Problem Set 3: Monetary Policy

Exercise 1. Using the Euler equation, determine the price of a bond paying off in three year's time. The level of consumption today is C_1 and the level of consumption in three year's time is C_4. If C_4 is much bigger than C_1, what do we know about the i) price and ii) rate of return on the bond. Explain the intuition.

Solution 1 (Euler Equation: Bond Yields & Prices)**.** Denoting p_t as the price of a bond paying off in three year's time, the marginal cost in terms of foregone consumption utility of purchasing one unit of this bond in period t is $p_t u'(C_t)$. Since the bond will not pay back for three years, the marginal benefit includes the discount β^3 (won't receive the payoff until three periods in the future) and has a payoff of one unit so the marginal benefit in terms of consumption utility will be $\beta^3 E_t(u'(C_{t+3}))$. The expectation term is included since at time t, C_{t+3} is unknown and so $u'(C_{t+3})$ is unknown. By arbitrage, the marginal cost must be equal to the marginal benefit, which yields the Euler equation. Solving: $p_t = \frac{\beta^3 E_t(u'(C_{t+3}))}{u'(C_t)}$.

Assuming diminishing marginal utility, if $C_1 < C_4$, then $u'(C_4) < u'(C_1)$ and so the price of the bond will be low and the return $R_t = (1 + r_t) = \frac{1}{p_t}$ will be high. Bond prices and yields are inversely related. Times seem to be better at $t = 4$ since $C_4 > C_1$ so $u'(C_4) < u'(C_1)$ and the bond pays out a higher return in this case. This bond would not make for a good insurance mechanism as it pays out well when times are good and *vice-versa*, so it commands a low price.

Exercise 2. What are the implications of each of the following developments for the yield curve:

- The central bank is permanently made independent of the government today.
- News that the government will start running large budget deficits in ten years time, as a result of baby-boomers retiring and the attendant strain on social welfare systems. (Assume the economy is closed).
- A new policy that starts in 5 years time that raises savings.
- A permanent fall in money growth today.

Solution 2 (Yield Curve)**.**

a) Inflationary expectations would fall right across the term structure; this would cause the yield curve to shift down.

b) Expectations of future natural rates would rise. From year 10 onwards, the expected natural rate would rise, causing the yield curve to move upwards at that point. The moves upwards would become more pronounced as we moved out. It is possible that the expectations of higher future interest rates would induce a rise in savings well before year 10 – as people saved in anticipation of higher future rates (though income effects for long-run savers would induce a fall in savings). In this case, interest rates would fall prior to year 10, in which case the yield curve would shift down before year 10. Empirically, however, the response of savings to higher interest rates is low.

c) Expectations of the future natural would would *fall*. As a result, the slope of the yield curve would fall for maturities of 5 years or more. I am assuming no behavioural responses before year 5.

d) Same answer as a) above.

Exercise 3. Suppose inflation rises by 5% in two countries, A and B. Financial markets know A follows a Taylor rule, but are unsure of the policies pursued by B. Explain what you think happens to long-run interest rates and the price of long-run bonds in both countries.

Solution 3 (Taylor Rule & Expectations Theory)**.** By the Taylor Rule, country A will raise short-run nominal interest rates by more than five percent when inflation rises (Taylor Principle), so after a while output will be slightly depressed via the IS curve as r_t rises, so inflation will eventually slow down by the New Keynesian Phillips Curve. By the expectations theory, since long-run rates are determined by short-run rates and expected future ones, long-run rates will decline too; long-run rates are also affected by expected future inflation and risk-premia, which will decline due to the fact that country A follows the Taylor Rule. Since financial markets are unsure of the policies pursued by B, the term/risk premium is unlikely to come down and there will be a rise in their expectations of future inflation so long-run rates may even rise; unless financial markets anticipate that short-run rates will decline significantly to offset the increased expected future inflation, long-run rates will rise. Since prices of long-run bonds are inversely related to long-run interest rates, prices will rise in country A and most likely will fall in country B.

Exercise 4. In a widely cited paper, Orphanides argued that the inflation in the U.S. in the seventies was primarily cased by the central bank following a Taylor-type rule, but not having discerned there was a *productivity slowdown*. Explain his argument.

Solution 4 (Taylor Rule & Natural Rate)**.** The Great Inflation: The Taylor Rule suggests lowering interest rates when output falls relative to its natural (potential) rate. Potential output and NAIRU are central to making TR operational but notoriously hard to measure, especially in real time, without the benefit of hindsight. However, if there was a productivity slowdown, then the natural (potential) rate would be lower so the magnitude of a negative output gap would not be as large if the natural rate was measured at its new, lower level. If the central bank had discerned there was a productivity slowdown, then there would not be a reason to lower interest rates as low as they did, which encouraged inflation. Mathematically: $i = 2+\pi+\frac{1}{2}(\pi-2)+\frac{1}{2}(y-y_n)$. So, excessive activism and failing to discern $y_n^{\text{actual}} < y_n$ would have resulted in too low an i and therefore real interest rate.

Exercise 5. In 2005, Donald Kohn, a FED Governor wrote

> 'Nothing better illustrates the need to properly account for risk premiums than the current interest rate environment: To what extent are long-term interest rates low because investors expect short-term rates to be low in the future... and to what extent do low long rates reflect narrow term premiums, perhaps induced by well-anchored inflation expectations or low macroeconomic volatility? Clearly, the policy implications of these two alternative explanations are very different.'

What does he mean by different policy implications?

Solution 5 (Expectations Hypothesis & Monetary Policy)**.** Kohn refers to two explanations for low long-term interest rates: i) low expected short-term rates and ii) low term premiums. He asserts the latter could be due to 'well-anchored inflation expectations' or 'low macroeconomic volatility'. Expecting low future short-term rates would mean that the economy could suffer under monetary policies that reversed the low short-term interest rates dramatically and unanticipated in the future. Open mouth operations and forward guidance could explain this. Quantitative easing relies on keeping interest-rates low for a while even after the economy recovers. Expecting that inflation will be kept under control even though short-term rates are currently low reflects credibility of the central bank. The central bank would have more room to manoevre in this second case than in the first because low long-term rates are not dependent on expected future low short-term rates.

Exercise 6. According to the Taylor rule, the federal funds rate should be

$$i^* = r_n + \pi + .5(\pi - \pi^*) + \psi(y - y^*)$$

a) Write this in terms of the target *real* rate.

b) Suppose the central bank intervenes to maintain the level of the nominal exchange rate at some value $\bar{\epsilon}$. Modify the Taylor rule to incorporate this objective.

c) Some central banks (i.e., "hawkish" ones) place more weight on their inflation objective than output stability. How could you represent this in the rule above?

Solution 6 (Taylor Rule)**.**

a) Implicit in the Taylor rule is a target *real* rate

$$r^* = r_n + .5(\pi - \pi^*) + \psi(y - y^*) \tag{1}$$

Note that the FED targets the natural real rate on average. Specifically, if output is at potential and inflation at target, the FED will aim for the natural rate. $r_n = 2.5$ is an estimate of the natural rate. Since the natural rate varies, however, a more general to way to write this is as in equation (1) where r_n denotes the natural rate.

b) Expressed in terms of the domestic price of foreign currency, when nominal exchange rate appreciates (ϵ rises), the current account worsens. To bring the exchange rate back in line with $\bar{\epsilon}$ (i.e. a depreciation), we need a capital outflow, reducing the demand for the domestic currency. We can achieve this by lowering interest rates, thereby making saving domestically less attractive relative to saving in foreign countries. So, the response of interest rates to nominal exchange rate ϵ rising relative to $\bar{\epsilon}$ should be negative. Let ξ denote the weight placed on the nominal exchange rate objective. Therefore, we get the following modified Taylor rule:

$$r^* = r_n + .5(\pi - \pi^*) + \psi(y - y^*) - \xi(\epsilon - \bar{\epsilon})$$

c) $\psi < .5$ (note $\psi = .5$ yields equal weight).

Exercise 7. If the yield curve is flat, what do investors expect about short-run interest rates in the future?

Solution 7 (Yield Curve & Liquidity Premium Theory)**.** A flat yield curve means that yield is independent of maturity. According to the liquidity premium theory, the interest rate on a long-term bond equals the average of the expected short-term bonds over the maturity length of the long-term bond plus a risk premium that typically depends on the maturity of the long-term bond. Given a positive term premium, a flat yield curve indicates that future short term interest rates are expected to fall. If we believe in expectations theory, neglecting the risk premium, $i_{nl} = \frac{\sum_{z=1}^{n} Ei_z}{n}$, i.e. expectations theory. In that particular case, as the yield is the same for different maturities, investors expect future short-run interest rates to be the same.

Exercise 8. The *forward rate* f_2 is the short-run rate that you can be *guaranteed* of next year (say). If a two year bond pays i_{2l} and today's short-run rate is i_1, find an expression for the next year's forward rate f2.

Solution 8 (Expectations Hypothesis & Forward Rate)**.** Assuming that the two year bond pays i_{2l} a year, by arbitrage, investing in either the two year bond or the one year bond for two years should earn the same return so

$$(1 + i_{2l})^2 = (1 + i_1)(1 + f_2) \tag{2}$$
$$2\log(1 + i_{2l}) = \log(1 + i_1) + \log(1 + f_2)$$
$$2i_{2l} = i_1 + f_2$$
$$f_2 = 2i_{2l} - i_1 \tag{3}$$

where the approximation $\log(1 + x) \approx x$ was used for (3).

Exercise 9. If output is at potential and inflation is at target, what does the Taylor rule prescribe? What is the best guess of the central bank's target rate in 10 year's time? What happens to the target if there is permanent rise in government expenditure?

Solution 9 (Taylor Rule)**.** If output is at potential and inflation is at target, the Taylor rule prescibes setting the interest rate at the natural rate, i.e. $i^* = r_n + \pi = r_n + \pi^*$ where π^* is target inflation, which equals actual inflation and r_n is natural real rate of interest. So, $r^* = r_n$ since $r^* = i^* - \pi^* = r_n$. The best guess of the central bank's target rate in 10 year's time is the natural rate. If there is a permanent rise in government expenditure, it is likely that there will need to be more borrowing in the future to finance this expenditure so interest rates will rise in the future, which would push up the natural rate and thereby push up the target rate.

Exercise 10. What would happen to the yield curve if the FED committed to keeping interest rates low for the next year *and* the level of investment demand rose permanently.

Solution 10 (Yield Curve)**.** Investment demand rises so firms will be more willing to borrow to finance investment – a rise in loanable funds. There will be a rise in the quantity of bonds supplied at any given price and interest rates will increase (supply of bonds shifts right like in figure 4 of Mishkin, Chapter 5). However, the FED committed to keeping interest rates low for the next year. Since the rise in investment is permanent, the long-run rates will rise, while the short-run rates will fall due to committment by the FED. As a result, the yield curve will *steepen*.

Exercise 11. Ireland currently 'needs' deflation to depreciate the real exchange rate. What implications does deflation have for the banking system and the credit channel of monetary policy?

Solution 11 (Deflation & Credit Channel of Monetary Policy)**.** *Aside*: Real exchange rate is $\xi = \frac{Pe}{P^*}$ where e is nominal exchange rate (foreign price of domestic unit of currency), P is domestic price level and P^* is foreign price level. E.g. $P = 1.50$, $P^* = \$2$ and $e = 2$ ($\$2 = 1$) so more expensive in Euro country than in Dollar country.

Deflation increases the real burden of debt and so weakens the balance sheet as firms can offer less collateral to banks, which in turn reduces banks' willingness to lend. Since the firms can offer less collateral to the banks, the moral hazard problem becomes more of an issue. A decrease in banks' willingness to lend reduces the money multiplier so reduces money supply. The fact that banks lend less in bad times is a consequence of the 'financial accelerator' – asset prices are procyclical. With respect to adverse selection, most firms rely on banks (and internal finance) as opposed to stock issuance so most firms depend upon banks' willingness to lend. Small firms are especially affected by banking problems since they are even more reliant on bank lending (small firms rarely issue equity). Also, for households on adjustable loans, a rise in the debt burden weakens their balance sheets too. Note that banks will lend less if they have less capital for themselves (since deflation increases the real burden of debt and reduces asset values, so they have less capital) – they suffer losses from default so lend less. Finally, banks have informational capital (e.g. credit records of their clients), which is important for financial intermediation. Banking collapses destroys this information capital and reduces overall lending in the economy.

Exercise 12. What are the implications for the credit channel of having debt denominated in foreign currencies?

Solution 12 (Credit Channel & Debt Denomination)**.** If debt is denominated in foreign currencies, then a domestic depreciation has a negative effect since it means that it is more expensive (in terms of domestic currency) to pay off the debt. Such currency risk is alleviated by having debt denominated in domestic currency. With more expensive access to reserves, banks ability and willingness to lend declines, which in turn reduces investment.

Exercise 13. Multiple Choice Questions: 2010 Midterm, Questions 1-3, 5, 8-10; 2009 Midterm, Questions 1-8, 11.

Solution 13 (MCQs)**.** 2010: b, c, a, b, c, c, b. 2009: e, b, e, b, d, c, d, a, c.