EMERGING CAPITAL MARKETS

Lecture 3: Foreign Exchange Determination and Forecasting

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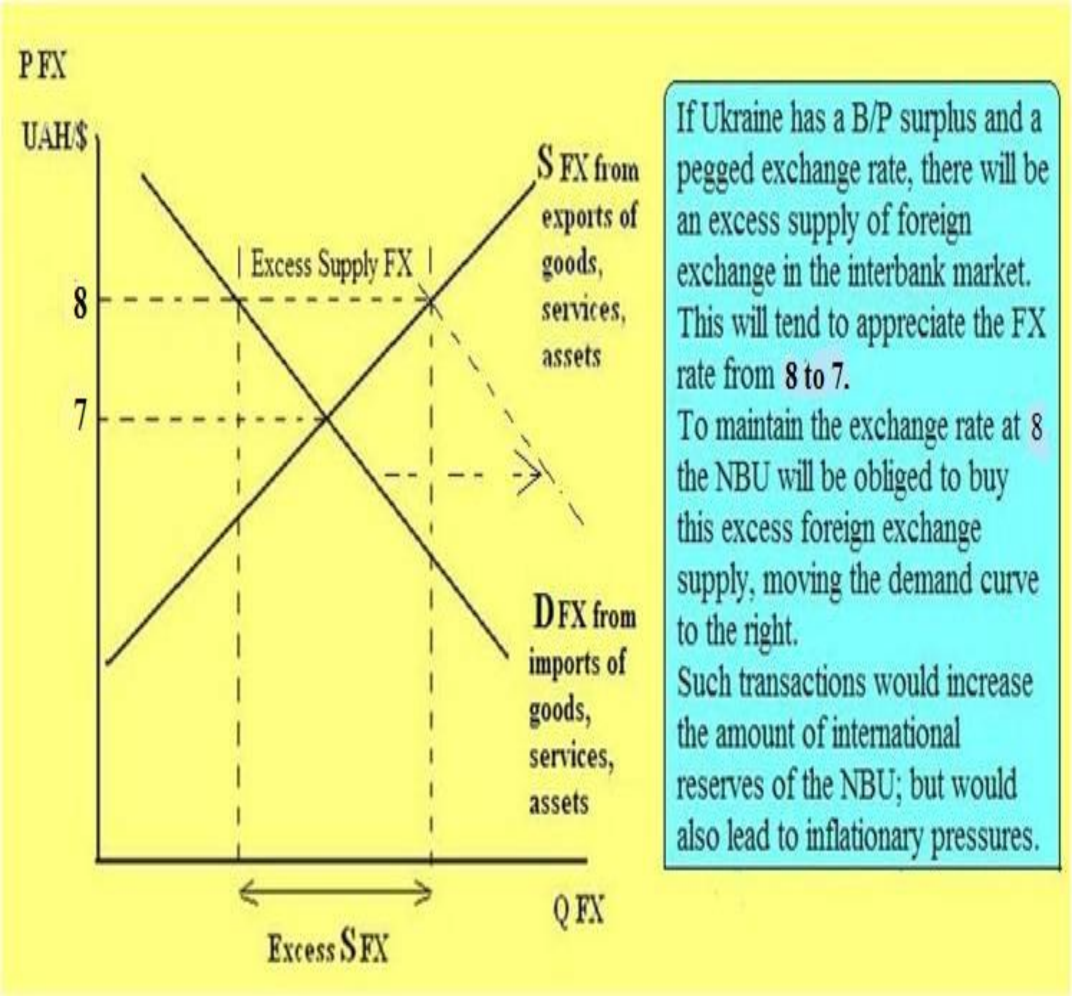
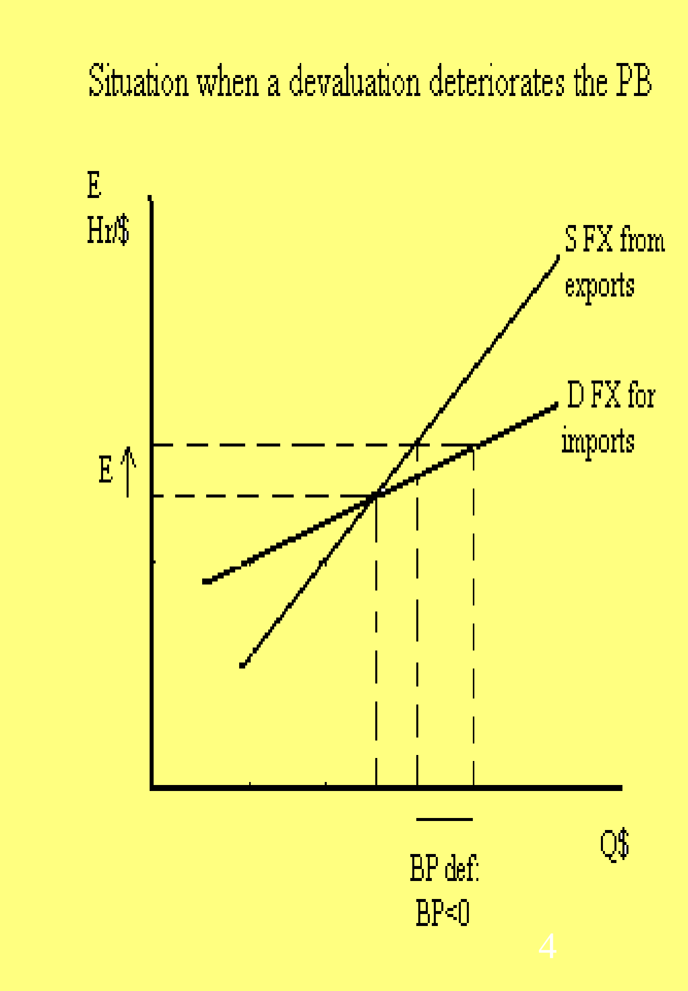
I. Foreign Exchange Rate Determination

- The foreign exchange **rate** is the **price** of a foreign currency.
- As any other price, it is determined by the interaction of demand and supply for the foreign currency (FX).
  - **FX is demanded** to buy foreign goods and services (imports), and to buy foreign financial assets (capital outflows).
  - The quantities of FX demanded will change in inverse relationship with its price (the FX rate as UAH/US$), *ceteris paribus*.
  - **But for FX rate prediction,** it is more important to understand the changes in FX demand that will occur when the entire FX demand curve moves or **shift**, right or left, as a result of changes in variables that affect imports of goods and services, and capital outflows.
  - These variables include *price levels (inflation), levels of interest rates, income levels, expectations (forward rates), or tastes*.
  - These variables, in turn, are affected by the *demand and supply for money* and other economic variables.

- The Supply of FX is derived from the demand for our goods and services (exports), and our financial assets (capital inflows) by foreign countries. These foreign receipt transactions are affected by similar economic variables in other countries (foreign interest rates, foreign inflation, foreign income, foreign money supply, etc.).





Under a Fixed Exchange Rate System, the exchange rate is determined by the Central Bank and the Government. But this fixed exchange rate will last only if fiscal and monetary policies are consistent with the requirements of the free floating market. Therefore, over the longer term, FX rates are also determined by the interaction of demand and supply for FX based on free markets.

Parity Relationships.

- From the above, it is clear that to understand FX rates, one need to understand the determinants of ***the demand for foreign currencies and the supply of foreign currencies***.
- This means that we need to look at the relationship between FX rates and such FX supply/demand "shifters" that influences imports, exports and capital flows.
- These "shifters" include variables such as ***price levels, interest rates, income, expectations (forward rates), money supply, etc., both at home and in other countries.***
- These relationships are called " FX Parity Relationships".

Six FX Parity Relationships are relevant for this purpose:

(1) Purchasing Power Parity (PPP)
(2) Covered Interest Rate Parity
(3) Forward Parity
(4) Uncovered Interest Rate Parity
(5) Domestic Fisher Effect
(6) International Fisher Effect.

Definitions:

S = Foreign exchange rate (Nominal, Spot)

P*, dP* = Foreign price and foreign inflation, respectively.

P, dP = Domestic price and domestic inflation, respectively.

S = (P)/(P*) American Notation: units of domestic currency per unit of foreign currency (for Ukr: UAH/US$. An increase in S is a depreciation of the domestic currency (UAH)).

F = Forward foreign exchange rate.

i*, r* = Foreign interest rates, nominal and real, respectively.

i, r = Domestic interest rates, nominal and real, respectively.

1. Purchasing Power Parity (PPP).

- PPP is a theory of exchange rate determination that states that the actions of **importers and exporters**, motivated by cross-country price differentials, induces changes in the spot exchange rate.
- PPP suggests that transactions in the country's B/P current account affect the value of the exchange rate in the foreign exchange market.
- PPP states that the exchange rate between two currencies are **in equilibrium** when their purchasing power (the amount of goods that the currency can purchase) is the same in the two countries.
- PPP is based on the "Law of One Price": If there is a price difference for a particular good between two countries, exporters and importers would trade across borders to exploit this price difference, until the good has the same price in the two countries, using the spot exchange rate for conversion ($P=SxP^*$).
- The PPP theory implies that international trade transactions will have a greater effect on the exchange rate than on the price of domestic goods.
- It also assumes low trade barriers and transportation costs.

- Generalizing from one good into all goods, the "Law of One Price" becomes the "Absolute Form of PPP" which says that :

  The exchange rate will continue to change until the national price "**levels**" of the two countries are equalized by the spot exchange rate. That is, if P and P* are now the domestic and foreign price "levels, then the two will be related by:

$$P = (S)\,(P^*)$$

- Taking differentials of the absolute PPP, we get the "relative" form of PPP, in which we deal with changes over time:

$$P=(S)(P^*) \;\rightarrow\; \%\Delta P \approx \%\Delta S + \%\Delta P^* \;\rightarrow\; \%\Delta S \approx \%\Delta P - \%\Delta P^*$$

That is, if domestic prices increase, the domestic currency will depreciate.

If trade barriers/transport are stable, the "relative" form of PPP holds better than "absolute" PPP.

– In other words, in its "relative form", PPP states that the rate of exchange S (S = P / P*) of one currency for another can be expected to change over time (%ΔS) at a rate equal to the relative expected inflation rates differential between the two countries [domestic inflation (%ΔP), foreign inflation (%ΔP*)]:

$$\%\Delta S \approx \%\Delta P - \%\Delta P^*$$

Or more precisely: $(1 + \%\Delta S) = (1 + \%\Delta P)/(1 + \%\Delta P^*)$

– An increase in domestic prices leads to an increase in the exchange rate (S)↑ which means a depreciation (more domestic currency to buy a unit of foreign currency).

- For an Ukrainian investor: S_0= UAH/$ ==> 8.0 UAH/$

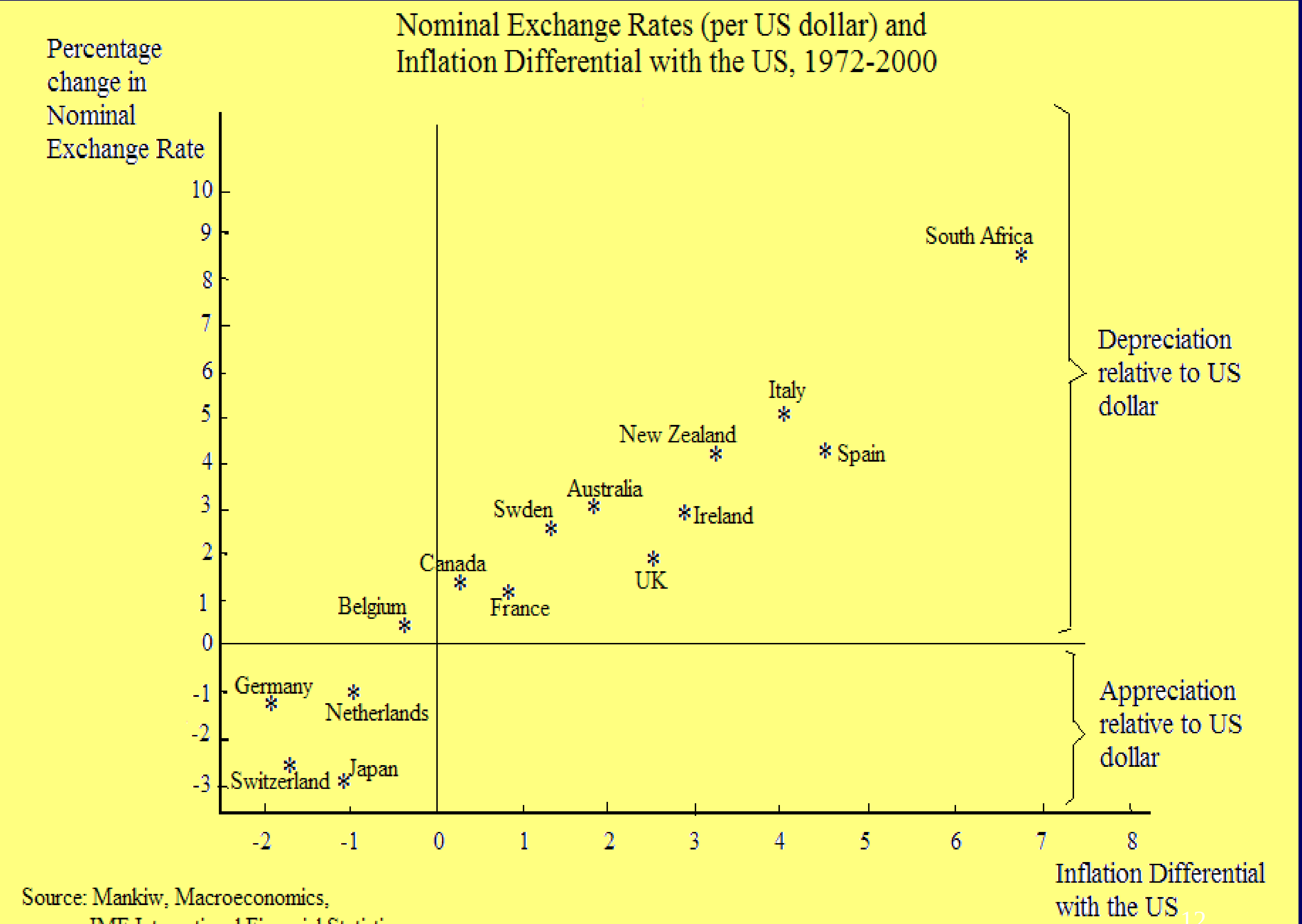
%ΔP=10%; %ΔP*=3%; → %ΔS = (1.10/1.03) – 1 = 0.068 or 6.8%

or approx by: %ΔS = 10% – 3% = 7% → S_1 = 8.5 UAH/$

- The adjustment may take time; but it will happen!!

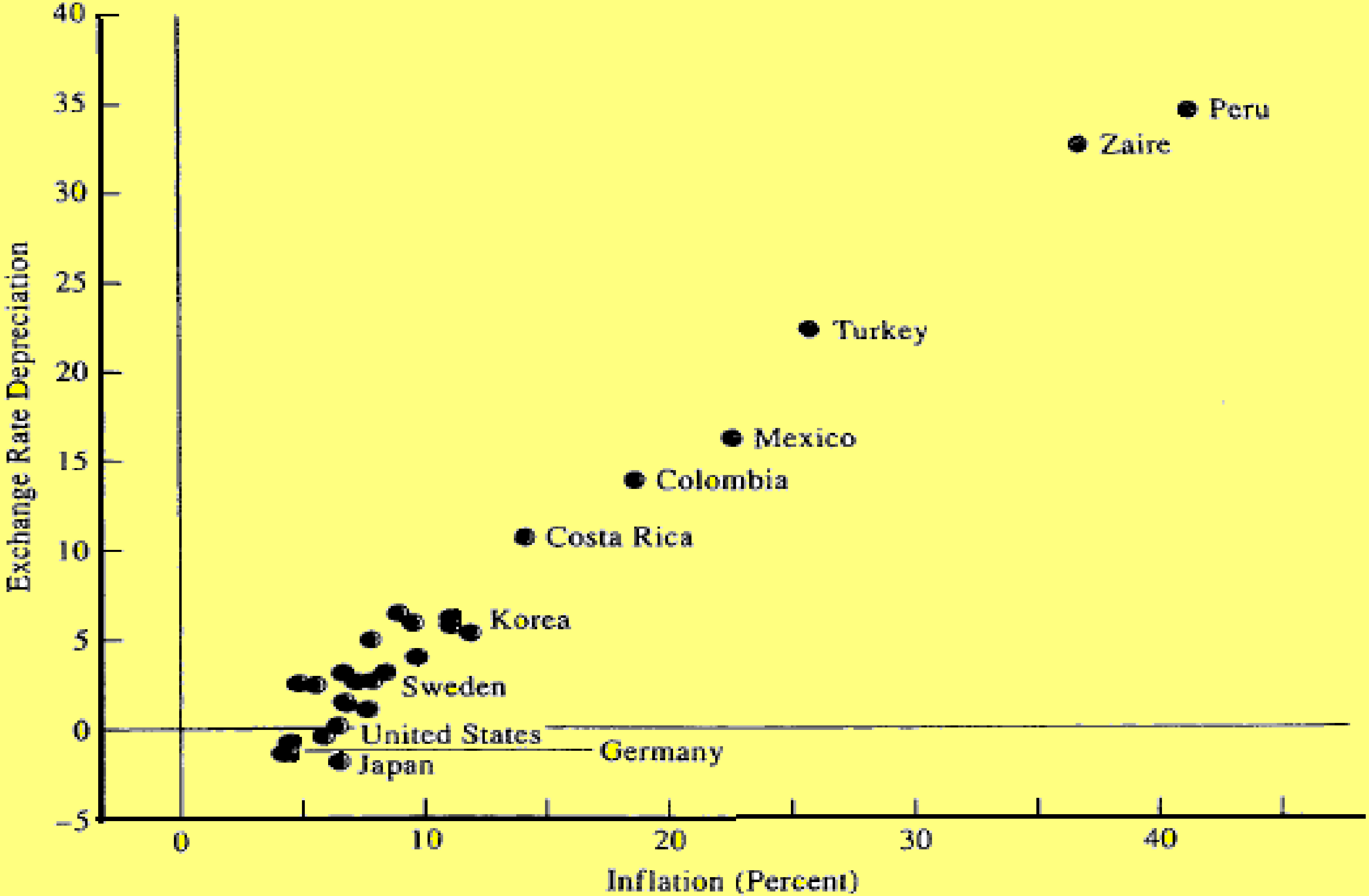
- PPP can be used to calculate the “correct value” or “long term equilibrium value” of a currency, which may differ from its current nominal spot market value, and to which the spot exchange rate may eventually converge.
- “Correct value” means the exchange rate that would bring Demand and Supply of a currency into equilibrium over the long-term. The current market rate is only a short-run static equilibrium.
- Economic theory says that once the exchange rate is pushed away from its PPP equilibrium value, trade flows in and out of a country can move into disequilibrium, resulting in potentially substantial trade and current account deficits or surpluses.
- But eventually, these current account deficits/surpluses will become unsustainable, forcing price (FX rate) adjustments that would return equilibrium to foreign trade and the exchange rate.
- Therefore, PPP is important in forecasting foreign exchange rates over the medium run, since overtime exchange rates will adjust until PPP (parity) is reestablished.

- PPP hold poorly for developed countries in the short term, but it holds better over the long term. For EMs, PPP is quite relevant.
- In fact, over the last few years, empirical work on PPP by Nagayasu (1998), Coakley and Fuertes (1997), and M-Azali et al. (2001), found support for the hypothesis that PPP relationships can be used for forecasting foreign exchange rates for the medium to long term (about 2 to 5 years) in a number of emerging countries.
- That is, when exchange rates are far out of line with the fundamentals (such as in many emerging markets), the models are useful in predicting that the exchange rate will return to its fundamental level over the medium to long term.
- Some economists argue that PPP is too narrow a measure for judging a currency's true value. They prefer the fundamental equilibrium exchange rate (FEER), which is the rate consistent with a country achieving an overall balance with the outside world, including both traded goods and services and capital flows.



Source: Mankiw, Macroeconomics,
IMF International Financial Statistics

Exchange-Rate Changes and Inflation in Selected Countries (Annual Averages), 1965–1985



Source: Sachs and Larain; Macroeconomics, 1993

Reasons for Poor Statistical Evidence of PPP in short term

- High and unstable transaction costs (transportation costs, duties, arbitrage costs).
- Non-tradable goods are more costly\difficult to arbitrage.
- Country risks and exchange rate volatility may discourage arbitrage.
- There may be measurement problems.
- There may be market imperfections (lack of adequate information, home bias, restrictions to trade, subsidies, autonomous capital inflows) that allow current account deficits to run unchecked for many years, without affecting price levels.
- There may be "real" economic effects (such as permanent productivity improvements) that change fundamentals and foreign exchange rate relations.

The **Real Exchange Rate (S_r)** is a useful concept related to PPP.

- The **Nominal** Exchange Rate is the ratio of the relative prices of the "**currencies**" of two countries (ie., how many Hryvnias per dollar).
- The **Real** Exchange Rate is the ratio of the relative prices of the "**goods**" of two countries: that is, the price of the foreign country goods converted at the "nominal" FX rate (S x P*) over the price of the goods of the domestic country (P):

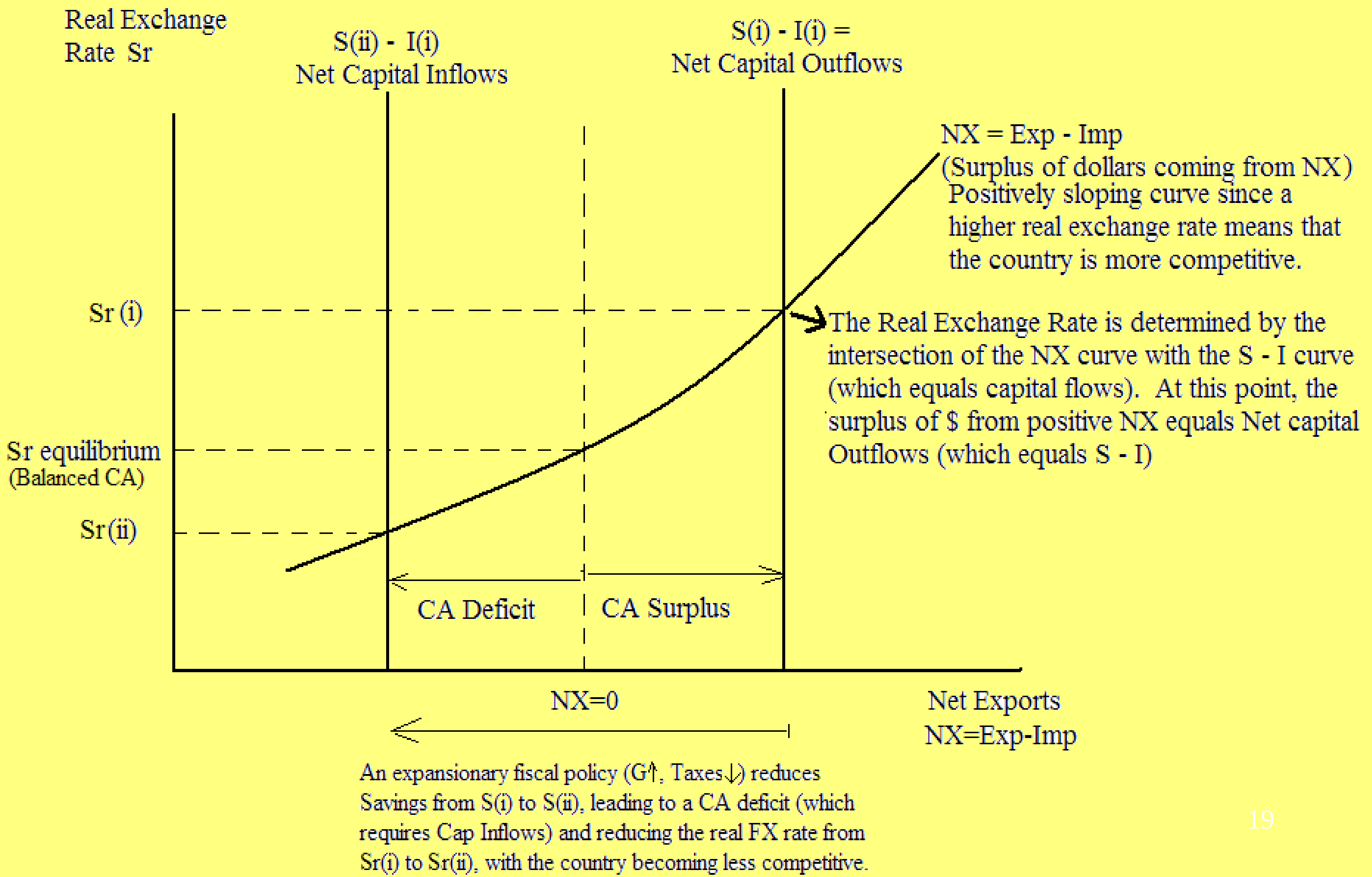
  (Foreign Price in Local Currency)/(Local price) => **(S** x **P*)/(P) =** S_r
- This is the **ratio** at which you can trade **"goods"** in one country for the goods of another.
- **S_r will equal 1.0 if PPP holds**, with perfect arbitrage, and **S** x **P*= P**
- The deviation of the real exchange rate from 1.0 is used to "measure" the price competitiveness of domestic goods.
- For example, if the price of a BigMac in the US is $4.0, and the nominal FX rate is 8 UAH/$, then in local currency the US BigMac cost 32 UAH. If the BigMac price in Ukraine is 17 UAH, then the Real exchange rate is 1.88
- That is, $S_r = S \times P^* / P = 8 \times 4.0 / 17 = 1.88$

- Thus, the BigMac is more expensive in the US (32) than the Ukrainian one (17 UAH) by 88%: Ukraine is **more competitive** than the US in the production of BigMacs (ie, in agriculture/food products).
- If the BigMac is a "typical" good, the Hryvnia is 47% "undervalued" in real terms against the dollar [(32-17/32)]. That is, the actual exchange rate could "appreciate" from 8.0 to **4.25** UAH/$ and the Hryvnia would then not be either undervalued or overvalued (**4.25** x 4.0 / 17 = 1.0).
- This BigMac analysis applies to one product, in which Ukraine is indeed competitive. But a similar analysis for other products may show that Ukraine may is less competitive and the currency "overvalued".
- To be valid, this analysis should be done for many products.
- In any case, this is a static analysis. A country may have its currency undervalued only because it has no exports or large barriers to trade.
- It is more useful to construct a real FX rate **index** that measures the "unofficial or real" **change** in value of the currency over a period of time due to **inflation differentials** (dP*/dP) between the two countries.
- Thus, the real exchange rate **index** is equal to the nominal exchange rate adjusted for differences in inflation over time.

- The real FX rate (index) is: $S_r = S(dP^*/dP)$ in which dP^*/dP are inflation rates and S is normally given as 100 for the initial period.
- If the real exchange rate index is lower than 100, domestic goods have become more expensive and the country is less competitive.
- When relative inflation doubles in the country, the "real" exchange rate declines by 50%, regardless of the "nominal/actual" exchange rate.
- That is, in this case: Sr = 100 x (100/200) = 50 or ½ of the old rate.
- If PPP had held (e.g., the nominal exchange rate should had adjusted as per inflation differentials), and the real exchange rate would not change.
- But if the nominal exchange rate is kept fixed (not adjusted for inflation), the real exchange rate will be under 100. Domestic goods have become more expensive due to local inflation, the country is less competitive and Net Exports will decline. This is referred to as a **real** appreciation of the domestic currency (an appreciated currency is less competitive) regardless of the nominal exchange rate.
- To return to equilibrium of the balance-of-payments, this real appreciation will need to be reversed by an **"external" devaluation** of the domestic currency. If a devaluation is not possible (due for example to a currency union), an "internal" devaluation is needed (by reducing domestic prices and wages through austerity measures).

- For example, from 1986 to 1994, Mexico followed a "stabilization" policy with peso devaluation less than inflation differentials. During this decade, the real exchange rate declined by 50% from 160 to 80 and the country became less competitive. It accumulated substantial Current Account deficits that led to the 1994 financial crises.
- The crises led to large external and internal devaluations.

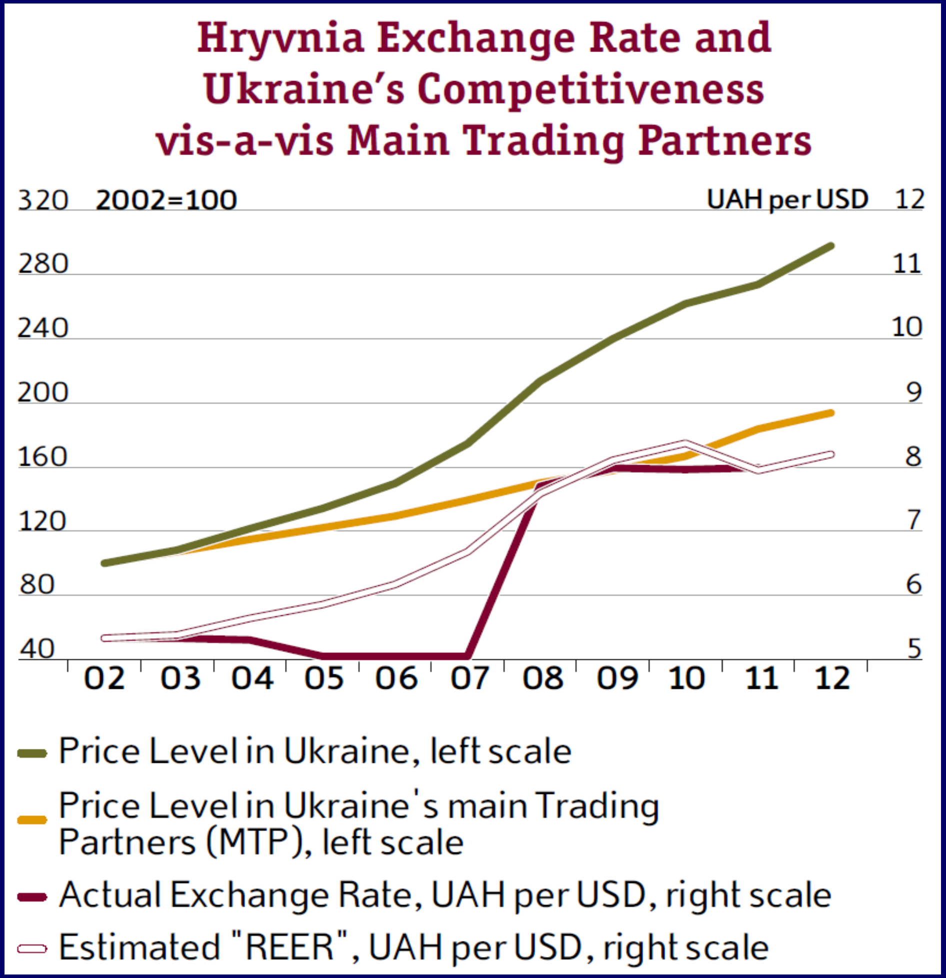
Determinants of Real Exchange Rate (Sr)

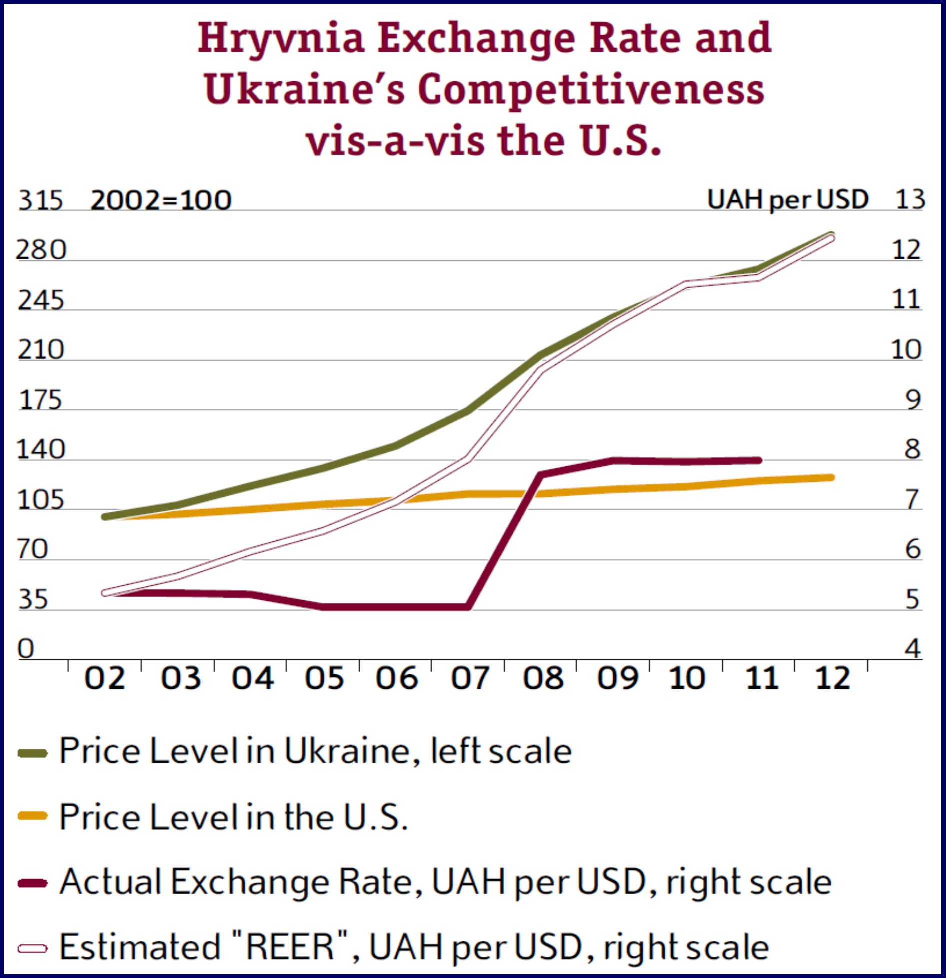


Effective Exchange Rate

- The **Effective Exchange Rate** is a useful related concept.
- It is an index based on the weighted average of bilateral exchange rates with all trading partners.
- The weighting reflects the size of bilateral trade.
- The Effective Exchange Rate measures the change in value of a currency due to value changes in the currencies of trading partners.
- Another similar concept is the Effective “Real” Exchange Rate, which is the weighted average of bilateral real exchange rates.

Hryvnia Exchange Rate and Ukraine's Competitiveness
(based on Purchasing Power Parity - Medium Term View)





- Higher inflation in Ukraine (10% pa over 2002-12) and virtually stable exchange rate until 2008, meant that over time, Ukraine lost competitiveness
- Adjustment took place in 2008 through exchange rate depreciation.

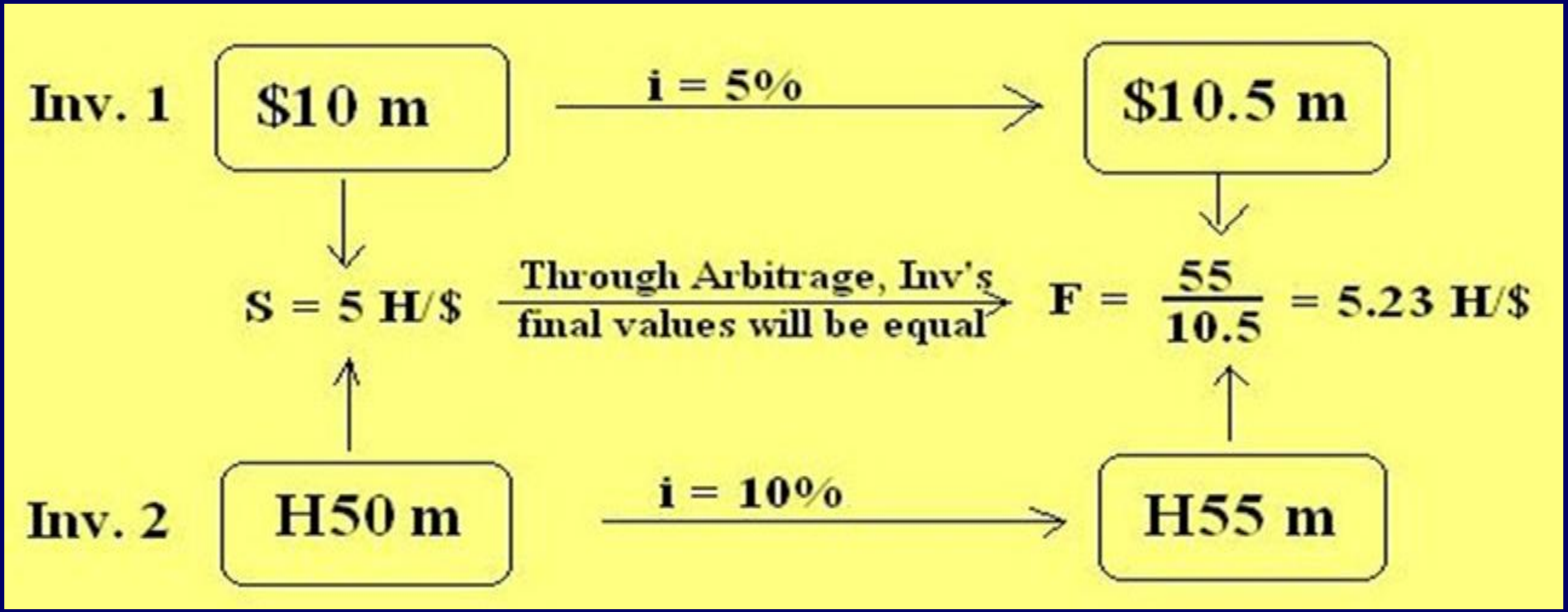
2. Covered Interest Rate Parity

- Whereas Purchasing Power Parity theory states that the actions of importers and exporters determine the exchange rate, the interest rate parity theory states that the **actions of investors**, whose transactions are recorded in the B/P capital account, induces changes in the exchange rate.
- To show this theory, we need to start with Currency Forwards.
- A **Currency Forward** is a firm agreement to buy or to sell foreign currency in the future at a pre-established foreign exchange rate (the forward rate, F). Its ratio to the spot rate (S) is called the forward foreign exchange rate premium or discount (F/S).
- A forward premium exists when the future exchange rate is trading at a higher value than the current spot price. The forward premium then is the proportion by which a country's forward exchange rate exceeds its current spot rate.
- A premium may imply the possibility of a future devaluation.

- CIRP says that the forward FX rate premium (F/S) of one currency relative to another should be equal to the ratio of nominal interest rates (i, i*) on securities of equal risk denominated in the two currencies:

  F/S= (1+i)/(1+i*) CIRP hold very well in the FX market.

- If this condition were not to hold, then it will be possible to engaged in arbitrage that will provide a riskless profit.
- Through arbitrage, two alternative investment approaches with the same risk should give the same terminal value.



Assume you have \$10 million and you have two investments:

(1) Initially exchange the \$10 (mm) for Hrivnias (at S = 5 Hr/\$) and buy a Hrivnia-denominated bond with interest (i) of 10%. Its final value in Hrivnias is: (\$10 x S Hr/\$)(1+i) = (\$10x5 Hr/\$)(1.1) = 55 Hrivnias

(2) Buy a dollar-denominated bond with interest (i*) of 5% and enter a forward contract to exchange the end-of-period dollar proceed into Hrivnias at a forward rate (F Hr/\$). Its final value in Hrivnias is: \$10 (1+i*)x(F Hr/\$) = \$10 (1.05)xF Hr/\$ = \$10.5xF Hr/\$

Through arbitrage both terminal values should be equal, then:

55 Hr = \$10.5 x F Hr/\$ or F = 55/10.5 = ***5.23 Hr/\$***

Any forward rate different to 5.23 Hr/\$ would give a riskless profit to one of the investment options. Therefore, the two investments should provide similar returns and : (\$10 x S) (1+i) = \$10 (1+i*)x(F)

Rearranging: ***F = S (1+i)/(1+i*) = 5 x 1.047 = 5.23 Hr/\$***

or ***(F - S)/S = (i - i*)/(1+i*)*** *which is approximate by:* ***(F - S)/S = i - i****

From here: ***F = S (i - i* +1)*** = 5 (0.10 - 0.05 + 1) = 5 x 1.05 = ***5.25 Hr/\$***

3. Forward Parity

– The Forward Parity says that forward exchange rates are unbiased predictors of **future spot prices**, even though they may not be “accurate” predictors: ***F = E(S)***

4. Uncovered Interest Rate Parity; or just Interest Rate Parity

- Replacing the Forward Parity in the equation of Covered Interest Rate Parity, we get the expression for the Uncovered Interest Rate Parity:

  (1) $E(S) / S = (1+i)/(1+i^*)$ *if* $i\uparrow$ *then* $[E(S)/S]\uparrow$

  An increase in domestic interest rates is associated with a depreciation.

  An approximation is: $(E(S)-S) / S = i - i^*$

- This same result can also be obtained by comparing expected returns from holding the domestic currency vs the foreign currency:
  - The return from holding the foreign currency ***(R*)*** in terms of the foreign currency is just the foreign interest rate ***(i*):*** $R^* = i^*$
  - The return from holding the domestic currency ***(R)***, as compared to the foreign currency, is equal to the domestic interest rate (i) minus the expected depreciation of the domestic currency: $R = i - (E(S)-S)$
  - Due to arbitrage and capital mobility, the differential between the foreign currency return and the domestic currency return should narrow close to zero; or $R = R^*$ ***or*** $i^* = i - (E(S)-S)$
  - Therefore: $(E(S)-S) / S = i - i^*$ as per equation (2)

- Equations (1) and (2), the Uncovered Interest Rate Parity (UIRP) says that the “expected” rate of change in the exchange rate should equal the ratio (differential) of nominal interest rate of the two countries.
- In the previous example, if interest rates were 10% in Ukraine and 5% in the US, the UIRP says that the domestic currency would be “expected” to depreciate vis-à-vis the dollar by a rate of 4.6% (1.10/1.05) or about 5%.

Role of Expectation on Exchange Rates

- From equation (2), we can see that:

$$(3) \quad \boldsymbol{E(S) = S\,(\,i - i^* + 1)} \qquad \textbf{\textit{if}} \quad \boldsymbol{i\uparrow} \qquad \textbf{\textit{then}}\ \boldsymbol{E(S)\uparrow}$$

- Equation (2) says that an **expected** depreciation of the domestic currency $E(S)\uparrow$ is associated with increases in domestic interest rates $(i)\uparrow$.
- This association of $E(S)\uparrow$ and $(i)\uparrow$ postulates that equilibrium in the capital goods markets is maintained only **if investors are compensated for an expected depreciation of the currency by means of higher nominal interest rates of that currency.**
- That is, an investor will not hold a currency that is expected to depreciate unless he is compensated by higher interest rates.

- From equation (2), we can also see that:

  $S = E(S) / (i - i^* + 1) \rightarrow$ if E(S) is constant, when $i\uparrow$, then ***($S\downarrow$)***
- This equation says that, **if the future expected exchange rate *E(S)* does not change (over the short term),** then an increase in domestic interest rates ***($i\uparrow$)*** is associated with an appreciation of the exchange rate ***($S\downarrow$).***
- This result occurs because an increase in interest rates ***(i)***$\uparrow$ would make the domestic currency more attractive – i.e., induce an inflow of capital -- which will "appreciate" the exchange rate ***($S\downarrow$)*** (assuming that the "expectation" about future exchange rate E(S) is not changed).
  - Therefore, over the short-term, if expectations on exchange rates do not change, an increase in interest rates ***(i)***$\uparrow$ will lead to an appreciation of the currency ***($S\downarrow$)*** .
  - But over the long term, for traders to hold the currency continuously, a domestic interest rate increase should be associated with the expectation that the currency will depreciate, or viceversa.
- The UIRP have permitted the growth of the so-called "**carry trade**" under which hedge funds borrow in a currency with low interest rates (e.g., Yen) and lends in a currency with higher interest rates (US$).

5. Domestic Fisher Effect.

- The DFE is also a market equilibrium condition, not a market arbitrage condition.
- It says that the nominal interest rate in a country (i) will be equal to the **real** rate of interest (r) compounded by expected future inflation (dP):

$$i = r + dP \quad \text{or more precisely:} \quad (1+i) = (1+r)(1+dP)$$

- It is based on the premise that investors are interested in real rates of returns and have no “monetary illusion”.
- If inflation is 10% and the nominal interest rate is 15%, then 5% is the cost of waiting and 10% is just to compensate for the lower value of the currency.
- The real interest rate reflects the time preference of money. It is quite stable over long periods of time for similar risks. Otherwise, there would be excess demand or supply of funds.
- The real interest rate depends on the riskiness of the asset:

$$(r = r_f + \Pi_{risk}).$$

6. International Fisher Effect (IFE).

- The IFE is based on the assumption that "real" interest rates for securities of similar risk are equal across the world: any differences in real interest rates across countries should motivate capital flows to take advantage to these differences.
- These capital flows will lead to equalization of real interest rates across countries.
- Based on this, the Domestic Fisher Effect should lead to the IFE:

$$(1+i)/(1+i^*) = (1+dP)/(1+dP^*)$$

- The IFE says that the interest rate differential between two countries $[(1+i)/(1+i^*)]$ should be equal to the expected inflation rate differential $[(1+dP)/(1+dP^*)]$ over the term of the interest rate.
- The IFE says that equilibrium can be maintained in the global capital markets only if investors are compensated for expected inflation by means of higher nominal interest rates.
- The IFE could also be derived from the combination of PPP and UIRP.

Conclusions:

The Parity Relationships imply the following:

Exchange Rate changes	=	*Inflation differentials*	=	*Interest Rate differentials*	=	*Competitiveness differentials*

- For developed countries, the Parity Relationships do not hold true over the short/medium term. Significant deviations may last a few years (2-4 year half-live). Therefore, they should be used cautiously for short term conclusions.
- Over the long term, they hold better, even for developed countries.
- On the other hand, the Parity Relationships hold better for Emerging Markets -- which could face wide variations on their economic variables, including prices and interest rates.
- But for all markets, these parity relationships are useful to organize and discipline our thinking about exchange rate determination.
- They are also sufficiently relevant to permit the formulation of economic models of FX rate determination & forecasting.

B. Theoretical Models of Foreign Exchange

Several economic models of FX rate determination and forecasting have been developed. The main ones are as follows:

1. **Balance of Payment Model**.
2. **Asset Models**

   A. Monetary Models (The Asset is Money):

   a. Monetary Inflexible-Price Model

   b. Monetary Flexible-Price Model

   b. Monetary Sticky-Price Model (Overshooting Model)

   c. Real Interest Differential Model

   B. Portfolio Balance Models (Assets are Money and Bonds)

   a. Preferred Local Habitat Model

   b. Uniform Preference Model

Note: In these models, **S = (P)/(P*)**; American Notation (UAH/US$).

An increase in S is a devaluation of the domestic currency (UAH).

1. Balance of Payments Model.

- A model of demand and supply for FX based on the "flows" of goods, services and capital passing through the B/P.
- The gap between exports – imports and capital flows reduces international reserves, and therefore the sustainability of the FX rate.
- B/P imbalances can be maintained over the short term, but eventually, B/P imbalances can not be left unchecked. They will need to be balanced through changes in the FX rate.
- Therefore, the exchange rate is determined by the main imbalances in the B/P: Current Account Balance (CA = Exports – Imports) and Capital Account Balance (CapAcc = Cap Inflows – Cap Outflows):

$$\ln S = f\,(CA, CapAcc)$$

(Export)↓ or (Imports)↑ → (S)↑ (depreciation)

(Cap inflows) ↑ or (Cap Outflows)↓ → (S)↓ (appreciation)

- The effect of a FX rate change will depend on the elasticities of demand for exports and imports: a devaluation will improve B/P equilibrium if the sum of elasticities exceeds 1 (Marshall-Lerner).

2. **Asset Models**

- The Asset Models focus on **financial assets** (principally money, but also bonds) either flowing across borders (capital flows) or outstanding (asset stocks) at a moment of time.
- When the key asset is money, domestic and foreign, the models are called Monetary Models. When the key assets are money and bonds, domestic and foreign, the models are called Portfolio Balance Models
- The initial models were developed by Mundell-Fleming who recognized that capital asset flows were becoming more important than trade flows, with higher speed of change thanks to the removal of capital controls in Europe.
- Since asset portfolios can be rebalanced quickly, these actions will affect the FX rate over the **short-term** more than foreign trade flows (goods and services), which can be played down or ignored.
- Long term asset models also focused on financial assets, bypassing short-term foreign trade flows, but assuming that PPP holds.
- All Asset Models assume a high degree of capital mobility.

2.A Monetary Models

- In Monetary Models, the most relevant assets are domestic money (m) and foreign money (m*).
- These models assume that domestic and foreign bonds are perfect substitutes once expected devaluations are offset by interest rate differentials (i.e., Fisher International holds).
- There are four types of Monetary Models, depending on the assumptions on the rigidity of commodity prices. That is, how quickly local prices adjust to changes in other economic variables:
  - **Monetary Inflexible-Price Model** (developed by Mundell-Fleming) – relevant for the short run.
  - **Monetary Flexible-Price Model** – Long run situation/PPP holds.
  - **Monetary Sticky-Prices Model**, which consider the move from short run to long run (inflexible prices initially by flexible later on. This "dynamic" model was developed by Rudy Dornbusch.
  - **Real Interest Differential Model**. Jeffrey Frankel expanded Dornbush "overshooting" model the include inflation and real interest rates.

2.A.a Monetary Inflexible-Price Model – Short-Term

- Developed by Mundell-Fleming, it assumes that in the short run, prices are inflexible.
- With fixed prices, PPP does not hold – which is true in the short-run.
- Also over the short-term, the money stock (M) is in fixed supply and will be willingly held at equilibrium currency prices.
- Therefore, the model assesses **the effects on interest rates of the excess of money demand (L) relative to their fixed supply (M).**
- On this basis, the willingness to demand money (hold a currency -- leading to capital flows into this currency) will depend only on its expected returns from holding that currency, which is given by its interest rate compared to alternative interest rates for other currencies.
- In an open economy **with capital mobility**, the flows of capital will be driven by the differential in returns, which is given by interest rate differentials (assuming that future FX expectation do not change): higher domestic interest rates leads to capital inflows and appreciation.
- If a monetary expansion takes place, it will reduce domestic interest rates ($i\downarrow$) below international interest (i^*). This leads to an unwillingness to hold the domestic currency and to capital outflows, which would in turn lead to a depreciation of the currency ($S\uparrow$).

- Therefore, over the short term (**without changes in expectations about future FX rates**), a reduction of interest rates (i↓) leads to a depreciation of the currency (S↑).
- In this model: $\Delta S = f\,(i^* - i)$
- This work was influential in indicating the existence of self-regulating mechanisms of international adjustment (CA deficits.)
- But this is contrary to the Uncovered Interest Rate Parity which requires a higher interest rate (i↑) for a currency which is "**expected**" to depreciate (S↑) over the longer term.
- The M-F "i↓ → S↑" relation is not feasible over the long run, because: (a) investors will not hold a local currency which is expected to depreciate and has lower interest rates, and (b) over the long run, interest rates differentials can not sustain capital flows indefinitely, without leading to a Financial crisis.
- But the M-F relation is true over the short run.

Short Term Forecasts of FX Rates

- We also know that short-term fundamental models do not perform satisfactorily: studies found that even when the fundamental exchange rate models fitted very well in-sample periods, they tended to have a very poor out-of-sample fit for short-run forecasts.
- Thus, the relationship between interest rate differentials and exchange rates tends to be unreliable over the short-term.
- This is because over the short term, exchange rate markets are not "economic efficient", are subjected to expectations (based on recent news) and many "noises" (such as speculation) and other irregularities.
- **On a non-quantitative basis,** one can get a sense of the direction of expectations of FX rates by observing the possible actions on supply and demand for domestic and foreign exchange by the main actors in the FX market, such as the Central Bank, the Treasurer, foreign creditors, international agencies, speculation by traders and the population, etc.
- **On a quantitative basis** for short term forecasting, most researchers have resorted to the so-called "technical analysis" of time-series: identify patterns, trends and information that could be obtained from past behavior of exchange rates to capture the relations between the future & past rates.
- It assumes that historical data incorporates all those behaviors and expectations and can play a major role on predictions.

- Practitioners resort to such techniques as sentiment and positioning surveys, FX dealer customer-flow data, trend-following trading rules, etc.
- Some also use classical linear statistical time-series techniques (such as autoregressive, moving averages) but they generally give poor results.
- However, a new contingent of economists have shown that non-linear "technical" models have much better forecasting power for the short run, since they are able to approximate the various nonlinearities in the data.
- As a result, models using nonlinear techniques, particularly those based on **artificial intelligence**, have developed rapidly. These include models such as artificial neural networks (directly inspired from the real neuron present in our nerve system) and multilayer feed-forward networks.
- The neural models have the ability to extract complex nonlinear and interactive relations from historical data. This is done as follows:
  - In the initial step the model compares the actual value of a time series with the forecast value of the linear components in order to extract and obtain a series of nonlinear components.
  - Once these nonlinear characteristics of the time series are captured, these data can be used to "train" the model. The model is "trained" by adjusting the model's parameters iteratively by a process of minimizing the forecasting errors resulting from additional fittings of the nonlinear components of the time series.

  - By training the neural model using previously generated nonlinear time series as inputs, the trained model is then used to generate a series of forecasts of the nonlinear components of time series.
- This data is then used to generate foreign exchange forecasts.
- Usually, the neuron model consists of an input layer, an output layer and one or more intervening layers also referred to as hidden layers.
- The hidden layers capture the nonlinear relationship between variables. Each layer consists of multiple neurons that are connected to neurons in adjacent layers. Since these networks contain many interacting nonlinear neurons in multiple layers, the networks capture complex phenomena.
- Also, recent studies show that using ensemble models consisting of a number of different neural network structures gives results that consistently outperform a single network design.
- Recently, more hybrid forecasting models have been developed that integrate neural network techniques with conventional forecasting methods such as fundamental econometric models to improve prediction accuracy.
- Some other studies have shown that a linear combination of forecasts would also give a smaller error variance than individual methods.
- Recently, the studies on these topics have expanded dramatically.

2.A.b Monetary Flexible-Price Model – Long-term/PPP

- It assumes that domestic good prices are fully flexible: that is, if money supply increases over money demand, prices will increase.
- It also assumes that PPP holds (which is valid over the long-term) and that money demand is a function of Y and i.

$S = P/P^*$	PPP holds (American term)
$\mathbf{P=M/L}$	Prices (P) = money supply (M)/ money demand (L)
$P^*=M^*/L^*$	Same for the foreign country
$L=K(Y^a)(e^{-bi})$	Money demand = Constant (k),+Income (Y), -interest (-i)

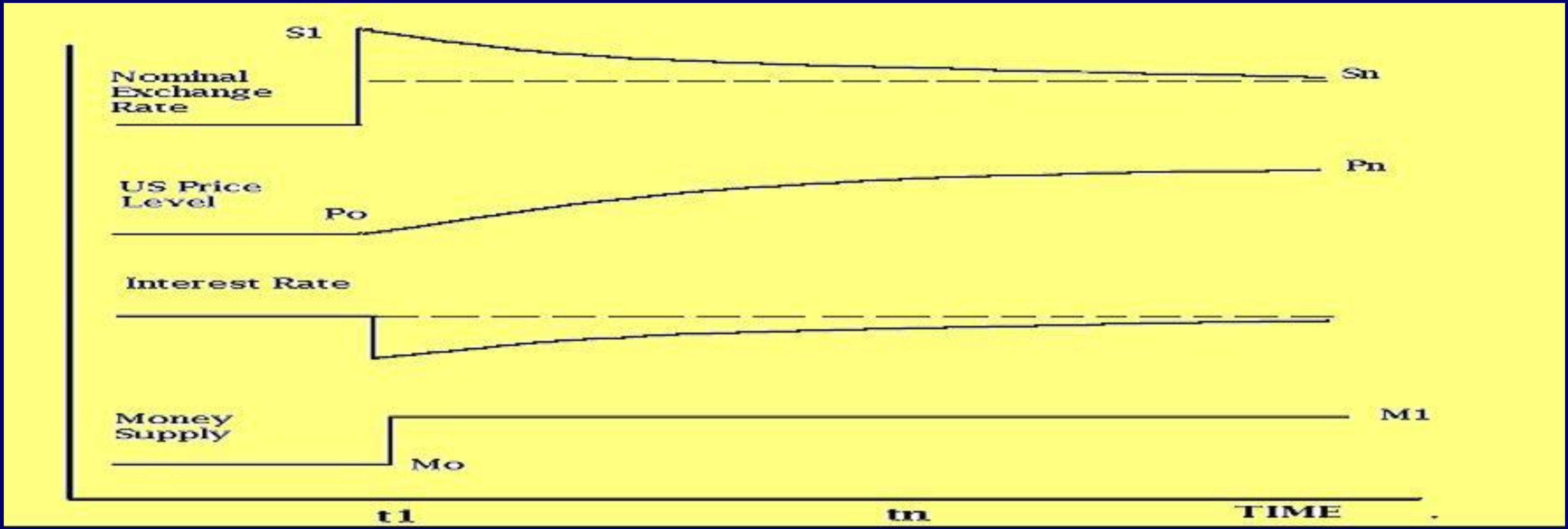
Or: $S = P/P^* = ML^*/M^*L = MK^*(Y^{*a})(e^{-bi^*}) / M^*K(Y^a)(e^{-bi})$

Using logs: $\ln S = (m-m^*) + a(y^*-y) + b(i-i^*) + (k^*-k)$

- This equation predicts the domestic currency will depreciate (S↑) with an increase in (domestic) money supply (m↑)
- An increase in interest rates (i↑) or decline in income (y↓) will also lead to depreciation (S↑) -- because both effects will reduce money demand (L) & increase prices (P).
- The predictions on interest rate effects on FX rates are contrary to predictions by M-F.

2.A.c Monetary Sticky-Price Model (Overshooting)

- Developed by Rudy Dornbusch in 1976 to revise the effect of interest rates on FX changes under the previous fixed/flexible price models.
- It was the first of the "dynamic" models, that trace the "move" from the short to the long term, setting a new standard for model-making.
- It is based on the premise that good prices adjust more slowly over time that financial asset prices (good prices are sticky).
- When changes in money supply are announced, Citibank acts faster to adjust security portfolio positions than Sears, which will act to adjust good prices only as inflationary pressures spreads.
- With sticky good prices, assets prices (i.e., interest rates) will need to move by a larger amount (overshoot) to permit a temporary equilibrium in the markets, returning to long term equilibrium slowly as good prices are adjusted over time.
- This also implies that FX rates will overshoot initially and return to long term equilibrium gradually.
- The short run equilibrium includes all the Mundell-Fleming features of inflexible prices in which $Ms\uparrow \rightarrow i \downarrow \rightarrow$ Cap Out $\rightarrow S\uparrow$ (dep)
- The long run equilibrium is consistent with the Monetary LT model in that: $Ms\uparrow \rightarrow P\uparrow \rightarrow S\uparrow$ (dep), with no effect on LT interest rates.



- In response to an anticipated jump in domestic money supply, domestic interest rate falls, capital will outflow and the domestic currency will depreciate (as per Mundell-Fleming).
- But this is not a feasible equilibrium (it is contrary to UIRP), since traders will not hold a domestic currency in which interest rates are lower than international rates and the currency is depreciating. To hold the currency with low “i”, there must be expectations that the exchange rate will appreciate.
- The key is that if the initial depreciation is overshot (due to sticky goods prices), then the currency will appreciate over time, which is needed for as long as interest rates remain low.
- Over time, the excess money supply leads to inflation, and interest rate raises.
- As the liquidity effect dissipates, the exchange rate gradually appreciates.

- In the long run, interest rates return to the original "international" level.
- The exchange rate depreciated in nominal terms, but in real terms, it is unaffected.
- Under the Sticky-Price model, the path of exchange rate movement is given by:

$$\ln S = (m-m^*) + a(y^*-y) + (1/H)(i-i^*)$$

where H is the rate at which FX rate adjust towards equilibrium and has a negative sign.

- In this model, initially, the decline in interest rates (i)↓ will cause the domestic currency to depreciate (S)↑ (as in the Mundell-Fleming model). But with the overshooting, gradually over time, interest rates will increase (i↑) as the exchange rate appreciates (S↓) to its long term equilibrium (consistent with UIRP and the Flexible Price Model).

2.A.c Real Interest Differential Model

- In 1979, Jeffrey Frankel argued that the pure sticky-price monetarist model was deficient because the nominal interest rate (i) reflected both, real interest rates (r) and inflation (dp).
- Frankel's modification led to another exchange rate equation

$$\ln S = (m-m^*) + a(y^*-y) + (1/H)(r-r^*) + b(dp-dp^*)$$

- This equation associates lower real interest rates (r)↓ with currency depreciation (S)↑ (as was the case with the sticky-price model).
- But it also associates higher inflation rates (dp)↑, with currency depreciation (S)↑.
- In other words, we expect the coefficient of (r - r*) to be negative and the coefficient of (dp - dp*) to be positive.

2.B Portfolio Balance Model

- The relevant assets are both domestic and foreign money (m, m*) and the supply of domestic and foreign bonds (b, b*).
- It assumes that domestic and foreign bonds are not perfect substitutes and investors will require a "foreign exchange risk premium", in addition to the interest rate differential, due to expected devaluations [E(S)].
- It also postulates that investors react to "changes" in interest rate differentials [$\Delta(i - i^*)$] not to the differentials per se.
- According to this model:

$$\ln S = f\,[(b - b^*),\ \Delta(i - i^*),\ E(S),\ W, C\,]$$

- Under one of its formulations, bond investors have a "Preferred Local Habitat": investors prefer to hold a larger share of their Wealth in local bonds (vs foreign bonds). In this case, Wealth (W) and Current Account balances (C) become relevant explanatory variables.
- Under the "Uniform Preference Model", W and C are not relevant.

Longer term forecasts

- Over the longer term, in addition to the previously mentioned fundamental economic variables (PPP, interest rates, etc) other economic forces are important in explaining foreign exchange rates.
- These are the economic forces that give rise to long-term cycles and that establish permanent differences in **real** exchange rates.
- These economic forces include:
  - changes in relative factor productivity growth rates (the Balassa-Samuelson effect: as a country becomes more efficient in a permanent way, this leads to an appreciation of its currency);
  - trends in a country's terms of trade (for example, the discovery of oil or a major improvement in the TOT may lead to appreciation);
  - changes in trade openness or trade preferences,
  - changes in the country's savings and investment bahaviours (which may also affect productivity);
  - changes in investment climate and creditworthiness (that would change the attractiveness of sustainable foreign capital).

Summary of FX Rate Effects of Asset Models:

(signs of coefficients)	m-m*	y-y*	i-i*	p-p*	b-b*
1. Inflexible Price Model			-		
2. Flexible Price Model	+	-	+	+	
3. Overshooting Model	+	-	-/+		
4. Real Interest Differential	+	-	-/+	+	
5. Portfolio Balance			+		+

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m-m*: domestic minus foreign money supply

y-y* : domestic minus foreign income

i-i* : domestic minus foreign interest rates

p-p* : domestic minus foreign inflation rates

b-b* : domestic minus foreign bond supplies

II. Foreign Exchange Forecasting
A. Empirical Evidence

1. Monthly Yen/US$ Exchange Rate for 1977-96

$$\text{Yen/US\$} = a_0 + a_1 (i_{us} - i_j) + a_2 (CA_{us} - CA_j) + a_5 (dv)$$

where i is interest rate, CA is the cumulative current account balance and dv is a dummy variable for the speculative bubble of 1984.

Variable	Coefficient	T-Value
Constant	226.50	85.3
$(i_{us} - i_j)$	2.82	4.3
$(CA_{us} - CA_j)$	3.01	22.2
dv	27.93	2.7

R-Squared = 0.89
Durbin-Watson = 0.51

Source: Merrill Lynch, Currency and Bond Market Review, Sep. 1994

2. Monthly DM/Pound Exchange Rate for 1970-77

$$St = ao + a1\, m_t + a2\, m^*_t + a3\, (i_t - i^*_t) + a4\, y_t + a5\, y^*_t + a6\, t$$

Where m is domestic money, i is interest rates and y is income.
A star (*) means foreign.

Variable	Coefficient	T-Value
Constant	-1.3280	-
m	1.0026	6.2
m*	-0.9846	6.2
(i - i*)	1.3853	2.8
y	-0.9009	3.3
y*	1.0183	3.6
T	-0.0049	3.3

R-Squared = 0.98
Durbin-Watson = 1.97

3. Monthly DM/US$ Exchange Rate for 1974-78

$$S_t = a_0 + a_1(m_t - m^*_t) + a_2(y_t - y^*_t) + a_3(i - i^*) + a_4(p_t - p^*_t)$$

Where p are prices

Variable	Coefficient	T-Value
Constant	1.33	-
m - m*	0.87	0.2
y - y*	-0.72	0.2
i - i*	-1.55	1.9
p - p*	28.65	2.7

R-Squared = 0.80
Durbin-Watson = 0.8

Consistency Model to Estimate Equilibrium Exchange Rates

1. From the Monetary Block (in local currency): $\Delta R = \Delta Ms - \Delta NDC$
2. From the B/P Block (in \$): $\Delta R = (X-J) + FY + TR + \Delta FDI + NFB - CBB$
3. From the Real Sector: $GDP = C + I + G + Se(X - J)$

$$\Delta Ms - \Delta NDC = Se\,\{(X-J) + FY + TR + \Delta FDI + NFB - CBB\} \qquad (1)$$

$$Se = \frac{\Delta Ms - \Delta NDC}{(X-J) + FY + TR + \Delta FDI + NFB - CBB} \qquad (2)$$

To introduce equilibrium in the real sector, from equation (1):

$$\Delta Ms - \Delta NDC = Se(X-J) + Se\{FY + TR + \Delta FDI + NFB - CBB\}$$

Since: $Se(X - J) = GDP - C - I - G$, then:

$$\Delta Ms - \Delta NDC = (GDP - C - I - G) + Se\{FY + TR + \Delta FDI + NFB - CBB\}$$

And: $$Se = \frac{\Delta Ms - \Delta NDC - (GDP - C - I - G)}{FY + TR + \Delta FDI + NFB - CBB} \qquad (3)$$

D. Guide to Medium-Term FX Rate Forecasting

- **<u>Balance of Payments</u>**: An increase in the current account deficit is an early sign of a future currency depreciation.
- **<u>Relative Inflation</u>:** Inflation would lead to loss of competitiveness, current account deficits, and then depreciation (PPP).
- **<u>Money Supply Growth</u>:** Will initially reduce interest rates that would lead to depreciation, with an initial "overshooting".
- **<u>Government Spending</u>:** This may lead to increases in money supply, inflation and then devaluation.
- **<u>Interest Rate Spreads</u>**: Will affect capital flows and FX rates.
- **<u>Foreign Exchange Reserves</u>**: Intervention to support the currency will deplete reserves and led to depreciation.
- **<u>GDP Growth</u>**: Growth will increase imports, and depending on export growth, may lead to FX rate changes.
- **<u>Exchange Rate Spreads</u>**: The black market is a good indicator.
- **<u>Capital Controls</u>:** Signal difficulties in keeping equilibrium.