UNIVERSITY OF COPENHAGEN
Department of Economics
Michael Bergman

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

May 31, 2013

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1. **Which of the following statements are correct? Remember to provide a brief explanation.**

   These questions relate to the learning objectives: Describe how the foreign exchange market is organized and how trades take place in the interbank and the retail segments of the market; describe the channels by which central bank intervention can affect the exchange rate, summarize the empirical evidence on these channels and describe the portfolio balance model and be able to use this model to analyze the effects of monetary and fiscal policy on the exchange rate.

   (a) Wrong! A market-maker is a firm or a bank (a dealer) engaged in buying and selling a particular currency, i.e., make a two-way price for a currency. In this way the dealer establishes a market for this currency against another currency. Brokers are not market-makers as they only act as an agent on behalf of customers wishing to sell or buy currencies. It is true that the market is global and open 24/7 but there are market-makers.

   (b) Wrong! This refers to secret vs public interventions. In, for example, the US the decision to intervene is taken outside the central bank, it is the Treasury Department that decides whether or not to intervene whereas it is the Federal Reserve Bank that carries out the intervention. It may be the case that the central bank finds that the intervention is not appropriate (the suggested intervention may not be consistent with other macroeconomic policies) and therefore secretly intervene on the foreign exchange market.

   (c) Correct! A trading strategy is based on the "forward premium puzzle" which states that low-interest currencies on average tend to depreciate. A trading strategy based on this puzzle thus implies that an investor should borrow in the low-interest currency and lend in the high-interest currency. If the puzzle holds, this investor will on average make a positive profit. This strategy is called carry trade.

2. **The portfolio balance model**

This question relates to the learning objective: describe the channels by which central bank intervention can affect the exchange rate, summarize the empirical evidence on these channels and describe the portfolio balance model and be able to use this model to analyze the effects of monetary and fiscal policy on the exchange rate.

(a) Basic assumptions underlying the portfolio balance model are:

- static exchange rate expectations (the expected exchange rate change is zero), focus only on short–run adjustments,
- domestic price and output are fixed,
- a small open economy,
- domestic and foreign bonds are not perfect substitutes,
- there is a fixed net supply of domestic bonds (the sum of bond holdings of households and the central bank is fixed) but the holdings of foreign bonds can change over time via a current account surplus or deficit, and
- the monetary base is the sum of domestic and foreign bonds held by the central bank.

(b) The portfolio balance model consists of the following equations

$$W \equiv M + B + SB^* \tag{1}$$

$$M = M\left(i, \hat{S}^e, W\right) \tag{2}$$

$$B = B\left(i, \hat{S}^e, W\right) \tag{3}$$

$$SB^* = B^*\left(i, \hat{S}^e, W\right) \tag{4}$$

$$CA = \dot{B}^* = T\left(S/P\right) + i^* B^* \tag{5}$$

In order to show that

$$\frac{\partial M}{\partial W} + \frac{\partial B}{\partial W} + \frac{\partial B^*}{\partial W} = 1,$$

we take the total differential of the wealth identity in equation (1) with respect to financial wealth W:

$$\mathrm{d}W - \frac{\partial M}{\partial W}\mathrm{d}W - \frac{\partial B}{\partial W}\mathrm{d}W - \frac{\partial B^*}{\partial W}\mathrm{d}W = 0$$

which implies that

$$\frac{\partial M}{\partial W} + \frac{\partial B}{\partial W} + \frac{\partial B^*}{\partial W} = 1.$$

This relation implies that an increase in wealth can be held as either money, domestic bonds or foreign bonds. The change in the demand for the three assets must sum to one (the balance sheet constraint).

To show that

$$\frac{\partial M}{\partial i} + \frac{\partial B}{\partial i} + \frac{\partial B^*}{\partial i} = 0$$

and

$$\frac{\partial M}{\partial \hat{S}^e} + \frac{\partial B}{\partial \hat{S}^e} + \frac{\partial B^*}{\partial \hat{S}^e} = 0$$

we take the total differential of the wealth identity in equation (1) with respect to the interest rate and the expected change in the exchange rate, we then find

$$\overbrace{\frac{\partial M}{\partial i}}^{<0} + \overbrace{\frac{\partial B}{\partial i}}^{>0} + \overbrace{\frac{\partial B^*}{\partial i}}^{<0} = 0$$

and

$$\overbrace{\frac{\partial M}{\partial \widehat{S}^e}}^{<0} + \overbrace{\frac{\partial B}{\partial \widehat{S}^e}}^{<0} + \overbrace{\frac{\partial B^*}{\partial \widehat{S}^e}}^{>0} = 0.$$

These relations imply that if the interest rate rises, then the investor adjusts its portfolio. Given the signs of the partial derivatives, the investor increases domestic bond holdings and decreases money and foreign bond holdings. A similar argument applies to the latter condition which states how the portfolio adjusts when the expected exchange rate changes.

(c) Derive the three asset market schedules and illustrate in a graph. Assume that

$$-\frac{B_i}{B_W} < \frac{B_i^*}{1 - B_W^*}.$$

First, the condition stated in the problem set implies that the BE–schedule is steeper than the FE–schedule. The reason for this is that if this would not be the case, then the portfolio balance model would be unstable.

We will now derive asset market equilibrium schedules in the exchange rate–interest rate plane. Our aim is to find relationships between exchange rates and interest rates where the three asset markets are in equilibrium.

Take the total differential of the wealth equation (1) and the asset demand functions (2), (3) and (4) with respect to i, W and S under the maintained assumption that in equilibrium $d\widehat{S}^e = 0$ and that $\mathrm{d}M = \mathrm{d}B = \mathrm{d}B^* = 0$. First, consider the wealth identity. The total differential of (1) is

$$\mathrm{d}W = \mathrm{d}M + \mathrm{d}B_p + \frac{\partial SB^*}{\partial S}\mathrm{d}S + \frac{\partial SB^*}{\partial B^*}\mathrm{d}B^*.$$

Under our assumptions above, this reduces to

$$\mathrm{d}W = B^*\mathrm{d}S. \tag{6}$$

The total differential of the money demand function with respect to i, W and S is

$$\mathrm{d}M = \frac{\partial M}{\partial i}\mathrm{d}i + \frac{\partial M}{\partial W}\mathrm{d}W + \frac{\partial M}{\partial \widehat{S}^e}\mathrm{d}\widehat{S}^e$$

which can be written as using the assumptions above as

$$0 = M_i\mathrm{d}i + M_w\mathrm{d}W. \tag{7}$$

The total differential of the demand to hold domestic bonds with respect to i, W and S is

$$\mathrm{d}B = \frac{\partial B}{\partial i}\mathrm{d}i + \frac{\partial B}{\partial W}\mathrm{d}W + \frac{\partial B}{\partial \widehat{S}^e}\mathrm{d}\widehat{S}^e$$

which can be written as using the assumptions above as

$$0 = B_i\mathrm{d}i + B_w\mathrm{d}W. \tag{8}$$

The total differential of the demand to hold foreign bonds with respect to i, W and S is

$$\frac{\partial SB^*}{\partial S}\mathrm{d}S + \frac{\partial SB^*}{\partial B^*}\mathrm{d}B^* = \frac{\partial B^*}{\partial i}\mathrm{d}i + \frac{\partial B^*}{\partial W}\mathrm{d}W + \frac{\partial B^*}{\partial \widehat{S}^e \mathrm{d}\widehat{S}^e}$$

which can be written as using the assumptions above as

$$B^*\mathrm{d}S = B_i^*\mathrm{d}i + B_W^*\mathrm{d}W. \tag{9}$$

The money market schedule (all combinations of the interest rate and the exchange rate where the money market is in equilibrium) can be found if we insert equation (6) into (7) such that

$$\mathrm{d}iM_i = -M_W B^*\mathrm{d}S$$

implying that the slope of this schedule is

$$\frac{\mathrm{d}S}{\mathrm{d}i} = -\frac{M_i}{M_W B^*} > 0$$

since $M_W > 0$ and $M_i < 0$. The domestic bond schedule (all combinations of the interest rate and the exchange rate where the market for domestic bonds is in equilibrium) can be found by inserting equation (6) into (8) such that

$$B_i\mathrm{d}i = -B_W B^*\mathrm{d}S$$

implying that the slope of this schedule is

$$\frac{\mathrm{d}S}{\mathrm{d}i} = -\frac{B_i}{B_W B^*} < 0$$

since $B_i > 0$ and $B_W > 0$. Finally, the foreign bonds schedule (all combinations of the interest rate and the exchange rate where the market for foreign bonds is in equilibrium) is found if inserting equation (6) into (9) implying that

$$B^* \mathrm{d}S = B_i \mathrm{d}i + B_W^* B^* \mathrm{d}S$$

such that the slope of this schedule is

$$\frac{\mathrm{d}S}{\mathrm{d}i} = \frac{B_i^*}{(1 - B_W^*)\, B^*} < 0$$

since $B_i^* < 0$ and $B_W^* > 0$.

Let us now plot all these three schedules in the interest rate–exchange rate plane as in the graph below. The portfolio balance model is in equilibrium when all three markets are in equilibrium, i.e., where the three schedules intersect.

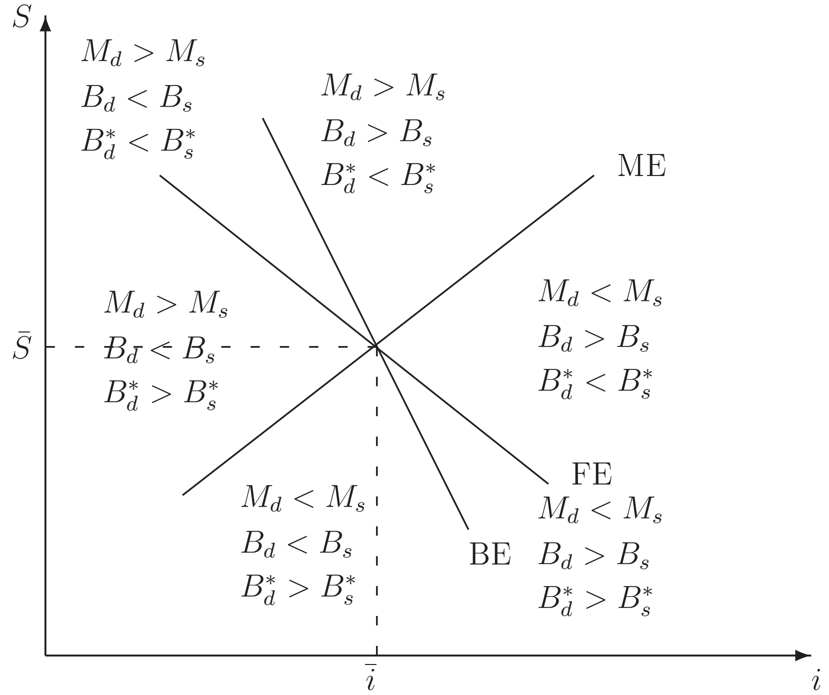
The ME–schedule is upward sloping and describes equilibrium in the domestic money market. The explanation is that a depreciation of the exchange rate (an increase in S) leads to an increase in the domestic investor's wealth (foreign assets are worth more after the depreciation). The increase in wealth leads to an increase in the demand for money. But since the money supply is fixed, the increase in the money demand can only be offset by an increase in the interest rate.

The BE–schedule is downward sloping since a depreciation that raises wealth also raises the demand for domestic bonds increases the price of bonds leading to a fall in the interest rate which will reduce the demand for domestic bonds. A depreciation must then be offset by a fall in the interest rate.

The FE–schedule depicting equilibrium on the market for foreign bonds is also downward sloping. The reason for this is that a depreciation of the exchange rate leads to an increased demand for domestic bonds and therefore investors are inclined to sell money and foreign bonds to buy domestic bonds. Alternatively, a rise in the interest rate makes domestic bonds more attractive and the exchange rate must depreciate in order to maintain equilibrium on the market for foreign bonds, i.e., to increase the value of foreign bonds measured in the domestic currency.

(d) Use the model to analyze the effects on the exchange rate and interest rate of a non–sterilized foreign exchange operation.

Figure 1: Equilibrium in the portfolio balance model.



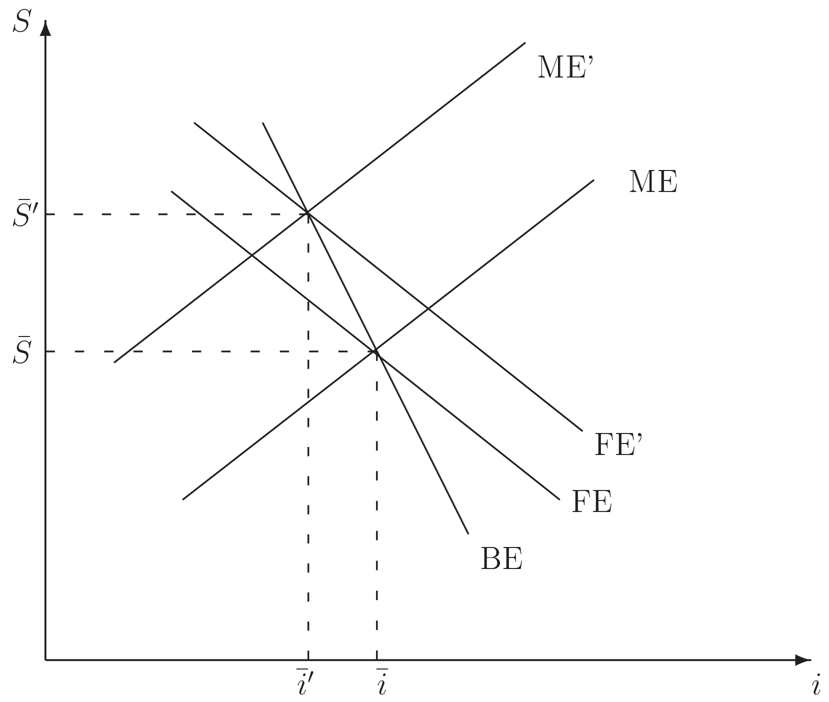
Assume that the monetary authority buys foreign bonds from the private sector and sells money. In this case

$$\mathrm{d}M = -S\mathrm{d}B^*$$

implying that the money supply increases such that the intervention is not sterilized.

Assume that the model is in full equilibrium. There is excess supply of money leading to a shift in the ME schedule up to the left to ME', see Figure 2. For a given interest rate, the money supply has increased and there is excess supply of money and excess demand for foreign bonds. The FE schedule shifts up to the right such that the exchange rate depreciates and the interest rate falls. The shortage of foreign bonds in the portfolios requires the exchange rate to depreciate which in turn tends to increase the domestic currency value of investor's remaining holdings of foreign bonds. The fall in the interest rate is required to encourage investors to hold money. The BE schedule is unchanged since the monetary authority swaps money for foreign bonds. In the short–run the interest rate must fall and the exchange rate must depreciate.

Figure 2: The effects of a non–sterilized foreign exchange operation.



3. **Data releases in the portfolio shift model**

   This question relates to the learning objective: describe and use microstructure based models to analyze price determination on the foreign exchange market and summarize the empirical evidence on these models.

   (a) Describe the basic underlying assumptions of the portfolio shifts model.

   The basic underlying assumptions are:

   - The foreign exchange market consists of two markets, the retail market where investors and dealers trade and the interbank market where dealers and the broker trade. Each market has its own trading mechanism.
   - Dealers trade directly and indirectly on the interbank market and quote prices and initiate trades.
   - No dealer has complete information about the state of the interbank market whereas the broker does, they provide market–wide information on quotes and transaction prices. But dealers do not observe the structure of limit orders that describe market liquidity. Dealers only have information on their own trades and trade simultaneously.

- Dealers are constrained on both the duration and size of asset positions and their overnight position is small (or zero).
- Customer orders on the retail market provides private information to the dealers. Dealers working at large banks with a large customer base have informational advantages.
- Customer orders are generated by different types of agents and for different reasons, for example for speculation or risk–management.
- The broker plays an important role in the model since it absorbs the imbalance of trades among dealers in such a way that dealers can achieve their desired holdings of foreign exchange. The broker also allows each dealer to hold no foreign exchange inventory overnight.
- There are two assets in the model, one risky asset (the foreign exchange) and one risk–free asset with a daily return equal to $1 + r$.
- The portfolio shift model describes how trades on the retail and the interbank markets relates to the spot exchange rate.
- There are D risk–averse dealers indexed by d, there is a continuum of risk–averse investors (customers) indexed by $n \in [0, 1]$.
- All trading decisions are motivated by the desire of each agent to maximize expected utility, neither dealers or investors are motivated to trade for information.

(b) Illustrate the daily timing in the portfolio shifts model and explain carefully the effects of public data releases on FX orders and spot exchange rates.

We divide one trading day into three rounds, in Round I dealers quote prices and receive orders from customers (the retail market), in Round II dealers trade among themselves and with the broker to share inventory risk and in Round III the retail market reopens and all three market participants trade simultaneously in order to share inventory risk more broadly.

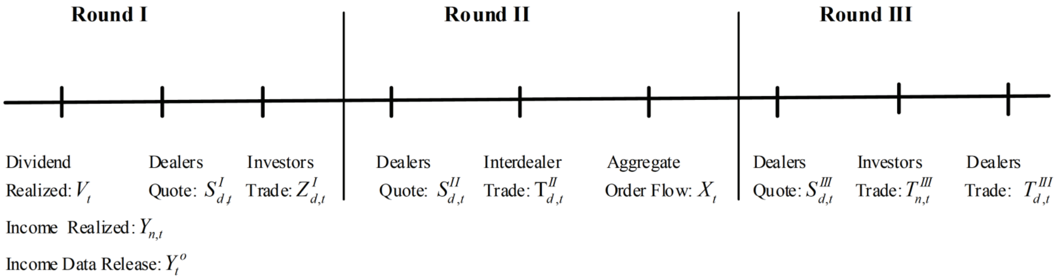


Figure 1: Daily Timing in the Portfolio Shifts Model on Data Release Days

The market opens and all customers and dealers observe the current payoff on foreign exchange V_t which represents the arrival of public news and customers receive income denominated in foreign currency $Y_{n,t}$ which is private information. The private information generates hedging motives for customer orders. Dealers enter the market with holdings of foreign currency and wealth (the sum of domestic and foreign currency holdings). Everyone also observes the data release which contains an estimate of aggregate foreign income. All dealers and the broker observe aggregate interdealer order flow $X_t = \sum_{d=1}^{D} T^{II}_{d,t}$.

Each dealer independently and simultaneously quotes a scalar price to his/her customers in all three Rounds ($S^I_{d,t}$, $S^{II}_{d,t}$ and $S^{III}_{d,t}$) at which the dealer will buy or sell currency. All dealers (and the broker) must quote the same price since a dealer deciding to quote a different price would be exposed to arbitrage trading losses. At any point in time, there is only one equilibrium spot exchange rate.

The price is publicly observed by all dealers and investors and are good for orders of any size. The quotes are determined before the dealers observe quotes by other dealers and are based on information available from the previous day and the new public information transmitted through the current payoff from foreign exchange holdings.

In order to analyze how data releases affect spot rates and order flows we need to consider the impact of data releases on the information sets available to investors, dealers and the broker.

Dealers: The information set available to any dealer d is

$$\Omega^{III}_{d,t} = \{X_t, Z^{II}_{d,t}, \Omega^{II}_{d,t}\}, \;\; \Omega^{II}_{d,t} = \{Z^I_{d,t}, \Omega^I_{d,t}\}, \;\; \Omega^I_{d,t} = \{D_t, Y^o_t, Z^{III}_{d,t-1}, \Omega^{III}_{d,t-1}\},$$

and from these we can infer the common information available to all dealers and the broker

$$\Omega^{III}_{D,t} = \{X_t, \Omega^{II}_{D,t}\}, \;\; \Omega^{II}_{D,t} = \Omega^I_{D,t}, \;\; \Omega^I_{D,t} = \{D_t, Y^o_t, \Omega^{III}_{D,t-1}\}$$

where we note that the customer order flows $Z^{III}_{d,t-1}$ and $Z^{I}_{d,t}$ are not common knowledge.

Data releases have two effects on dealers' common information:

1. they augment the information available to all dealers before they choose their round I quotes.
2. they affect the incremental information conveyed by aggregate interdealer order flow, X_t.

Note that in the absence of data releases, X_t is the only source of common information, information about Y_t cannot be incorporated before round III. But information about Y^o_t is common information and will affect quotes in round I. Therefore, interdealer order flow must convey additional information about Y_t that was not present in the data release.

The evolution of investor n's information is given by

$$\Omega^I_{n,t} = \{S^I_t, D_t, Y^o_t, Y_{n,t}, \Omega^{III}_{n,t-1}\}, \qquad \text{and} \qquad \Omega^{III}_{\mathrm{d,t}} = \{\mathrm{S}^{III}_{\mathrm{t}}, \Omega^{I}_{\mathrm{d,t}}\},$$

On days with data releases the investors know more about foreign income than dealers ($Y_{n,t}$ provides information about aggregate income and is known only to investors). But, the value of Y^o_t provides information about aggregate income to both investors and dealers. Therefore, investors' knowledge of their own income provides them with an informational advantage over dealers. The difference between investors' and dealers' information is that dealers only observe the data release (that they use to forecast aggregate income) whereas investors observe both their own foreign income and the data release.

Equilibrium comprises: (1) a set of FX orders by investors in rounds I and III; (2) a set of spot rate quotes by dealers in rounds I-III, and the broker in rounds II and III; and (3) a set of dealer trading decisions in rounds II and III. All these decisions must be optimal and consistent with market clearing.

Data releases directly affect quotes in rounds I and III (Remember that $S^{II}_t = S^I_t$ as in the standard model since the common information set does not change between Round I and II). Quotes in round III are affected because order flows contain information about foreign income. On non-release days, order flows represent information on foreign income but on data release days, this information adds to the data release Y^o_t in round I. There is therefore more information to dealers on release days and quotes are adjusted by a larger amount. Data releases affect both the customer orders received by dealers in round I (through the effect on actual foreign income Y_t) and trades initiated by dealers in round II (through effects emanating from dealers spot rate forecasts and their estimate of investor's hedging demand).

(c) Summarize the empirical evidence on the effects of news releases on exchange rates and order flows.

Macro exchange-rate models predict that spot rates will respond immediately to the public release of macro data if it induces: (1) a change in current real interest rates and/or the foreign exchange risk premium, (2) a revision in expectations concerning future real interest rates and/or the risk premia, or (3) a revision in the expected long-run real exchange rate. Event-studies provide qualitative empirical evidence linking variations in spot rates with the release of macroeconomic data in a manner consistent with the predictions of for example monetary exchange rate models using Taylor rules. Quantitatively, macro data releases account for less than 1 percent of the total variation in spot rates.

Micro-based models suggest that data releases affect the transmission of information to dealers via order flow, data releases affect spot rates both directly and indirectly (through order flows). Studies using daily data find that about 60 percent of the variance of spot rate changes is due to order flow and about 40 percent is due to other factors. Order flow's 60 percent breaks roughly into: 20 percent that is induced by macro news and 40 percent that is not news induced.

Empirical studies of intraday data indicate that data releases affect spot rates directly and indirectly via induced order flows. Order flows carry more price-relevant information that is incorporated into spot rates when there are data releases. More than 1/3 of the total variance in daily spot rate changes can be related to the direct and indirect effects of macro data releases and other news sources. Macro data releases can affect customer order flows and spot rate returns up to a week following the releases - consistent with the risk-management activities of dealers.