IMEP 2014 Lectures 17 and 18:

Taylor rule models of the exchange rate

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Outline of today's lectures

Lecture 17

- The Taylor rule
- Should Taylor rules respond to the real exchange rate?
- The New Keynesian model

Lecture 18

- Engel and West (2006)
- Molodtsova and Papell (2009)
- Summary: Taylor rule models

Lecture 17

Modern developments:

Taylor rules and New Keynesian models

Key reading:

1. Taylor (1993): Discretion versus policy rules in practice
2. Hatcher and Minford (2014), Section 2.1

The Taylor rule

- Monetary models of the exchange rate assume that the central bank sets the money supply directly
- Central banks did pursue money supply growth targets in the 1970s and 1980s, but not any longer
- They now have inflation targets and set nominal interest rates directly
- The Taylor rule describes how central banks set interest rates

The Taylor rule cont'd

- Idea: the central bank should raise nominal interest rates if
  1. Inflation rises above target
  2. The 'output gap' is positive
- The Taylor rule is as follows:

$$i_t = \overline{i_{bar}} + \gamma_y y_t + \gamma_\pi(\pi_t - \overline{\pi})$$

  where $\gamma_y > 0$ and $\gamma_\pi > 0$

- Here, $\overline{i_{bar}}$ = long run nominal interest rate and y = output gap

The US Taylor rule (1987-92)

- If $\overline{i_{bar}} = 4$, $\overline{\pi} = 2$, $\gamma_y = 0.5$, and $\gamma_\pi = 1.5$, then the Taylor rule is close to the actual Federal funds rate:

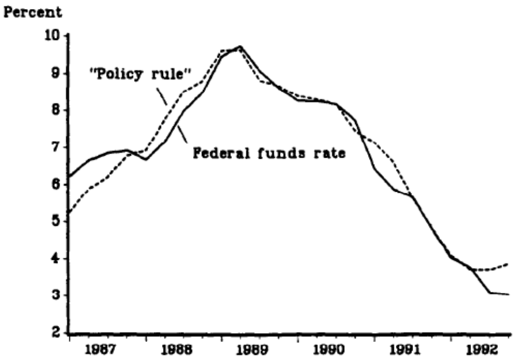


Figure 1. Federal funds rate and example policy rule.

Source: Taylor (1993, p. 204)

The Taylor rule: a simple example

- Suppose that the central bank follows the rule

$$i_t = 4 + 0.5y_t + 1.5(\pi_t - 2)$$

- If the output gap is 2% and inflation is 4%, what interest rate should the Fed set?

- Answer: $i = 4 + 1 + 3 = 8\%$

- **What interest rate should it set if the output gap is** -8% **and inflation is** 4%**?**

The Taylor rule and the real exchange rate

- In an open economy, policymakers might want to respond to the exchange rate. This possibility is discussed in Taylor (2001).
- A depreciation in the real exchange rate will make home goods more attractive to foreigners, raising GDP
- So we could consider a Taylor rule that raises interest rates when the real exchange rate rises:

$$i = \overline{i_{bar}} + \gamma_y y_t + \gamma_\pi(\pi_t - \overline{\pi}) + \gamma_q q_t$$

where $\gamma_q > 0$

The Taylor rule and the real exchange rate...cont'd

- Taylor (2001, pp. 264-66) discusses some studies which conclude that this rule would make inflation and GDP more stable
- But the gains are modest – and some studies suggest losses
- Consequently, the optimal response to the real exchange rate could be positive but small, or it could be zero
- Practical considerations reinforce the view that it might be unwise to respond to the real exchange rate:
  1. Interest rates would be very volatile unless γ_q is close to zero
  2. Real exchange rates are not measured perfectly in practice

The New Keynesian model

- New Keynesian models combine sticky prices with

  1. Utility-maximising households

  2. Profit-maximising monopolistic firms

- Consequently, the aggregate demand and aggregate supply equations in these models are consistent with optimal behaviour

- This is one advantage of these models over the Dornbusch model

- Another is that these models can explain some stylized macro facts and predict macro variables reasonably well out-of-sample (see Hatcher and Minford, Section 5.1)

The New Keynesian model

- The most popular version includes Calvo price-setting
- This means that each firm must keep its price fixed with probability θ. With probability $1 - \theta$, each firm is free to set its price optimally to maximise profit.
- The probability that a firm will be able to change its price is independent of the amount of time since it last changed price
- So, if we take a snapshot at any point in time, there will be some firms who changed price very recently and others who have not changed price for a long time

Calvo price-setting and data

- Calvo price-setting gives us an economy where some firms change price more frequently than others – just as in the data:

Table 1 – Frequency of US consumer price changes

Frequency	Duration	Sector
Average	3.3 months	All
Min	0.6 months	Gasoline
Max	79.9 months	Coin-operated laundry

Source: Bils and Klenow (2004)

- Typical calibrations for the reset probability θ are 0.5–0.75, implying that prices are fixed on average for 2–4 quarters

The New Keynesian Phillips curve (NKPC)

- The assumption of a fixed probability of changing price means that we can easily aggregate firms' optimal pricing decisions

- This aggregation leads to the New Keynesian Phillips curve:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t$$

  where $0 < \beta < 1$ and $\lambda > 0$

- The variable y_t is the output gap and π_t is economy-wide inflation

- The NKPC states that inflation rises with

  1. Excess demand
  2. Expected *future* inflation

The IS curve

- The IS curve is the result of utility-maximising choices by households:

$$y_t = -\psi r_t + E_t y_{t+1}$$

where $r_t = i_t - E_t \pi_{t+1}$

- There are two key points to note:

  1. Output gap depends negatively on the real interest rate r_t
  2. Output gap rises with the expected future output gap

- The central bank can influence the output gap through the Taylor rule for i_t

The New Keynesian model: a summary

- New Keynesian models consist of a Phillips curve, an IS curve and a Taylor rule
- The NKPC and IS curve are consistent with optimal choices by firms and households
- The NKPC also embodies the assumption that prices are sticky due to Calvo price-setting
- These models are useful for explaining and forecasting changes in macro variables, so it will be interesting to see if NK models with Taylor rules can successfully explain and forecast exchange rates

Lecture 18...

- In Lecture 18 we will study a Taylor rule model of the exchange rate due to Engel and West (2006)
- We will look at whether Taylor rule models of the exchange rate can
  1. Explain real-world movements in exchange rates
  2. Predict exchange rates out-of-sample
- We will return to the question of where the New Keynesian model might fit in at the end of the lecture

THE END

Lecture 18 – Taylor rule models of the exchange rate

Key reading:

1. Engel and West (2006): Taylor rules and the DM-$ real exchange rate
2. Molodtsova and Papell (2009): Out-of-sample exchange rate predictability

Engel and West (2006)

- EW wanted to know whether a general model with a Taylor rule could help explain the DM-dollar real exchange rate
- To find out, they set up a 2-country Taylor rule model and calculated its predicted real exchange rate
- One difference relative to Lecture 17 is that they assume the Taylor rule responds to expected future inflation
- This paper is an early example from the literature on Taylor rule models of exchange rates

Engel and West (2006): model

- Germany is the home country (h); US is the foreign country (*)
- Both countries follow forward-looking Taylor rules and variables are written as deviations from trend to avoid the need for intercepts
- The Taylor rule in Germany is given by

$$i_t^h = \gamma_\pi E_t \pi_{t+1}^h + \gamma_y y_t^h + \gamma_q q_t + u_{mt}^h$$

- The Taylor rule in the US is given by

$$i_t^* = \gamma_\pi E_t \pi_{t+1}^* + \gamma_y y_t^* + u_{mt}^*$$

where u_m^h and u_m^* are monetary policy shocks

Engel and West (2006): model cont'd

- Uncovered interest parity (UIP) holds:

$$i_t^h = i_t^* + E_t e_{t+1} - e_t$$

where e_t is the log nominal exchange rate

- Subtracting i_t^* from both sides:

$$i_t = E_t e_{t+1} - e_t \qquad \text{where } i_t = i_t^h - i_t^*$$

- The log real exchange rate q_t is

$$q_t = e_t + p_t^* - p_t^h \Longrightarrow e_t = q_t - p_t^* + p_t^h \qquad (1)$$

where p is the log price level

- Moving (1) forward one period:

$$e_{t+1} = q_{t+1} - p^*_{t+1} + p^h_{t+1} \qquad (2)$$

- Taking expectations on both sides of (2):

$$E_t e_{t+1} = E_t q_{t+1} - E_t p^*_{t+1} + E_t p^h_{t+1} \qquad (3)$$

- Subtracting (1) from (3):

$$E_t e_{t+1} - e_t = E_t q_{t+1} - q_t + \overbrace{E_t p^h_{t+1} - p^h_t}^{E_t \pi^h_{t+1}} - (\underbrace{E_t p^*_{t+1} - p^*_t}_{E_t \pi^*_{t+1}}) \qquad (4)$$

Engel and West (2006): model cont'd

- If we denote the inflation differential by $\pi = \pi^h - \pi^*$:

$$E_t e_{t+1} - e_t = E_t q_{t+1} - q_t + E_t \pi_{t+1} \qquad (5)$$

- Using (5) in the UIP equation:

$$i_t = E_t q_{t+1} - q_t + E_t \pi_{t+1} \qquad (6)$$

- We now need an expression for i_t

- Subtracting the foreign Taylor rule from the home Taylor rule:

$$i_t = \gamma_\pi E_t \pi_{t+1} + \gamma_y y_t + \gamma_q q_t + u_{mt} \qquad (7)$$

where $y = y^h - y^*$ and $u_m = u_m^h - u_m^*$

Engel and West (2006): model cont'd

- Finally, substituting for (7) in (6) and rearranging:

$$q_t = bE_t q_{t+1} + x_t \qquad (8)$$

where $b = 1/(1+\gamma_q)$ and $x_t = b(1-\gamma_\pi)E_t\pi_{t+1} - b\gamma_y y_t - bu_{mt}$

- This is similar to the equations we solved in the flex-price and Dornbusch models

- The no-bubbles exchange rate solutions are:

$$q_t = \sum_{s=t}^{\infty} b^{s-t} E_t \left\{ b(1-\gamma_\pi)\pi_{s+1} - b\gamma_y y_s - bu_{ms} \right\} \qquad \text{(Real ER)}$$

$$e_t = q_t - p_t^* + p_t^h \qquad \text{(Nominal ER)}$$

Engel and West (2006): model cont'd

- Assuming $\gamma_\pi > 1$, the exchange rate depends negatively on the current and expected home-foreign differentials in

  1. Inflation expectations
  2. Output gaps
  3. Monetary policy shocks

- Output matters as in monetary models of exchange rates

- But expected inflation matters here, and money supplies play NO role

- These are the main implications of the Taylor rule approach to exchange rates

Engel and West (2006): results

- EW compare the predictions of the model to monthly real exchange rate data over the period 1979 to 1998
- Inflation and output expectations are estimated using a vector autoregression (VAR) with 4 lags
- EW calibrate rather than estimate the parameters of the model; they set $\gamma_q = 0.1$, $\gamma_\pi = 1.75$ and $\gamma_y = 0.25$ (p.1184)
- EW report autocorrelations and cross-correlations of actual exchange rates with the predicted exchange rate from the model

Engel and West (2006): results cont'd

Table 2 – Model vs actual correlations[a]

Correlation	Model	Data
q, q_{-1}	0.97	0.98
$\triangle q, \triangle e$	0.94	1.0
$q, \widehat{q}$	0.32	–

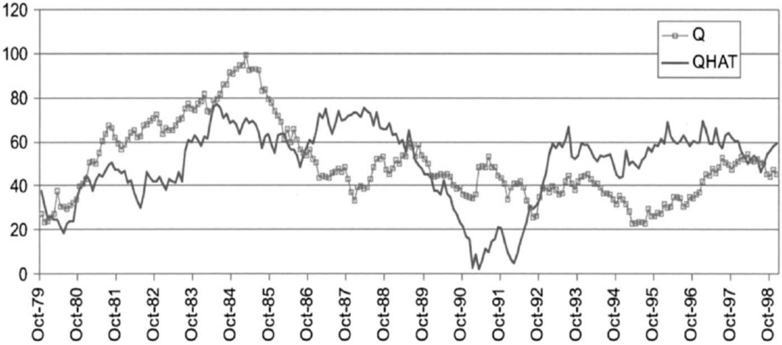
(a) Engel and West (2006), Table 1, p. 1185.

- **Key points**

  1. Real exchange rate is very persistent as in the data
  2. Model does a good job of matching the high correlation between real and nominal exchange rates
  3. Actual and predicted real exchange rate have a correlation of 0.32

Dollar-DM real exchange rate in-sample (1979-98)

- Graph compares the actual real exchange rate (light grey line) with that from the model (dark grey line)



Source: Engel and West (2006), Fig 2, p. 1186.

Molodtsova and Papell (2009): model

- Since EW (2006) takes an in-sample approach, researchers wanted to know whether Taylor rule models could predict exchange rates out-of-sample
- MP (2009) investigate this using a Taylor rule model similar to that in EW (2006)
- The main difference is that the Taylor rule is not forward-looking in MP (2009). This avoids the problem of having to estimate expected inflation.
- MP also allow the home and foreign countries to have potentially different Taylor rule coefficients

Molodtsova and Papell (2009): model

- MP (2009) include the flex-price monetary model, PPP, and a random walk as benchmark models against which the Taylor rule results can be compared

- They also test against an 'interest rate fundamentals' model:

$$e_{t+1} - e_t = \alpha + \omega(i_t^h - i_t^*)$$

where the sign of ω is not restricted

- The motivation is that there may be a relationship between nominal exchange rates and interest differentials – eg due to UIP

Molodtsova and Papell (2009): data

- MP have monthly data on 12 industrialised countries and the US from March 1973 to June 2006
- They use 'real time' data – ie data that was available at the time – to construct a measure of the output gap
- Regressions are estimated over the period March 1973 to Feb 1982
- The rest of the data is used in out-of-sample forecasting tests

Molodtsova and Papell (2009): results

- The following results are for 1-month-ahead forecasts:

Table 3 – Superior predictive ability vs random walk[a]

Model	Superior predictive ability?
Taylor rule fundamentals	YES: 11 out of 12 countries
Flex-price model	YES: 1 out of 12 countries
Purchasing power parity	NO
Interest rate fundamentals	YES: 3 out of 12 countries

(a) Molodtsova and Papell (2009), Tables 6-9, pp. 175-76.

Molodtsova and Papell (2009): results cont'd

- The Taylor rule model leads to a statistically significant improvement in predictive ability over a random walk in 11 of the 12 countries
- It therefore appears that the Meese-Rogoff (1983) result has finally been overturned!
- Moreover, the Taylor rule model comfortably beats the alternative models
- In short, the out-of-sample forecast performance of the TR model is very impressive!

Summary: Taylor rule models (1)

- Taylor rule models predict that a different set of economic fundamentals will matter for exchange rates to monetary models
- In these models, the money supply does not even figure directly in exchange rate determination
- Engel and West (2006) showed that a Taylor rule model had surprisingly good in-sample performance against the Deutschmark-Dollar real exchange rate
- In out-of-sample tests, Molodtsova and Papell (2009) find that TR models can
  1. Overturn the Meese-Rogoff result
  2. Outperform alternative models based on economic fundamentals

Summary: Taylor rule models (2)

- One weakness of the Taylor rule models, however, is that they are not complete models of the economy, because there are not separate equations determining the output gap and inflation
- Ideally we want a model that can forecast these variables as well. The New Keynesian model seems a good bet, but exchange rate predictability does not seem to have been tested yet in these models.
- Future research should test whether NK models with Taylor rules can deliver results like those of the general Taylor rule models discussed in this lecture
- The early signs look encouraging, but only time will tell!

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