Monetary Policy and Quantitative Easing in an Open Economy: Prices, Exchange Rates and Risk Premia

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Motivation

Perils of Quantiative Easing (McMahon, Peiris, Polemarchakis, 2012

- Under normal conditions, monetary policy sets a target for the short-term (here one period) interest rates, and conducts open market operations or repo transactions, using as collateral Treasury securities, with various maturities, but to conform to an ex-ante determined overall portfolio composition which has an exclusive focus on Treasuries of short maturity.
- Unconventional monetary policy expands the balance sheet by increasing the maturity range (and possibly range of assets) of the monetary authority portfolio.

Motivation

Perils of Quantiative Easing (McMahon, Peiris, Polemarchakis, 2012

- As under conventional monetary policy, under the recent US experience of Credit Easing it is the explicit target for the composition of the balance sheet that allows the monetary authority to target the stochastic path of inflation: the target for the composition of the portfolio guarantees the necessary restrictions to obtain determinacy.
- The absence of such restrictions under the UK and Japanese versions of QE manifests nominal (and possibly) real indeterminacy.

Motivation

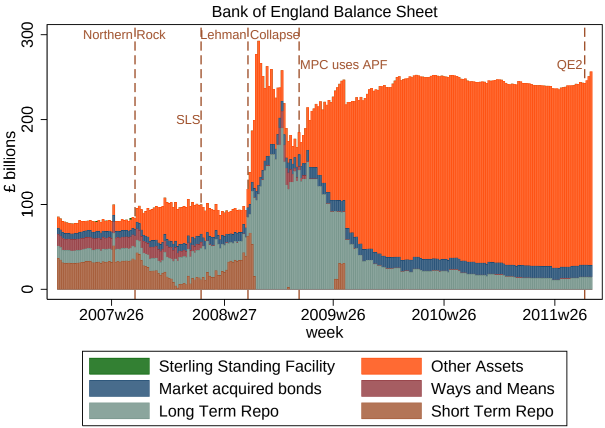

Figure : Bank of England Balance Sheet - Assets

Notes: This figure shows the asset side of the Bank of England balance along with important economic events and policy decisions dates marked with vertical lines. Source: Bank of England.

Motivation

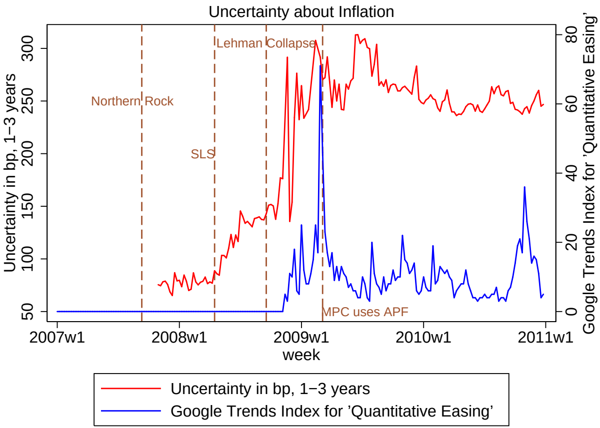

Figure : Measures of Dispersion of Inflation Expectations I

Notes: This figure shows the standard deviation of the options implied probability distribution of annual RPI outturns for 2-3 years ahead. Important economic events and policy decisions are marked

Question

Why Open Economy?

- Do large open monetary economies display nominal indeterminacy:
- whether monetary policy determines the path of prices under uncertainty and;
- whether it transmits price (in)stability abroad.

Motivation

Why Inflation?

- The failure to control inflation domestically can be the cause of suboptimal domestic fluctuations if indeterminacy is real;
- ccan de-stabilise trading partners via current account changes;
- Optimal fiscal-monetary policy supports an optimal allocation of resources; if such a policy is also consistent with other, suboptimal, equilibrium allocations, then, it does not "implement" the targeted allocation.

Results

In a simple, stochastic, cash-in-advance economy

- indeterminacy arises
- is characterized by the initial price level;
- a probability measure associated with state-contingent nominal bonds;
- the stochastic distribution of exchange rates (rather than the initial level of exchange rates).
- non-traditional methods of conducting monetary policy such as quantitative easing affect the path of prices and furthermore, the interaction with interest rate rules generate specific risk premia associated with the correlation between interest rates and the martingale measure in an open economy.

Results

Equivalently, in each country, monetary policy determines an average, but not the distribution of inflation across realizations of uncertainty.

Previous Work

Deterministic Closed Economy

- In a deterministic monetary model the initial price level is indeterminate;
- Given the initial price level, the inflation rates in subsequent periods are determined by monetary policy that sets either the path of money supplies or the path of short-term nominal interest rates;
- This determination of inflation rates is understood by the Fisher equation, which describes the relationship between the nominal and real interest rates and the inflation rate.

Previous Work

Stochastic Closed Economy

- In a stochastic economy, there is a higher degree of indeterminacy, and monetary policy no longer suffices to determine the path of inflation rates;
- This is because the Fisher equation in a stochastic economy holds only in expected terms;
- In the case of flexible prices, such indeterminacy may be characterized by the indeterminacy of the “distribution” of inflation rates across states of nature.

Previous Work

In an open economy, this indeterminacy proliferates.

- In a deterministic economy, given the initial exchange rates, the path of exchange rates is determined from uncovered interest parity;
- The stochastic distribution of prices is independently indeterminate in each country;
- If all countries coordinate on to an interest rate monetary polocyrule, the indeterminacy is purely nominal;
- while if even one country runs a money supply rule, then via current account changes, the indeterminacy becomes (globally) indeterminate.

Model

Benchmark economy with flexible prices and characterize the set of equilibria

- All markets are perfectly competitive;
- Money is valued through a cash-in-advance constraint, as in Lucas and Stokey (1987);
- Indeterminacy is characterized by the initial price level,
- the probability measure associated with nominal state prices, which is referred to as the nominal equivalent martingale measure and
- unique exchange rates in the second period.

Model

A simple, stochastic, cash-in-advance economy

- There are three periods: $t = \{0, 1, 2\}$
- Production and consumption only occur in Periods 0 and 1, with Period 2 being an "accounting" period.
- A stochastic shock, $s \in \mathcal{S} = \{1, \ldots, S\}$, realizes at the beginning of Period 1. Each state occurs with a probability $f(s^1) > 0$.
- Given s^1, there is no further uncertainty in Period 2 and that date-event is denoted s^2.

Model

A simple, stochastic, cash-in-advance economy

- The world is inhabited by a continuum of individual producer-consumers, of unit mass, each of whom produces a single homogeneous good.
- There are $N > 1$ countries
- Agents of different nationalities differ only in that they must sell their produce in the currency of the country which they are native to.

Model

Producer-Consumers

- At each date-event, households produce a single, homogeneous product, identical in all countries.
- The output produced by a domestic representative household of country n in period 0 is $y^n(0)$ and at state s in period 1, it is $y^n(s^1)$; consumption of products from country k are $c_k^n(0)$ and $c_k^n(s^1)$.
- As goods are identical across countries, we further define for representative agent n $c^n(0) = \sum_k c_k^n(0)$ and $c^n(s^1) = \sum_k c_k^n(s^1)$ where the first subscript refers to the period, and the second to the country of origin of the good consumed.

Model

Households

- The preferences of the representative household are described by the lifetime expected utility

$$\left\{ u\left[c^n(0), \bar{y}(0) - y^n(0)\right] + \beta \sum_s u\left[c^n(s^1), \bar{y}(s^1) - y^n(s^1)\right] f(s^1) \right\}. \tag{1}$$

- $\bar{y}$: endowment of time, and $\bar{y} - y$ as the consumption of leisure, l.

Model

Timing of Transactions

- At each date-event the asset market and currency market in each country open simultaneously and before the goods market.
- An important consequence of this assumption is that the cash the households obtain from sales of its output has to be carried over to the next period.

Model

Timing of Transactions

- The representative household enters the initial period 0 with nominal assets in country n of $w_k(0)$. Then, the asset market opens, in which cash and a complete set of contingent claims are traded, as well as the currency market, in which cash denominated in one currency is traded for cash denominated in another currency.
- The price level in each country is given by $p_n(0)$ and $p_n(s^1)$ in Period 0 and 1, state s, respectively.

Model

Timing of Transactions

- Let $r_k(0)$ be the nominal interest rate in period 0, and thus, $1/(1 + r_k(0))$ be the price of a nominally riskless bond that pays one unit in every state of nature in the next period.
- Let $q_k(s^1)$ be the price of the contingent claim in country n that pays off one unit of currency if and only if state s occurs in the next period and $e_k(0)$, $e_k(s^1)$ and $e_k(s^2)$[1] be the nominal exchange rate (rate at which a unit of country k money is worth in terms of a unit of country 1 money $t = \{0, 1, 2\}$).

[1] $e_1(0) = 1$, $e_1(s^1) = 1$ and $e_1(s^2) = 1$.

Model

Household Budget Constraint

The budget constraints for the representative household of country n:

$$\sum_k e_k(0)\left[p_k(0)c_k^n(0)+\sum_s q_k(s^1)b_k^n(s^1)+m_k^n(0)\right] \\ \leq e_n(0)\left[w^n(0)+p_n(0)y^n(0)\right]. \tag{2}$$

$$\sum_k e_k(s^1)\left[p_k(s^1)c_k^n(s^1)+\frac{b_k^n(s^2)}{1+r_k(s^1)}+m_k^n(s^1)\right] \\ \leq e_k(s^1)p_n(s^1)y^n(s^1)+\sum_k e_k(s^1)\left[b_k^n(s^1)+m_k^n(0)\right], \tag{3}$$

Model

Interest Rates and No-Arbitrage

- Let $r_i(0)$ be the nominal interest rate in period 0, and thus, $1/(1 + r_i(0)$ be the price of a nominally riskless bond that pays one unit in every state of nature in the next period.
- The no-arbitrage condition then implies that

$$\sum_s q_i(s^1) = \frac{1}{1 + r_i(0)}. \tag{4}$$

Model

Cash-in-Advance

The cash-in-advance constraint in his home country, n and in foreign countries, $k \neq n$

$$m_n^n(0) \geq p_n(0)y^n(0), \qquad m_k^n(0) \geq 0. \tag{5}$$

$$m_n^n(s^1) \geq p_n(s^1)y^n(s^1), \qquad m_k^n(s^1) \geq 0. \tag{6}$$

Model

Law of One Price

In equilibrium the Law of One Price must hold for goods,

$$p_1(0) = e_k(0)p_k(0) \quad p_1(s^1) = e_k(s^1)p_k(s^1) \tag{7}$$

and (redundant) assets,

$$q_1(s^1) = \frac{e_k(0)q_k(s^1)}{e_k(s^1)}. \tag{8}$$

The uncovered interest parity condition can be derived by summing across states as follows:

$$e_k(0)\frac{1 + r_1(0)}{1 + r_k(0)} = \sum_s \mu_1(s^1)e_k(s^1) \tag{9}$$

Model

Lifetime Budget Constraint

Substituting these into the budget constraints reduce to the single, lifetime budget constraint in terms of country n (home) currency:

$$p_n(0)c^n(0) + \sum_s q_n(s^1)p_n(s^1)c^n1(s^1)$$
$$\leq w^n(0) + \frac{p_n(0)y^n(0)}{1+r_n(0)} + \sum_s q_n(s^1)\frac{p_n(s^1)y^n(s^1)}{1+r_n(s^1)}. \quad (10)$$

Model

Fiscal-Monetary Authority

The flow budget constraints that the monetary-fiscal authority faces are

$$\frac{r_i(0)}{1+r_i(0)} M_i(0) + \sum_s q_i(s^1) W_i(s^1) = W_i(0), \tag{11}$$

$$\frac{r_i(s^1)}{1+r_i(s^1)} M_i(s^1) + \frac{1}{1+r_i(s^1)} W_i(s^2) = W_i(s^1), \tag{12}$$

where $M_i(0)$ and $M_i(s^1)$ are money supplies, $W_i(0)$, $W_i(s^1)$, $W_i(s^2)$ are the total domestic liabilities of the monetary-fiscal authority.

Model

Fiscal-Monetary Authority

We can obtain a single period budget constraint as:

$$\frac{r_i(0)}{1+r_i(0)} M_i(0) + \sum_s q_i(s^1) \frac{r_i(s^1)}{1+r_i(s^1)} M_i(s^1) = W_i(0) \qquad (13)$$

Model

Monetary Policy

Monetary policy sets nominal interest rates, $r_i(0) \geq 0$ and $r_i(s^1) \geq 0$

Model

Fiscal Policy

- We assume that fiscal policy is non-Ricardian
- We consider the simplest version of this which is to fix the initial liability of the monetary authority is the initial wealth of private agents
- This is 'outside money' or 'little m' in the terminology of Geanakoplos
- It is the fiscal transfers which are monetised
- This constitutes the present value of seignorage profits of the monetary authority

Equilibrium Conditions

Market Clearing

Since households are identical, the market clearing conditions are

$$\sum_{n \in N} c_i^n = y_i(0), \quad \sum_{n \in N} c_i^n(s^1) = y_i(s^1),$$
$$m_i^i(0) = M_i(0), \quad m_i^i(s^1) = M_i(s^1),$$
$$\sum_{n \in N} w_i^n(s^1) = W_i(s^1), \quad \sum_{n \in N} w_i^n(s^2) = W_i(s^2).$$

Also, consistency requires that

$$\sum_{n \in N} w_i^n(0) = W_i(0).$$

Equilibrium Conditions

No-Arbitrage

The no-arbitrage condition implies that the prices of elementary securities, $q_i(s^1)$, $s \in \mathcal{S}$, can be written as

$$q_i(s^1) = \frac{\mu_i(s^1)}{1 + r_i(0)}, \tag{14}$$

for some $\mu_i(s^1)$, $s \in \mathcal{S}$, satisfying

$$\sum_s \mu_i(s^1) = 1.$$

Equilibrium Conditions

No-Arbitrage

It follows that μ is viewed as a probability measure over $\mathcal{S}$, and called the *nominal equivalent martingale measure*. We shall see that there are no equilibrium conditions that determine μ, regardless of whether monetary policy sets interest rates or money supplies or if the currency board is active. A competitive equilibrium with interest rate policy is defined as follows:

Equilibrium Conditions

Definition of Equilibrium

Given initial nominal wealth, $\sum_{n \in N} w_i^n(0) = W_i(0)$ and interest rate policy, $\{r_i(0), r_i(s^1)\}$, a competitive equilibrium consists of an allocation, $\{c_0^n, c_1^n(s^1), y_0^n,\ y_1^n(s^1)\}$, a portfolio of households, $\{m_i^n, m_i^n(s^1), w_i^n(s^1), w_i^n(s^2)\}$, a portfolio of the monetary-fiscal authority, $\{M_i(0), M_i(s^1), W_i(s^1), W_i(s^2)\}$, $\{P_0, P_1(s^1)\}$, exchange rates, $\{e_{0ij}, e_{1ij}(s^1)\}$ and a nominal equivalent martingale measure, μ, $\forall i, j \in N$ and $s \in S$ such that

Equilibrium Conditions

Definition of Equilibrium

1. the monetary authority accommodates the money demand, $M_i(0) = m_i(0)$ and $M_i(s^1) = m_i(s^1)$;
2. given interest rates, $r_i(0)$, $r_i(s^1)$, spot-market prices, $P_i(0)$, $P_i(s^1)$, exchange rates. $e_{ij}(0)$, $e_{1ij}(s^1)$, and nominal equivalent martingale measure, μ_i, the household n of country i's problem is solved $\forall k \in N$ by $c_k^n(0)$, $c_k^n(s^1)$, $y^n(0)$, $y^n(s^1)$, $m_k^n(0)$, $m_k^n(s^1)$, $w_k^n(s^1)$, and $w_k^n(s^1)$;
3. all markets clear.

Traditional Monetary Policy and Credit Easing

Definition

Traditional Monetary Policy and Credit Easing is defined as an explicit target for the value, relative to other states, of the marketed wealth the monetary-fiscal authority carries into the subsequent period. Formally, $W_n(s^{t+1}|s^t) = \xi_{s_{t+1}|s^t} \sum_{s^{t+1}|s^t} W_n(s^{t+1}|s^t)$ where $\sum_{s^{t+1}|s^t} \xi_{s^{t+1}|s^t} = 1$ is chosen by the monetary-fiscal authority.

Traditional Monetary Policy and Credit Easing

Proposition

Given initial nominal wealth, $\lambda_n w_n^n(0) = W_n(0)$ and traditional monetary policy or credit easing under interest rate policy, $\{r_n(s^t)\}$, for all $n, k \in N$, the nominal equivalent martingale measure, $\mu_n(s^{t+1}|s^t)$, are determinate in each country.

Consequence of complete markets *and* the budget constraints of all monetary authorities binding individually. Otherwise, Dupor (2000)

Traditional Monetary Policy and Credit Easing

- Determinacy of allocation consequence of complete markets *and* the budget constraints of all monetary authorities binding individually. Otherwise, Dupor (2000)
- Given the allocation and initial price level, the stochastic path of prices can be determined recursively
- Given the initial money supply, the money supply at proceeding date-events is determined by the (i) the allocation and (ii) the value of the (existing) assets of the monetary authority portfolio
- Having a target value for the assets then pins down the liabilities (money supply) and hence price level

Quantitative Easing

Under the UK and Japanese conduct of Quantitative Easing, the monetary authority committed to purchase assets to a pre-sepcified total value, but not to a target composition of its portfolio, as contrasted with traditional monetary policy or Credit Easing.

Quantitative Easing

- The reason that μ is indeterminate is simple, and closely related to the well known fact that only relative prices are determined in equilibrium.
- Interest rate policy does two things: (i) it adds one restriction on the nominal state prices as shown in the no-arbitrage condition (4); (ii) it determines the relative prices of consumption goods and real balances: $r_n(0)/[1 + r_n(0)]$, $r_n(s^1)/[1 + r_n(s^1)]$, as shown in equation (10).
- The latter determines the equilibrium quantities of real money balances, but does not reduce the indeterminacy; the former determines the sum of the nominal state prices, $q_n(s^1)$, but their distribution, μ, remains indeterminate.

Quantitative Easing

- This is why in an stochastic economy with active monetary policy indeterminacy is characterized by μ.
- In an open economy, the indeterminacy proliferates for similar reasons. Even with perfect substitutes, as we have here, only the relative prices in countries are determined.
- As the absolute price level is indeterminate, then so is the exchange rate. Put differently, fixing the exchange rate fixes only the ratio of prices in countries but not price levels globally.

Risk Premia in a Monetary Open Economy

- The cash-in-advance constraints result in a positive demand for money and positive interest rates are a necessary condition such that the model exhibits nominal determinacy.
- However, this comes with a loss in efficiency by introducing a wedge between the marginal utilities of leisure and consumption.
- Here we study the risk premia associated with the correlation between interest rates and the martingale measure in an open economy.

Risk Premia in a Monetary Open Economy

We consider three alternative objectives.

1. The first is choosing a stable growth rate in inflation: we call this *inflation targeting*.
2. The second targets money supplies to grow in a non-stochastic manner, and is consistent with the Friedman k% rule. We call this *nominal GDP targeting*.
3. Finally we consider the result of the monetary-fiscal authority holding a portfolio composed of a nominally riskless bond. We call this *Financial Stability targeting*

Primitives

- There are two periods. In the second period uncertainty is resolved.
- Production and consumption occur in the first two periods.
- Continuous state space and continuous set of assets in each country.
- Two countries with a representative agent in each.
- In the second period, one country has constant interest rates, the other has 'some' distribution of interest rates.

Monetary Policy Options

- **Monetary stability (nominal GDP targeting)**: monetary policy that sets interest rates and money supplies in the second period which are *state independent*.
- **Price stability (inflation targeting)**: monetary policy that sets interest rates and prices in the second period which are *state independent*.
- **Financial Stability**: Central Bank purchases equal quantities of state-contingent bonds.

Monetary Policy and the Forward Interest Rate Premium

- A higher expected spot interest rate in one country reduces consumption and production globally in that state.
- The (stochastic) rate of inflation depends on the choice of nominal targets.
- **Monetary Stability** results in expected interest rates being negatively correlated to the price level and exchange rate. Negative nominal and positive real risk premium. Overall -.
- **Financial Stability** results in expected interest rates being negatively correlated to the price level and exchange rate. Negative nominal but positive real risk premium. Overall +.
- **Price Stability** results in expected interest rates being uncorrelated with the price level and exchange rate. No nominal but positive real risk premium. Overall +.

Monetary Policy and Forward Exchange Rate Premium

Proposition

Monetary Policy results in the Forward Exchange Rate being

1. *downwardly biased under Financial Stability,*
2. *unbiased under Price Stability,*
3. *downwardly biased under Monetary Stability.*

Monetary Policy and Forward Exchange Rate Premium

Interest rates in the two countries follow a bivariate log-normal distribution.

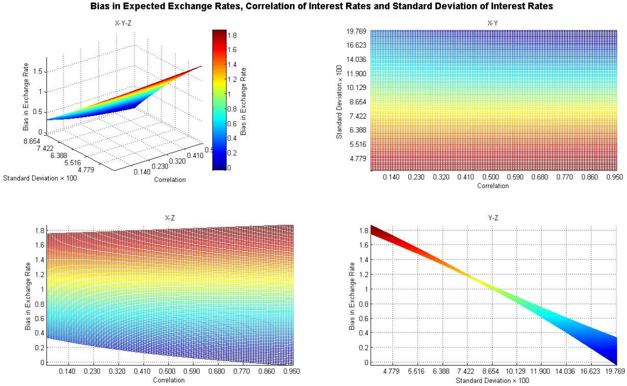

Figure : Log Difference between Objective and Risk Neutral Expected Exchange Rate

Monetary Policy and Forward Exchange Rate Premium

The (negative) size of the bias increases with both the correlation of the monetary policy and decreases with the standard deviation of each monetary policy. The higher the correlation, the lower the natural insurance opportunities avaialable to hedge the risk transmitted through monetary policy.