University of Copenhagen
Department of Economics
Michael Bergman

Solution to written exam for the M. Sc in Economics International Finance

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1. This question covers central bank intervention and is related to the learning objectives: describe the channels by which central bank intervention can affect the exchange rate and summarize the empirical evidence on these channels; describe and use the portfolio balance and the signaling models to analyze the effects of policy interventions (central bank interventions, monetary and fiscal policy) on the exchange rate. The question focuses on the signaling model by Reeves.

   (a) Official intervention serves as a signal of future monetary policy by providing the foreign exchange market with new relevant information. It is assumed that the current exchange rate is a function of current and discounted expected future fundamentals. An intervention on the FX market sends a signal to the market participants about future fundamentals. If future fundamentals change, the current exchange rate will also change. Sterilized interventions affect expectations about future movements in the relative money supply, income and interest rates with a feedback effect on the exchange rate. This effect also occurs in the monetary models, when foreign and domestic bonds are perfect substitutes. An underlying assumption is that the monetary authority has superior information and that they can reveal this information to the market by intervening on the foreign exchange market.

   (b) This is a standard monetary model. Domestic (and foreign) real money balance is a function of output and interest rates. M_t is the money supply, P_t is the price level, Y is real output which is assumed to be exogenous (and constant) and r_t is the real interest rate. All variables are in logs. Note that we assume identical money demand functions in the two countries.

   The third equation is UIP which is assumed to hold (no risk premium so domestic and foreign bonds are perfect substitutes).

   The fourth equation is PPP which is assumed to hold instantaneously.

   Further, it is assumed that households only hold their own currency. Since UIP holds we have ruled out portfolio balance effects. This setting also implies that sterilized interventions have no real effects.

(c) Solve for the price level in the two money demand functions and insert these solutions into the PPP relation and rearrange such that

$$S_t = M_t - M_t^* - \alpha_1(Y - Y^*) + \alpha_2(E_t S_{t+1} - S_t)$$

Rearrange this difference equation, substitute forward, assume no bubbles and collect terms to find the solution

$$S_t = \frac{1}{1+\alpha_2} \sum_{k=0}^{\infty} \left(\frac{\alpha_2}{1+\alpha_2} \right)^k E_t(M_{t+k} - M_{t+k}^* - \alpha_1(Y - Y^*))$$

The solution should include a statement about the no bubble assumption.

(d) Under the assumption that the money supplies and output levels remain constant for all time periods it is straightforward to use the solution above to find that

$$S_0 = M_0 - M_0^* + \alpha_1(Y - Y^*) \tag{1}$$

(e) We first must assume that the signal is perfectly credible. Agents know that the central bank will carry out the policy it has announced.

According to the hint in the question, $M_2 = M_0 + \gamma I$ and $M_2^* = M_0^* + \gamma I^*$. Under the assumption that monetary policy remain constant after period 2 we can use the exchange rate equation in 1(c) to find that

$$S_2 = (M_2 - M_2^*) + \alpha(Y - Y^*) \tag{2}$$

and using $M_2 = M_0 + \gamma I$ and $M_2^* = M_0^* + \gamma I^*$ we find that our period 1 expectation of the future exchange rate in period 2 is given by

$$E_1 S_2 = S_0 + \gamma(I - I^*) \tag{3}$$

Use the exchange rate equation in 1(c) for period 0 and insert (7) to find that

$$S_1 = S_0 + \frac{\alpha_2}{1+\alpha_2}\gamma(I - I^*)$$

This equation shows that the exchange rate in period 1 has changed even though money supply is unchanged (to derive the expression above we have actually assumed that $M_1 = M_0$ and that $M_1^* = M_0^*$). The intervention in period 1 signals that monetary policy in period 2 and onwards has changed. Therefore there is an immediate effect on the exchange rate.

The reason why the exchange rate moves in period 1 is that households revise their expectations about future monetary policy (full knowledge about the model, central bank is credible).

Answers that include the following should get extra points. The model above implies that the exchange rate in period 1 moves in the same direction as the long-run solution but falls short of the entire long-run adjustment. Using the expression for S_2 above we find that

$$S_2 = S_0 + \gamma(I - I^*)$$

which is higher than S_1. The exchange rate changes in period 1 but not fully to S_2.

(f)
- Hutchison and Fatum conduct an event study focusing on the direction of exchange rate movements on days (and windows) following an official intervention. They find that interventions affect exchange rates in the shortâĂŞrun and there are larger effects when intervention is combined with interest rate changes. The authors argue that this evidence is consistent with the assumption that interventions signal monetary policy.
- Dominguez and Frankel use an alternative approach and perform tests of the signaling channels without assuming rational expectations of exchange rates. Instead they use survey data on dollar-mark exchange rate expectations. The empirical evidence suggest that reported intervention significantly affect exchange rate expectations and that the effectiveness of intervention is enhanced if it is publicly announced. Overall, Dominguez and Frankel provide strong statistical evidence that sterilized intervention is effective through the signaling channel.
- Other papers often find that the signaling channel cannot be rejected but results are dependent on sample periods, methods and data.
- Another approach used in the literature is to test whether central bank interventions signal future changes in monetary policy. Lewis uses publicly available data on US foreign exchange rate intervention for the period from 1985 through 1990 and examines the relationship between foreign exchange market intervention and monetary policy, testing the hypothesis that official interventions signal changes in future monetary policy. Lewis' study suggests that official intervention may predict monetary policy variables and vice versa. More recently, Kaminsky and Lewis examine the prediction of signaling channel theory that central banks signal a more contractionary monetary policy in the future by buying domestic currency today and, therefore, that expectations of future tighter monetary policy make the domestic currency appreciate, even though the current monetary effects of the intervention are typically offset by sterilization. Kaminsky and Lewis then argue that this expectation presumes that central banks support interventions with subsequent changes in monetary policy. Their empirical results support this assumption. Another contribution is a paper by Bonser-Neal, Roley and Sellon who re-examine the

relationship between the Federal Reserve monetary policy actions, US interventions in currency markets and exchange rates using the Federal funds rate. The authors find that the exchange rate generally responds immediately to US monetary policy actions and that this response is usually consistent with the overshooting hypothesis. The authors also find evidence of signaling and leaning against the wind in US intervention policies over the sample period.

- The overall conclusion from the empirical literature is that the evidence on the effectiveness of official intervention, through the signaling channel is still mixed. However, the recent literature does suggest a significant effect of official intervention on both the level and the change of exchange rates and there is more empirical support for the signaling channel than the portfolio balance channel.

2. This question relates to the learning objectives: describe and use microstructure based models (rational expectations and portfolio shift models) to analyze price determination on the foreign exchange market and summarize the empirical evidence on these models; describe and use the portfolio shift model to analyze the effects of news (macro data releases and central bank interventions) on the exchange rate.

   The model used in the question combines microstructure and macro perspectives to allow for an analysis of the effects of macro news releases on the spot exchange rate.

   (a) The first equation defines the risk premium. UIP under the assumption that domestic and foreign bonds are not perfect substitutes implies that the foreign exchange risk premium can be written as

   $$\delta_t = \mathbb{E}[\Delta s_{t+1}|\Omega_t] + \hat{r}_t - r_t$$

   where r_t is the domestic interest rate, $\hat{r}_t$ is the foreign interest rate, s_t is the spot exchange rate (defined as home currency units per unit foreign currency) and Ω_t is the common information set. The second equation is the definition of the real exchange rate

   $$\varepsilon_t = s_t + \hat{p}_t - p_t$$

   and the two last equations define the real interest rates $r_t - \mathbb{E}[\Delta p_{t+1} \mid \Omega_t]$ and $\hat{r}_t - \mathbb{E}[\Delta \hat{p}_{t+1} \mid \Omega_t]$.

   (b) The unexpected variation in the real exchange rate between the start of period t and some point before the start of period $t+1$, say $t+\epsilon$, for some $\epsilon < 1$ can be written as

   $$\varepsilon_{t+\epsilon} - \mathbb{E}[\varepsilon_{t+\epsilon} \mid \Omega_t] = \eta_{t+\epsilon,t+1} - \mathbb{E}[\eta_{t+\epsilon,t+1} \mid \Omega_t] +$$

   $$\sum_{j=1}^{\infty} \{\mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_t]\} + \varepsilon_{t+\epsilon}^{\infty} - \varepsilon_t^{\infty} \tag{4}$$

where

$$\eta_{t,t+1} = (\hat{r}_t - \mathbb{E}[\Delta\hat{p}_{t+1}|\Omega_t]) - (r_t - \mathbb{E}[\Delta p_{t+1}|\Omega_t]) - \delta_t$$

and $\varepsilon_t^\infty = \lim_{h\to\infty} \mathbb{E}[\varepsilon_{t+h} \mid \Omega_t]$ as stated in the question.

Assume that the interval $[t, t+\epsilon]$ covers just a few minutes. Variations in nominal and real exchange rates then mirror one another over such short time periods because prices are effectively constant. We can therefore write the change in the spot rate as

$$s_{t+\epsilon} - s_t = \varepsilon_{t+\epsilon} - \varepsilon_t = \mathbb{E}[\varepsilon_{t+\epsilon} - \varepsilon_t \mid \Omega_t] + \varepsilon_{t+\epsilon} - \mathbb{E}[\varepsilon_{t+\epsilon} \mid \Omega_t]$$

Substituting for $\varepsilon_{t+\epsilon} - \mathbb{E}[\varepsilon_{t+\epsilon} \mid \Omega_t]$ in equation (4) we obtain

$$s_{t+\epsilon} - s_t = \{\eta_{t+\epsilon,t+1} - \mathbb{E}[\eta_{t+\epsilon,t+1} \mid \Omega_t]\} + \sum_{j=1}^{\infty} \{\mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_t]\} + u_{t+\epsilon} \tag{5}$$

where $u_{t+\epsilon} = \mathbb{E}[\varepsilon_{t+\epsilon} - \varepsilon_t \mid \Omega_t] + \varepsilon_{t+\epsilon}^\infty - \varepsilon_t^\infty$.

This equation provides a decomposition of high-frequency changes in the log spot rate.

A macro data release affects the spot rate via:

1. unexpected changes in the current risk-adjusted real interest differential $(\{\eta_{t+\epsilon,t+1} - \mathbb{E}[\eta_{t+\epsilon,t+1} \mid \Omega_t]\})$
2. revisions in the forecasts for future differentials $(\sum_{j=1}^{\infty}\{\mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_t]\})$
3. changes in long-term real-exchange rate expectations $(\varepsilon_{t+\epsilon}^\infty - \varepsilon_t^\infty)$.
   Note that this component is zero if PPP holds in the long-run.

Expected depreciation $\mathbb{E}[\varepsilon_{t+\epsilon} - \varepsilon_t \mid \Omega_t]$ may also contribute but this term does not include unexpected data releases, the information set does not include information arriving at $t + \epsilon$.

(c) Data releases may well contain new information on current and future macro variables but they need not affect spot rates if the information they convey has offsetting effects on the risk-adjusted interest differentials.

When central banks conduct monetary policy by controlling short-term interest rates, most data releases (other than policy changes) have negligible affects on current real interest rates.

Suppose that the central bank announces an increase in the interest rate and that the market did not anticipate this change. There will be an unexpected increase in the short-term interest rate ($r_{t+\epsilon} - \mathbb{E}[r_{t+\epsilon} \mid \Omega_t] > 0$). It may be that market participants revise their expectation about future inflation, they expect inflation

to rise and this rise may match the increase in the short-term interest rate such that $r_{t+\epsilon} - \mathbb{E}[r_{t+\epsilon} \mid \Omega_t] = \mathbb{E}[\Delta p_{t+1} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\Delta p_{t+1} \mid \Omega_t]$. If this is the case, there is no unexpected change in the risk-adjusted interest rate differential $\eta_{t+\epsilon}$. If the expectation about future interest rates is mirrored by a change in inflation expectations then $\mathbb{E}[\eta_{t+i} \mid \Omega_{t+\epsilon}] = \mathbb{E}[\eta_{t+i} \mid \Omega_t]$ for $i \geq 1$. Then there will be no response in spot rates to unexpected monetary policy announcements.

Data releases may contain new information on current and future macro variables, but it is not always the case that the spot rate will adjust. Most macro news (other than monetary policy announcements) do not affect current real interest rates. Therefore, any exchange rate response occurs via changes in the risk premium and/or revisions in expectations about the future course of real interest rates. This works through the component $\sum_{j=1}^{\infty}\{\mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+j,t+j+1} \mid \Omega_t]\}$. A data release on GDP could lead market participants to believe that the FED will tighten monetary policy relative to ECB next year. This implies that $\mathbb{E}[\eta_{t+i} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+i} \mid \Omega_t] < 0$ for $i > 0$ such that the dollar should appreciate when the GDP data are released. Conversely, if market participants believe that future US inflation will increase more quickly than the FED will raise interest rates and their forecast of future US real interest rates will fall. If this is the case, the forecast of future US real interest rates will fall, then $\mathbb{E}[\eta_{t+i} \mid \Omega_{t+\epsilon}] - \mathbb{E}[\eta_{t+i} \mid \Omega_t] > 0$ and the dollar should depreciate. Ignoring potential effects on the risk premium, the direction of the exchange rate response to GDP data releases is ambiguous.

Absent restrictions on the expected response of future interest rates and inflation to the new information in the data release, the exchange-rate effects of a macro data release are theoretically ambiguous.

(d)
- Macro perspective: Initial studies using daily data found statistically significant effects fro macro data releases on exhcnage rates but effects were quite small and only accounted for a fraction of the variation in spot rates during the event windows. Subsequent studies use intraday data (event windows of 5 to 25 minutes). One study by Andersen et al find that most of the exchange-rate response to the data release is within the first 5 minutes. They also find that exchange rates respond to the unexpected component of the data release rather than prior expectations. Another study by Faust et al also found significant effects. However, the results from these studies suggest that only a very small fraction of the total variation in spot rates can be accounted for, in the range of 1% of the variance in the spot rate.
- Micro perspective: In this literature the focus is on how order flow transmit information contained in data releases. Love and Payne use spot prices and order flows to study the impact of data releases on trading. They provide two different sets of estimates, the direct effect of data releases on spot rates and second the indirect effect of data releases on order flows. They find that

the indirect effects contribute to between 30% and 60% of the variance, a significant fraction of the price relevant information contained in data release affect spot rates through order flow.

Evans and Lyons design a different test where they distinguish between (a) common knowledge that has no impact on customer order flow, (b) the effect of dispersed information on order flows. In their model there are 3 channels through which data releases could affect the dynamics of spot rates and order flows: (1) directly via common knowledge news, (2) indirectly via the dispersed news, and (3) data releases can affect the transmission of dispersed information shocks. They find that order flow contributes more to spot rate changes following macro data releases than at other times. This suggest that macro data releases do not only contain new common news. A macro data release triggers trading that reveals new dispersed information that affects spot rates indirectly. The finding that order flow is very important following scheduled data releases supports this result.

- Longer term effects: Evans and Lyons consider the daily change in log spot rates (USD/Euro) and Citibank's order flows from six end-user segments. They find that a large number of news releases have significant impact on the order flow on the day of the announcement and the following 4 days (18 items out of 43) have a significant impact on the order flow variance. Next they consider the return variance and show that some data releases have significant effects (10 items out of 43 have a significant effect on return variance). Overall, the empirical evidence suggests that macro data releases can affect customer order flows and spot rate returns up to a week following the releases.