Exchange rate regimes in a Liquidity Trap

Very preliminary version, Please do not quote

Ibrahima Sangaré*

Abstract

We analyze whether or not it is relevant for a country to be in a Monetary Union rather than to keep its own currency in a Zero Lower Bound environment. We find that, under complete international asset markets and Producer Currency Pricing, the traditional ranking between the independent floating exchange rate regime and the monetary union regime is reversed when the nominal interest rate is constrained at zero. Indeed, the Monetary Union welfare-dominates at Zero Lower Bound. Additionally, we find that the independent floating exchange rate prolongs the duration of the liquidity trap compared to the monetary Union due to the perverse endogenous adjustment of exchange rate. We extend our analysis to more realistic assumptions of the incomplete international asset markets and the Local Currency Pricing. The findings appear broadly robust under these alternative assumptions.

Keywords: Monetary Union, DSGE, Floating, Zero Lower Bound.

JEL Classification: E52, F33, F34, F41

* LAREFI, University of Bordeaux, Avenue Léon Duguit, 33608 Pessac Cedex.
E-mail: ibrahima.sangare@u-bordeaux.fr

1. Introduction

One of the main features of recent crises, in developed counties (such as United State, the Euro Area, the United Kingdom and Japan), is that the central banks' policy interest rates are reduced to unprecedentedly low levels due to a large negative demand shock. In such a context where the nominal interest rates are constrained by the zero bound, the effectiveness of the monetary policy to simulate the economy or respond to shocks via its standard instrument is limited. This macroeconomic situation is known as a liquidity trap.

The recent literature proposes the exit strategies in a liquidity trap. The first and most popular strategy is the standard Keynesian prescription which is to use fiscal policy, in the form of tax cuts or government spending increases, in order to simulate the economy (Christiano et al. (2011), Eggertsson (2009), Farhi et al. (2013), Erceg and Lindé (2014), Cook and Devereux (2011)). This could be effective in a liquidity trap because of the lack of eviction effects through higher interest rates. Since the liquidity trap leads to a negative "natural" interest rate and low inflation rate, the second strategy proposed by the macroeconomic studies is the expansionary monetary policy by creating expectations of inflation through the price-level targeting (Eggertsson and Woodford (2003)) or exchange rate channel (Orphanides and Wieland (2000), Svensson (2001), Coenen and Wieland (2003, 2004)).

In particular, the exchange rate channel is presumed to be effective when the nominal interest rate is bounded at zero because of effects of the nominal and real depreciations on the demand. According to authors who have studied this important role of exchange rates in a liquidity trap, central banks should act on the exchange rate in order to generate its depreciation, exogenously regarding the shocks that push economies into a liquidity trap. The fact that the central bank would achieve a target of exchange rates could leads to a conflict with other policy objectives and the long term credibility problem of the monetary policy. Then, what is the endogenous path of exchange rate when a large negative demand shock occurs and drives the countries in the liquidity trap? The answer to this question is undoubtedly linked to the choice of exchange rate regimes. Otherwise, what is the best exchange rate regime at the Zero Lower Bound?

Recently, many commentators on the Euro crisis have indicated that the lack of independent monetary policy is the one of the biggest obstacles to a more rapid adjustment of southern countries of euro area following their debt crisis. In normal times, the merit of independent floating exchange rate is known to deal with country-specific shocks compared to a Monetary Union (See the theory of optimum currency area, Mundel (1961), Kenen (1969)). Is it the same case in a liquidity trap?

In this paper, we want to know theoretically whether or not it is relevant for a country to be in a Monetary Union rather than to keep its own currency in a zero lower bound environment.

Cook and Devereux (2013) were interested in the similar question in a very stylized two-country model, while we analyze it in a more realistic model with two countries and two sectors. Since the Cook and Devereux (2013)'s model is a standard New Open Economy Macroeconomics (NOEM) Model with Producer Currency Pricing and complete international asset markets, we start by comparing the two exchange rate regimes under these simplest assumptions and subsequently we extend our model by introducing the incomplete international asset markets and

Local Currency Pricing assumptions[1]. Unlike Cook and Devereux (2013), we do not assume the absence of predetermined state variables in the model and our framework allows the duration of the liquidity trap to be affected endogenously by the dynamic of exchange rate, thence by the choice of exchange rate regime. As these authors, we assume that the liquidity trap is caused by an adverse preference (or negative demand) shock sufficiently large to push one or both countries into liquidity trap (asymmetric or symmetric liquidity trap). We compare exchange rate regimes in normal times and in a symmetric liquidity trap (in an asymmetric liquidity trap, respectively) in order to derive the ranking between them. We conduct the welfare analysis to strengthen our results.

We find that, under complete asset markets and Producer Currency Pricing, the traditional ranking between the independent floating exchange rate regime and the monetary union regime is reversed when the nominal interest rate is constrained at zero, consistent with the results of Cook and Devereux (2013). Furthermore, we find that the independent floating exchange rate prolongs the duration of the liquidity trap compared to the monetary Union due to the perverse exchange rate adjustment. These findings are broadly consistent when the assumptions of incomplete asset markets and Local Currency Pricing are made.

The remainder of the article is organized as follows: Section 2 lays out the two-sector two-country general-equilibrium model. Section 3 presents the calibration and solution strategy of the model. The sections 4 and 5 analyze the results in normal times and in a symmetric (and asymmetric) liquidity trap, respectively. Section 6 gives the results of the extended model and the section 7 presents de welfare comparison. Section 8 concludes.

[1] These extensions are justified by some empirical findings in the literature. For example, Rabanal and Tuesta (2010), using data for the United-States and the Euro Area, find that a model with local currency pricing and incomplete markets make a good job in explaining the real exchange rate volatility and fits the dynamics of domestic variables well. The authors points out that the complete markets assumption could deliver a similar fit only when the structure of shocks is rich enough.

2. A two-sector two-country model

The world economy consists of two countries of equal size: Home (H) and Foreign (F). Each economy is populated by a continuum of unit mass households with infinite life, and produces non-tradable goods and tradable goods using sector-specific labor. Monopolistic competition and sticky prices are introduced in order to address issues of monetary policy.

Firstly, we consider a baseline model with the complete asset markets structure at the international level and where the law of one price holds at exports level (« Producer-Currency Pricing », *henceforth* PCP), which allows the perfect pass-through of exchange rate. Later, we extend the model to allow for the incomplete asset market structure at the international level and imperfect pass-through of exchange rate (LCP, for « Local-Currency Pricing »). These extensions are justified by some empirical findings in the literature. For example, Rabanal and Tuesta (2010), using data for the United-States and the Euro Area, find that a model with local currency pricing and incomplete markets make a good job in explaining the real exchange rate volatility and fits the dynamics of domestic variables well. The authors points out that the complete markets assumption could deliver a similar fit only when the structure of shocks is rich enough.

Since the general setup of the foreign country is similar and symmetrical to that for the Home country, this section presents the details of the model from the latter. Variables for the foreign country are denoted by an asterisk.

2.1. Households

The households derive utility from consumption (C_t) of tradable and non-tradable goods and disutility from hours worked (N_t).
The representative Home-household maximizes her following expected value of her lifetime:

$$\mho = E_t \sum_{t=0}^{\infty} \beta^t \{U_t(C_t, \mathcal{E}_t, N_t)\} \tag{1}$$

where $\mho$ is household's expected discounted sum of utilities, $U_t(C_t, \mathcal{E}_t, N_t)$ denotes her utility function and $\mathcal{E}_t$ represents a shock to preferences or a "demand" shock. A negative $\mathcal{E}_t$ shock implies that agents wish to postpone consumption over time, and will thus increase their desired savings. $\mathcal{E}_t$ follows a first-order autoregressive process :

$$\log(\mathcal{E}_t) = \rho_\varepsilon \log(\mathcal{E}_{t-1}) + e_{\varepsilon,t} \text{ , with } e_{\varepsilon,t} \sim i.i.d(0, \sigma^2_{e_\varepsilon});$$

The final consumption index is an aggregate of non-tradable ($C_{N,t}$) and tradable ($C_{T,t}$) goods with constant elasticity of substitution > 0 :

$$C_t = \left[\alpha^{\frac{1}{\upsilon}}\left(C_{T,t}\right)^{\frac{\upsilon-1}{\upsilon}} + (1-\alpha)^{\frac{1}{\upsilon}}\left(C_{N,t}\right)^{\frac{\upsilon-1}{\upsilon}}\right]^{\frac{\upsilon}{\upsilon-1}} \tag{2}$$

where $\alpha \in [0,1]$ is the share of tradable goods in total consumption.

The associated price index is given by:

$$P_t = \left[\alpha\left(P_{T,t}\right)^{1-\upsilon} + (1-\alpha)\left(P_{N,t}\right)^{1-\upsilon}\right]^{\frac{1}{1-\upsilon}} \quad (3)$$

The non-tradable consumption basket is made up of a continuum of differentiated varieties of goods $C_{N,t} \equiv \left(\int_0^1 C_{N,t}(j)^{\frac{\epsilon-1}{\epsilon}} d_j\right)^{\frac{\epsilon}{\epsilon-1}}$ with the corresponding price $P_{N,t} = \left(\int_0^1 P_{N,t}(j)^{1-\epsilon} d_j\right)^{\frac{1}{1-\epsilon}}$ and $\epsilon > 1$, the elasticity of substitution between varieties.

The tradable consumption good is a composite of home ($C_{H,t}$) and foreign ($C_{F,t}$) tradable goods, with κ as the constant elasticity of substitution:

$$C_{T,t} = \left[\omega^{\frac{1}{\kappa}}\left(C_{H,t}\right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}}\left(C_{F,t}\right)^{\frac{\kappa-1}{\kappa}}\right]^{\frac{\kappa}{\kappa-1}} \quad (4)$$

where ω is the share of tradable goods produced in the Home country. The corresponding price index is

$$P_{T,t} = \left[\omega\left(P_{H,t}\right)^{1-\kappa} + (1-\omega)\left(P_{F,t}\right)^{1-\kappa}\right]^{\frac{1}{1-\kappa}} \quad (5)$$

where ($P_{F,t}$) is the price of the foreign tradable consumption good and ($P_{H,t}$) denotes the price of the domestic tradable good.
The baskets of home ($C_{H,t}$) and foreign ($C_{F,t}$) tradable goods and their associated prices ($P_{H,t}$ and $P_{F,t}$) are defined from the similar manner of the differentiated varieties aggregation that for the case of the non-tradable basket. Therefore, the elasticity of substitution between varieties,ϵ, is identical across sectors.
By the expenditure minimization problem, the following optimal demands for different goods yield:

$$C_{N,t} = (1-\alpha)\left(\frac{P_{N,t}}{P_t}\right)^{-\upsilon} C_t \quad (6)$$

$$C_{T,t} = \alpha\left(\frac{P_{T,t}}{P_t}\right)^{-\upsilon} C_t \quad (7)$$

$$C_{H,t} = \omega\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\kappa} C_{T,t} \quad (8)$$

$$C_{F,t} = (1-\omega)\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\kappa} C_{T,t} \quad (9)$$

The household faces the following period-by-period budget constraint:

$$P_t C_t + E_t Q_{t+1} B_{t+1} = W_t N_t + B_t + \Delta_t \quad (10)$$

where W_t denote household's nominal wage, Δ_t are profits rebated equally to the households by firms, $B_{t+1}$is a portfolio of state-contingent securities ensuring complete financial markets, as in Chari et al. (2002), with Q_{t+1} the corresponding stochastic discount factor between dates t and

$t+1$. Traditionally, the complete market environment ensures that agents have access to state contingent securities that allow them to optimally share risk across countries.

The solution to the household problem implies the following optimality conditions:

$$\frac{-U_{N,t}(C_t,\mathcal{E}_t,N_t)}{U_{C,t}(C_t,\mathcal{E}_t,N_t)}=\frac{W_t}{P_t} \qquad (11)$$

$$U_{C,t}(C_t,\mathcal{E}_t,N_t)=E_t(1+i_t)\frac{P_t}{P_{t+1}}U_{C,t+1}(C_{t+1},\mathcal{E}_{t+1},N_{t+1}) \qquad (12)$$

where $(1+i_t)^{-1}=E_t(Q_{t+1})$ is the price of the portfolio.

Under ***complete markets assumption*** (perfect capital mobility), the optimal risk sharing implies:

$$\frac{U^*_{C,t}(C^*_t,\mathcal{E}^*_t,N^*_t)}{U_{C,t}(C_t,\mathcal{E}_t,N_t)}=\frac{S_tP^*_t}{P_t} \qquad (13)$$

S_t is the nominal exchange rate expressed as units of domestic currency per one unit of foreign currency and $\frac{S_tP^*_t}{P_t}\equiv RR_t$ is the real exchange rate.

The relation (13) states that the relative consumption across countries is proportional to real exchange rate and predicts a positive high cross-correlation between the real exchange rate and the relative consumptions. In our model, the presence of non-traded goods prevents full risk-sharing across countries, even if the law of one price holds (Salaive and Tuesta (2003)). Furthermore, the shock to preferences in order to generate the ZLB breaks the strong link between real exchange rate and relative consumption (see Benigno (2009)).
Foreign household preferences and choices can be defined symmetrically.

2.2. Open economy expressions

Let us define the terms of trade (T_t) and the relative price of traded goods (Q_t) as, respectively: $T_t=\frac{P_{F,t}}{P_{H,t}}$ and $Q_t=\frac{P_{T,t}}{P_{N,t}}$.

Given the definition for the terms of trade, the relative price of traded goods, (3) and (5), the following equation holds:

$$\frac{P_{T,t}}{P_{H,t}}= [\omega+(1-\omega)(T_t)^{1-\kappa}]^{\frac{1}{1-\kappa}} \equiv f(T_t) \qquad (14)$$

$$\frac{P_t}{P_{N,t}}= [\alpha(Q_t)^{1-\upsilon}+(1-\alpha)]^{\frac{1}{1-\upsilon}} \equiv f(Q_t) \qquad (15)$$

Finally, we can relate the real exchange rate to the terms of trade and the relative price of traded goods as follows:

$$RR_t=\frac{f^*(Q^*_t)Q_tf^*(T^*_t)T_t}{Q^*_tf(Q_t)f(T_t)} \qquad (16)$$

2.3. Firms and Price Setting

In each country, we assume that the production occurs in two sectors: tradable and non-tradable. In this section, the two sectors in domestic economy are indexed by $i \in \{H, N\}$.
In both sectors, a continuum of monopolistically competitive firms of measure unity, indexed by j, produces output $Y_{i,t}(j)$ using the technology:

$$Y_{i,t}(j) = A_{i,t}N_{i,t}(j) \tag{17}$$

where $A_{i,t}$ is a technological shock that is common to all firms and follows a stationary first-order autoregressive process : $\log(A_{i,t}) = \rho_A \log(A_{i,t-1}) + e_{A,t}$, with $e_{A,t} \sim i.i.d(0, \sigma^2_{e_A})$;
Cost minimization by firms implies that the real marginal cost of production in each sector (i) is:

$$mc_{i,t} = \frac{W_t}{A_{i,t}P_{i,t}} \tag{18}$$

Following Calvo (1983), we assume that firms set nominal prices on a staggered basis: at each period, a fraction $(1-\phi^i)$ of firms are randomly selected to set new prices while the remaining fraction $\phi^i \in [0,1]$ of firms keep their prices unchanged.
The optimal price setting problem for a firm (j) of the sector (i) that is able to reset its price at time t is:

$$\max_{P^n_{i,t}(j)} E_t \left\{ \sum_{s=0}^{\infty} (\phi^i)^s \Lambda_{t,t+s} \left[\frac{P^n_{i,t}(j)}{P_{i,t+s}} \left(\frac{P^n_{i,t}(j)}{P_{i,t+s}} \right)^{-\epsilon} Y_{i,t+s} - mc_{i,t+s} \left(\frac{P^n_{i,t}(j)}{P_{i,t+s}} \right)^{-\epsilon} Y_{i,t+s} \right] \right\} \tag{19}$$

where $\Lambda_{t,t+s} = \beta^s \frac{U_{C,t+s}(C_{t+s}, \mathcal{E}_{t+s}, N_{t+s})}{U_{C,t}(C_t, \mathcal{E}_t, N_t)}$ is the discount factor for future real profits.

The first order condition implies:

$$P^n_{i,t}(j) = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{s=0}^{\infty} (\beta\phi^i)^s U_{C,t+1}(C_{t+s}, \mathcal{E}_{t+s}, N_{t+s}) Y_{i,t+s} P^{\epsilon}_{i,t+s} mc_{i,t+s}}{\sum_{s=0}^{\infty} (\beta\phi^i)^s U_{C,t+1}(C_{t+s}, \mathcal{E}_{t+s}, N_{t+s}) Y_{i,t+s} P^{\epsilon-1}_{i,t+s}} \tag{20}$$

Given the Calvo-type setup, the aggregate domestic sectorial price index evolves according to the following law of motion,

$$P^{1-\epsilon}_{i,t} = (1-\phi^i)(P^n_{i,t})^{1-\epsilon} + \phi^i P^{1-\epsilon}_{i,t-1} \tag{21}$$

The foreign economy has an analogous price setting mechanism.
Since the assumption that prices are set in the producer currency for exports and that the international law of one price holds for the tradable goods in this baseline model, the prices of home goods sold abroad and those of foreign goods sold in home country are given, respectively, by:

$P^*_{H,t} = P_{H,t}/S_t$ and $P_{F,t} = S_t P^*_{F,t}$.

2.4. Monetary policy Rules

The monetary authority sets the short term nominal interest rate by reacting to endogenous variables (active monetary policy), except when the zero bound constraint is active. Following Monacelli (2004), Faia (2010), Cook and Devereux (2013) and Born *et al*. (2013), each exchange rate regime will be identified with a differentiated specification of the monetary policy rule. We present here the policy rules with the zero bound constraint.

Independent pure Floating

Under this regime with separate currencies, the monetary authority of each country sets its own interest rate, which follows a Taylor rule truncated at zero,

$$i_t = \max(Z_t, 0) \tag{22}$$

where

$$Z_t = \frac{1}{\beta}\left(\frac{\Pi_t}{\Pi}\right)^{\varphi_1} - 1 \tag{23}$$

with $\varphi_1 > 1$ is the reaction coefficients on gross inflation ($\Pi_t = P_t/P_{t-1}$) and Π is the steady-state value of Π_t.

Monetary Union

Under this regime with a single currency, the common central bank sets the nominal interest rate according to the following Taylor-type interest rate rule truncated at zero,

$$i_t = \max(Z_t^{mu}, 0) \tag{24}$$

where,

$$Z_t^{mu} = \frac{1}{\beta}\left(\frac{\Pi_t^{mu}}{\Pi^{mu}}\right)^{\varphi_1} - 1 \tag{25}$$

with $\Pi_t^{mu} = (\Pi_t)^{0.5}(\Pi_t^*)^{0.5}$ is the gross inflation rate in the currency union, Π^{mu} its steady state's value.

2.5. Market Clearing

The aggregate goods market clearing in the tradable and non-tradable sectors satisfies,

$$Y_{H,t} = C_{H,t} + C_{H,t}^* \tag{26}$$

$$Y_{N,t} = C_{N,t} \tag{27}$$

where $C_{H,t}^* = \alpha(1-\omega)\left(\frac{P_{H,t}^*}{P_{T,t}^*}\right)^{-\kappa}\left(\frac{P_{T,t}^*}{P_t^*}\right)^{-\upsilon} C_t^*$ denotes total exports to foreign country.

The aggregate labor market clearing requires,

$$N_t = N_{H,t} + N_{N,t} \tag{28}$$

The foreign market clearing conditions are symmetrical.

3. Calibration

The calibration of the model is summarized in Table 1 below. A period in the model corresponds to one quarter. We use the piecewise-linear method developed by Guerrieri and Iacoviello (2015) to solve the model with ZLB. We assume that the two countries are calibrated in a symmetric fashion, except in the magnitude of preference shocks that we set voluntary different across countries in order to analyse the relative dynamics of variables. The preference shock is calibrated sufficiently large in order to generate the liquidity trap and in asymmetric way between domestic country and foreign country. This asymmetry allows us to focus only on the analysis of effects of the shock on the domestic economy, which move relatively to the foreign economy dynamic. Therefore, the dynamics of domestic variables are considered as effects of a relative demand shock (Country-specific shock). Following Monacelli (2004), Eggertsson et al. (2014), we employ the utility function:

$$U_t(C_t, \mathcal{E}_t, N_t) = \mathcal{E}_t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\eta}}{1+\eta} \right] \tag{29}$$

We calibrate the parameters by following the literature.

Table 1: Calibration

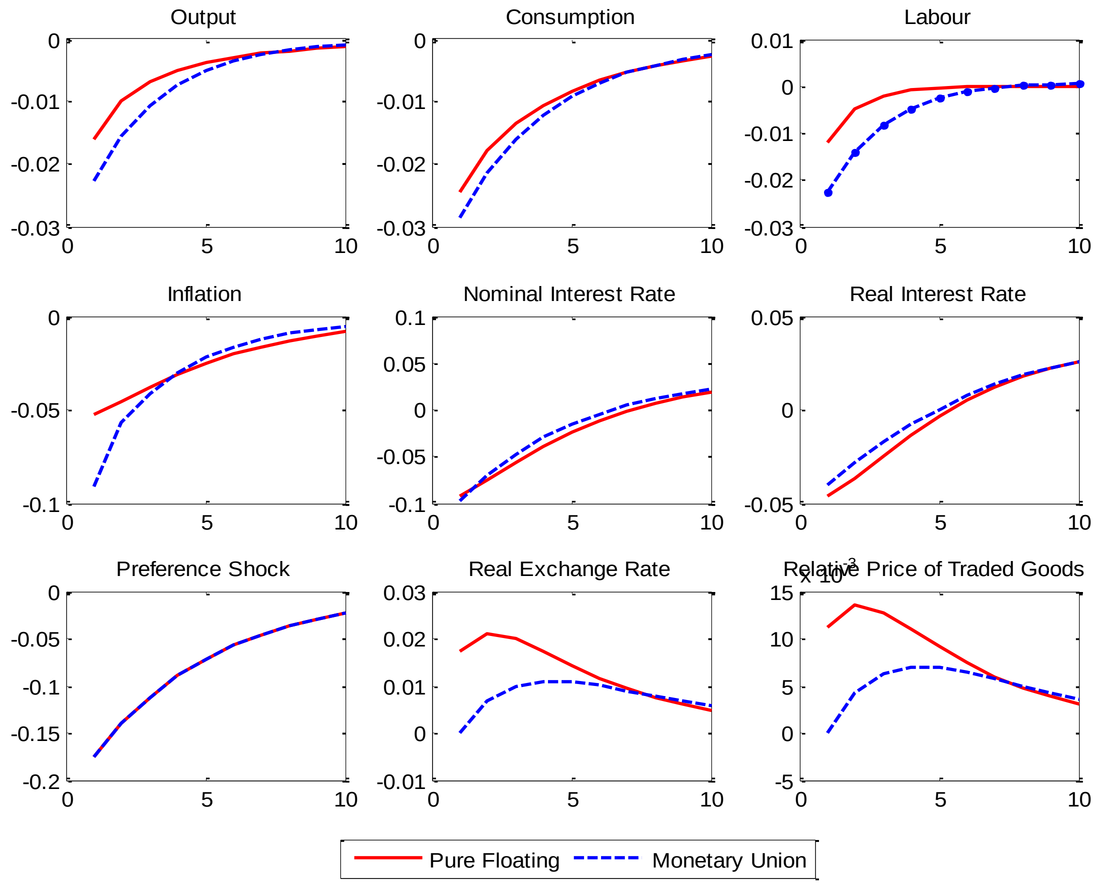
Description	Parameter	Value	References
Subjective discount factor	β	0.99	Standard in the literature
Inverse of the Frisch elasticity of labour supply	η	1	Cook and Devereux (2013)
Inverse intertemporal elasticity of substitution in consumption	σ	2	Cook and Devereux (2013)
Share of Home-traded goods	ω	0.57	Eggertsson et al. (2014)
Share of non-traded goods	$1-\alpha$	0.62	Eggertsson et al. (2014)
Elasticity of substitution between Traded and non-traded goods	υ	0.5	Mendoza (1991)
Elasticity of substitution between Home and Foreign-traded goods	κ	1.5	Backus et al. (1994)
Calvo Probability	ϕ^i	0.75	Consistent with 4 quarters between price adjustments
Elasticity of substitution among differentiated goods in each sector	ϵ	7	Farhi and al. (2013)
Smoothing coefficient in the monetary rule	ρ_r	0.8	Faia (2010)
Inflation stabilizing coefficient in the monetary rule	φ_1	1.5	Faia (2010)
Autocorrelation of preference shock	ρ_ε	0.8	Cook and Devereux (2011)
Autocorrelation of technology shock in each sector	ρ_A	0.8	Standard in the literature
Standard deviation of the preference shock in Country H	σ_ε	0.875	Cook and Devereux (2013)
Standard deviation of the preference shock in Country F	σ_ε^*	0.5	Consistent with the asymmetry in shocks

4. Exchange rate regimes in Normal Times

Figure 1 displays the dynamics of the main domestic variables in response to a (relative) negative demand shock under the two monetary regimes (Monetary Union and Independent Pure Floating), when the zero lower bound constraint is not active.

This shock induces a decrease in both inflation and output. Under both regimes, the central bank revises downwardly the nominal interest rates for stabilizing the inflation. As consequence, the nominal exchange rate depreciates under independent floating regime and this leads to real exchange rate depreciation. But under Monetary union regime, there is not the nominal exchange rate, the real exchange rate depreciation come from the relative (gradual) fall in domestic prices. Finally, the difference between both regimes in terms of responses of all variables comes from the nominal exchange rate depreciation that mitigates the adverse effects of the shock under the Independent Pure floating regime. This latter has a stabilization power superior to that of the Monetary Union facing country-specific shocks in normal times. The traditional ranking between both regimes works well here.

Figure 1: Effects of a (relative) negative demand shock in normal times



Notes: Time, measured in quarters, is on the horizontal axis. All variables are measured in log deviations from steady state, except the nominal interest rate, the real interest rate and inflation which are measured in annualized levels.

5. Exchange rate regimes at the Zero Lower Bound

Now, considers that the zero lower bound constraint is active and the shock is enough large to stick both countries in a liquidity trap (symmetric liquidity trap). Under the two monetary regimes, the dynamics of the domestic country variables in response to a (relative) negative fall in preferences are depicted in Figure 2.

The mechanisms are as follow: the negative preference (demand) shock is characterized by the reduction of households' consumption. As consequence, the inflation falls. Because, the nominal interest rate is bonded at zero, falling inflation means a higher real interest rate. The longer the interest rate is bonded, the more inflation initially falls, and the more the real interest rate goes up. This higher real interest rate works to choke off demand, by reducing output and hours worked. The output, consumption and the labor are superior under Monetary Union compared to the independent floating exchange rate.

Three notable results emerge here compared to the previous results.

Firstly, the standard ranking between both exchange rate regimes is reversed because of the real exchange rate appreciation under independent floating regime. Indeed, the current exchange rate depends on the expected future price level in liquidity trap. The agents expects a low inflation rate in medium-long term due to the monetary policy rule that must sharply react to the potential future inflation (when ZLB constraint is expired), which would come from the path of the Purchasing Power Parity (PPP)'s inflation. This expectation translates into a lower current consumption, which lead to the currency appreciation through the risk sharing condition under flexible regime. However, under the Monetary Union, the real exchange rate depreciates and its relative dynamic is independent to policy rule; it depends on the response of firms' marginal costs and gradual price adjustments. The long-run PPP requires the increase in domestic inflation so that to compensate the initial fall. Indeed, in short run domestic firms responds to the lack of demand consecutive to shock by reducing prices, which make them competitive relatively in the world market. As demand progressively reverts to its initial level, firms need to raise their prices by re-optimizing them. Since the policy rule does not react only to domestic inflation, expectations of future inflation remain high in Home country. Therefore, the current terms of trade and real exchange rate depreciate. These intuitions work also in an environment without ZLB as developed by Corsetti and al. (2010). The fact that exchange rate follows divergent paths is an important distinction between the Monetary Union and Independent floating at the Zero lower bound. In order to understand this result, let to take the linearized version of the Home household's Euler equation in (12) by using the utility function defined in (29), put it in the linearized version of the risk sharing condition (13) and solve forward. One obtains the following expression of the current real exchange rate (by supposing the shock is temporary: $\lim_{l\to\infty} C_{t+l} = C^*_{t+l} = 0$), which is simply the uncovered interest rate parity (UIP):

$$RR_t = E_t \sum_{l=0}^{\infty} (i^*_{t+l} - \Pi^*_{t+1+l}) - E_t \sum_{l=0}^{\infty} (i_{t+l} - \Pi_{t+1+l}) \tag{30}$$

With the economy expected to be at ZLB for T periods and outside ZLB (with an aggressive inflation Taylor rule) for $T + 1$, the equation (30) becomes :

$$RR_t = E_t \sum_{l=0}^{T} (0 - \Pi^*_{t+1+l}) + E_t \sum_{l=T+1}^{\infty} (i^*_{t+l} - \Pi^*_{t+1+l}) - E_t \sum_{l=0}^{T} (0 - \Pi_{t+1+l}) - E_t \sum_{l=T+1}^{\infty} (i_{t+l} - \Pi_{t+1+l}) \quad (31)$$

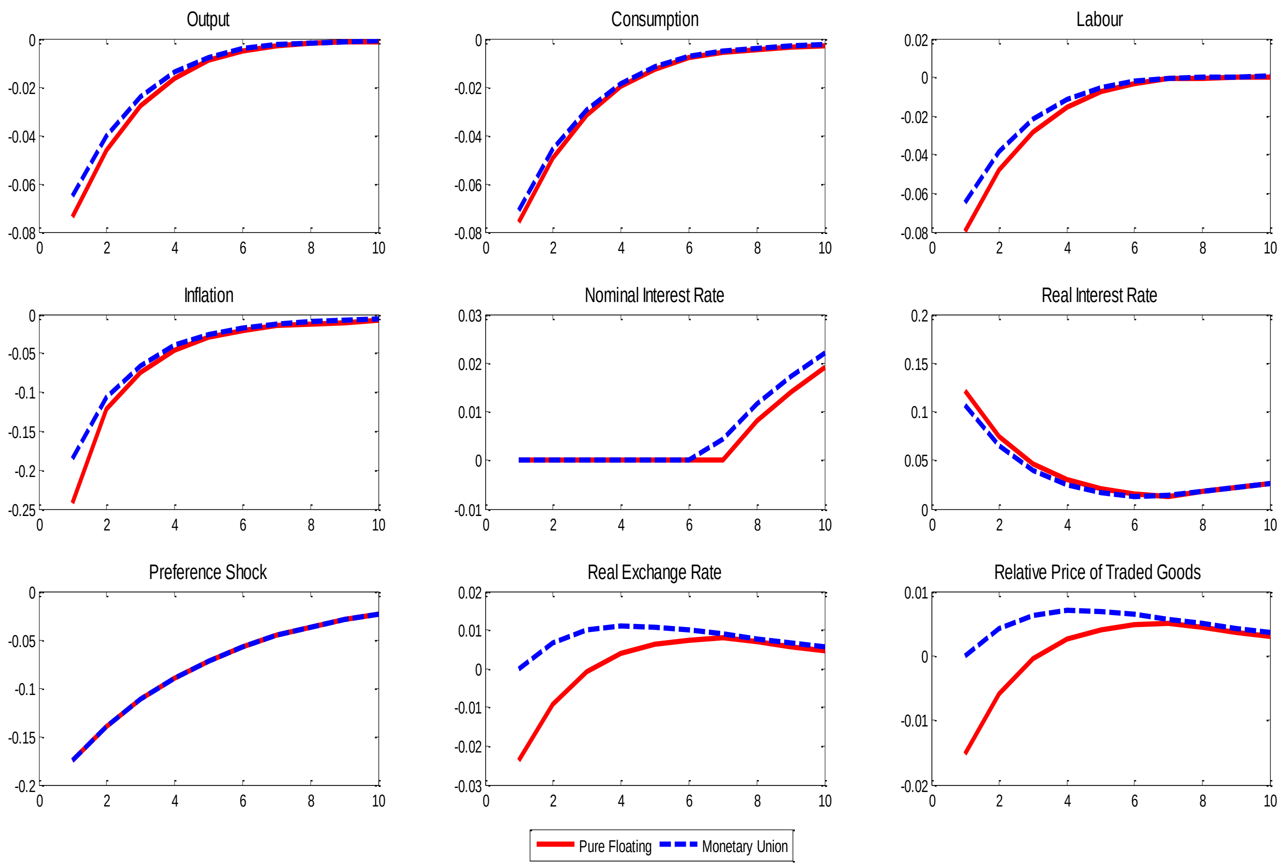
This equation allows us to inspect the mechanism that lead to the currency appreciation under independent floating regime contrary to the Monetary Union when the ZLB is binding. Under independent regime, the shock induces a fall in both short and long runs relative inflation. Indeed, because of the price level must to satisfy the PPP condition in long run, the future inflation need to augment. But the expected monetary policy with Taylor rule, which react aggressively to inflation (2.5), allows anticipating a low inflation in the future, so that $E_t \sum_{l=0}^{T}(0 - \Pi_{t+1+l}) > 0$ and $E_t \sum_{l=T+1}^{\infty}(i_{t+l} - \Pi_{t+1+l}) > 0$. The future inflation for the foreign country must diminish in order to attain the PPP level, therefore the foreign expected inflation is high, such as $E_t \sum_{l=0}^{T}(0 - \Pi^*_{t+1+l}) < 0$ and $E_t \sum_{l=T+1}^{\infty}(i^*_{t+l} - \Pi^*_{t+1+l}) < 0$. As consequence, the current domestic nominal and real exchange rates appreciate. In contrast, under Monetary Union the future policy rule is not sensitive to future home relative inflation because there is an opposite force (foreign inflation) in the targeting rule. Then, the PPP path imposes the increase in future domestic inflation rate and decrease in future foreign inflation, such that $E_t \sum_{l=0}^{T}(0 - \Pi_{t+1+l}) < 0$, $E_t \sum_{l=T+1}^{\infty}(i_{t+l} - \Pi_{t+1+l}) < 0$, $E_t \sum_{l=0}^{T}(0 - \Pi^*_{t+1+l}) > 0$ and $E_t \sum_{l=T+1}^{\infty}(i^*_{t+l} - \Pi^*_{t+1+l}) > 0$. That leads to domestic exchange rate depreciation.

The second notable result is that the duration of the zero lower bound is more prolonged under the independent floating than under the Monetary Union. This is a direct consequence of the first result. The endogenous duration of the ZLB depends on endogenous the path of exchange rate in our model. As we have seen, the high expected inflation, by reducing the long real interest rate, allows to escaping from the ZLB constraint. The exchange rate depreciation serves to create the expected future inflation as recommended by Svensson (2001, 2003). Accordingly, the duration of the liquidity trap is shorter under Monetary Union compared to the Independent floating regime in our model.

Thirdly, the impacts of a negative demand shock are greater at zero lower bound than in the normal times.

Finally, these results suggest that Monetary Union, by achieving risk sharing among countries, is preferable in the liquidity trap.

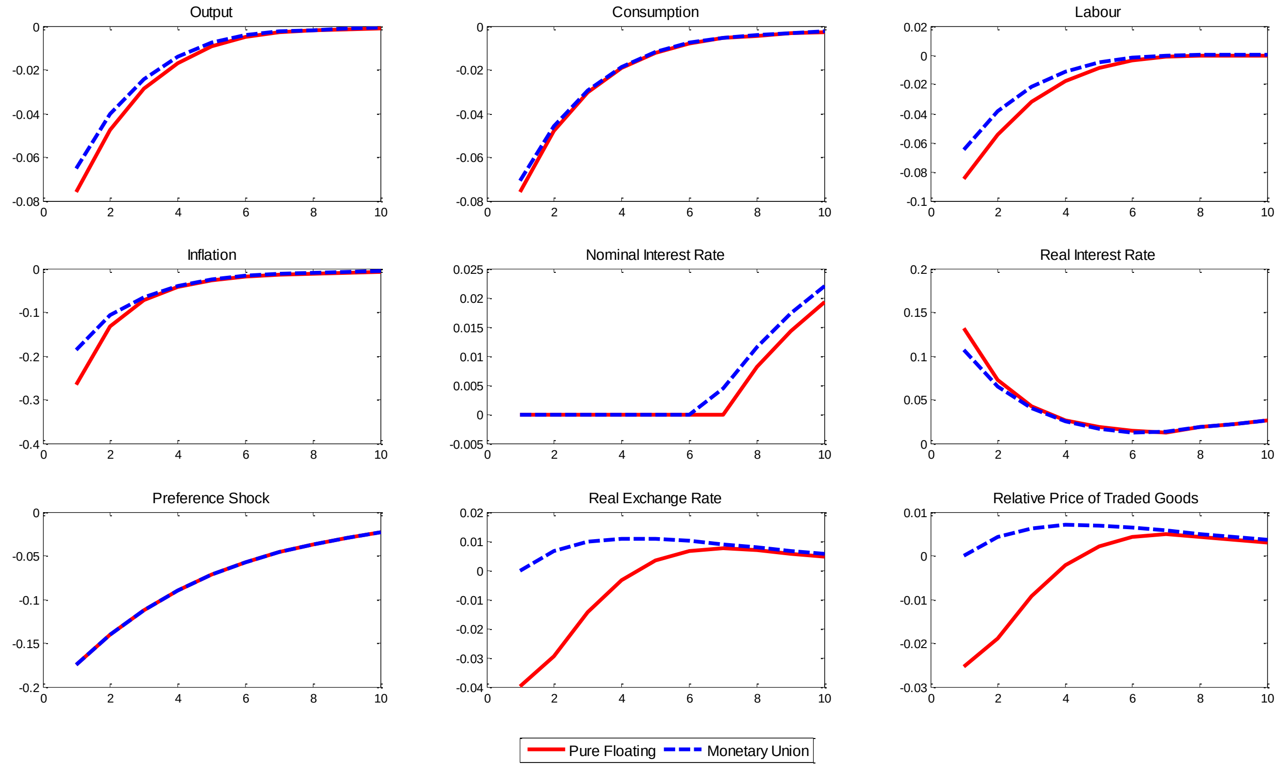
Figure 2: Effects of a (relative) negative demand shock in a symmetric liquidity trap



Notes: Time, measured in quarters, is on the horizontal axis. All variables are measured in log deviations from steady state, except the nominal interest rate, the real interest rate and inflation which are measured in annualized levels.

Furthermore considers an asymmetric zero lower bound constraint defined by the fact that the Home country is constrained by the zero bound, but the foreign country operates freely under a Taylor rule. The Figure 3 displays the dynamics of the main variables in response to a (relative) negative demand shock under the two monetary regimes (Monetary Union and Independent Pure Floating). The previous results concerning the symmetric Zero Lower Bound have not changed qualitatively. The independent flexibility leads to a currency appreciation whereas the single currency union allows the depreciation of exchange rate and the reduction of the ZLB duration.

Figure 3: Effects of a (relative) negative demand shock in an asymmetric liquidity trap



Notes: Time, measured in quarters, is on the horizontal axis. All variables are measured in log deviations from steady state, except the nominal interest rate, the real interest rate and inflation which are measured in annualized levels.

6. Robustness and Extensions

So far, we have presented our analysis under the assumptions of complete financial markets and producer currency pricing (PCP). We now would explore the framework to which our results are sensitive to an alternative structure of financial markets and another mode of firms pricing, using only incomplete markets and both incomplete market and local currency pricing. We further check the model robustness by varying some key parameter values in order to underscore their potential role in explaining our results.

6.1.Incomplete market

The uncomfortable implications of the assumption of international complete markets (perfect international mobility of capital) and the empirical evidences (which clearly show the lack of consumption risk-sharing across countries)[2] force us to introduce the international incomplete markets structure. We opt for a simple and tractable way. We assume that the Home households can trade two nominal risk-less bonds denominated in the domestic and foreign currency. The bonds are issued by households in both countries in order to finance their consumption. Following Benigno and Thoenissen (2008), it is assumed that home currency-denominated bonds

[2] See for example Rabanal and Tuesta (2010).

are only traded domestically, such as foreign households allocate their wealth only in bonds denominated in the foreign currency[3]. Home households face a cost (i.e. transaction cost) of undertaking positions in the foreign bonds market. This cost is proportional to the Net Foreign Asset (NFA) position of the home economy as in Benigno (2009). Accordingly, the Home household's budget constraint can be written as:

$$P_t C_t + \frac{B_t}{(1+i_t)} + \frac{S_t B_t^*}{(1+i_t^*)\Gamma_t\left(\frac{S_t B_t^*}{P_t}\right)} = W_t N_t + S_t B_{t-1} + B_{t-1}^* + \Delta_t \qquad (32)$$

where W_t denote household's nominal wage and Δ_t are profits rebated equally to the households by firms. B_t and B_t^* are the individual's holdings of domestic and foreign nominal risk-less bonds denominated in the local currency, i_t and i_t^* are the corresponding interest rates, S_t denote the nominal exchange rate defined as before. The function $\Gamma_t(\frac{S_t B_t^*}{P_t})$ captures the cost of international borrowings. This spread is increasing in the aggregate level of foreign debt ($\Gamma_t\left(\frac{S_t B_t^*}{P_t}\right) \equiv \exp\left(-\gamma(\frac{S_t B_t^*}{P_t})\right)$ with $\Gamma_t'(.) < 0$) and is equal to zero when the net foreign asset position is at its steady-state level ($\Gamma_t(0) = 1$)[4]. The deviation from uncovered interest rate parity (UIP) is introduced by this cost.

Given this market structure, the following optimal risk sharing condition holds:

$$E_t\left(\frac{U_{C,t+1}^*(C_{t+1}^*, \mathcal{E}_{t+1}^*, N_{t+1}^*)}{U_{C,t}^*(C_t^*, \mathcal{E}_t^*, N_t^*)}\frac{P_t^*}{P_{t+1}^*}\right) = E_t\left(\frac{U_{C,t+1}(C_{t+1}, \mathcal{E}_{t+1}, N_{t+1})}{U_{C,t}(C_t, \mathcal{E}_t, N_t)}\frac{P_t}{P_{t+1}}\frac{S_{t+1}}{S_t}\Gamma_t\left(\frac{S_t B_t^*}{P_t}\right)\right) \qquad (33)$$

This relation is the equivalent of (13) and is the basis of the real exchange rate determination under incomplete markets. Now, the risk-sharing condition holds in expected variation terms and is affected by the Net Foreign Asset position because of bond-holding cost. It is simply a version of the uncovered interest rate parity (UIP) with international imperfect mobility of capital. Consequently, under incomplete markets assumption the dynamic of the real exchange rate depends, among other things, on the Net Foreign Asset Position (surplus or deficit of the current account).

By combining Home household's budget constraint and goods markets equilibrium conditions[5], one can obtains the following law of motion of the internationally traded bonds (NFA), which states that the flow of external debt must equate net exports:

$$\frac{S_t B_t^*}{(1+i_t^*)\Gamma_t\left(\frac{S_t B_t^*}{P_t}\right)P_t} = \frac{S_t B_{t-1}^*}{P_t} + \frac{P_{H,t}^*}{P_t}C_{H,t}^* - \frac{P_{F,t}}{P_t}C_{F,t} \qquad (34)$$

The equivalent expression of (30) under Incomplete markets assumption is given by:

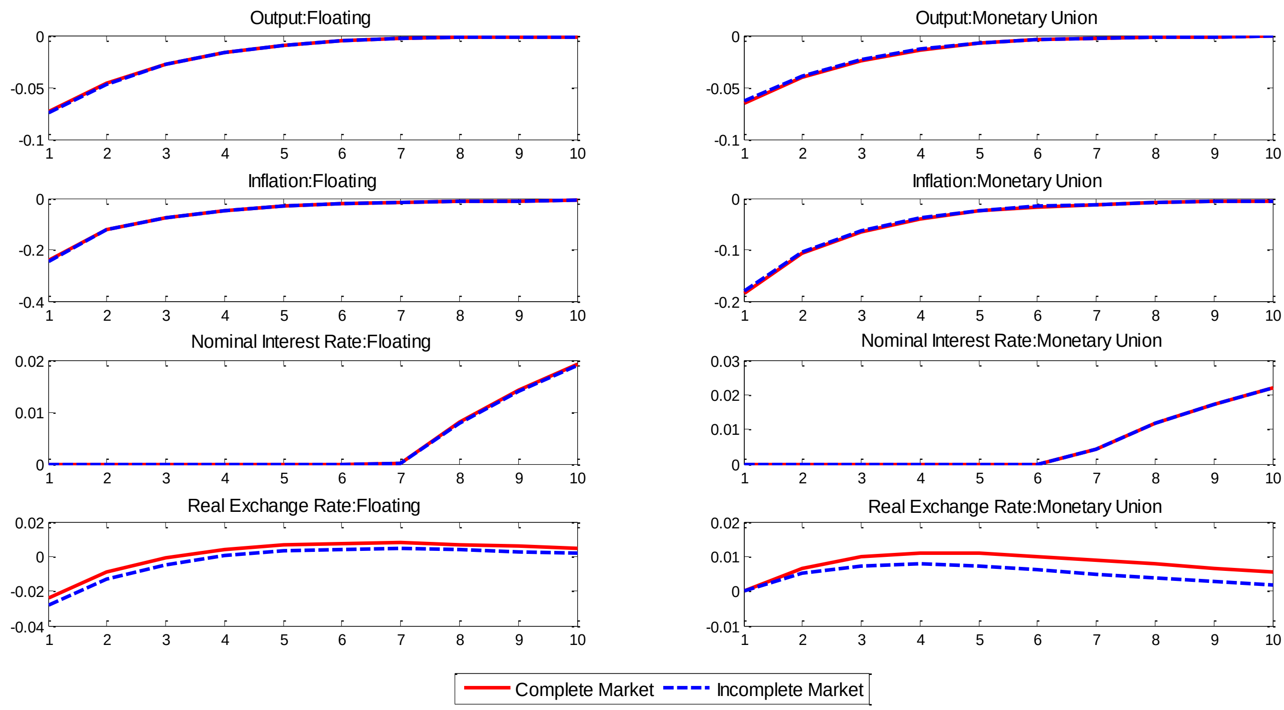
[3] This asymmetry in the financial market structure is made for simplicity. The results would not change if we allow home bonds to be traded internationally. We just would need to add an additional arbitrage condition.
[4] As discussed in Schmitt-Grohé and Uribe (2003), introducing the transaction cost $\Gamma_t(.)$ has a technical advantage to deal with a non stationarity problem in the open economy models.
[5] Since households in the domestic economy are identical, the domestic bonds market is in zero net supply.

$$RR_t = E_t \sum_{l=0}^{\infty} (i^*_{t+l} - \Pi^*_{t+1+l}) - E_t \sum_{l=0}^{\infty} (i_{t+l} - \Pi_{t+1+l}) - \gamma E_t \sum_{l=0}^{\infty} b^*_{t+l} \tag{35}$$

where $b^*_t = S_t B^*_t / P_t$.

The figure 4 contrasts the results under Complete and Incomplete markets when ZLB is active for both the Independent Floating regime and the Monetary Union regime. The results are identical qualitatively for the two market structures. The currency depreciation/appreciation (depending on the regimes) is lower with incomplete markets than complete markets, corresponding to the different dynamics of long-term real interest rates (if risk is not shared completely, one does not need higher movements in terms of trade or exchange rate)[6]. From a quantitative side, however, differences in the responses of output, consumption and interest rate are very low[7].

Figure 4: Effects of a (relative) negative demand shock under Complete and Incomplete Markets



Notes: Time, measured in quarters, is on the horizontal axis. All variables are measured in log deviations from steady state, except the nominal interest rate and inflation which are measured in annualized levels.

[6] See Benigno and Thoenissen (2008) for more details.

[7] This result is consistent with the literature without ZLB constraint, which finds that the allocation under incomplete financial markets is quite close to the allocation under complete markets, unless the trade price elasticity is substantially different from one on either side and, for the case of a high elasticity, shocks are persistent or follow a diffusion process (see Corsetti et al. 2008).

6.2. Local Currency Pricing

In the previous sections, we assumed the complete pass-through of exchange rate to imports prices (PCP). This assumption is inconsistent with several empirical evidences that underscore a rather low degree of pass-through from exchange rates to import prices[8]. Now, we take into account this possibility, by supposing that each producer of traded good price discriminates between home and foreign markets[9]. The firms are assumed to be monopolistically competitive and set its price in the destination market currency rather than its own currency (Price-to-Market). This assumption allows generating deviations from the law of one price (such as $P_{H,t} \neq S_t P^*_{H,t}$ and $P_{F,t} \neq S_t P^*_{F,t}$) and therefore the low degree of exchange rate pass-through. $P_{H,t}$ and $P^*_{H,t}$ denote the prices charged by home traded goods firm in home market (in domestic currency) and foreign market (in foreign currency), respectively. As before, a given domestic firm may optimally reset its prices with probability $(1-\phi^H)$ each period. When the firm (j) resets its price, it will be able to reset its prices for sales in both markets, so to solve the following problem:

$$\max_{P^n_{H,t}(j),P^{*n}_{H,t}(j)} E_t \left\{ \sum_{s=0}^{\infty} (\phi^i)^s \Lambda_{t,t+s} \left[\frac{P^n_{H,t}(j)}{P_{H,t+s}} C_{H,t+s}(j) + \frac{S_t P^{*n}_{H,t}(j)}{P_{H,t+s}} C^*_{H,t+s}(j) - mc_{H,t+s} C_{H,t+s}(j) - S_t mc^*_{H,t+s} C^*_{H,t+s}(j) \right] \right\} \quad (36)$$

where $\Lambda_{t,t+s} = \beta^s \frac{U_{C,t+s}(C_{t+s},\mathcal{E}_{t+s},N_{t+s})}{U_{C,t}(C_t,\mathcal{E}_t,N_t)}$ is the discount factor for future real profits,

$C_{H,t+s}(j) = \left(\frac{P^n_{H,t}(j)}{P_{H,t+s}}\right)^{-\epsilon} C_{H,t+s}$ denote the demand coming from domestic market,

$C^*_{H,t+s}(j) = \left(\frac{P^{*n}_{H,t}(j)}{P_{H,t+s}}\right)^{-\epsilon} C^*_{H,t+s}$ is the export demand and $mc^*_{H,t+s} = \frac{W_t}{A_{H,t} S_t P^*_{H,t}}$ represents the real marginal cost of exports, priced in the local currency[10].

The optimal price setting conditions for domestic consumers and foreign consumers (in foreign currency) are given, respectively:

$$P^n_{H,t}(j) = \frac{\epsilon}{\epsilon-1} \frac{\sum_{s=0}^{\infty} (\beta\phi^i)^s U_{C,t+1}(C_{t+s},\mathcal{E}_{t+s},N_{t+s}) C_{H,t+s} P^{\epsilon}_{H,t+s} mc_{H,t+s}}{\sum_{s=0}^{\infty} (\beta\phi^i)^s U_{C,t+1}(C_{t+s},\mathcal{E}_{t+s},N_{t+s}) C_{H,t+s} P^{\epsilon-1}_{H,t+s}} \quad (37)$$

[8] For example, Engel (1993) shows empirical evidence that the volatility of the price of a good relative to a similar good within a country is lower than the volatility of the price of a good relative to the price of the same good in a different country. Engel and Rogers (1996) show that the "border effect" introduces significant variation in the price of a good sold in different countries. See also Betts and Devereux (2000).

[9] The price setting for non-tradable goods remains described by relations (19), (20) and (21).

[10] Let define $lopg_t \equiv S_t P^*_{H,t}/P_{H,t}$, we can therefore rewrite the real marginal cost of exports as a function of the home real marginal cost, so that $mc^*_{H,t} = mc_{H,t}/ lopg_t$. The similar transformation works for the foreign country.

$$P_{H,t}^{*n}(j) = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{s=0}^{\infty} \left(\beta \phi^i\right)^s U_{C,t+1}(C_{t+s}, \mathcal{E}_{t+s}, N_{t+s}) C_{H,t+s}^* P_{H,t+s}^{*\epsilon} mc_{H,t+s}^*}{\sum_{s=0}^{\infty} (\beta \phi^i)^s U_{C,t+1}(C_{t+s}, \mathcal{E}_{t+s}, N_{t+s}) C_{H,t+s}^* P_{H,t+s}^{*\epsilon-1}} \quad (38)$$

Finally, the evolutions of corresponding aggregate prices are, respectively:

$$P_{H,t}^{1-\epsilon} = \left(1 - \phi^i\right)\left(P_{H,t}^n\right)^{1-\epsilon} + \phi^i P_{H,t-1}^{1-\epsilon} \quad (39)$$

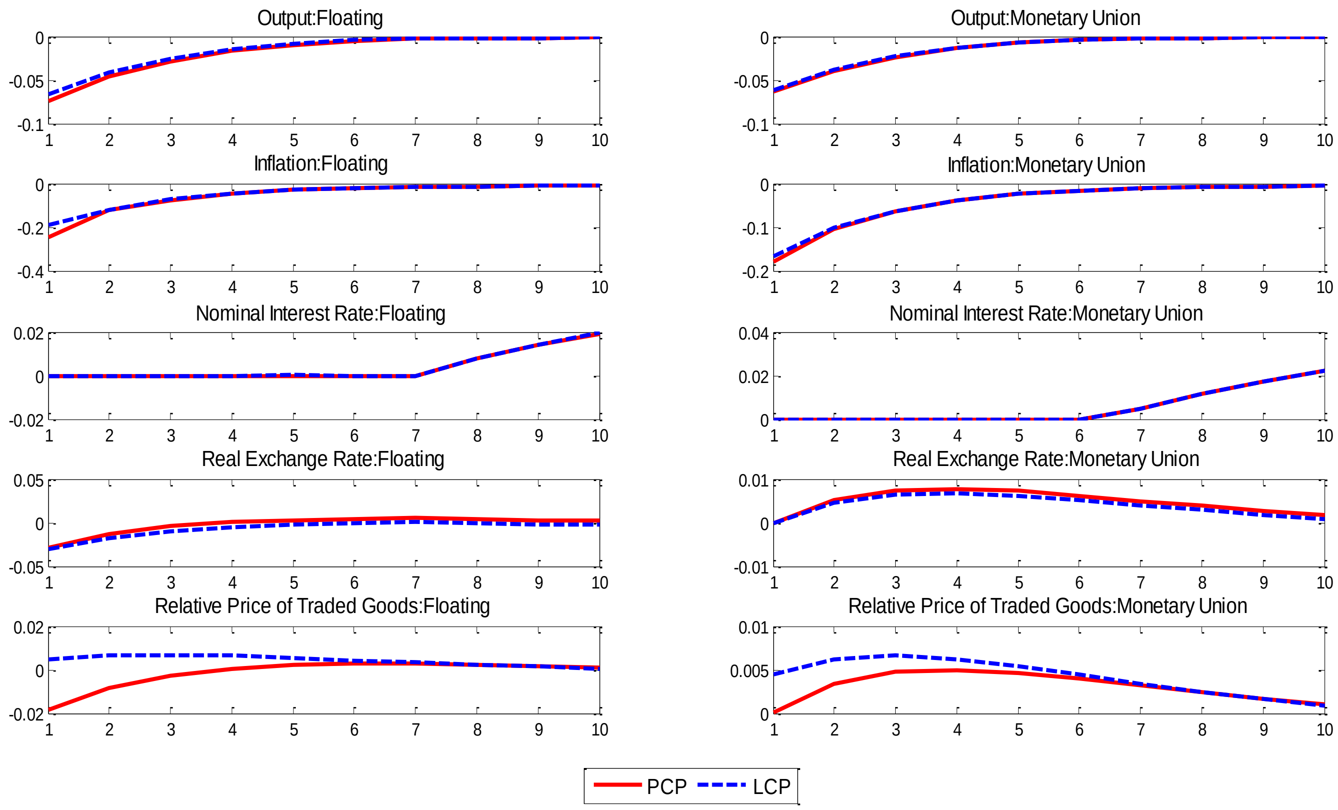
$$P_{H,t}^{*1-\epsilon} = \left(1 - \phi^i\right)\left(P_{H,t}^{*n}\right)^{1-\epsilon} + \phi^i P_{H,t-1}^{*1-\epsilon} \quad (40)$$

The similar expressions are usable for foreign country.

Figure 5 shows the results with PCP and LCP under both Monetary Union and Independent Floating regime. This exercise is experienced by assuming that the markets are incomplete. The findings appear broadly qualitatively unchanged after the introduction of LCP, unless the relative price of traded goods that depreciates and leads to a superior output under flexible regime, contrary to the case without LCP. This difference come from the fact that the LCP is applied with rigidity in imports prices and low (or not) pass-through of exchange rate. Following the relative decline in demand when the shock occurs, the traded goods prices fall less than those of non-traded goods because of imports goods prices in domestic currency, which decreases with delay. However, in PCP, imports prices in domestic currency sharply decrease in short run following the nominal exchange rate appreciation.

Under both regimes of Independent floating and Monetary Union, the dynamic of real exchange rate is inferior in LCP due to the lower expected inflation originating from staggered imports prices.

Figure 5: Effects of a (relative) negative demand shock under PCP and LCP assumptions



Notes: Time, measured in quarters, is on the horizontal axis. All variables are measured in log deviations from steady state, except the nominal interest rate and inflation which are measured in annualized levels.

1.1.Parameters modification

TO BE COMPLETED

2. Welfare analysis

To obtain robusted ranking among monetary policy arrangements, welfare comparison is relevant. Following Lucas (1987), we use a measure of the welfare costs in terms of business cycles given by the fraction of steady state consumption that households would be willing to give up in order to be indifferent between a constant sequence of consumption and working hours and the stochastic sequences of the same variables under the monetary regime considered.
Formally, the unconditional[11] welfare metric is u such as:

$$E\big((1+u)C,N\big) = E\big(U_t(C_t,\mathcal{E}_t,N_t)\big) \tag{41}$$

[11] An alternative operation to evaluate the welfare criteria is to take it under the conditional form (defining the relation (41) without E, which is the unconditional expectations operator). Since the quantitative differences between the conditional and unconditional measure is quite small manly face to the preference shocks as in Lester et al. (2014), we use the unconditional welfare measure.

where the variables without subscript t are the steady state variables.

u is the welfare measure in terms of the "consumption compensation percentage". A positive value for u means that household prefers the stochastic allocation compared to that of the steady state and willing to pay a percentage of consumption for this (welfare benefit). In contrast, a negative value of u means that household prefers the non-stochastic allocation and willing to give up a percentage of consumption to be under the shock (welfare cost).

Table 2 shows that the welfare costs analysis confirms the previous results provided by impulse responses functions. Indeed, the Monetary Union welfare-dominates the Independent Floating regime at the Zero Lower Bound regardless the assumptions on Currency Pricing and the asset markets structure. There is a welfare cost with complete asset markets, whereas, incomplete markets yield a welfare gain. This difference comes from the imperfect risk sharing under incomplete asset markets following to the external bonds accumulation, which generates a wealth effect in the medium term favourable to the welfare.

Table 2: Welfare costs (Percentage units of steady-state consumption)

Assumptions	Exchange rate Regimes	Outside ZLB	Two Countries under ZLB	One Country under ZLB
Complete Markets with PCP	*Independent Pure Floating*	-0.042	-0.034	-0.028
	Monetary Union	-0.04	-0.042	-0.042
Incomplete markets with PCP	*Independent Pure Floating*	0.034	0.014	0.006
	Monetary Union	0.027	0.025	0.025
Incomplete Markets with LCP	*Independent Pure Floating*	0.032	0.03	0.03
	Monetary Union	0.026	0.04	0.057

3. Conclusion

Traditionally, the theory of optimum currency areas argues in favour of the flexible exchange rate since the latter is able to deal with country-specific shocks through the currency depreciation. We analyzed this recommendation in a context where the economy is in a depression characterized by the ZLB constraint. We first experiment under the assumptions of complete international asset markets and Producer Currency Pricing. We remarkably find that the traditional ranking between the independent floating exchange rate regime and the monetary union regime is reversed when the nominal interest rate is constrained at zero. Indeed, we find that, the Monetary Union compared to the independent floating regime, by maintaining the expected inflation in high level at ZLB, leads to endogenous exchange rate depreciation. The Monetary Union works as a kind of central bank "commitment" in favour of a high rate of future inflation, which is a good endogenous strategy to exit from ZLB. Consequently, the duration of liquidity trap being determined endogenously is shorter in Monetary Union than in the floating regime. We extend our analysis to more realistic assumptions of the incomplete international asset markets and the Local Currency Pricing. The findings appear robust under these alternative assumptions.

References

Backus, D., Kehoe, P., Kydland, F. (1992), “International real business cycles”, *Journal of Political Economy,*100, 745–775.

Benigno, P., (2009), “Price Stability with Imperfect Financial Integration”, *Journal of Money, Credit, and Banking 41, 121–149.*

Benigno, G., Thoenissen, C., (2008), “Consumption and real exchange rates with incomplete markets and non-traded goods”, *Journal of International Money and Finance* 27 (2008) 926–948.

Betts, C., Devereux, M., (2000), “Exchange rate dynamics in a model of pricing-to-market”, *Journal of International Economics 50, 215–244*.

Betts, C., Devereux, M. (2001), “The international effects of monetary and fiscal policy in a two country model”, In: Calvo, G.A., Dornbusch, R., Obstfeld, M. (Eds.), *Money, Capital Mobility and Trade*: *Essays in Honor of Robert Mundell*, MIT Press, Cambridge.

Born, B., Juessen, F., Müller, G. (2013), “Exchange rate regimes and fiscal multipliers”, *Journal of Economic Dynamics & Control 37 (2013) 446–465*.

Calvo, G. (1983), “Staggered prices in a utility-maximizing framework”, *Journal of Monetary Economics,*12, 383–398.

Christiano L., Eichenbaum M., Rebelo S. (2011), “When is the Government Spending Multiplier Large?”, *Journal of Political Economy*, 119, 78-121.

Coenen, G., Wieland, V., 2003. The zero-interest-rate bound and the role of the exchange rate for monetary policy in Japan, *Journal of Monetary Economics*, 50 (5), 1071–1101.

Cook D., Devereux M. (2011), “Optimal Fiscal Policy in a World Liquidity Trap”, *European Economic Review*, vol 35, n°4, pp 443-462.

Cook D., Devereux M. (2013), ‘‘Exchange Rate Flexibility under the Zero Lower Bound: the Need for Forward Guidance’’, mimeo.

Correia I., Fahri E., Nicolini J-P., Teles P. (2012), « Unconventional Fiscal Policy at the Zero Bound », *American Economic Review*, vol 103 n°4, juin.

Corsetti, G., Kuester, K., Mueller, G. (2010), “Floats, Pegs and the Transmission of Fiscal Policy”” in Luis Felipe Cespedes and Jordi Gali (eds.), *Fiscal Policy and Macroeconomic Performance*, Santiago, Chile: Central Bank of Chile, 2010.

Eggertsson, G., Ferrero A., Raffo, A. (2014), “Can structural reforms help Europe?”, *Journal of Monetary Economics*, (2014) 2–22.

Eggerston G., Woodford M. (2003), “The Zero Interest Bound and Optimal Monetary Policy”, *Brookings Papers on Economic Activity*, vol. 29.

Engel, C., (1993), “Real exchange rates and relative prices”, *Journal of Monetary Economics 32, 35–50*.

Engel, C., Rogers, J., (1996), “How wide is the border?”, *American Economic Review 86, 1112–1125*.

Guerrieri, L., Iacoviello, M. (2015), “OccBin: A Toolkit for Solving Dynamic Models with Occasionally Binding Constraints Easily”, *Journal of Monetary Economics, March, vol. 70, pages 22-38*.

Lester R., Pries M., Sims E. (2014), “Volatility and welfare”, *Journal of Economic Dynamics & Control* 38 (2014) 17–36.

Lucas, R. (1987), “Models of Business Cycle”, *Yrrjo Jahnsson Lectures Series*, *London: Blackwell*.

Monacelli, T., (2004), “Into the mussa puzzle: monetary policy regimes and the real exchange rate in a small open economy”, *Journal of International Economics* 62, 191–217.

Mundell, A.R., (1961), “A theory of optimum currency areas”, *The American Economic Review* 51 (4), 657–665.

Orphanides, A., Wieland, V. (2000), “Efficient monetary policy design near price stability”, *Journal of the Japanese and International Economies* 14, 327–365.

Rabanal, P. Tuesta,V. (2010), “Euro-dollar real exchange rate dynamics in an estimated two-country model: An assessment”, *Journal of Economic Dynamics & Control*, 34 (2010) 780–797.

Schmitt-Grohe S., Uribe, M. (2003), “Closing Small Open Economy Models”, *Journal of International Economics*, 61, 163-185.

Svensson, Lars E.O. (2003), "Escaping from a Liquidity Trap and Deflation: The Foolproof Way and Others," *Journal of Economic Perspectives* 17(4), 145-166,

Svensson, L.E.O., (2001), “The zero bound in an open-economy: a foolproof way of escaping from a liquidity trap”, *Monetary and Economic Studies* 19, 277–312.