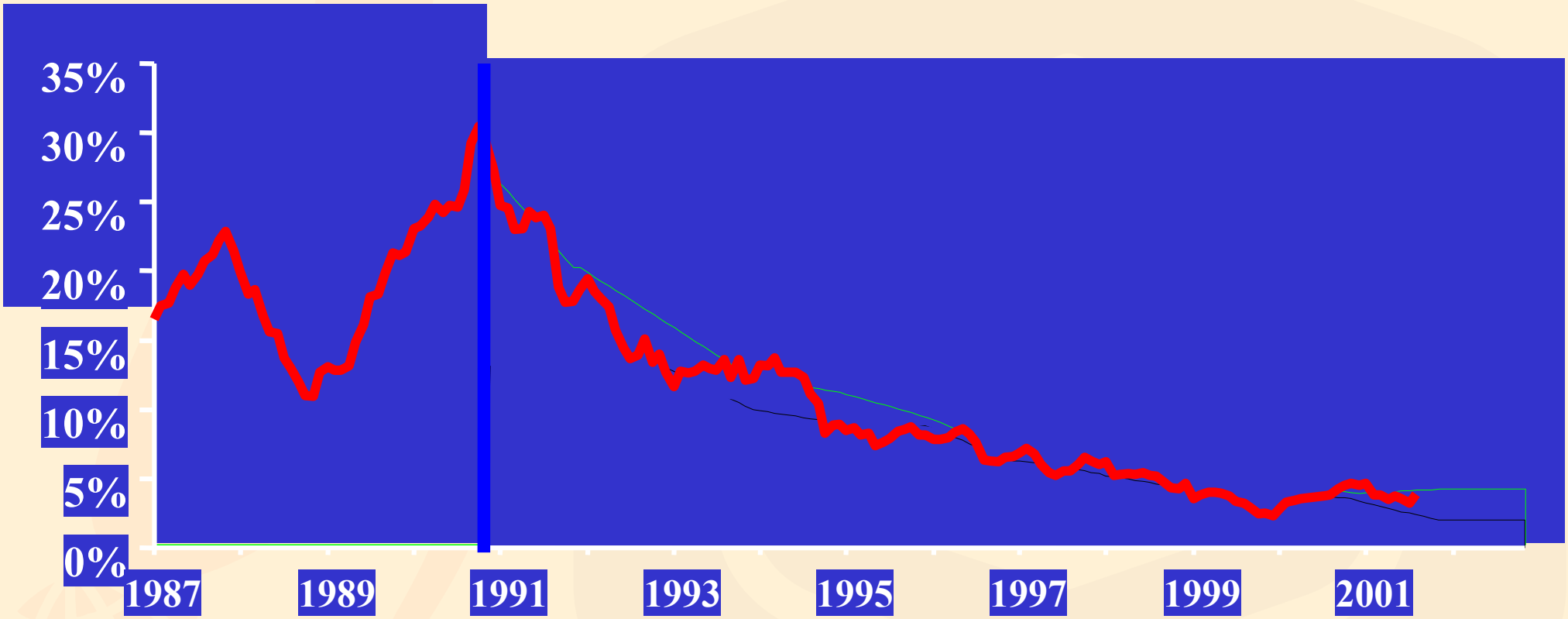
Inflation Targeting

2. The CB can use a "money growth anchor": monetary policy aims at controlling the rate of growth of money supply. This policy however has been almost abandoned now by CBs, since the relation between money supply and inflation is unstable. Inflation is caused by the difference between money supply and money demand and money demand is unstable. Studies in many countries show that there is no predictive power to monetary aggregates when forecasting inflation: whatever information monetary aggregates have seems to be already contained in measures of past inflation, economic activity, and interest rates.
3. The CB can use "inflation targeting (IT)" as a nominal anchor to bring inflation down to desired levels. Inflation targeting has worked well in many countries: It is consistent with modern view of the power and limits of monetary policy. It addresses directly the need to determine a long-run inflation objective. It provides more transparency and accountability to monetary policy. It provides an stable policy guidance (forces the CB to take into account long-term consequences of short-term actions). It shields CB from political pressures from government and private sector to relax monetary policy for short-term gains. It provides a "framework of constrained discretion" (Bernanke et al.)

Many countries have adopted IT under different inflation levels



Chile: Inflation and Inflation Targets: 1987-2002

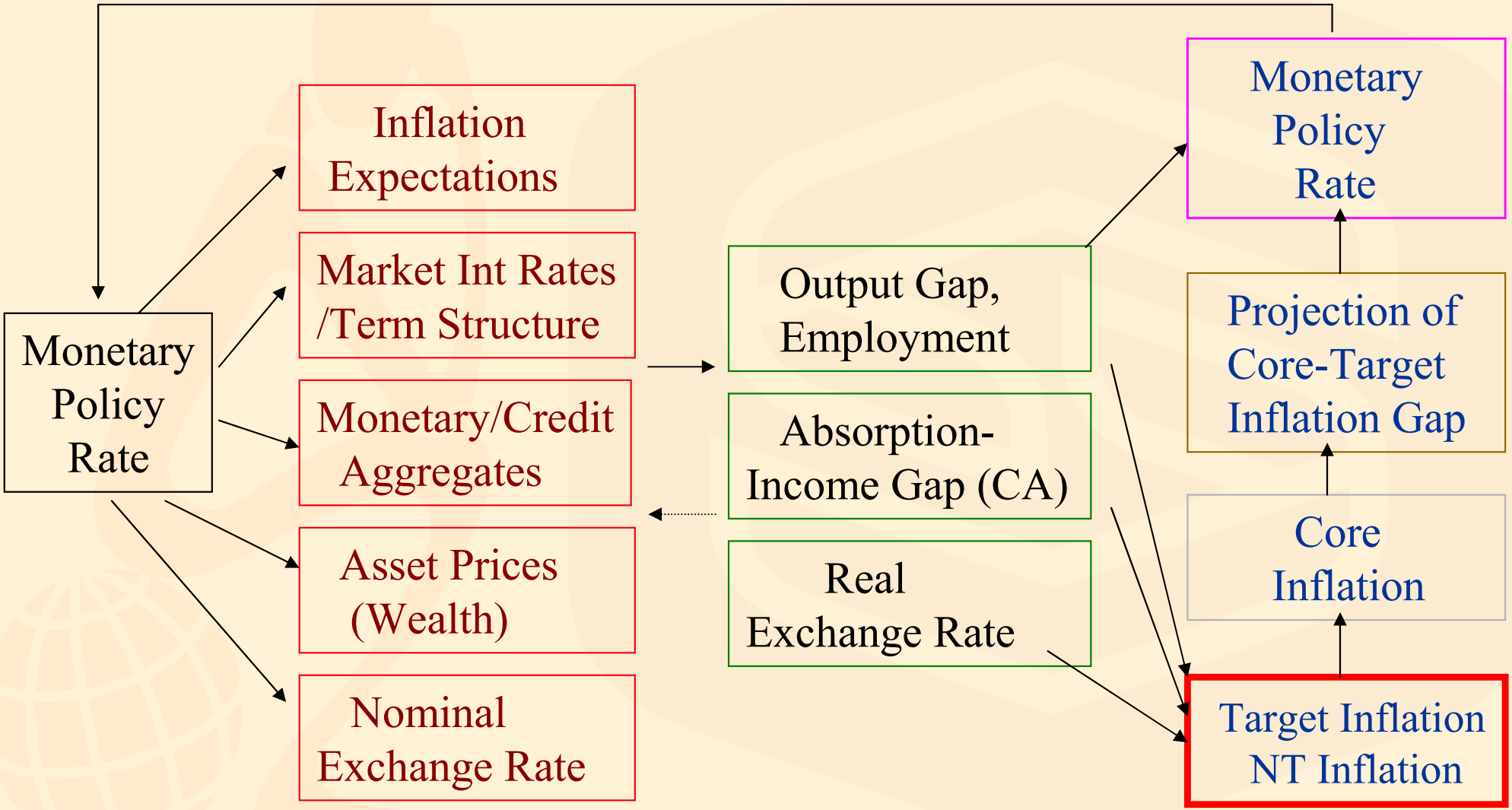


Sound Policy Framework: (1) Robust fiscal stance and healthy banking system; (2) Fiscal policy anchored by a 1% of GDP structural surplus; (3) Non-performing loans as low as 1.8% reflect the strength of the banking system; (4) Central Bank enjoys complete legal and instrument independence; (5) Exchange Rate float - clean between September 1999 and July 2001, dirty since August 2001.

The Central Bank and IT

- Under the IT system, the central bank manages monetary policy instruments with the direct goal of containing inflation over the medium run. In this setup, inflation becomes the overriding goal of monetary policy.
- All the other indicators (output gap, money stock growth, the exchange rate, etc) become auxiliary variables; the central bank will take them into account only if this information helps it to improve its inflation forecast.
- IT involves the following three steps:
  1. The CB sets a "target" rate of inflation for the country for the "medium" term: experience with monetary policy management in developed countries has shown that the impact of monetary policy changes on inflation works its effects with a significant lag (at least nine months, and up to two years for a full impact).
  2. The CB makes forecasts of the likely rate of inflation based on current conditions. This step requires the developing of sound inflation forecasting methods. This inflation forecast may indicate that inflation may be likely to be above the "target".
  3. The Central Bank uses monetary policies (particularly the level of interest rates) to close the gap between the likely inflation rate and the "target" rate. This requires the central bank to have a good model of the "transmission mechanisms" from changes in monetary policy (such as interest rates) into aggregated demand and then into inflation rates.

Monetary Transmission and Policy Rule in Open Economies



IT design features:

- **Inflation index**:
  - Most countries use the annual rate of headline CPI
  - A few countries adjust CPI to exclude volatile items, interest payments, taxes (Core Inflation).
- **Inflation Target range**:
  - Choice between a point forecast, a central point forecast with a range, a range, or just upper bounds.
  - Trade off between target accuracy and policy credibility.
  - Range targets are adopted when uncertainty is high (usual range 1 to 3 points variation).
  - Point target adopted when seeking credibility.
- **Inflation target horizon:**
  - Time period long enough to for monetary policy to have an effect on aggregate demand and inflation.
  - One calendar year horizon when far from stationary inflation.
  - Multi-year horizon when closer to stationary inflation.

Forecast Procedure

Most Central Banks have two types of models:

a. Models to Forecast Inflation based on current conditions without any monetary policy action

b. Models to Target Inflation based on the adjustment over time of interest rates and their transmission mechanisms to affect demand and inflation.

For these models, CBs follow a well-defined sequence of steps for preparation and presentation to policy-makers and public:

1. Gathering information
2. Input data into the database
3. Maintaining a system to monitor and record news that could affect inflation outlook
4. Presenting interest rate scenarios to Monetary Policy Committee
5. Discussing technical proposals of the staff at policy level
6. Interact with staff on impact of alternative scenarios for future policy interest rates
7. Communicating inflation forecast to the market
8. Follow up

I. Models to Forecast Inflation based on Current Conditions without Monetary Policy Actions

Short-term forecasting:

A. Consumer Surveys and Expert Judgments

B. Statistical (time series) Econometric Techniques

Medium-term forecasting:

C. Structural Models based on Economic Parameters

Empirical studies show that no one single model predict inflation consistently better than others.

For this reason, many researchers and central banks use a combination of various models to forecast inflation.

Consumer Surveys and Expert Judgments

Many countries include surveys of inflation expectation (for one or two years ahead) in their periodic consumers surveys. Surveys could be directed to consumers or to a pre-selected group of expert analysts.

- The monthly European Commission's Consumer Survey ask by phone 50,000 consumers in the Euro area on their inflation expectations one-year ahead.
- Results in the Euro area suggest that surveyed expectations are unbiased predictors of future prices and they incorporate – though not always completely – a broad set of macroeconomic information.
- In addition, although persistent deviations between consumers' expectations and rational outcome occur, consumers are shown to rationally adjust their expectations in order to eventually "weed out" any systematic expectational errors.
- Inflation expectations are also important from the perspective of aggregate price formation: the expectations augmented Phillips curve posits a relationship whereby the actual change in the price level is driven - in part - by expectations of its future change.

B. Statistical Inflation Forecasting Models

- Statistical time-series techniques: e.g., changes in inflation 12-month ahead depends on recent (Lagged – L) changes in 1-month inflation:

$$\pi_{t+J} - \pi_t = \alpha + \beta(L)(\pi_t - \pi_{t-1}) + \varepsilon_{t+J}$$

$$\pi_t = \ln p_t - \ln p_{t-1}$$

Linear Stationary Models:

- Autoregressive Moving Average Models (ARMA –or Box-Jenkins), consists of two parts, an autoregressive part (lag of previous observations) and a moving average part (of the forecasting errors) .
- Autoregressive Integrated Moving Averages Models (ARIMA), an ARMA with differenced time series to make it stationary.
- Autoregressive Fractionally Integrated Moving Average (ARFIMA), which generalizes the previous ones.

Non-Stationary and Nonlinear Models:

- Autoregressive Conditional Heteroskedasticity (ARCH) models, which captures changes in variance over time.
- Artificial intelligence models, including artificial neural networks (inspired from the real neuron present in our nerve system) and multilayer feed-forward networks, which capture the non-linearity of data and "train" the model based on actual experience.

C. Structural Inflation Forecasting Models

1. **Standard Philips-Curve model** (NAIRU) represents an empirical relationship between inflation and the gap between actual and potential output (or unemployment). When the output gap is positive, inflation accelerates:

$$\pi_t = \gamma\,(y_t - y^p_t) + \varepsilon_t$$

2. **Expectations Augmented Philips-Curve model,** based on Lucas's rational expectations in which workers "forecast" wages and supply labor accordingly (which yields a demand/supply shifter Δx).

$$\pi_t = -\alpha_2 + (1-\alpha_1)\Delta x_t + \alpha_1\,\Delta x_{t-1} - \alpha_1\,(y_{t-1} - y^n_{t-1})$$

3. **New Keynesian Phillips curve**, introducing inflation expectations:

$$\pi_t = \beta\,E_t\,\pi_{t+1} + \lambda(y_t - y^p_t) + \eta_t$$

4. **Generalized Philips-Curve model**: changes in annual inflation depends on recent changes (Lags) in inflation and on current and past (Lag) values of real economic activity index (α_t)

$$\pi_{t+J} - \pi_t = \alpha + \beta(L)(\pi_t - \pi_{t-1}) + \gamma\,(L)\alpha_t + \varepsilon_{t+J}$$

Forecasting Models

5. The P Star model (P*) disregards output gaps (since potential output is hard to measure and the curve is unstable, with coefficients changing over time). It is derived from the quantity theory of money, assuming that velocity (v) and income (y) will converge relatively quickly to their long-term equilibrium, v*, y*:

$$p^*_t = m_t + v^* - y^*_t$$

- On this basis, inflation in the backward-looking P* model is:

$$\pi_t = A(L^k)\pi_{t-k} + B(L^k)(p^*_{t-k} - p_{t-k}) + \varepsilon_t$$

- Inflation for the forward-looking P* model will be:

$$\pi_t = \pi^e_t + \beta(p^*_t - p_t) + \eta_t$$

- Other variants of the P* model:

Real-Money gap: $\pi_t = E_t\pi_{t+1} + \beta(m^*_t - m_t) + \varepsilon_t$

Exchange rate: $p^* = Ep^*f/ER^*$

E -equilibrium nominal fixed exchange rate;

R* -equilibrium real exchange rate.

Interest rate : $\pi_t = E_t\pi_{t+1} + \gamma(i^*_t - i_t) + \varepsilon_t$

Forecasting Accuracy

1. Ability to forecast magnitude of inflation. Comparing out-of-sample forecast performance of different statistical models based on Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{1/N \sum(x_{t+h+i} - \hat{x}_{t+h+i})}$$

2. Ability to forecast direction of change of future inflation: percentage of directional prediction that are correct (PDPC) in a particular sample period

$$\hat{D}_{t+J} = \begin{cases} +1 \text{ if } \pi_{t+J} > \pi_t \\ -1 \text{ otherwise} \end{cases} \qquad PDPC = 1/T \sum I\{\hat{D}_{t+J} = D_{t+J}\}$$

Forecast accuracy can vary significantly depending on variable being forecasted, the type of forecast model, theoretical assumptions, available information

The Chilean Inflation Forecast Models

Chile has developed a toolkit comprised by various models:

- Leading indicators of prices and activity.
- Small semi-structural Vector AutoRegressive models (4 to 7 variables).
- Flow-stock (IMF) consistency model.
- Small backward-looking macro model for key relations and variables (π, Phillips curve unemployment, output, absorption (or CA), potential output, imperfect interest parity, yield curve).
- Micro-founded forward-looking rational expectations model for key relations and variables.

- Forecasts are made for a base scenario (most probable), with deviations derived from an assessment of the main risks.
- Base Scenario:
  - Key exogenous variables: international conditions (external borrowing costs, terms-of-trade, exchange rate), productivity, fiscal policy, trend growth
  - Policy assumption: current policy rate is maintained in the future (consistency, commitment)
  - Base scenario forecasts are the result of the interacion of predetermined and endogenous variables
- Alternative scenarios: based on forecasts reflecting alternative assumptions for the trajectory of predetermined variables.

II. Transmission Mechanism Models to Target Inflation

- These models aim at establishing the effects of interest rate policy rules on the economy and identifying the sequence of interest rate changes that would generate a target inflation rate in the future.
- The models consist of a number of equations that include measures of aggregate demand, aggregate supply, and the transmission mechanism of the monetary policy tool (interest rates) into aggregate demand and then on inflation.
- They are Based on the New Neoclassical Synthesis/New Keynesian Economics, the model usually has the following equations:
    1. New Keynesian Phillips curve
    2. IS curve
    3. Interest rate rule
    4. Exchange rate equation based on uncovered interest rate parity extended with risk factor
    5. In the long-run, supply shocks represented by Cobb-Douglas/CES production function

A Typical Transmission Mechanism Model for Monetary Policy under IT

- Consider a closed economy characterized by the following two equations: The first one is a Phillips curve for **inflation (π)** and the **output gap (y):**

$$(1) \qquad \pi_t - \pi_{t-1} = \alpha_1 y_{t-1} + \varepsilon_t$$

- This equation is closely related to the short-term aggregate supply curve with sticky prices/wages.
- The second equation is related to the aggregate demand - IS curve that relates output to the (policy) lagged real interest rate (i - π):

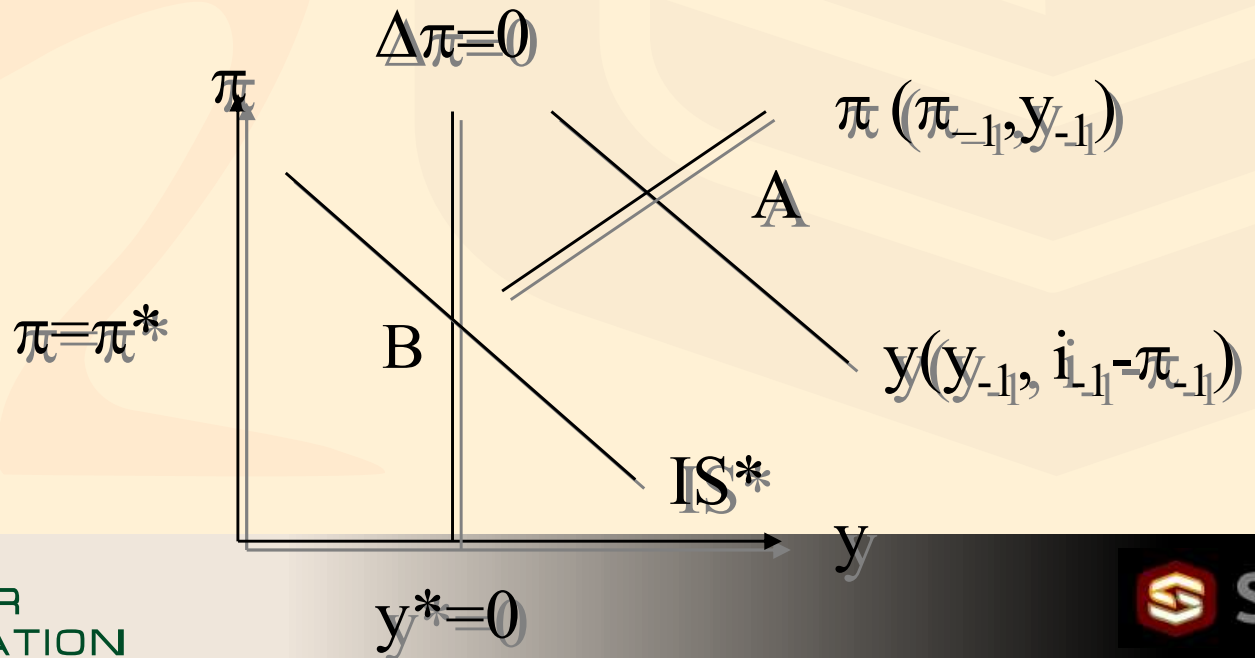
$$(2) \qquad y_t = \beta_1 y_{t-1} - \beta_2 (i_{t-1} - \pi_{t-1}) + \eta_t, \ \beta_1 < 1,$$

- The negative coefficient on the real interest rate on future output in the *IS* relationship can reflect intertemporal substitution effects on consumption as in recent new Keynesian models as well as traditional effects on investment operating through both the cost and availability of credit.

- Next, we assume that the CB seeks to stabilize both inflation and the output gap. Thus, the CB sets its policy instrument to further these objectives. Subject to (1) - (2), the CB minimizes the expected discounted infinite sum of inflation deviations from CB's inflation target (p*) and output deviations, as follows:

$$(3) \qquad U_t = E_t \left\{ \sum_{h=t}^{\infty} \delta^{h-t} \left[\frac{(\pi_h - \pi^*)^2 + \lambda y_h^2}{2} \right] \right\}$$

- Hence the problem faced by the CB is how to bring the economy from the current (short-term) equilibrium at A to long-term equilibrium at B:



- The CB's problem can be broken down into a series of one-period problems because of the two-period lag from i to π: it → yt+1 → πt+2.
- Hence πt predicts πt+2 , πt+3, ...
- The result of this problem is a policy function (an analytically-derived "Taylor rule") that sets the policy interest rate (i_t) as a function of inflation and output gaps:

$$(4) \quad i_t = \gamma\left(\pi_t - \pi^*\right) + \rho\left(y_t\right)$$

where γ and ρ are non-linear reaction parameters that depend on CB preferences and the economy's behavioral coefficients. The CB's anti-inflation stance, compared with growth ("hawkishness") is reflected by:

$$(5) \quad \gamma - \rho = f(\lambda, \alpha_1, \beta_1, \beta_2, \delta)$$

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- Hence CB hawkishness: rises with inflation; rises with Phillips curve verticality; falls with output inertia, and is ambiguos regarding IS interest-sensitivity and CB's discount rate.

IT Model extensions

- Introducing other monetary transmission mechanisms
- Open economy: Introducing the exchange rate ***S*** in the transmission mechanism of the model. This could be done by introducing foreign exchange gaps in selected equations and a separate equation reflecting the uncovered interest parity condition:

$$E(S)/S = (1+i)/(1+i^*)$$

- Itroducing imperfect policy credibility, model uncertainty, CB aversion to policy changes, conflicting fiscal-monetary objectives, etc.
- These models are also used to forecast inflation (unconditional on policy rules) by ommiting the policy rule and assuming that deviations from the target are zero.

Need for Better Understanding of Monetary Transmission Mechanisms

Channels: expectations, interest rate and term structure, monetary and credit aggregates, asset prices (wealth), exchange rate.

- Emerging economies: Channels are more blurred because of less developed financial markets and more pervasive price rigidities
- Chile and Israel: widespread indexation (raises devaluation-inflation passthrough).
- Brazil: financial sector does little lending to the private sector.

- Asymmetries and non-linearities: More prevalent in emerging economies
- Uncertainty of model structure, parameters, exogenous variables: Stable time series are rather short and/or unstable in emerging countries with long inflation histories or recent economic reforms
- Leads and lags: More uncertain / unstable in emerging economies

IT Requirements

Requirements for successful IT:

1. Ability of CB to conduct independent monetary policy
   - Strong fiscal budget position to avoid fiscal dominance in setting monetary policy
   - Central bank independence to enhance credibility -- de jure (New Zealand, Chile) or de facto (UK, Israel, Brazil)
2. A clear CB mandate for price stability over other conflicting objectives (such as exchange rates or GDP growth). For many emerging economies a case could be made to add a maximum current account deficit as a policy objective. This leads to a more conservative monetary policy.
3. A reasonably well-developed ability to forecast inflation;
4. A well understood transmission mechanisms between monetary policy instruments and inflation;
5. a well-developed financial system;
6. Transparency and accountability for monetary policy.

Main Technical Requirements for Conducting Monetary Policy under IT

(a) Technical capability:
- to understand and model monetary transmission mechanisms
- to model and forecast inflation

(b) (Timely) availability of relevant information to monitor the economy and technical capability to do it right

(c) A set of criteria for using policy instruments to keep the economy on track to meet the target (policy rule)

(d) Timely use of effective policy instruments, making full and unconstrained use of available instruments

Inflation Forecasting: Poland

Forecasting system

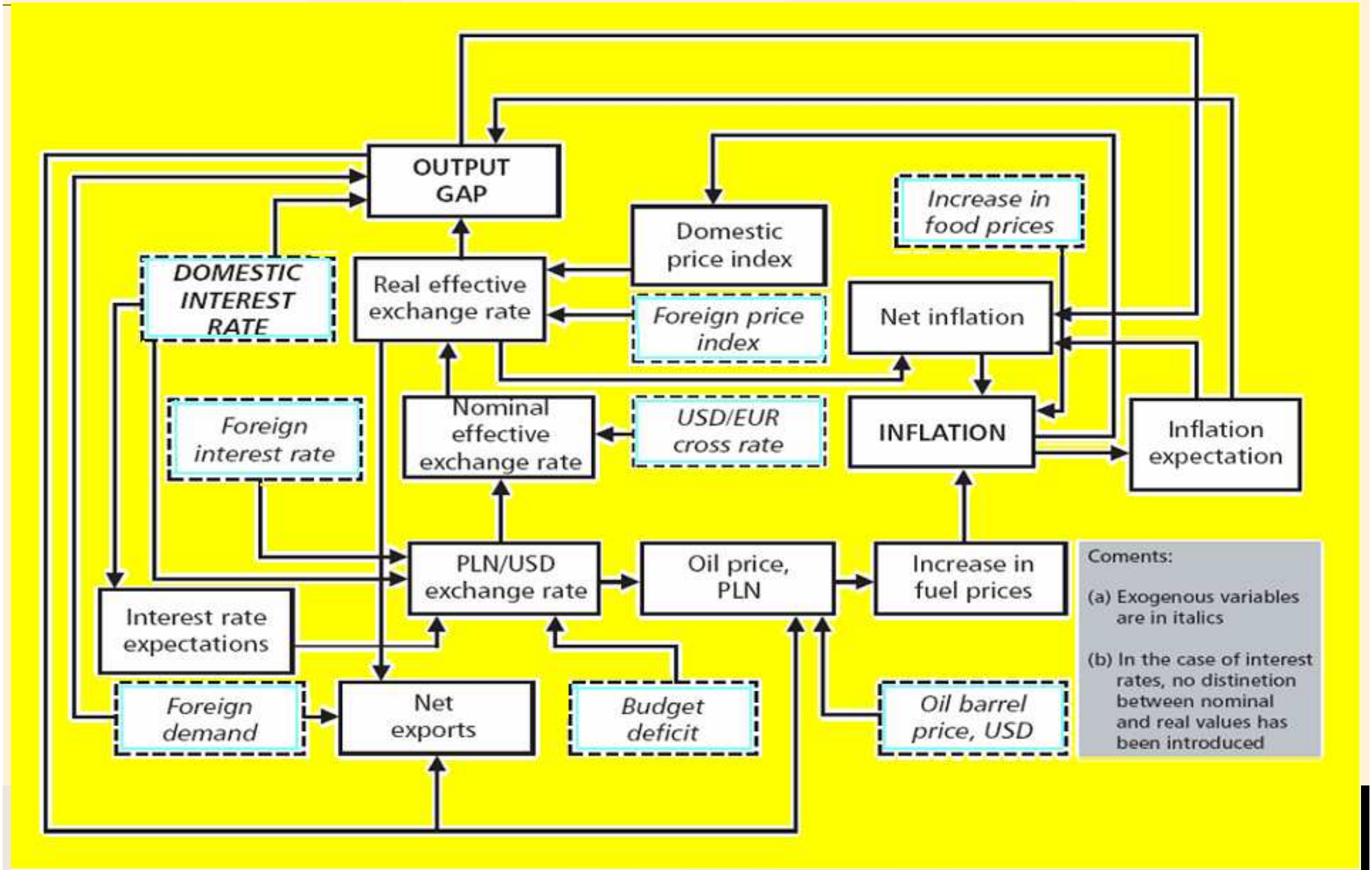
- Forecast result: point estimates and scenarios
- Horizon and frequency: near-term (4-6 quarters), medium-term (up to 4 years); monthly
- Transparency: quarterly publication of backward-looking analysis
- Methodology: structural models, time series models, expert judgment

Inflation Forecasting: Poland

Forecasting Methodology

- Linear combinations of forecasts derived from two structural models with weights obtained from minimizing historical errors of forecast:
- New Analytical Scheme (NAS): an aggregate structural model describing the monetary transmission mechanism
- Small Structural Inflation Model (MSMI) focused on the supply side

Poland- Basic building blocks of the NAS



Core Model of Poland

$\hat{Y}$ – output gap

y^{EU} – real GDP growth rate in the euro zone

i – WIBOR 3M interbank market rate in nominal terms

$i^{WIBOR1M}$ - WIBOR 1M interbank market rate in nominal terms

i^{r} – WIBOR 3M interbank market rate in real terms

i^{f} - LIBOR 3M foreign interbank market rate in nominal terms

e^{n} – nominal effective exchange rate (in logs)

e^{r} - real effective exchange rate (in logs)

$e^{USD/PLN}$ – USD/PLN exchange rate (in logs)

$e^{EUR/USD}$ – EUR/USD exchange rate (in logs)

w^{EUR} – euro weight used for the determination of the nominal effective exchange rate (55%)

π^{C} – rate of growth of consumer price index net of food and fuel prices, quarter over quarter

Core Model of Poland

π^F – rate of growth of food prices, quarter over quarter

π^P – rate of growth of fuel prices, quarter over quarter

π – inflation, quarter over quarter

π^* - central bank inflation target

π^e – households' inflation expectations (for the next quarter)

w^C – weight of consumer goods and services net of food and fuel prices in the CPI basket

w^F - weight of foods in the CPI basket

w^P - weight of fuels in the CPI basket

p^F – food price index

p – consumer price index (goods and services)

g – budget deficit related to GDP

b^{USD} – oil price per barrel on world markets (USD, in logs)

Core Model of Poland (New Analytical Scheme)

Aggregate demand curve for open economy:

$\hat{y}_t = c_{\hat{y}} + \alpha_1 \hat{y}_{t-1} + \alpha_2 i^r_{t-1} + \alpha_3 e^r_{t-2} + \alpha_4 \Delta(\Delta_4 y^{EU}_t)$ - Output gap equation

$\pi_t = w^C_t \pi^C_t + w^F_t \pi^F_t + w^P_t \pi^P_t$ - Inflation identity

$\pi^C_t = c + \beta_1 \pi^e_t + \beta_2 \hat{y}_{t-1} + \beta_3 e^r_{t-2}$ - **Philips curve**

$\pi^F_t = c + \gamma_1 \pi_t + \gamma_2 \pi^F_{t-1} + \gamma_3 (p^F_{t-1} - p_{t-1})$ - Food inflation equation

$\pi^P_t = \pi^O_t$ lub: $\pi^P_t = \lambda_1 \pi^O_t + \lambda_2 \pi_{t-1} + \lambda_3 \Delta \hat{y}_t$ - Fuel inflation equation

where $\pi^O_t = \Delta b^{USD}_t - \Delta e^{USD/PLN}_t$

$\pi^e_t = \theta_1 \pi_{t-1} + (1 - \theta_1) \pi_{t+1}$ - Households' inflation expectations

Exchange rate equation with uncovered interest rate parity:

$e^{USD/PLN}_t = c + \varphi_1 e^{USD/PLN}_{t-1} + (i_t - i^f_t) + \varphi_2 (i_t - i^{WIBOR1M}_t) - \varphi_3 g_{t-1} - e^{EUR/USD}_t$

$e^{USD/PLN}_t = e^{USD/PLN}_{t+1} + (i_t - i^f_t)$

$e^n_t = e^{USD/PLN}_t + w^{EUR}_t e^{EUR/USD}_t$ - Nominal effective exchange rate

Monetary policy rule:

$i_t = 0.5 \hat{y}_t + 1.5 (\pi_t - \pi^*_t)$ lub: $i_t = \pi^e_t + 0.8 i_{t-1} + 0.2[0.5 (\pi_{t+1} - \pi^*_{t+1}) + 0.5 \hat{y}_t]$