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

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1. (a) False, bandwagon effect is when the current expected change in the exchange rate is greater than the most recent expected change.

   (b) Correct, it is this fact that chartists use when they formulate strategies.

   (c) Correct! New information on current and future macro variables regardless of whether the news is anticipated or not may not affect spot exchange rates if the information has offsetting effects on the risk adjusted interest rate differentials. For example, news that the Fed will increase the interest rate may lead market participants to expect higher future inflation matching the interest rate increase such that there is no change in the risk adjusted interest rate differential.

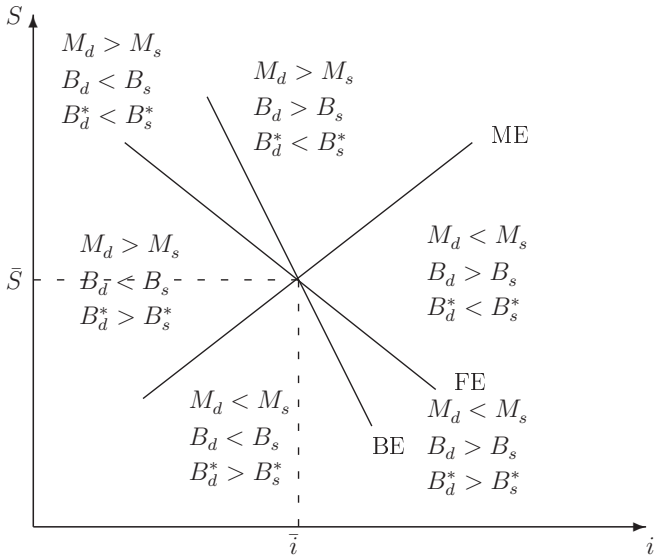
2. This question relates to the learning objective "describe the channels by which central bank intervention can affect the exchange rate, summarize the empirical evidence on these channels and describe the portfolio balance model and be able to use this model to analyze the effects of monetary and fiscal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

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

   - There are three types of assets in the model; Money, domestic bonds and foreign bonds.
   - We assume that domestic and foreign bonds are not perfect substitutes.
   - Static exchange rate expectations (the expected exchange rate change is zero).
   - We focus only on short–run adjustments.
   - Domestic price and output are fixed.
   - A small open economy.
   - 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.

- The monetary base is the sum of domestic and foreign bonds held by the central bank.

The portfolio balance model is illustrated in the graph below



where the ME–schedule describes all combinations of interest rates and exchange rates where the money market is in equilibrium, the BE–schedule describes all combinations of interest rates and exchange rates where the domestic bonds market is in equilibrium, and the FE–schedule describes all combinations of interest rates and exchange rates where the foreign bonds market is in equilibrium

- 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 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 an increase in the interest 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.

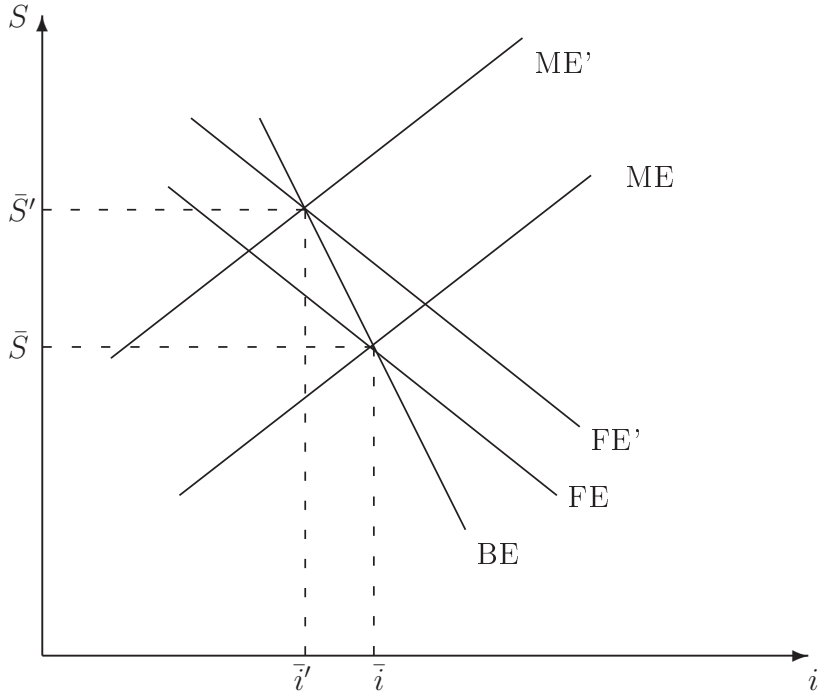
- The BE–schedule is steeper than the FE–schedule since the model would be unstable otherwise.
- Consider a point where the exchange rate is equal to $\overline{S}$ but where the interest rate is above its equilibrium value. If the exchange rate is fixed and the interest rate is above $\overline{i}$, then the demand for money must be lower than at equilibrium, there is excess supply of money $M_d < M_s$. This implies that all points above the ME–schedule there is excess demand of money and all points below the ME–schedule correspond to excess supply. If the interest rate is above its equilibrium level indicating lower prices on domestic bonds and therefore greater demand for domestic bonds, there is excess demand $B_d > B_s$ for bonds above and to the right of the BE–schedule and excess supply of domestic bonds below and to the left of the the BE–schedule. At the same combination of interest rate and exchange rate, the demand for foreign bonds must decrease since a higher interest rate increases the demand for domestic bonds, a fall in the demand for money and the demand for foreign bonds. Therefore, above and to the right of the FE–schedule there is excess supply of foreign bonds $B_d^* < B_s^*$. Alternatively, assume that the interest rate is at its equilibrium value $\overline{i}$. If the exchange rate is below its equilibrium value $S < \overline{S}$ (the exchange rate has appreciated) there is excess demand for foreign bonds which will drive up the exchange rate S, i.e., depreciate the currency so that equilibrium on the foreign exchange market is restored.
- The portfolio balance model is in equilibrium when all three markets are in equilibrium, i.e., where the three schedules intersect.

(b) A non–sterilized foreign exchange operation where the central bank is buying foreign bonds and sell money, i.e.,

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

Assume that the model is in full equilibrium. If the central bank sells money, there is excess supply of money leading to a shift in the ME schedule up to the left to ME', see the graph below. 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. The main effects are that the interest rate must fall and the exchange rate must depreciate.



A Sterilized foreign exchange operation is when the operation above is combined with an open market operation. Assume therefore that the central bank buys foreign bonds from the public as above then the central bank sells domestic bonds to the public such that the money supply is unchanged. This implies that

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

and

$$-\mathrm{d}M = \mathrm{d}B$$

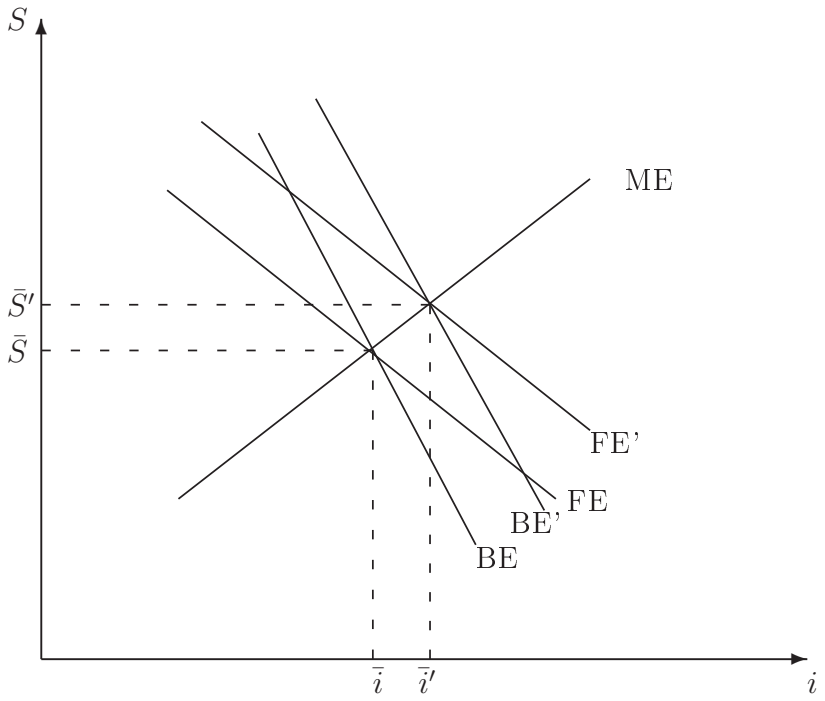
so that $-S\mathrm{d}B^* = \mathrm{d}B$. Thus, the sterilized foreign exchange operation only affects the currency positions in private portfolios which change from foreign bonds to domestic bonds.

Since the money supply is unchanged, the ME schedule is unaffected. There is excess demand for foreign bonds (the monetary authority buys foreign bonds)

which will lead to a shift up to the right from FE to FE'. The excess supply of domestic bonds causes a shift in the BE schedule up to the right to BE'. The net effect is a higher domestic interest rate and a depreciated currency. The reason why the currency depreciates is that there is excess demand for foreign bonds requiring an exchange rate depreciation to restore equilibrium. The excess supply of domestic bonds leads to a fall in bond prices and thus a rise in the interest rate.

If the two assets are perfect substitutes as in the FPMM and the SPMM models, a swap of domestic for foreign bonds is an exchange of identical assets that cannot have any effect whatsoever on interest rates and exchange rates.

Comparing the two operations we find that a non–sterilized foreign exchange operation leads to a fall in the interest rate and a depreciation whereas a sterilized foreign exchange operation leads to a depreciation but a higher interest rate. The reason for this is that the latter operation creates an excess supply of domestic bonds leading to lower bond prices and therefore a higher interest rate.



3. This question relates 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" and "describe and use microstructure based models to analyze price determination on the foreign exchange market and summarize the empirical evidence on these models". The first question is on the basic assumptions made in the portfolio shift model, the second question focuses on the use of the model whereas the last

question considers the empirical evidence. It is not required that answers include the full mathematical model, but main assumptions/results must be mentioned such as that all dealers and the broker observes the aggregate interdealer order flow. Since the empirical evidence on this model is vast, the last question only considers results obtained using single–currency tests.

(a) 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.
- The portfolio shift model describes how trades on the retail and the interbank markets relates to the spot exchange rate.

(b) The basic portfolio shift model is illustrated below. The time line should be thought of as one trading day. The market opens and all customers and dealers observe the current payoff on foreign exchange which represents the arrival of public news and customers receive income denominated in foreign currency 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).

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. This could imply that the information aggregation does not operate, for example if Round I orders offset each other.

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. The time line of the model is illustrated below.

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.

In round I: Each dealer independently and simultaneously quotes a scalar price to his/her customers, $S^I_{d,t}$ at which the dealer will buy or sell currency. (Adding bid–ask spreads would not affect the main arguments.) 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 is based on information available from the previous day and the new public information transmitted through the current payoff from foreign exchange holdings. Investors place their orders and these could be placed with more than one dealer. Customer orders are only observed by the dealer implying that total demand is unobserved. The customer orders received by a dealer is denoted $Z^I_{d,t}$ and is positive for net customer purchases and negative for net customer sales.

It is important to distinguish between the two types of information in the model, the public information (dividends) and the private information (income).The public information arrives at the start of each trading day and are immediately incorporated into the quotes in round I. The information embedded into the private information cannot affect the quotes. Investors place their orders based on their own income. Each dealer receives a fraction of the aggregate customer orders and therefore receives a noisy signal about the aggregate component of customer income.

Round II: Each dealer and the broker simultaneously and independently quotes a

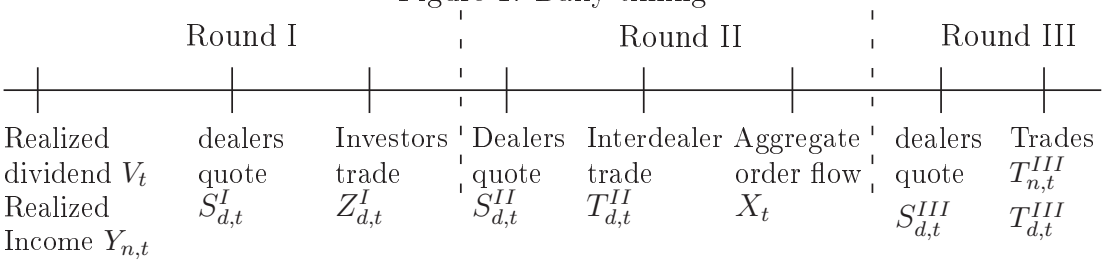
price to other dealers, $S_{d,t}^{II}$. Dealers act on the information they received through customer orders in Round I, the trades each dealer initiate depends on the customer order received in Round I. Dealers trade among themselves and with the broker. it takes time for the public information concerning income becomes reflected in dealer quotes. Information about income is transmitted to dealers via customer orders in Round I. Each dealer then has some information about the aggregate income at the start of Round II but the information is imprecise. The optimal strategy is for all dealers to quote the same price and base this quote solely on the common information available in Round I. The reason is that it would otherwise expose the dealer to arbitrage trading losses. This further implies that the spot exchange rate must be unchanged between Round I and II even though dealers have some information about the aggregate income. Information aggregation (transmitting private imprecise information about the customer income between dealers) takes place via interdealer trades in Round II. Interdealer order flows convey information on aggregate income that becomes common information to dealers towards the end of Round II. At the end of Round II, the dealers and the broker observe the aggregate interdealer order flow. This is a very important variable in the model.

Round III: The retail market reopens. The broker and the dealers simultaneously and independently quote new prices, different from the quotes in Round I and II. Investors observe these prices and place orders with dealers. Dealers also trade on the interbank market and when each dealer has filled the customer orders, the dealer can trade with the broker. Since the dealers have learned about the aggregate interdealer order flows from Round II, this order flow is incorporated into the price quoted at the start of Round III. In particular, it is the unexpected aggregate order flow that determines the quotes. It is this transmission of information that is the distinguishing feature of the microstructure model.

Dealers share overnight risk with customers and the broker. Customers willingly absorbs all dealer inventory imbalances so that all dealers and the broker's foreign exchange holdings overnight are zero. This is consistent with actual behavior of dealers and ensures that there is no incentive for further trades in Round III.

In order to be rewarded full points, the answer must also include a discussion of information flows. The order flow between customers and dealers in Round I incorporates new information relevant for the determination of the spot exchange rate. Customers are assumed to have this information and then it is transmitted to dealers through order flows. Dealers learn about how customers value currencies through their willingness to sell or buy currencies at quoted prices. Dealers cannot

Figure 1: Daily timing



explore this information as it is not publicly known, i.e., known by other dealers. In the model, interdealer order flows in Round II (that are observable) conveys new information which will be used when quoting prices in Round III. Dealers do not want to hold foreign exchange overnight, overnight risk can be more efficiently shared by investors.

The quotes in Round III must then be such that investors would like to hold the entire existing stock of foreign exchange. It would not be possible for dealers to calculate the existing stock of foreign exchange. At the same time the model implies that customer income is the only source of price changes. Thus, dealers can infer from customer income what aggregate overnight foreign exchange position that investors must be induced to hold. Aggregate interdealer order flows in Round II conveys information about customer income and therefore also the overnight positions investors must hold. Interdealer order flows convey information about the shift in the portfolios of investors needed to achieve efficient risk–sharing (this is the portfolio shift).

(c) The empirical evidence based on single–equation estimates can be divided into two groups; (1) the relation between interdealer order flows and spot exchange rates and (2) the relationship between customer order flows and spot exchange rates.

Interdealer order flows:

- Empirical evidence suggest that there is indeed a positive link between interdealer order flows and spot exchange rate. The fraction of the spot exchange rate that can be explained increases substantially when also including order flows.
- Although the standard approach is to use daily data, the estimation results have implications for the behavior of spot rates over much longer periods. The spot rate seems to be highly correlated to the cumulative order flow.
- There is no detectable serial correlation in daily order flows. This implies that previous order flow cannot explain current order flow. Order flows represent news to dealers!
- Interdealer order flows are important at the intraday and daily frequencies, the price impact is stronger on short term horizons but falls for longer horizons. The explanatory power also falls for longer time horizons.

Customer order flows: In the Portfolio Shift model, interdealer order flow conveys price-relevant information to dealers which initially entered the market in dispersed form via the customer orders received by individual dealers. Customer order flows should therefore have some empirical explanatory power in accounting for exchange rate changes.

- Rime (2001) found that customer flows accounted for a large fraction of the variation in the NOK/DM spot rate at a weekly frequency over a three year period from January 1996 to May 1999.
- Customer flows disaggregated by customer type have more explanatorily power for exchange rate returns than the aggregate flows received by individual banks. There is a close correspondence between spot price and order flow.
- Disaggregated order flows account for more variations in excess returns than aggregate flows and the effect increases with the time horizon, and there are very different price impacts depending on the source of the order flow.
- At the daily frequency, disaggregated flows can account for less of the variation in exchange rate returns than aggregate interdealer order flows, but the explanatory power of customer and dealers flows are comparable at lower frequencies.