Handout 1: Exchange Rate Determination

1 Elasticities approach

The price of the foreign exchange, $s(t)$, is determined by the demand for and supply of foreign currency. The demand for and supply of foreign currency are derived from the demand for and supply of imports and exports. Those in turn depend on domestic and foreign incomes and the relative price of domestic goods in terms of foreign goods, q (the terms of trade or real exchange rate).

$$s\text{: D}(q, Y, h) = \text{S}(q, Y^*, h^*)$$

D(.), S(.) : demand and supply of imports

h, h^* : preference parameters

1.1 Effects of exchange rate changes on the trade balance

A domestic currency devaluation (depreciation) - s goes up - improves the trade balance (*TB*) if the sum of import and export elasticities exceeds unity (*Marshall-Lerner (ML) condition*).

J-curve: It is possible that short and long term elasticities differ. If the M-L condition is satisfied in the long run but not in the short run then we may observe a J-pattern following a devaluation: an initial deterioration of the *TB* followed by an improvement

Long term elasticities tend to exceed short term due to:

- Long term trade contracts (advance orders at a pre-specified price)
- Learning about price changes

1.2 Effects of an increase in domestic income on the exchange rate

An increase in domestic income leads to a depreciation of the domestic currency and a deterioration of the *TB*. For instance, an acceleration of economic growth in Switzerland will depreciate the CHF and improve the international competitiveness of Swiss products

1.3 The empirical evidence on the effects of a devaluation

On the trade balance (*TB*)

Must filter out the effects of the other determinants of the TB.

Testing strategy: *TB* = f(*Y*, *Y**, *fiscal policy*, ...).

Econometric estimation problems: Simultaneity. Relate the residuals of the estimated regression to the timing of the devaluation. Mixed findings.

Possible reasons for not observing an improvement in the trade balance following a devaluation:

a) The M-L condition is not satisfied

b) There is no associated <u>real</u> devaluation and hence no gain in international competitiveness (note that $q = sp^*/p$)

   - p increases because of labor union pressures for salary compensation. As a result, the nominal devaluation does not translate into

- *p* goes up either because productivity-efficiency worsens (complacency) or because the domestic firms raise prices to increase profits rather than market share (US auto industry)
- *p** decreases because foreign exporters lower their prices to maintain market share. A good example is the practice of Japanese companies exporting to the US in the late 80s (note, however, that profits get squeezed; also may run into problems with anti-dumping legislation)

c) there are offsetting developments in other variables that are not included in the regressions (for instance, a change in world interest rates)

On output

A devaluation seems to serve as a temporary output stimulus.

1.4 A related question: Does a weaker CHF improve the TB and stimulate the Swiss economy?

It will be argued later that this is not a well posed question because, under a flexible exchange rate system, the exchange rate is an endogenous variable which is simultaneously determined with the TB. Must know the underlying shock that induced the exchange rate change in order to answer this question (more on this later). For instance, was it due to fiscal expansion, or a change in monetary policy, or a change in productivity……

1.5 Main shortcoming of the elasticities approach

Ignoring capital movements (which dwarf trade flows nowadays). Trade flows are also too smooth in the short run to account for the observed large short term real (and nominal) exchange rate volatility. The theory may make more sense in the determination of the long term real exchange rate.

In the long run (steady state)

$$q: CA(q, Y, Y^*) = 0$$

because of the country's *intertemporal budget constraint* on international borrowing and lending: All borrowing must be eventually repaid. A Swiss current account (*CA*) surplus means that the Swiss are increasing their international asset holdings ("lending" to the rest of the world). Recall that

$$CA + KA = 0$$

A CA surplus requires a KA deficit, that is investment abroad. Equivalently:

$$\sum_0^\infty CA(t) = 0$$

$$CA = TB + \textit{interest payments}$$

If the international <u>net</u> asset position of a country is small then

$$CA \cong TB \cong 0$$

But

$$TB = TB(q, Y, Y^*)$$

If domestic and foreign output grow in the long run at similar rates then the only factor that can bring about the long term (or average) $TB = 0$ is the exchange rate. *Prediction*: Sustained trade deficits ("borrowing" from abroad) lead eventually to a currency depreciation in order to generate the future trade surpluses required to pay back the external debt.

2 The Mundell-Flemming (Keynesian) Model

Main emphasis: How the policy mix affects the exchange rate, international trade competitiveness and aggregate economic activity.

Fixed goods prices. IS-LM: The IS curve now includes imports and exports.

$$Y + IM = C + I + G + EX \qquad Y = C + S + T$$

$$S + T = I + G + NX \qquad NX = EX - IM$$

$$NX(q, Y^*, Y)$$

Monetary and fiscal policy affect the exchange rate through their effects on the domestic real interest rate relative to the foreign interest rate.

Interest Rate Parity (UIRP):

$$i - i^* = s(t+1) - s(t)$$

Position of the IRP curve: higher $s(t+1)$ or i^* shift the curve out.

2.1 Short term effects of fiscal and monetary policy

Monetary policy

Temporary monetary expansion: Lower interest rates, domestic currency depreciation, output expansion.

Permanent monetary expansion: Lower interest rates (?), domestic currency depreciation, output expansion (greater compared to a temporary monetary expansion).

Fiscal policy

Temporary fiscal expansion: Higher interest rates, domestic currency appreciation, output expansion

Permanent fiscal expansion: No effect on interest rates, domestic currency appreciation, no effect on output

2.2 Main shortcomings of the Mundell-Flemming (MF) model

- Ignores the inflationary effects of policy. It does not deal with expectations
- Does not give a complete picture because it ignores the dynamic repercussions of current changes. Trade imbalances must be eventually corrected in the long run.

3 Asset Based Models

Forward looking prices

$$s_t = \mathrm{V}\,[K_t, \mathrm{E}(s_{t+1})]$$

V[.] : a function

K(t) : fundamentals (M-policy, productivity, ..)

E(.) : a function that takes the expected value of the term inside the brackets

4 The Monetary Model

The demand for and supply of foreign currency are derived from the demand for and supply of domestic and foreign money (s is now the relative price of monies rather than goods), i.e.:

$s(t)$: $M(t)/p(t) = \mathrm{F}(i(t), y(t))$

The relevant fundamentals are the determinants of the supply of and demand for money

4.1 Important assumptions

All prices are flexible (Aggregate Supply is vertical).

Domestic and foreign goods are perfect substitutes (PPP):

$$p(t) = s(t)p^*(t)$$

Domestic and foreign assets are perfect substitutes (IRP):

$$\frac{1+i_t}{1+i_t^*} = \frac{\mathrm{E}_t(s_{t+1})}{s_t}$$

4.2 Implications

$M\uparrow$ $s\uparrow$ (depreciation)

$i\uparrow$ $s\uparrow$ (depreciation)

$y\uparrow$ $s\downarrow$ (appreciation)

4.3 Comparison to the predictions of the MF model

$i\uparrow$ $s\downarrow$ (depreciation)

Understand the source of disagreement:

i (*Fisher equation*): $i = r + \mathrm{E}\pi$

Sources of variation in *i* - the role of *inflation* and *inflationary expectations*

4.4 The combination of the monetary approach and the asset based model

Derivation of a forward looking expression for s(t).

$$M(t) = P(t)Y^{a}\exp^{-bi(t)}$$

Combine the above equation with the foreign country counterpart + PPP + IRP to get:

$$(1+b)s(t) - bE_{t}s(t+1) = k_{t}$$
$$k(t) = \ln M(t) - \ln M^{*}(t) - a[\ln Y(t) - \ln Y^{*}(t)]$$
$$s(t) = \ln S(t)$$

Solving first order difference equations (all asset prices take the form of a difference equation) – two solutions

- The solution to the homogeneous part (bubble[1])

$$(1+b)s(t) - b\,\mathrm{E}_{t}\,s(t+1) = 0$$

In general, any current exchange rate that satisfies the condition

$$s(t) = \left(\frac{b}{1+b}\right)\mathrm{E}_{t}\,s(t+1)$$

Hence,

$$s(t) = A(0)\left(\frac{b}{1+b}\right)^{t}$$

is a valid solution. We typically set the initial condition of this difference equation to eliminate the bubble, A(0) =0.

To gain a better understanding of bubbles consider the IRP:

$$\frac{1+i_{t}}{1+i_{t}^{*}} = \frac{\mathrm{E}_{t}\left(s_{t+1}\right)}{s_{t}}$$

[1] *Price bubble*: If the only reason that today's price is high is because the future price is expected to be high (and not because of fundamentals) then we have a bubble.

For any $i(t)$ and $i^*(t)$, the value of the current exchange rate is undetermined unless we fix a value for the future exchange rate. For an arbitrary expectation, we get an arbitrary current spot rate!

The dollar in the eighties: was it a bubble?

A simple calculation based on the appreciation of the $ in the early 80s

$i - i^* = 3\%$ $\Delta s(t) = -13\%$ Probability of the bubble bursting

Econometric tests of bubbles. Omitted variables

- Particular solution (fundamentals)

Postulate that the current spot rate is determined by its fundamentals, k(t)

$$s(t) = A + Bk(t)$$

or

$$s(t) = \frac{1}{1+b} E_t \sum_{j=0}^{\infty} \left(\frac{b}{1+b}\right)^j k(t+j)$$

Two ways of testing the model

- Estimation of the above equation together with the stochastic equation (process) for the fundamentals, e.g.:

$$k(t) = ck(t) + u(t)$$

Test the model using cross equation restrictions.

→ A diversion into the econometrics of *cross equation restrictions* under rational expectations

- *Variance bounds test*: conditional variance of s(t) should be bounded above by conditional variance of k.

4.5 Policy implications

- Monetary policy affects the nominal exchange rate but not int'l trade competitiveness (*q*).
- Both current and expected future developments matter

4.6 Main shortcomings:

- The real exchange rate (q = sp*/p) is not constant (PPP does not hold).
- IRP does not seem to hold either.

5 Disequilibrium or Overshooting Model (Dornbusch)

The assumptions are the same as above with an important exception: Goods prices are taken to be flexible only in the long run but sticky in the short run.

Effects of monetary expansion:

$$M(t)/p(t)= F(i(t),y(t))$$

$$\frac{1+i}{1+i*}=\frac{s(t+1)}{s(t)}$$

Exchange rate *overshooting*.[2] The short run exchange rate jumps above its long run value. "Excessive" nominal and real exchange rate volatility

In the *short run*, the real exchange rate (the terms of trade) moves in tandem with s because p and p* are sticky in the short run.

In the *long run* good prices are flexible so q returns to its earlier value.

[2] Overvalued (undervalued) currencies: A currency is said to be overvalued (undervalued) when it is stronger (weaker) compared to what is implied by PPP. Mote that in this model overvalued means less competitive

5.1 Interesting implications

- The policymakers can use monetary policy to induce temporary change in international trade competitiveness (q) by manipulating the nominal exchange rate, s.
- An increase in the nominal interest rate is associated with a currency appreciation.
- Unlike the IS-LM (Mundell-Fleming) model the effects of monetary policy are short lived.

5.2 Strengths and weaknesses of the Dornbusch model

Strengths: It matches the stylized fact that almost all of the short run variation in real exchange rates is due to variation in the nominal rate.

Weaknesses: It has difficulty accounting for the fact that deviations from PPP are long lived. It predicts a transitory, short lived change in q.

6 Equilibrium model (Stockman)

Everything is as in the monetary model except for the fact that it assumes that domestic and foreign goods are not perfect substitutes.

The emphasis is on *real* - mostly supply - (rather than monetary) shocks.

Equilibrium in the goods market:

$$q = \frac{u_y}{u_x}$$

Equilibrium in the money market:

$$M(t)/p(t) = \mathrm{F}(i(t), y(t))$$

Exchange rate equation:

$$s(t)p^*(t)/p(t) = \mathrm{MRSC}(x,\mathrm{y})$$

$$s(t) = \frac{M \cdot \mathrm{F}(i^*, y^*)}{M^* \cdot \mathrm{F}(i, y)} \cdot \frac{u_y}{u_x}$$

6.1 Implications

with regard to the effects of changes in *M*, and *i* are as in the monetary model.

The effect of *M* on *s*(*t*) may be ambiguous if inflation redistributes international income and preferences are non homothetic (transfer problem).

Nevertheless, *monetary policy cannot be used to manipulate q*.

The effects of *Y* on *s* are ambiguous: income effect (money market) pushes *s*(*t*) down; The elasticity of substitution between domestic and foreign goods effect pushes *s*(*t*) up.

6.2 Interesting points

- The concept of international competitiveness is *meaningless*. The correlation between changes in the nominal and real exchange rate is not unique. Its sign depends on the type of shock that hits the various markets. In any case correlation does not imply causality. Nevertheless, we know that this correlation has on average been strongly positive.

- Government expenditure (or taste) shocks: Expansionary fiscal policy leads to appreciation

6.3 Evaluation

Can account for high persistence in real exchange rates with supply shocks.

However, in order to account for great volatility of nominal exchange rate relative to inflation rates with supply shocks it needs var(p) < var(e) (large elasticity of substitution compared to the elasticity of the demand for money with regard to income).

But this requires

$$\mathrm{Cov}(e,x) > 0$$

which is unrealistic.

Nontradeables do not help to account for these failures. The model does a better job when demand shocks (preferences or government expenditure shocks) are introduced.

7 The Balassa-Samuelson Hypothesis

Fast growing countries should experience a real exchange rate appreciation

Rich countries have higher price levels than poor countries

Theory:

$$q(t) = \frac{s(t)\,p(t)^*}{p^*(t)} \qquad\qquad p(t) = p_{Tt}^{a}\, p_{Nt}^{1-a}$$

Cross country differences in productivity growth in traded goods industries relative to nontraded goods industries

7.1 Empirical evidence

The theory works very well for the Yen-USD real rate

Cross industry productivity differences explain well changes in the relative prices of traded in terms of non traded. They do a less satisfactory job explaining changes in the real exchange rate, though.

8 Portfolio Balance

Assumption: Domestic and foreign assets are imperfect substitutes (differences in riskiness).

IRP does not hold:

$$\frac{1+i}{1+i^*} = \frac{Es(t+1)}{s(t)} - rp \qquad\qquad rp = risk\ premium$$

The demand for and supply of foreign currency are derived from the demand for and supply of all domestic and foreign assets (not just money); s is now the relative price of assets.

8.1 The effectiveness of official intervention

Non sterilized intervention: involves change in the money supply

vs

Sterilized intervention: involves swap of domestic + foreign bonds with no change in money

If assets denominated in different currencies are imperfect substitutes then sterilized intervention ought to work

It usually does not

Sterilized intervention as a signal of future intentions. Credibility

9 New Theories: A Shift away from Macro Determinants towards Micro Determinants

The dynamics of trading behavior. The relationship between volume and price changes, thickness of markets, heterogeneous sentiments. Trading patterns, procession of information

FX markets:

- Huge trading volume
- Inter-dealer trading is very high (80% vs 20% in stock markets)
- Low transparency of order flows (no disclosure requirement)

Trades between FX dealers and their customers are not observed by others

Customer bases introduce a source of private info at the dealer level

There is also public info about order flows that comes from trading through brokers (1/3 of total volume)

Dealers: Risk averse speculators + information intermediaries

Role of inventory adjustment: The hot potato hypothesis Implications for informational role of orders

Does heavy trading indicate much or little information being processed?

10 A Digression: The Yield Curve

The relationship among interest rates on bonds with different terms to maturity (but with the same tax, default characteristics)

A successful theory of the term structure should account for the fact that

- it is almost always upward sloping. Exception: sometimes it slopes downwards when short term rates are very high
- positive comovements of R's

10.1 Theories

Expectations theory

Key assumption: Bonds of different maturities are perfect substitutes

Long term is the average of the corresponding short term rates

An example: Calculating the rate of return on a two period bond

Segmented markets theory

Perfect lack of substitutability of bonds of different maturities

Preferred habitat

Partial substitutability

Long term bonds have higher risk $\rightarrow$ If investors are risk averse then there will be a liquidity (maturity) premium

Long term rate = expected future rates + liquidity premium

Difference from expectations theory:

Example: The interpretation of a flat yield curve

An implication for public finance: The shape of the yield curve and the cost of government borrowing. Should the government issue short term liabilities when the slope is upward?

10.2 The term structure and the exchange rate

The information contained in the term structure about expected future exchange rate changes over various time horizons. Position and slope of domestic and foreign curves.

11 Evaluating the Validity of Alternative Theories

11.1 Methods

- Case studies

  Example: The policy mix and the appreciation of the dollar in the early 80s.

- Draw a list of stylized facts and examine whether the model can account for those stylized facts

  Example: Deviations from PPP are long lived, correlation of real and nominal exchange rate changes is almost perfect, strong trade positions (surpluses) tend to be associated with a strong currency and so on.

- Variance bounds

$$s(t) = \frac{1}{1+b} E_t \sum_{j=0}^{\infty} (\frac{b}{1+b})^j k(t+j) \tag{1}$$

  Direct estimation of an equation (1) together with a stochastic process for the fundamentals $k(t)$. For instance, $k(t) = \mathrm{A}k(t-1) + u(t)$

Cross equation restrictions

Note: this is more restrictive than estimating the exchange rate equation in the form:

$$s(t) = B_1 + B_2\,k(t) + B_3\,[i(t) - i^*(t)]$$

because (1) rules out bubble solutions and it also imposes auxiliary hypotheses (that the stochastic process for k(t) is well specified)

- Other tests (news, policy announcements, comparisons across different exchange rate systems)

11.2 Exchange rate forecasting

Meese and Rogoff (1983), Empirical Exchange Rate Models of the Seventies: Are Any Fit to Survive?, JIE 14, 3-24:

$$s(t) = a_0 + a_1\,[m(t) - m^*(t)] + a_2\,[y(t) - y^*(t)] + a3\,[i(t) - i^*(t)] + a_4\,[\pi(t) - \pi^*(t)] +$$
$$a_5\,[(TB(t) - TB^*(t)] + a_6\,[p(t) - p^*(t)] + u(t)$$

$p(t) = (P_T/P_{NT})_t$: relative price of *traded*/ *non traded* (Balassa - Samuelson)

All variables, except for the interest rates are either in logs or in growth rates

Rolling regression. Calculate out of sample forecasts over different time horizons.

Use <u>actual</u> values of the RHS variables (in place of expected) to generate the forecasts. Compute test criterion (RMSE, AE..).

Compare the quality of these forecasts to those generated by

- random walk
- other univariate statistical processes
- multivariate statistical processes

11.3 Econometric estimation issues

- *Stationarity*: Alternative detrending techniques: Stochastic vs deterministic trends (unit roots)
- Determining the *number of lags* in the estimated statistical models
- Choosing the *frequency* of data. Average vs spot rates
- *Seasonality*

Finding: Naive *random walk model* dominates everything else in the short and medium term

11.4 Econometric estimation problems: Can the failure of the model be accounted for by econometric problems?

- Simultaneity: Detection with VARs

  Solution: 1. Instrumental variables (problem with autocorrelation)

  2. Use information from estimated money demand equations to pin down the values of the parameters (a0, a1, a2)

- Model mispecification.
  - Same coefficients for domestic and foreign variables
  - Non-linear relationships (the exchange rates have a fat tailed distribution); regime switching, ARCH models
- Small sample bias

  Peso problem: small probability of an -unusual- event (such as a devaluation, a regime switch..). The unusual event does not occur (or occurs infrequently) during the sample period

- Modeling of expectations.

11.5 Short-medium term forecasts

Verdict: The structural models fail to account for short and medium term exchange rate movements. This does not seem to be the result of econometric failures. It seems to be due to the fact that we do not know what the appropriate fundamentals are at high medium frequencies or that those fundamentals change over time. Note that some economists attribute this failure to bubbles; nevertheless, tests for the existence of bubbles are very weak

11.6 New literature: long term forecastability?

<u>Time series data</u>

Long horizon data sets and PPP

- The last 150 years

  Finding: PPP holds in the long run. Long term changes in the nominal exchange rate are predictable

  Half life of PPP deviations 3-6 years

  Problems: a) Mixing different exchange rate regimes (fixed and flexible)

  Long horizon data are available only for the currently industrialized. Similar growth experience (see Balassa and Samuelson). Does PPP hold for industrial-non industrial pairs?

- The very long run

  Using annual data on prices for grains and dairy products in England and Holland: 14-20th centuries

  Result: Patterns of PPP deviations (for instance, volatility) very similar to those observed nowadays

New econometric methods: *Cointegration*

Results: The Error Correction Model (ECM) specification produces better forecasting results in the long run (3 years) than the RW

$$\Delta s(t) = A_0 + A_1 \Delta k(t\text{-}1) + A_2\, \mathrm{ECM}(t\text{-}1) + u(t)$$

$$\mathrm{ECM}(t) = s(t) - Bk(t)$$

Testing PPP:

Regress

$$s(t+k)\text{-}s(t) = a + bz(t) + u(t)$$

where $z(t) = \mathrm{ECM}(t)$. Test the hypothesis that b is positive and increasing in z.

<u>Pooled data (both time series and cross section data)</u>

For example: 1948-92, 150 countries

Half life of PPP deviations: 3-5 years (15% per year)

Problem: Cross section dependence in real exchange rates invalidates statistical methods used

$$q_i = p_i - s_{ij} - p_j$$

$\mathrm{Cor}(q_G, q_F) = 0.96$ when USD is used as the reference currency (as j) (because of common shocks)

$Cor(q_{G,} q_{F)}$ = 0.39 when NLG is used as the reference currency (as *j*)

12 Technical analysis

Detect trends, changes (reversals) in trends → *Local peak* (resistance level); *Local trough* (support level)

Device a rule for when to buy and sell a currency

Filter rule: Buy when the exchange rate rises x% over the previous recent minimum

What is the size of filter (x)? E.g. 0.5-3%

How far back should one go to find the recent minimum (width of window) e.g. 5 days

Moving average rule: Buy signal when short term moving average (MA) is above long run MA

That is, **buy** when the short run MA crosses the long run MA from above

Sell when the short run MA crosses the long run MA from below

Typical short run MA: 1-5 days Typical long run MA: 10-50 days