Andreas Krause
The effect of monetary shocks
NEW YORK STOCK EXCHANGE
NYSE
LIVERMORE

Outline

- Monetary policy decisions
- Money market
- Goods market
- Equilibrium
- Summary

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Outline

- Exchange rates are adjusting to changes in the macroeconomic environment. With prices in an economy only adjusting slowly to changed conditions, it will be generally be the interest rate and the exchange rate that adjust quickly.
- While the interest rate parity would capture the effect through the impact any such changes have on the interest rate, it would be interesting to look at the implications on the exchange rate directly.
- We will therefore look at the impact money supply has on exchange rates
- The money supply might change as a result of monetary policy and thus we indirectly assess the impact monetary policy has on exchange rates.

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Outline

- We will look at the equilibria in the money market and then the goods market, where prices adjust slowly. Bringing these two markets together will then allow us to assess how exchange rates adjust to any change sin the money supply.

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- We initially start by looking at looking at monetary policy decisions and what impact we should expect on exchange rates, before we then continue with a more detailed analysis.

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Changes in money supply

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Changes in money supply

→ We will now, at a very basic level, assess the impact an increase in the money has on exchange rates.

- The monetary policy tool of central banks encompasses, simplified decisions on the interest rates at which commercial banks can borrow funds from the central and the interest the central bank pays commercial banks if they deposit funds with the central bank.
- In addition, they can also affect the amount they lend to commercial banks. This will affect the money available in an economy and it is hence indirectly a decision on the money supply.

- A common consequence of increasing the money supply, with which we are concerned here, is that the larger amount of money available will increase the prices in an economy, thus increase inflation.
- This result depends on the assumption that the output produced is constant, at least in the short term.

- With inflation increasing, we can then use the purchasing power parity to see that the exchange rate should adjust to this increased inflation.
- In reality, prices are not adjusting quickly, so-called 'sticky prices', and the main adjustment in the economy will have to be conducted through other channels that are quicker to adjust than prices. This would then ensure that despite prices adjusting slowly, the economy remains in equilibrium.

→ We will now look in more detail at the adjustment process to the new equilibrium.

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- If money supply is increased, the price level should increase

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- From purchasing power parity, the exchange should adjust as well

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- However, prices will generally not adjust quickly

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Responses to changes in the money supply

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- If we assume that output is given, for example due to full employment, then an increase in the money supply will increase price levels, thus cause inflation.
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- If we want to ensure that markets clear and hence the economy is in equilibrium, we need to look at other variables in the economy that can adjust.
- The exchange rate is one variable that could adjust quickly and we will now consider how the exchange rate would adjust to ensure the economy is in equilibrium.

→ In order to conduct this analysis we wneed to build a basic macroeconomic model of the money and goods market.

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- Changing the money supply changes price levels if there is full employment as output is given

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- We will first consider the money market.

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Money demand

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→ We first have to determine how the demand for money is determined. In an equilibrium, this demand will then have to be equal to the supply of money as set by the central bank.

- As is common in macroeconomics, we assume that the demand for money is increasing in the interest rate. The higher the interest that is paid on money, the more individuals are willing to hold money and postpone consumption in favour of later and larger consumption.
- The money demand will also be increasing in the output of the economy as a larger out put would require larger amounts of money to purchase the goods produced.
- The strengths of these two factors are given by their elasticities and we assume the demand for real money, that is after adjusting for the price level, is given by a Cobb-Douglas function.

- *Formula*
- We now assume that interest rate parity holds and the exchange rate changes in line with the interest rate differential to the interest rate in a foreign country.
- [⇒] From out money demand, we can now take the logarithm and make the approximation that $\ln(1+r) \approx r$.
- [⇒] We can now insert the interest rate parity by solving it for r.

→ We can establish how a change in the money demand will affect exchange rates.

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- Real money demand depends on the interest rate
- $\frac{M}{P} = (1 + r)$

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- Real money demand depends on the interest rate and output
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Exchange rate change

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Exchange rate change

→ We can now look at how the exchange rate will adjust if the prices cannot adjust instantly.

- We have an equilibrium if no variables change, that is we would require here that the exchange rate remains stable.
  - This will be require prices to adjust such that the equilibrium from above is achieved.
- We here assume that the output cannot adjust due to full employment, and a reduction in output is also not possible.
- At the price level at which the exchange does not change, we can determine the equilibrium by setting $\Delta e = 0$.
- [⇒] We can now eliminate $\ln M + \varepsilon_Y \ln Y$ by combining the money demand in the long-term equilibrium after the prices have adjusted and the short-term equilibrium where prices are constant and the exchange rate adjusts.
- [⇒] This expression can now be solved for the change in the exchange we should observe.
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Exchange rate change

- The equilibrium requires that exchange rates are stable, $\Delta e = 0$

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Monetary policy decisions

Money market

Goods market

Equilibrium

Summary

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- We now turn to the goods market and will seek to determine the equilibrium there and see how much the price level will adjust int he long-term. This will then allow us to assess the impact monetary policy has on exchange rates.

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Demand in goods markets

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Demand in goods markets

→ We will first look at how the demand in goods markets is determined.

- We assume that the total demand for goods in a country depends on the price of the goods when compared to the price of such goods in another country. The more expensive the goods in the own country are (high P compared to a low P^*), adjusted by the exchange rate, the lower the demand will be.
  - It will also depend on the total output the country produces, as that will in turn determine the amount of funds available to purchase goods.
  - A higher interest rate will reduce the demand as more funds are saved.
  - The importance of these three factors is determined by there elasticities and we again assume the the demand is determined by a Cobb-Douglas function.
- *Formula*
- [⇒] We can now take the logarithm of this expression and make the approximation $\ln(1+r) \approx r$.
- Let us now assume that prices are sticky and adjust only at a slow rate to their equilibrium. We assume that the price adjustment is proportional to the difference in demand and supply (the production of goods),
- We simplify the analysis by normalising the price level in the foreign country and assume it to be constant. This allows us to set thie price level to 1, ensuring that the expression can be neglected in the further analysis.

→ We can now continue by determining the equilibrium inflation.

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- Demand depends on the relative prices of goods
- $D = \left(\frac{eP^*}{P}\right)$

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Inflation

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Inflation

→ We can now look at the implications of these relationships for the inflation in equilibrium.

- We can solve the money demand from above for the interest rate.
- [⇒] We can now insert into the price change, representing inflation from the above. We insert for the demand, $\ln D$, and the interest rate, r, and obtain this *formula*.
- In equilibrium, we assume that the price level and exchange rate are such that there is no inflation. We denote these variables with upper bars.
- [⇒] Replacing the variables with their equilibrium values, we then have that this *formula*.
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  - We see that we have inflation if the current exchange rate is above its equilibrium value
  - and the price level is below its equilibrium value. This latter results emerges as the term in brackets will be negative because $\hat{\varepsilon}_r < 0$.

→ We have thus established the equilibrium in the goods markets, namely the equilibrium inflation.

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Inflation

- From the money demand we have $r = \frac{\ln P - \ln M + \varepsilon_Y \ln Y}{\varepsilon_r}$

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Inflation

- From the money demand we have $r = \frac{\ln P - \ln M + \varepsilon_Y \ln Y}{\varepsilon_r}$

$$\Rightarrow \Delta P = \lambda \left(\hat{\varepsilon}_P \left(\ln e - \ln P \right) - \frac{\hat{\varepsilon}_r}{\varepsilon_r} \left(\ln M - \ln P \right) + \left(\frac{\hat{\varepsilon}_r \varepsilon_Y}{\varepsilon_r} + \hat{\varepsilon}_Y - 1 \right) \ln Y \right)$$

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→ We have thus established the equilibrium in the goods markets, namely the equilibrium inflation.

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Inflation

- From the money demand we have $r = \frac{\ln P - \ln M + \varepsilon_Y \ln Y}{\varepsilon_r}$

$$\Rightarrow \Delta P = \lambda \left(\hat{\varepsilon}_P \left(\ln e - \ln P \right) - \frac{\hat{\varepsilon}_r}{\varepsilon_r} \left(\ln M - \ln P \right) + \left(\frac{\hat{\varepsilon}_r \varepsilon_Y}{\varepsilon_r} + \hat{\varepsilon}_Y - 1 \right) \ln Y \right)$$

- The equilibrium requires that prices are stable, $\Delta P = 0$, at some price level $\overline{P}$ and exchange rate $\overline{e}$

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Monetary policy decisions

Money market

Goods market

Equilibrium

Summary

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- We can now combine the equilibrium in the goods market and the money market.

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Relationship between price level and exchange rate

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Relationship between price level and exchange rate

→ We will first establish the relationship between price levels and exchange rates in the long-term equilibrium before then considering the way this equilibrium is reached.

- In the long-run equilibrium we assume that there is no inflation at the relevant equilibrium price level and exchange rate.
- In the long-run equilibrium we assume that the exchange rate does not change at the relevant equilibrium price level and exchange rate. We also assume that interest parity holds and hence the domestic and foreign interest rates are identical in the long-run equilibrium.
- [$\Rightarrow$] Using the expression from $\ln M - \ln \overline{P}$ from the long-run money market equilibrium and the expression for the long-run goods market equilibrium, we get this *formula*.
- As the (log-) differences between the exchange rate and price level are some constant, we see that there is a positive relationship between these two long-run variables; a higher price level would require a higher exchange rate.

→ We can now use these relationship to asses how this equilibrium will be reached over time as prices adjust slowly.

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Out-of equilibrium dynamics

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Out-of equilibrium dynamics

→ We will now consider the dynamics that will lead to the long-run equilibrium. Strictly speaking this is not out-of-equilibrium as an equilibrium is obtained by adjusting the exchange rate, but this will not be the long-term equilibrium.

- From the previous money market equilibrium we had the conditions as shown in the *formulae*, reproduced here.
- These two equations show the relationships between the exchange rate and the price level. They together form a system of difference equations that can be solved.
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  - We can solve these difference equations and obtain the result shown in the *formula*, where ξ summarises some other variables. We thus see that the difference of the exchange rate to its long-run average is related to the difference of the price level to its long-term average.
  - We can show that the coefficient is negative.
- We thus have a negative relationship between exchange rate and price level, as the price level increases, the exchange rate will reduce.

→ Thus far we have analysed how an economy adjusts to a situation where the long-run equilibrium is different to the current state of the economy, we will now see how a new long-run equilibrium can be determined.

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Out-of equilibrium dynamics

- The evolution of the exchange rate and price level is given by

$$\Delta e = \frac{\ln P - \ln \overline{P}}{\varepsilon_r}$$

$$\Delta P = \lambda \hat{\varepsilon}_P \left(\ln e - \ln \overline{e}\right) + \lambda \left(\frac{\hat{\varepsilon}_r}{\varepsilon_r} - \hat{\varepsilon}_P\right) \left(\ln P - \ln \overline{P}\right)$$

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- The adjustment towards the equilibrium has a negative slope

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  - We can solve these difference equations and obtain the result shown in the *formula*, where ξ summarises some other variables. We thus see that the difference of the exchange rate to its long-run average is related to the difference of the price level to its long-term average.
  - We can show that the coefficient is negative.
- We thus have a negative relationship between exchange rate and price level, as the price level increases, the exchange rate will reduce.

→ Thus far we have analysed how an economy adjusts to a situation where the long-run equilibrium is different to the current state of the economy, we will now see how a new long-run equilibrium can be determined.

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Out-of equilibrium dynamics

- The evolution of the exchange rate and price level is given by

$$\Delta e = \frac{\ln P - \ln \overline{P}}{\varepsilon_r}$$

$$\Delta P = \lambda \hat{\varepsilon}_P \left(\ln e - \ln \overline{e}\right) + \lambda \left(\frac{\hat{\varepsilon}_r}{\varepsilon_r} - \hat{\varepsilon}_P\right) \left(\ln P - \ln \overline{P}\right)$$

- These equations characterise the relationship between price levels and exchange rates outside of the equilibrium
- The solution shows that the equilibrium is only reached if

$$\ln e - \ln \overline{e} = \underbrace{\frac{\xi + \lambda \left(\hat{\varepsilon}_P - \frac{\hat{\varepsilon}_r}{\varepsilon_r}\right)}{\hat{\varepsilon}_P}}_{<0} \left(\ln P - \ln \overline{P}\right)$$

- The adjustment towards the equilibrium has a negative slope

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Out-of equilibrium dynamics

→ We will now consider the dynamics that will lead to the long-run equilibrium. Strictly speaking this is not out-of-equilibrium as an equilibrium is obtained by adjusting the exchange rate, but this will not be the long-term equilibrium.

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Impact of monetary policy

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Impact of monetary policy

→ We will look at the impact of monetary policy on shifting the long -run equilibrium of an economy. We start with the economy being ina long-run equilibrium.

- We know that the long-run equilibrium in the money market is given by this *formula*, using that in this long-run equilibrium the exchange rate change is zero.
- The right-hand side is given with our assumption that output cannot increase and hence an increase in the money supply, M, will necessitate and increase in the long-run price level $\overline{P}$.
- Thus we have established a new long-run price level and the long-run exchange rate will adjust accordingly to ensure that purchasing power parity is maintained and the exchange rate will increase accordingly.

→ We can now analyse the adjustments the economy undergoes until reaching the new long-run equilibrium.

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- From the money demand we had $\ln \overline{P} - \ln M = \varepsilon_r r^* - \varepsilon_Y \ln Y$

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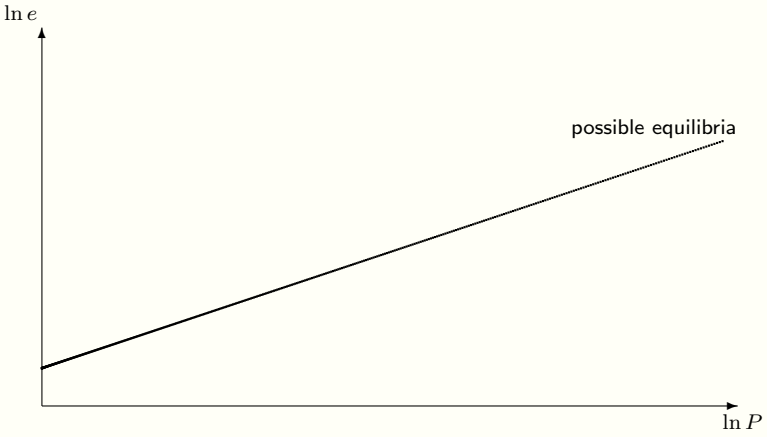

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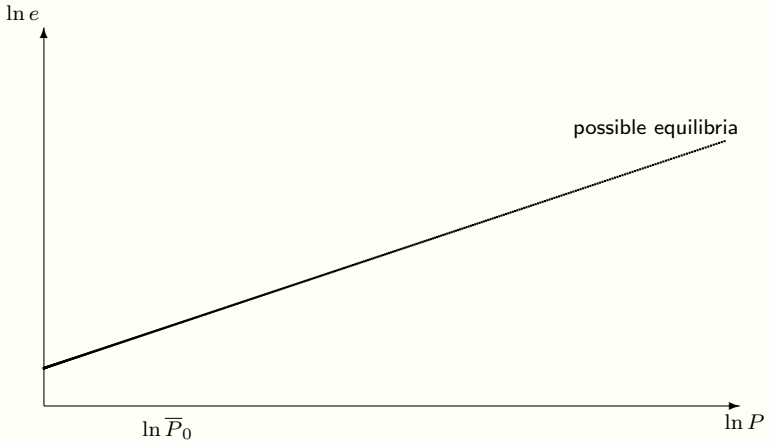

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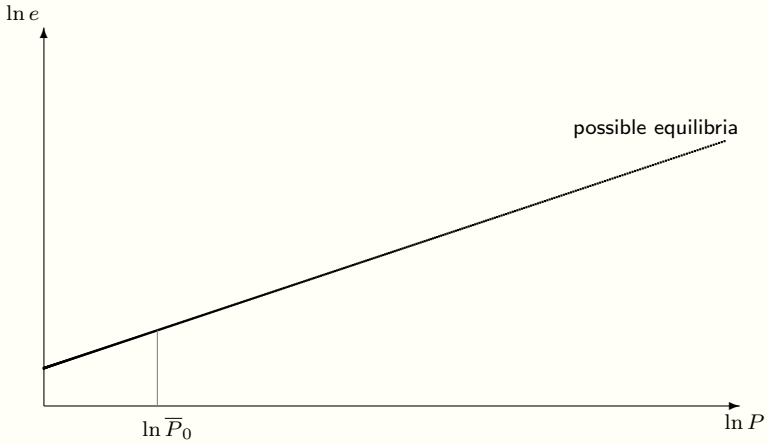

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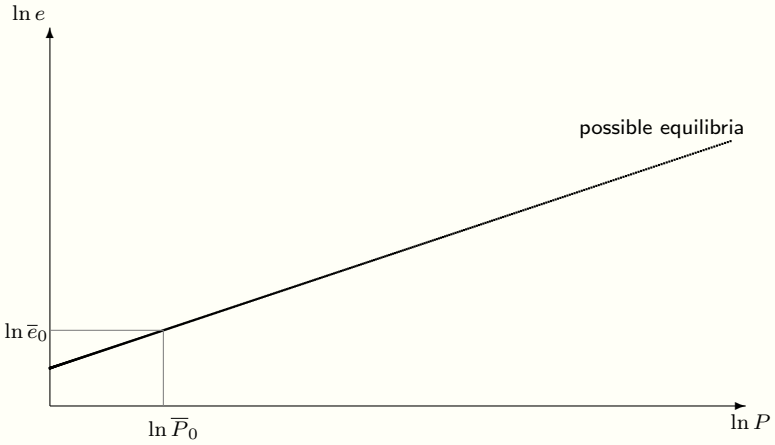

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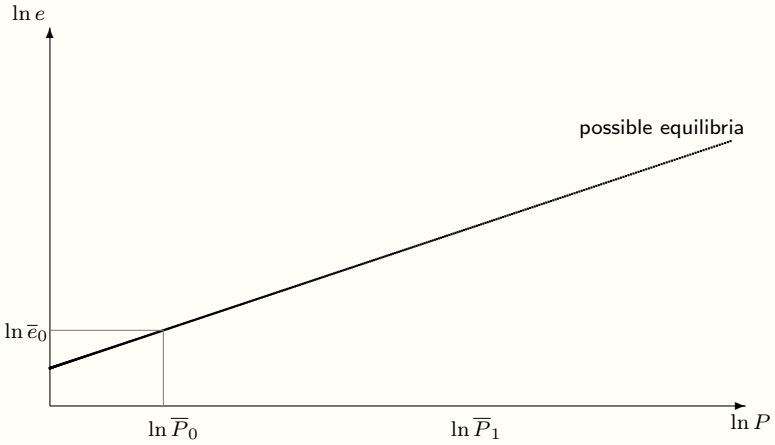

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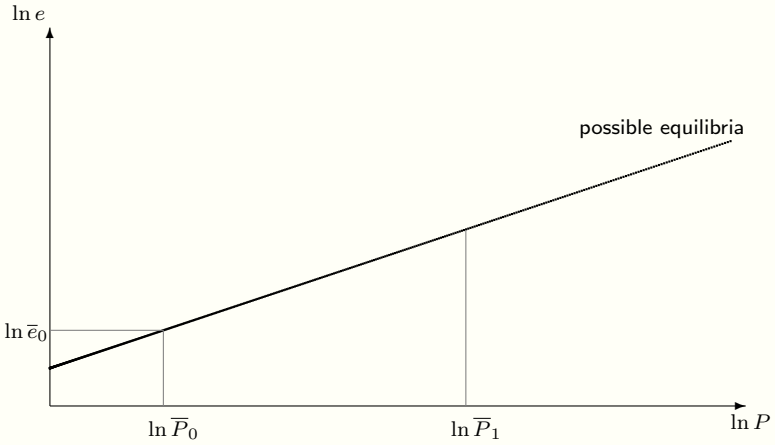

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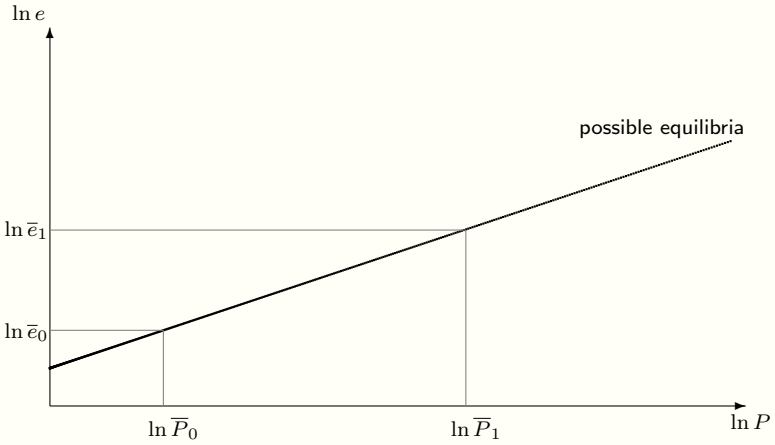

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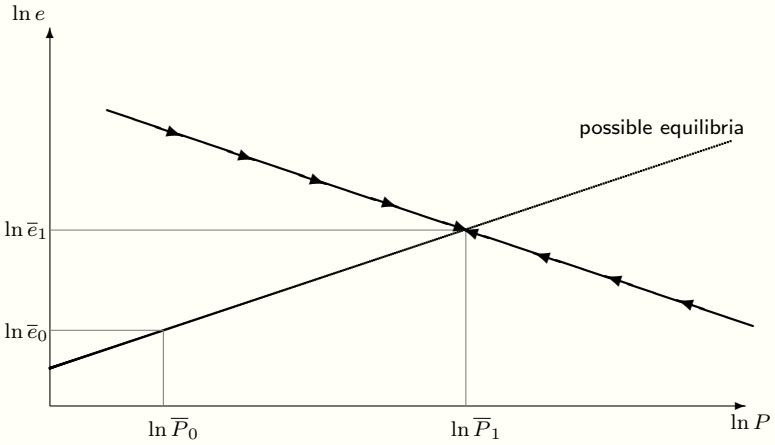

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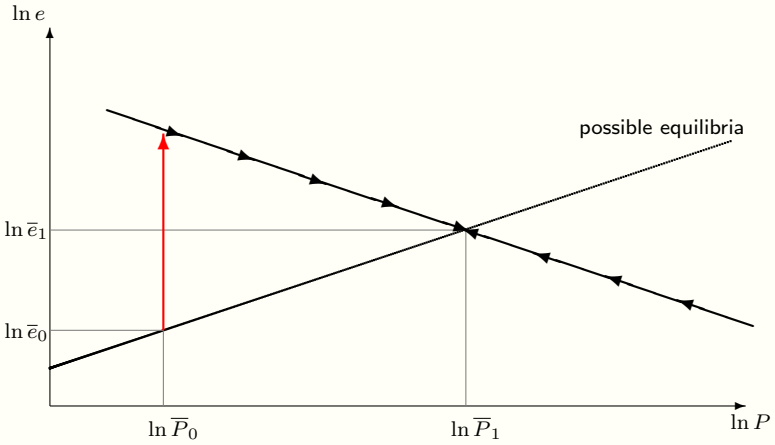

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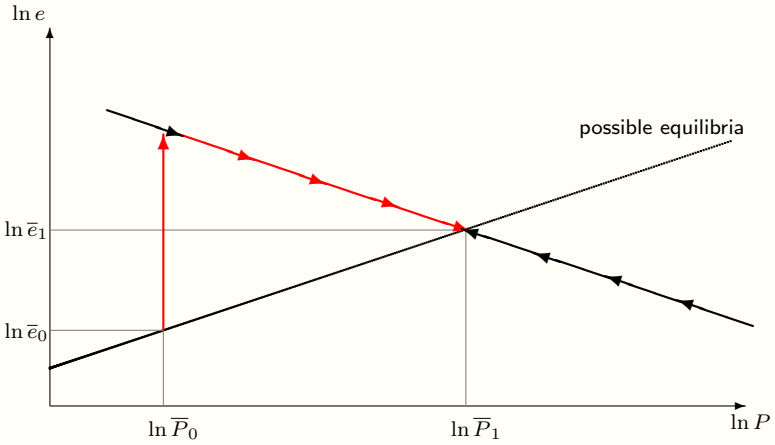

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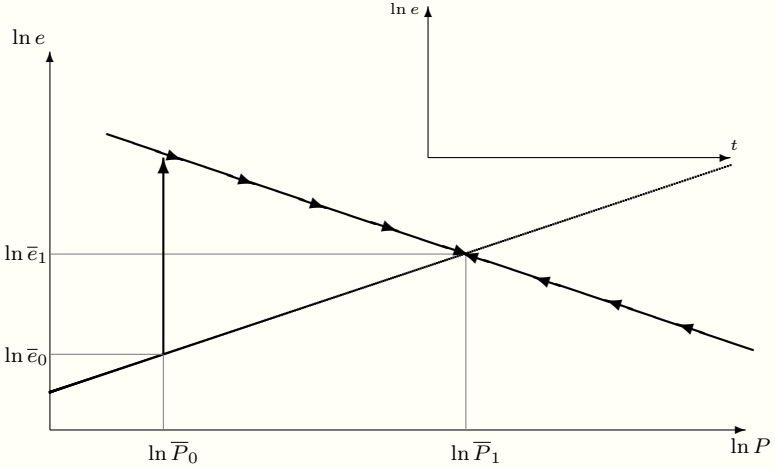

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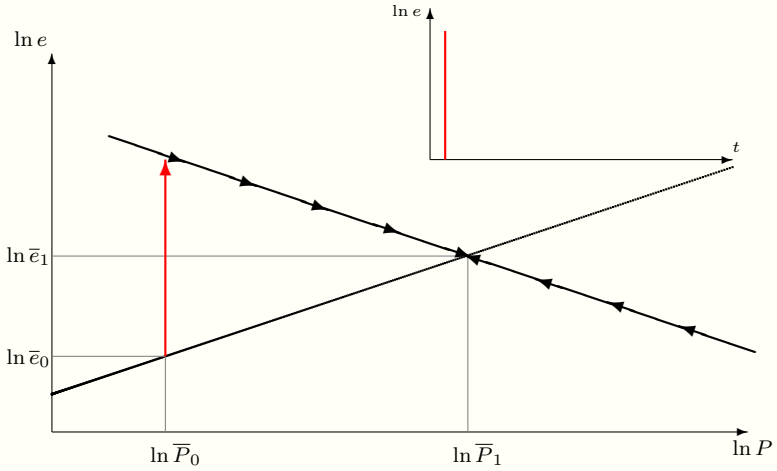

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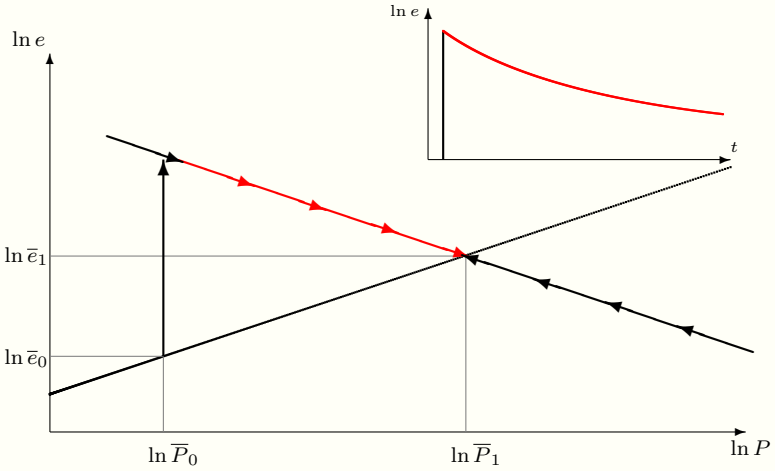

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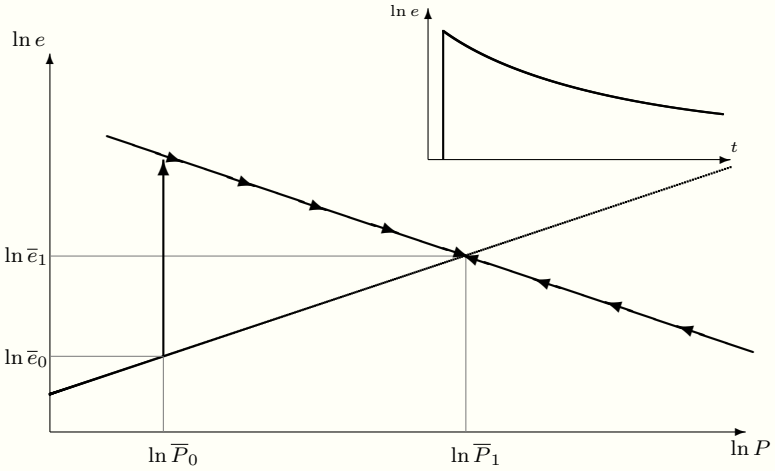

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Overshooting exchange rates

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- Monetary policy decisions
- Money market
- Goods market
- Equilibrium
- Summary

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- We can now summarize the main results of this model.

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Sticky prices

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Sticky prices

→ A key assumption for our model was that prices only adjust slowly to new macroeconomic conditions.

- We assumed that prices only adjust gradually to any change sin the money supply, while exchange rates (and through interest rate parity also interest rates) are fully flexible.
- This quick adjustment of exchange rates wallows the economy to be in equilibrium at any point in time; money and goo0ds markets both clear.
- The exchange rate adjusts more than is needed for the long-run equilibrium as in this case prices and exchange rates adjust both. It is the inflexibility of prices in the short run that require the exchange rate to change more than is justified by the long-term equilibrium.
- With prices slowly adjusting, the exchange rate will then fall back to account for the adjustment taken by prices.

→ Hence, temporarily, exchange rates overshoot their 'target' (the new long-run equilibrium) and fall back over time.

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Sticky prices

→ A key assumption for our model was that prices only adjust slowly to new macroeconomic conditions.

- We assumed that prices only adjust gradually to any change sin the money supply, while exchange rates (and through interest rate parity also interest rates) are fully flexible.
- This quick adjustment of exchange rates wallows the economy to be in equilibrium at any point in time; money and goo0ds markets both clear.
- The exchange rate adjusts more than is needed for the long-run equilibrium as in this case prices and exchange rates adjust both. It is the inflexibility of prices in the short run that require the exchange rate to change more than is justified by the long-term equilibrium.
- With prices slowly adjusting, the exchange rate will then fall back to account for the adjustment taken by prices.

→ Hence, temporarily, exchange rates overshoot their 'target' (the new long-run equilibrium) and fall back over time.

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Exchange rates over-adjust

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Exchange rates over-adjust

→ We can now establish some relationship between long-term and short-term exchange rates.

- Initially exchange rates bear the full adjustment to a monetary shock and will therefore move significantly.
- As the remainder of the economy adjusts to the monetary shock, such as rices changing, the exchange rate reverses some of its initial movement. In a different model we could similar make other, slow, adjustment, for example by allowing production to increase, and obtain qualitatively similar results.
- We see a large reaction of the exchange rate to the monetary supply shock, which is then reversed over time.

→ Thus in the long run interest rate parity and purchasing power parity are fulfilled, but in the short run we can see substantial deviations of the exchange rate, or the changes in the exchange rate, from these theories. This is due to exchange rates being able to adjust faster than other macroeconomic variables and hence bearing the burden of the initial adjustment alone, before then falling back.

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