Current Account Adjustment and Monetary Policy : Can International Cooperation Be Benefic?

Damien DEJEUFOSSE

Preliminary Draft with microfunded loss functions

Abstract

In this paper, we're trying to see if, in case of a current account adjustment, the implementation of a monetray policy can be benefic, in term of welfare, for countries. Moreover we're going to put into the light that international cooperation can have an important role to play, but it will be difficult to settle due to a bigger loss of welfare in the country which do not face the shock, and the nature of the shock implemented. In this paper, we used a two countries DSGE model inspired from the one presented in an article of Gali and Monacelli (2005). We are studying the effect of a cost push and technological shock. We simulate the model using Dynare and the perturbation method and make comparisons of welfare between a benchmark situation in which the central bank do not react and situation in which the central bank follows an optimal monetary rule in an Nash Equilibrium case and a cooperative case.

The main result of this analysis is that international monetary cooperation, when central banks implement the optimal interest rule, leads to disparities of situation according to the country considered and to the shock implemented. We find out that under a cooperation equilibrium, the impact of external adjustment is sharper than in the Nash case, in term of welfare, for the Foreign country when the Home economy face a cost push shock. In the case of technological shock, the cooperation does not appear to be benefic, looking at the welfare, for the Home economy neither for the Foreign one. We note too that the impact on the exchange rate variation is slightly smaller under the cooperation equilibrium, and tend to reach an lightly appreciated long term level in comparison with its start steady state value. We note too that cooperation does not play on the volatility of exchange rates. So we conclude that using international cooperation in term of monetary policy is efficient to reduce the loss of welfare of the Home country but cooperation can be viewed as a non-cooperative game.

1 Introduction

6,15%. This number can appear harmless, looking at it out of context. Nevertheless, it represents the US deficit of current account in 2006. Knowing that the United States reprensents approximatively twenty percent of the world wealth, it takes another dimension. Actually, the US current account deficit reaches 6,15% of GDP in 2006 against 6,07% in 2005 and 0,59% in 1999[1]. As Figure 1 and Figure 5 display, the US current account have a pronounced tendancy to accelerate its deterioration over the last decade. In the same time, the Euro Area[2] experimented a current account dynamic totally different : over the decade, the european current account

[1] Current Account evolution, for the United States is presented in Appendix

[2] Note we will refer to Euro Area by EA in the following of the article

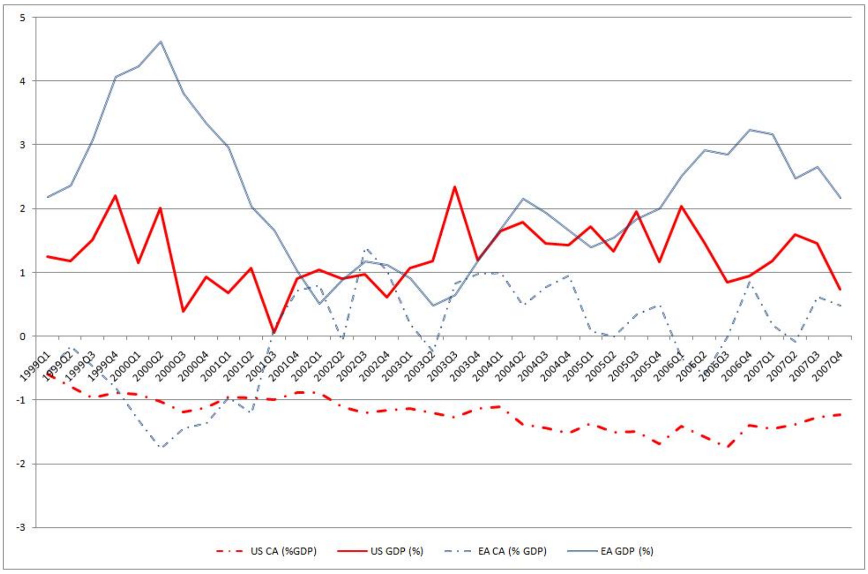

Figure 1: GDP and Current Account for the Euro Area and United States, *quarterly datas.*

seems to have reach equilibrium. This can leads us to the conclusion that the US current account dynamic is singular accross the world. Asian countries tend to experiment large current account excedent for example. In the same time, the United States faced a sustained economic growth, stronger than the one experimented by the Euro Area, which can explains a part of the deficit by the needs of importations. It appears that according to the economic theory, the nominal Euro/dollar exchange rate tend to depreciate itself as long as the US current account deficit tend to grow (see Figure 2). As a matter of fact, we can see that the aggravation of the US external deficit starts at the begining of 2001 and that, at the same time, the exchange rate of the Euro against the Dollar tends to apprise until it reaches some records at the begining of 2008. Over the 2001-2007 periods, the exchange rate increases from 0,8455 to 1,4232 at the end[3]. In other words, the dollar depreciates 68,11% by over the periods considered here.

Economic litterature over the subject of current account adjustment can be divided in two paradigms according the way the adjustment takes place - progressively or abrutly. In one hand, following Dooley, Folkerts-Landau and Garber (2004), the current account deficit of the United States is considered as normal. The United States play the role of international financial intermediary and, in this situation, the deficit will resolve itself progressively and without any correction in the exchange rate value. In this case, the current account deficit is a sign of good economic heath and finds its causes in the financing needs of developping countries, those countries facing a limitation due to the faintness of their collateral. In the same line, Cavallo and Tille (2006) find that, in a financial context of strong integration and taking into account of the valuation effects, the adjustment will occurs but in a smooth landing way even if there is a relatively strong reaction of the exchange rate. The main results come from the presence of valuation effects which caused the smooth adjustment. On the other hand, some authors presents the argument of non sustainable current account deficit. Obstfeld and Rogoff (2004, 2005) unlighted that the adjustment will have two repercussions : a strong instant depreciation of the exchange

[3] Sources: EuroStat. It picks up to 1.5931 on 2008 April 22th

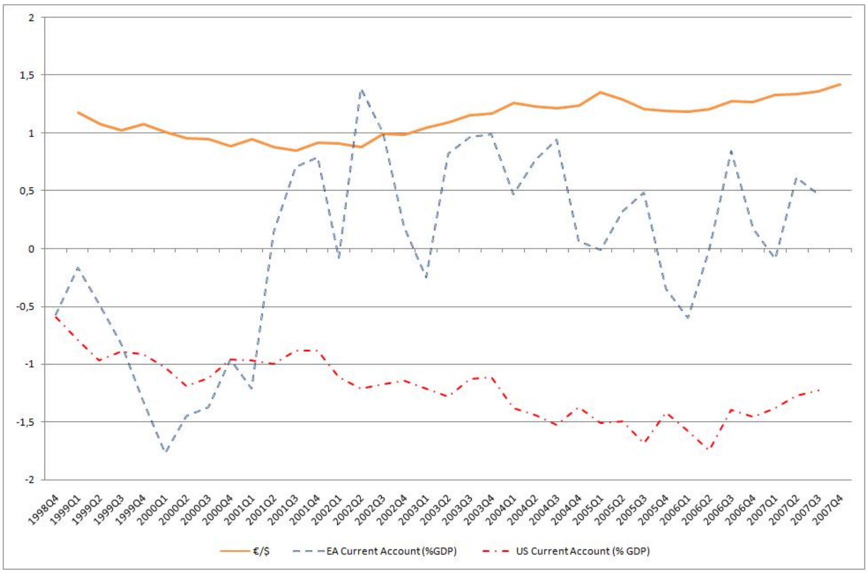

Figure 2: Euro/Dollar Echange Rate and Current Account

rate (between 15% and 34%) and a expenditure switch toward the US non-tradable goods. Facing a real exchange rate adjustment, linked to the terms of trade deterioration needed to have the expenditure switch, the United States have to transfer a part of their GDP toward the rest of the world in order to satisfy foreign economies which have decided to stop financing the US economy. In the same line, Kortelainen (2007) find, in a DSGE framework, that the deficit will only become sustaible if the excompte factor falls or the risk premium rises but this can push the interest rate toward the zero-bound. This sign can be interpreted as a mark of current account unsustainability.

Facing facts and litterature, the major consensus is that their will be an adjustment but we do not really know when. Can the adjustment be in motion with the subprimes crisis and the strong dollar depreciation we have experimented up to now? In this paper, we're trying not to find when the adjustment will take place but we're trying to respond to a different kind of question : when the adjustment will take place, how should reacts centrals banks and will this reaction matters? Do they have to treat the problem in a national point of view or do have they interest in treating it in a cooperative way? The issue is to determine, in a two country framework, what is the optimal monetary to implement in an open economy. After identifying the Ramsey optimal interest rules under the two kind of equilibrium we consider here, we lead the analysis for the Euroland/United States situation. We conclude that cooperation is a kind of non cooperative game. Cooperation is better for the United States than for the Euro Area in terms of welfare. In fact, cooperation induces a loss for the Euro Area whereas it experiments no change of welfare under the Nash equilibrium, when the shock experimented by the Home economy is a cost push one. The United States see, on the contrary, its loss of welfare reduced. We can say the United States have interest in implementing this monetary policy due to a kind of international spillover effect on the weight of adjustment cost. Nevertheless, if they implement it, Europe will have incitations in deviating from the optimal cooperative rule toward the Nash one. However cooperation is not always the best respond to be implemented. In case of technological shock, Cooperation seems to induce more welfare losses than in the Nash equilibrium for both countries.

We will present our two-country general equilibrium framework,inspired from Gali and Monacelli's small open economy model (2005) with the optimal interest rules, in Section 2. Section 3 will presents our calibration. Section 4 contains the results of our simulations for the Nash and Cooperative case both for a xost push shock and a technological one. Finally, we make some concluding remarks in Section 5.

2 A two contries model for the analysis of current account adjustment

In this section, we present the model where the world economy is composed of two countries. This will allow us to identify and analyse the effect of a shock to an economy with current account and see its implications on the country affected but also on the other commercial partner. We consider $\alpha \in [0,1]$ as the mesure of home bias in the consuption for the domestic household which is also a good approximation of the mesure of openess. By assumption, it follows that $1-\alpha$ is the degree of domestic bias in the Foreign economy.
Our economy is made of three types of agents: the households, whom choices are on Consumption - C_t,the hours of labor - N_t, and the detention of international bound D_t; the productive sector is divided into two according to the nature of the different goods produced : final and intermediate goods. And finally, the monetary authority which implements the domestic monetary policy.
Note that a variable marked by an asterix - X^* - is a variable for the Foreign economy. In the same way, x denotes the log-deviation from its steady states value of the X variable.

2.1 Representative Households and Firms behaviours

2.1.1 Households

Our model is traditionally expressed, in coherence with the literature. We have a representative household who aims at the maximisation of its intertemporal utility expressed as

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \tag{1}$$

where the consumption basket C_t is define as

$$C_t = [(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \tag{2}$$

where $\eta > 0$ is the mesure of the elasticity of substitution between domestic and foreign goods, $C_{H,t}$ is the index of consumption of domestic goods and $C_{F,t}$, the index of consumption of foreign-produced goods. Each can be define as a CES function :

$$C_{H,t} = (\int_0^1 C_{H,t}(j)^{\frac{\xi-1}{\xi}})^{\frac{\xi}{\xi-1}}$$
$$C_{F,t} = (\int_0^1 C_{F,t}(j)^{\frac{\xi-1}{\xi}})^{\frac{\xi}{\xi-1}}$$

where j denotes the good variety and $j \in [0,1]$. As we will see latter, each country produces a continuum of differentiated goods. ξ is the elasticity of substitution between varieties in any

given country. We could have set a different value for each country, but it implies a complication of analytical treatment, in the market clearing conditions for example.
The representative household seeks to maximise its intertemporal utility function under the following budget constraint

$$\int_0^1 P_{H,t}(j)C_{H,t}(j)dj + \int_0^1 P_{F,t}(j)C_{F,t} + E_t[Q_{t,t+1}D_{t+1}] \leq D_t + W_tN_t + T_t \tag{3}$$

where D_{t+1} is the nominal pay-off at $t+1$ of the bonds held in period t expressed in Home currency, T_t is a lump-sum transfert received by the household, W_t is the nominal wage. All this is under the assumption of a free access to a complet set of contingent claims traded internationally. We can derive the optimal allocation of expenditure for each variety of goods. This conducts to the demand functions

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\xi} C_{H,t} \tag{4}$$

$$C_{F,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\xi} C_{F,t} \tag{5}$$

for $j \in [0,1]$, where $P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{1-\xi}dj\right)^{\frac{1}{1-\xi}}$ is the domestic price index or the price index of domestic-produced goods. The same apply to $P_{F,t}$, the index price of imported good.

It follows that the optimal level of consumption of imported goods and domestic goods, expressed as a fraction of the total level of consumption is expressed by

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t; \tag{6}$$

$$C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{7}$$

where $P_t = \left[(1-\alpha)\left(P_{H,t}\right)^{1-\eta} + \alpha\left(P_{F,t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$ is the consumption price index (CPI)[4].

Households' choices The household makes its choices according to a budget constraint that can be rewritten as

$$P_tC_t + E_t\left[Q_{t,t+1}D_{t+1}\right] \leq D_t + W_tN_t + T_t \tag{8}$$

If we considere that the utility fonction is additively separable in consumption and worked hours, so

$$U\left(C_t, N_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \tag{9}$$

Then maximising its intertemporal objective under the budget constraint (8), it yields that the optimality conditions for the households are traditionnal. We find the Euler equation :

$$\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right) = Q_{t,t+1} \tag{10}$$

[4]Note that in the case of $\eta = 1$, then, $P_t = P_{H,t}^{1-\alpha}P_{F,t}^{\alpha}$.

which can be rewrite using the fact that $R_t = E_t\left[Q_{t,t+1}\right]^{-1}$ and taking conditional expectations on both sides as

$$\beta R_t E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1 \tag{11}$$

Where R_t is the gross return on a riskless one-period discount bond pays-off in national currency unit in $t+1$. The analogous condition for the Foreign economy can be expressed using the nominal exchange rate ϵ, it follows

$$\beta^* R_t^* E_t \left\{ \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma^*} \left(\frac{P_t^*}{P_{t+1}^*} \right) \left(\frac{\epsilon_t}{\epsilon_{t+1}} \right) \right\} = 1 \tag{12}$$

The optimality condition relative to the choice of worked hours can be expressed as

$$C_t^{-\sigma} N_t^{\varphi} = \frac{W_t}{P_t} \tag{13}$$

These equations will be log-linearized to get the form of the aggregate demand curve.

Useful links between exchange rate, terms of trade, domestic inflation and CPI inflation For our future analysis, we need to introduce some definitions and links between some variables. Lets start with the definition of the effective terms of trade. It is given, for the Home country, by

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}}$$

Note that as we are in a two-countries model, the effective and bilateral term of trade are identical. The term of trade of the Foreign economy is define as $S_t^* = S_t^{-1}$.

We can rewrite the CPI index as follow

$$\frac{P_t}{P_{H,t}} = \left[(1-\alpha) + \alpha S_t^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{14}$$

At the steady state, $S = 1$ implies that $\frac{P_t}{P_{H,t}} = 1$. And loglinearising, it leads us to

$$p_t = p_{H,t} + \alpha s_t \tag{15}$$

Lets define the CPI inflation as $\pi_t = P_t - P_{t-1}$ and the domestic inflation as $\pi_{H,t} = P_{H,t} - P_{H,t-1}$. We have in consequence a relation between CPI inflation and domestic inflation given by

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \tag{16}$$

Assuming the law of one price holds for each goods, we can write $P_t(j) = \epsilon P_t^*(j)$ and log-linearizing, we obtain $p_{F,t} = e_t + p_{F,t}^*$. This leads us to an expression of a relation between the exchange rate, the terms of trade and levels of prices

$$s_t = e_t + p_{F,t}^* - p_{H,t} \tag{17}$$

and the definition of the variation of the exchange rate

$$\Delta e_t = s_t - s_{t-1} + \pi_{H,t} - \pi^*_{F,t} \tag{18}$$

To establish a relationship between the terms of trade s_t and the real exchange rate,we need to define the real exchange rate as $Q_t \equiv \frac{\epsilon_t P^*_t}{P_t}$. Take the last definition in log and use the previous results,we obtain

$$q_t = (1-\alpha)\, s_t \tag{19}$$

Now we have the definition of the real exchange rate, we can combine equations (11) and (12) and, after iterating, we obtain, for all t

$$C_t = \upsilon \left(C^*_t\right)^{\frac{\sigma^*}{\sigma}} Q_t^{\frac{1}{\sigma}} \tag{20}$$

where $\upsilon = \frac{C_0}{\left(C^*_0\right)^{\frac{\sigma^*}{\sigma}} Q_t^{\frac{1}{\sigma}}}$ is a constant depending on the relative net asset position. Taking the log, and using (19), we get

$$c_t = \frac{\sigma^*}{\sigma} c^*_t + \left(\frac{1-\alpha}{\sigma}\right) s_t \tag{21}$$

Note that we're going to consider the case of symetrical preferences over consumption behaviour inducing that $\sigma = \sigma^*$.

2.1.2 Firms

Final goods The final good is produce using a continuum of intermediates goods as input according to CES technology

$$Y_t = \left(\int_0^1 Y_t\,(j)^{\frac{\xi}{\xi-1}}\, dj\right)^{\frac{\xi-1}{\xi}} \tag{22}$$

where Y_t is the aggregate ouput in the Home economy, and $Y_t\,(j)$ is the intermediate goods of the j^{iest} quality level. The demand curves for each input can be obtain by the profit maximization, taking the price of the final good - $P_{H,t}$ - as given, which yields :

$$Y_t\,(j) = \left(\frac{P_{H,t}\,(j)}{P_{H,t}}\right)^{-\xi} Y_t \tag{23}$$

Intermediate goods Each firm producing intermediate goods follows a simple technology using labour as input. This technology also have a parameter A_t which can be defined as a technical progress index.

$$Y_t\,(j) = A_t N_t\,(j) \tag{24}$$

We define

$$A_t = \rho_A A_{t-1} + \epsilon_A$$

as the technological shock the economy can experimented. Each intermediate good firm choose its level of production minimizing its production cost. It results that the real marginal cost can be expressed as

$$MC_t = \frac{(1-\tau)\,(W_t/P_{H,t})}{A_t} \tag{25}$$

where τ is an employement subsidy received by the firm which role is to overbalanced the distorsions due to the monopolistic competition. It effect implies that the only real distorsion is the nominal distorsion induces by the mechanism of price fixation *a la Calvo.*

Note that we can define the aggregate production as

$$Y_t = \frac{A_t N_t}{Z_t} \tag{26}$$

where $Z_t = \int_0^1 \frac{P_{H,t}(j)}{P_{H,t}} dj$ is a measure of price dispersion. Note that up to the first order approximation, this term doesn't matter, so we obtain (in log)

$$y_t = a_t + n_t \tag{27}$$

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Calvo rigidities Hence, each period, $1-\theta$ randomly selected firms can change their price by re-optimizing their actualised profits. The individual probability for a firm of re-optimizing at any period is independant of the time elapses since the previous opportunity. The firm seek to maximise

$$\max_{\bar{P}_{H,t}} \sum_{i=0}^{\infty} \theta^i Q_{t,t+i} Y_t(j) \left(\bar{P}_{H,t} - P_{H,t+i} MC_{t+i}\right) \tag{30}$$

subject to the demand curve (23). $\bar{P}_{H,t}$ is the new price fixed by a firm when it has the possibility to re-optimise its profits. The first order condition is then

$$E_t \sum_{i=0}^{\infty} \theta^i Q_{t,t+i} Y_t(j) \left(\bar{P}_{H,t} - \frac{\xi}{\xi-1} P_{H,t+i} MC_{t+i}\right) = 0 \tag{31}$$

Here $\frac{\xi}{\xi-1}$ represents the mark up a firm can have on its marginal cost due to its market power issued of the monopolistic competition. Using the fact that $Q_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right)$, and rearranging, we can express the new price as

$$\bar{P}_{H,t} = \frac{\xi}{\xi-1} \frac{\sum_{i=0}^{\infty} (\beta\theta)^i E_t \left\{P_{t+i}^{-1} C_{t+i}^{-\sigma} Y_{t+i}\right\} P_{H,t} MC_t}{\sum_{i=0}^{\infty} (\beta\theta)^i E_t \left\{P_{t+i}^{-1} C_{t+i}^{-\sigma} Y_{t+i}\right\}} \tag{32}$$

We can see directly that the method of price fixation induces a forward-looking formation of prices due to the incertainty faced by the firm on the number of period it may stay without possibility of a new price adjustment. In log terms, the first order condition can be rewriten

$$\bar{p}_{H,t} = \mu + (1-\theta\beta) \sum_{i=0}^{\infty} (\beta\theta)^i E_t \left\{mc_{t+k} + p_{H,t}\right\} \tag{33}$$

where $\mu = log\left(\frac{\xi}{\xi-1}\right)$ is the log of the gross mark up. In the same time, it follows that the domestic price index can be rewritten as

$$P_{H,t} = \left[\theta \left(P_{H,t-1}\right)^{1-\xi} + (1-\theta)\left(\bar{P}_{H,t}\right)^{1-\xi}\right]^{\frac{1}{1-\xi}} \tag{34}$$

2.2 Equilibrium

We're going to present the main market clearing condition and deduce the main equations of our representative Home economy. Note that a similar set of equations holds for the Foreign country.

2.2.1 Good Market clearing condition

Market clearing condition The good market clearing can be expressed as

$$\begin{aligned} Y_t(j) &= C_{H,t}(j) + C^*_{H,t}(j) && (35) \\ &= \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\xi} \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha \left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\eta^*} C^*_t\right] && (36) \end{aligned}$$

for each good $j \in [0,1]$. Aggregating over j, using equation (7) for each country and plugging this condition in the definition of the aggregate output (22), and making the hypothesis of similar preferences across countries implying that $\sigma = \sigma$ and introducing (20), we obtain

$$Y_t = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha \left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\eta^*} C^*_t$$

$$Y_t = C_t \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} + \alpha \left(\frac{P_{H,t}}{P_t}\right)^{-\eta^*} S_t^{-\eta^*} Q_t^{\eta^* - \frac{1}{\sigma}}\right] \tag{37}$$

The first order approximation of the market clearing condition for goods is then

$$y_t = c_t - \alpha(\eta^* - \eta)s_t + \alpha\left(\eta - \frac{1}{\sigma}\right) q_t$$

$$y_t = c_t + \frac{\alpha\omega}{\sigma} s_t \tag{38}$$

where $\omega = (1-\alpha)\left[\sigma\left(\eta^* - \eta\right) + \left(\sigma\eta^* - 1\right)\right]$ [5].

We can express then the terms of trade in a log approximation using equations (21) and (38), and the market clearing condition for foreign goods, we can write

$$s_t = \sigma_\alpha \left(y_t - y^*_t\right) \tag{39}$$

where $\sigma_\alpha \equiv \frac{\sigma}{(1-\alpha)+\alpha\omega+(1-\alpha)\omega^*}$.

The supply side: a New Keynesian Phillips curve Traditionally, in a model using Calvo staggered prices, the expression of the relation between domestic inflation and the real marginal cost can be expressed as follows

$$\pi_{H,t} = \beta E_t\left\{\pi_{H,t+1}\right\} + \lambda mc_t \tag{40}$$

where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$.

The real marginal cost can be log-linearized and using the household's first order condition

[5] In the special case of symetry $\omega \equiv (\eta\sigma - 1)(1-\alpha)$ and when $\eta = \sigma = 1$, then $\omega = 1$

relative to the choice of the worked hours (13), the production function (29) and the link between domestic and foreign consumption (21), it follows

$$\begin{aligned} mc_t &= -\nu + (w_t - p_{H,t}) - a_t \\ &= -\nu + \sigma c_t + \varphi y_t + \alpha s_t - (1+\varphi) a_t && (41) \\ &= -\nu + (\sigma + \varphi) y_t + \sigma y_t^* - \sigma \left(y_t - \frac{\alpha \omega}{\sigma} s_t \right) + s_t - (1+\varphi) a_t && (42) \end{aligned}$$

where $\nu = log(1-\tau)$, and this equation is obtained by using the world market clearing condition $y_t + y_t^* = c_t + c_t^*$, and equation (38). Substituing s_t by its expression, we have

$$mc_t = -\nu + (\varphi + \sigma_\alpha (1 + \alpha\omega\sigma)) y_t + (\sigma - (1 + \sigma\alpha\omega)) y_t^* - (1+\varphi) a_t \tag{43}$$

We have an influence of the level of output in the Foreign Economy which impact depend not only on the value of Home parameters but also of Foreign ones. This influence extend to the impact of Home production too, partly due to ω.

In order to obtain the New Keynesian Phillips Curve, let the output gap in term of log deviation of y_t from the flexible equilibrium level of production, $\bar{y}_t$, be $\tilde{y}_t = y_t - \bar{y}_t$. We need to have the level of $\bar{y}_t$. The flexible equilibrium is defined as the equilibrium with no nominal rigidities which imply that the real marginal cost is equal to $mc = -\mu = log(\frac{\xi}{\xi - 1})$, for all t. This leads us to

$$\bar{y}_t = \Omega + X a_t - \Psi y_t^* \tag{44}$$

where $\Omega = \frac{\nu - \mu}{\sigma_\alpha (1 + \sigma\alpha\omega) + \varphi}$, $X = \frac{1+\varphi}{\sigma_\alpha (1+\sigma\alpha\omega)+\varphi}$ and $\Psi = \frac{\sigma - \sigma_\alpha (1+\sigma\alpha\omega)}{\sigma_\alpha(1+\sigma\alpha\omega)+\varphi}$.

And the real marginal cost, in term of output deviation is

$$mc_t = (\sigma_\alpha (1 + \sigma\alpha\omega) + \varphi) \tilde{y}_t$$

So, the NKPC can be expressed as

$$\pi_{H,t} = \beta E_t \{\pi_{H,t+1}\} + \kappa_\alpha \tilde{y}_t + u_t \tag{45}$$

where $\kappa_\alpha = \lambda (\sigma_\alpha (1 + \sigma\alpha\omega) + \varphi)$ and the shock can be represented as

$$u_t = \rho_u u_{t-1} + \epsilon_t^u$$

As we can see, we have a relationship between inflation today and the level of anticipated inflation, and the output gap. Openess has an influence only on the relationship by the output gap. The impact of an output gap variation on the marginal cost come from its impact on employment captured by φ and on terms of trade σ_α and ω.

The Aggregate Demand equation Finally, to get the aggregate demand equation, we combine the log version of the good market clearing condition with the Euler equation of the Home representative Household and we get

$$y_t = E_t \{y_{t+1}\} - \frac{1}{\sigma} (r_t - E_t \{\pi_{H,t+1}\}) - \frac{\alpha(\omega - 1)}{\sigma} E_t \{\Delta s_{t+1}\}$$

Using the definition of the terms of trade and rearranging, we obtain the aggregate demand

$$y_t = E_t \{y_{t+1}\} - \frac{1}{\sigma_\alpha} (r_t - E_t \{\pi_{H,t+1}\}) + \alpha(\omega - 1) E_t \left\{\Delta y_{t+1}^*\right\} \tag{46}$$

It's easy to express the aggregate demand in term of output gap. It follows from (46)

$$\tilde{y}_t = E_t\left\{\tilde{y}_{t+1}\right\} - \frac{1}{\sigma_\alpha}\left(r_t - E_t\left\{\pi_{H,t+1}\right\} - \bar{rr}_t\right) \tag{47}$$

where the natural interest rate of the economy can be expressed as

$$\bar{rr}_t \equiv \alpha\left((\omega - 1) + \Psi\right) E_t\left\{\Delta y^*_{t+1}\right\} + \sigma_\alpha E_t\left\{\Delta \bar{y}_{t+1}\right\}$$

We have caracterised the equilibrium in our two-countries model by a forward-looking IS-curve in which the degree of openess have an influence on the impact of interest rate changes on the output gap. We note that the natural interest rate of the economy depends on the variation of foreign output.

2.2.2 Current account

The next step in our model is to define the current account NX_t. Let $NX_t = \frac{1}{Y}\left(Y_t - \frac{P_t}{P_{H,t}} C_t\right)$ represents the net exports expressed as a fraction of the steady state production. In a log linear version, the current account is

$$nx_t = y_t - c_t - \alpha s_t$$

$$nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right) s_t \tag{48}$$

Some remarks can be benefic. First, if $\frac{\omega}{\sigma} = 1$, then , the last equation shows that trade is always balanced for all t. Second, we can identify a threshold between a situation where the volume effet is stronger than the price effect. If volume effect is the main effect on the current account, then a degradation of the terms of trade i.e. $\Delta s_t > 0$, induce a degradation of the current account. This is verified if $\frac{\omega}{\sigma} > 1$ or in other words

$$\eta < \frac{(1-\alpha)(2\eta^*\sigma - 1) - \sigma}{\sigma(1-\alpha)}$$

In our model, the elasticity of substitution between home-made and foreign-made goods plays an important role. Here, it determines if the Marshall-Lerner condition is respected or not for the economy. If the value of η is under the threshold unlighted above, the a depreciation of the terms of trade followed by au depreciation of the exchange rate induces an increase in the current account position, due to an increase in the exports of the country. Moreover, as Corsetti and *al.* has enlighted, this parameters is important relatively to the magnitude of the exchange rate reaction. Highter is the value of η, smaller the reaction of the exchange rate will be. In this case, the expenditure switch will be a large one and induices a smaller need of exchange rate depreciation to realise the adjustment.

2.3 Central bank and monetary policy

Each country is doted with an independant central bank whose role is to implement monetary policy according to the traditional unemployment/domestic inflation trade-off. We make the assumption that there is no commitment technology. The authority can't choose credibly, once and for all, an optimal state dependant plan. It seeks to minimize the quadratic loss fonction of welfare in the domestic output gap and the domestic inflation. We consider two seprate cases: the Nash equilibrium case where the central bank acts only according to the Welfare of the Home representative household without considerations for the other economy; and the cooperative case

where the central bank seek to minimize the welfare loss taking into account the domestic household and the foreign one.
The correction of welfare (gain or losse) following the shock will be expressed as a percent of steady state consumption.

2.3.1 Loss functions

We derive the loss function from the household's utility. It depends on output gap variability and inflation variablility, pondered by the coefficient χ representing the relative weight of output gap in the objective of the monetary authority [6]

$$W^N = -\frac{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}}{2}\Lambda E_0 \left\{ \sum_{t=0}^{t=\infty} \beta^t \left[\pi_{H,t}^2 + \chi \tilde{y}_t^2\right] \right\} \tag{49}$$

where $\Lambda = \frac{\xi}{\lambda}$ and $\chi = \frac{\kappa_\alpha \lambda}{\xi}$. A similar objective function holds for the Foreign economy.

In case of cooperative equilibrium, the monetary authority also take into account the foreign output gap variability and inflation variability. It follows the loss function of the central bank can be expressed as

$$W^C = -\frac{1}{2}\Lambda E_0 \sum_{t=0}^{t=\infty} \beta^t \left[\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(\pi_{H,t}^2 + \chi \tilde{\tilde{y}}_t^2\right) + \frac{\alpha\omega\sigma_\alpha}{\sigma}\left(\pi_{F,t}^2 + \chi^* \left(\tilde{\tilde{y}}_t^*\right)^2\right) - 2\Phi \tilde{\tilde{y}}_t \tilde{\tilde{y}}_t^*\right] \tag{50}$$

where $\Gamma = \frac{\xi}{\lambda}$, $\chi = \frac{\lambda\kappa_\alpha}{\xi}$, $\chi^* = \frac{\lambda^*\kappa_\alpha^*}{\xi}$ and $\Phi = \frac{\lambda(1-\sigma)\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)}{\xi}$.

2.3.2 Optimal monetary policy rule under Nash and cooperative equilibrium

Optimal interest rule in the Nash case [7]

The monetary authority minimise the Loss function under the New Keynesian Phillips Curve, and using the IS curve, we get the following optimal interest rule :

$$r_t^{Nash} = r\bar{r}_t + \frac{\sigma_\alpha \xi}{\chi}\pi_{H,t} + \left(1-\frac{\sigma_\alpha \xi}{\chi}\right) E_t\left\{\pi_{H,t+1}\right\} \tag{51}$$

We can see that the Nash interest rate depends on the natural interest rate. So if we face a shock then the terms of trade and it results in an elevation of the level of inflation above its steady state level. According to this optimal rule, the interest rate should rise above its steady state value.

The optimal interest rule in the cooperative case [8] The other situation we can study is the cooperative one. We consider now that the different central banks act together that is to say that they consider an objective function taking into account the domestic situation, but also the situation in the Foreign economy. This explain the formulation of (49). We apply the same derivation method to this case, except for the need to define a new output gap expressed in term of deviation of the output to a worldwilde flexible price production. This leads us to the following optimal interest rule

[6] See appendix A for more details on the derivation
[7] See the derivation in Appendix B
[8] See the derivation in Appendix B

$$
\begin{aligned}
r_t^{Coop} &= r\bar{r}_t + E_t\{\pi_{H,t+1}\} - \frac{\xi\kappa_\alpha\sigma_\alpha}{\lambda}(\chi^* - \chi\Psi\Xi)\varpi[E_t\{\pi_{H,t+1}\} - \pi_{H,t}] \\
&-\frac{\sigma_\alpha\xi^*}{\lambda^*}\left[\frac{\Psi^*}{\chi\Phi} + \frac{\Phi}{\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\chi} - \kappa_\alpha\Psi + \frac{\kappa_\alpha\Phi\Psi\Psi^*}{\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\chi}\right]\varpi[E_t\{\pi_{F,t+1}\} - \pi_{F,t}] \quad (52)
\end{aligned}
$$

where $\varpi = \frac{1}{\kappa_\alpha\chi^* - \Phi(1-\sigma)}$ and $\Xi = \frac{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}}{\frac{\alpha\omega\sigma_\alpha}{\sigma}}$.

This rule is a complex one. But we find out that it reacts not only to domestic inflation today and anticipated, but with respect to the evolution of foreign inflation too. This is the main difference in comparison to the Nash case if we expect the complexity of the different coefficients.

3 Calibration

Here, we make a point on the value of the different parameters of our model using litterature. We make a distinction between what we can called Structural parameters (actuarial factor, main elasticities) and frictions parameters which englobed the parameters linked to the nominal rigidites and the objective of the monetary authority. We set the home bias coefficient to reflect the relative-size of the US population in a world economy composed by the USA and the Euro Area. In consequence, as the EuroArea population is of 313 096 300 inhabitants and the US of 299 398 500[9], we set $\alpha = 0.48$. The United States is considered as the Home country and Euro Area as the foreign economy.

Parameters		US	Euroland
Actuarial factor	β	$1.03^{-0.25}$	0.99
Degree of openness	α	0.48	0.52
Inverse of the Freisch elasticity	φ	3	3
Substituabilyty between Foreign and domestic goods	η	1.74	1.74
Substituability between Foreign goods	γ	1	1
Intertemporal elasticity of substitution	σ	1/0.8	1/0.8
Probability of no-reoptimization	θ	0.7	0.75
Monopoly power	ξ	6	6
Shock correlation	ρ	0.85	0.85
Employment subsidies rate	τ	0.25	0.25

Table 1: Calibrated parameters for the US and the Euro area

We choose to present a quasi-symetric case in order to have simpler results. One of the following steps in future research will be to try an estimation of the model over datas. Moreover, we can consider taht the United States and the Euro Area are similar but not identical. With this point ov view, we identified the following calibration.

3.1 Structural parameters

United States We found the value of our paramietrization in the litterature. For the US, our main sources is from the paper of Christiano, Eichenbaum and Evans (2005) where they analyse

[9] OCDE, Population statistics ==> $\alpha = 0.48$

the impact of nominal rigidities in the United States. We take the value of the actuarial factor equal to $1.03^{-0.25}$ implying a steady state interest rate of 3%.
Gali and Monacelli (2002) set the value of the labour supply elasticity at $\frac{1}{3}$ which implies $\varphi = 6$. Juillard and al (2006) set the value of the intertemporal elasticity of substitution for the US economy at 0.8, implying $\sigma = 1/0.8$.

The value of the elasticty of substitution between domestic and foreign goods is difficult to set due to its different impacts on the exchange rate reaction [10]. In fact, if this elasticity of substitution is set to a high level, the resulting expenditure switch effect is large so the exchange rate will reacts only modestly to restaure the external equilibrium. In another hand, if this elasticity is low, we have the opposite effect. It can be assimilated to the static argument of the Marshall Lerner condition which implies that there is a critical value for the elasticity of substitution between domestic and foreign goods. If this value is biten, then the effect of a depreciation on the current account is inversed. In dynamic, we have the same phenomenon but in a more complexe way inducing the wealth effect to dominate over the expendtures switching effects. We can envisage to test the model over a $\eta = 1.74$ trying to respect the Marchall Lerner conditions[11].

Euro Area For the Euro Area, we based our calibration on Smets and Wouters (2003). They estimated the same model as Christiano Eichenbaum and Evans with a comparable methodology. We set $\beta = 0.99$ consistent with an annual interest rate of 4% at the steady states. This is consistent with the fact that the European Central Bank sets its interest rate at a higher level than the Federal Reserve. The intertemporal elasticity of substitution is considered to be $\sigma = 1/0.8$ too.
At last, we set two different values to the elasticity of substitution between domestic and foreign goods : $\eta = 1.74$. So xwer can see that structurally speaking, the USA and the Euro Area differs only with the value of their steady state interest rate.

3.2 Frictions parameters

United States In the same way, we set $\xi = 6$ so that the average mark up of firms on the market is $\mu = 1.2$ as in Christiano, Eichenbaum and Evans (2005) and Gali Monacelli (2002). The value of the θ-probability of no price re-optimization, is estimatd by Walque, Smetz and Wouters (2005). They found that $\theta = 0.7$ in the United States, implying that a price contract last on average 3 quarters.

Euro Area The Euro Area is caracterized by a higher level of nominal frictions than the United States. In order to capture this phenomenon, we set the probability of no price re-optimization at $\theta^* = 0.75$, which imply that the average duration of price contracts is 4 quarters [12]. This show directly that the US market is more flexible than in the Euro Area. As mentioned above, we set $\xi = 6$ too for Europe due to simplifications of treatment.

The two differences we consider in our calibration are relative to the steady state interest rate and the degree of nominal rigidities.

[10] Cosetti and al. (2003)
[11] Values taken in De Walque, Smets and Wouters (Draft 2005).These values are estimated on a Bayesian way over the 1974-2004 period.
[12] Walque, Smets and Wouters (Draft 2005)

4 Nash Equilibrium vs. Cooperation equilibrium

In this section, we will present the results of our different simulations when the monetary authorities implement the optimal rule deduced above. We will look at two kind of shocks. First, we simulate the response of our economy to a cost push shock, then to a technological shock. We will look at the welfare correction issued by this shocks and try to conclude about the importance of monetary cooperation. We assumed our shocks are persistant in fixing the correlation parameter equal to 0.85. We calibrated the standard error of the shock in order to get a current account deficit in the Home country approximatively equal to the one experimented by th US nowaddays.

4.1 Optimal monetary policy and Welfare when the Home counry faced a cost push shock

4.1.1 Exchange rate reaction and current account adjustment

Table 2 presents the instant depreciation of the real and nominal exchange rate linked to the current account deficit experiemented by the USA (-6,0502%). The first conclusion we can draw is that the cost push shock lead to a deterioration of the terms of trade which change the current account position to a deficit in the Home economy. This is associated to a nominal and real exchange rate depreciation. This depreciation is a strong one (24,686%) in deviation of the steady state value. We have to note that, even if the reaction of the nominal exchange rate has the same kind of shape under the two regimes, the cooperation induces a new steady state level a little higher than before the shock, and a little higher than the one reach under the Nash equilibrium, even if the differences is a very small one[13]. On the other hand, the real exchange rate has the same reaction under the different cases. We are tempted to conclude that cooperation do not have an important impact on the evolution of the exchange rate following the shock.

	Nash Equilibrium	Cooperative Equilibrium
Nominal depreciation (%)	24,686	24,661
Real depreciation (%)	12,848	12,826

Table 2: Comparison Nash vs. Cooperative equilibrium

4.1.2 Mains IRF and Welfare analysis

We present the main impluse response function in appendix C, Figure9 and 10. The cost push shock induces different situations for our two countries. The home country experimented a reduction of its level of consumption and an economic expansion while the Foreign economy sees its production reduced of 1,7216% and its aggregated consumption increased by 4,5517% in the period following the shock. This can illustrates the transfert from the USA toward the Euro Area that occur in order to reduce the current account deficit: the USA have to produce more in order to transfert au part its output to the Euro Area. In the same time, production in the EA decreases lightly. We have to note that the cost push under cooperation induces a bigger excedent of the european current account. In the same time, the central banks react in the same direction whatever the situation we consider. However, the cooperation implies a smaller reaction of the interest rates to the cost push, as we can see in Table (3). This can be explain by the fact that the monetary authorities react as if there were only a worldwilde economy. So

[13] a significant one?

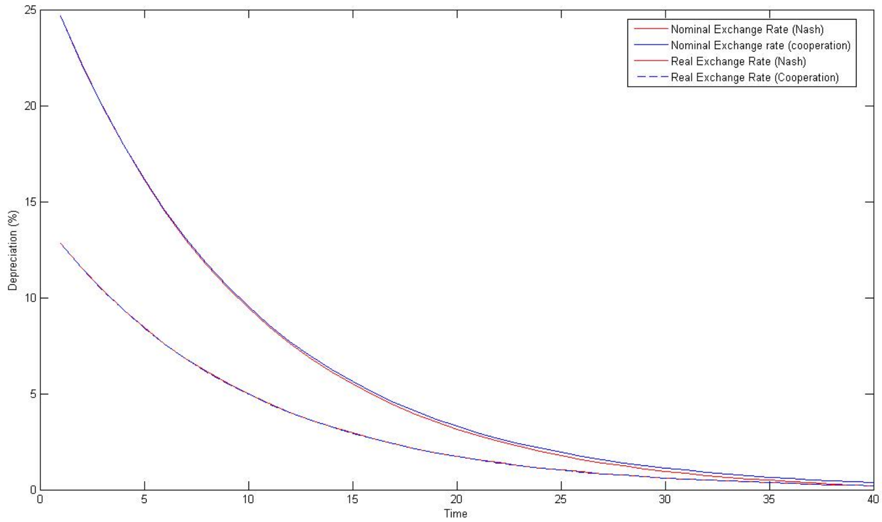

Figure 3: Nominal and Real exchange rate reaction to a cost push shock

concertation leads to a better response in terms of interest rate variations. In the same line, the output expansion and recession in the Home and foreign countries are considerably smaller under cooperation. We can conclude that international cooperation induces a smaller volatility of output if the economies experimented a cost push shock.

	Nash Equilibrium	Cooperative Equilibrium
US current account	-6,0502	-6,0521
EA current account	6,5745	11,939
US output	2,7917	0,53424
EA output	-1,7216	-0,30632
US consumption	-3,0175	-5,2527
EA consumption	4,5517	0,5807
US real interest rate	-0,82686	-0,53109
EA real interest rate	-1,8718	-1,3225

Table 3: Nash vs Cooperative equilibrium: instant deviation of main variables (%)

We note too that the "adjustment" took time, all variables considered deviate from their steady state value for at least thrity quaters, even if the big part of it in the first fifteen periods. The economy adjusts itself gradually.

Do cooperation has an important impact on Welfare? As we can see in Table 4, cooperation tend to reduce drastically the welfare loss experimented by the Home country. The Home country experiments a loss of Welfare of about 8,7363% of its steady state consumption when it reacts in the Nash way facing a cost push. If it succeed in implementing cooperation, its Welfare loss tends now to zero (0,005% of its steady state consumption). The problem is that the Foreign economy do not suffer from the cost push in the Nas equilibrium whereas, even if it's very small on, the loss is positive under cooperation (0,0054%).

	United States	Euro Area
Welfare correction under the Nash case (%)	8,7363	0
Welfare correction under cooperation (%)	0,0075	0,0054

Table 4: Matrix of Welfare corrections

It appears that cooperation can be difficult to implemented in this contexte because the Foreign economy have no direct interest in doing it.

4.2 Technological shock in the Home shock

4.2.1 Exchange rate reaction and current account adjustment

In the case of a technological shock, we observe at the same conclusion for the Nominal and real exchange rate than before. We see no real difference in the response of these variable to a technological or a cost push shock between cooperation or no cooperation case. However, here the instant depreciation is a little stonger than before and at the end, the nominal exchange rate reach a slighty and new appreciated steady state level. Cooperation seems to conduct to a more appreciated level than the Nash case. This can be linked ti the fact that the Home economy experimenting a positif technologic schock, it leads to a modification of prices and so on, to a change in the steady state value of the nominal exchange rate. Concerning the real exchange rate, its reaction is the same under the two cases.

	Nash Equilibrium	Cooperative Equilibrium
Nominal depreciation (%)	26,64	26,508
Real depreciation (%)	13,865	13,841

Table 5: Comparison Nash vs. Cooperative equilibrium

4.2.2 Mains IRF and reactions

We observe that the cooperation do not induce important changes in the reaction of the main variables of our economy (see Table 6. We find out again that the shock induce an expansion in the Home country wheareas its partner experimented a diminution of its leve of output. This is coupled with the inverse reaction of consumption. Note that cooperation, if the shock is a technological one, tend to increase slightly the negative response of interest rate. In the same line, we note that it takes ime to get back to the setady state. It seems to take the same time whatever the shock we consider. Once again, the bigger part of the adjutment is over the first periods we consider here.

Welfare correction The technological shock induces an interesting configuration in terms of welfare. We note that, indeed, no one has an interest in implementing cooperation. The Home and Foreign economy see their losses of welfare increase under the cooperation regime to 0,264% and 0.7657% respectively (see Table 7) whereas under the Nash case, the loss of Home is of 0,0103 and the Foreign economy loose nothing (0,0003% of its steady state consumption).

We draw the conclusion that, under the optimal monetary policy regime, the international cooperation in terms of monetary policy is benefic neither for the Home economy which face the technological shock, nor the Foreign one.

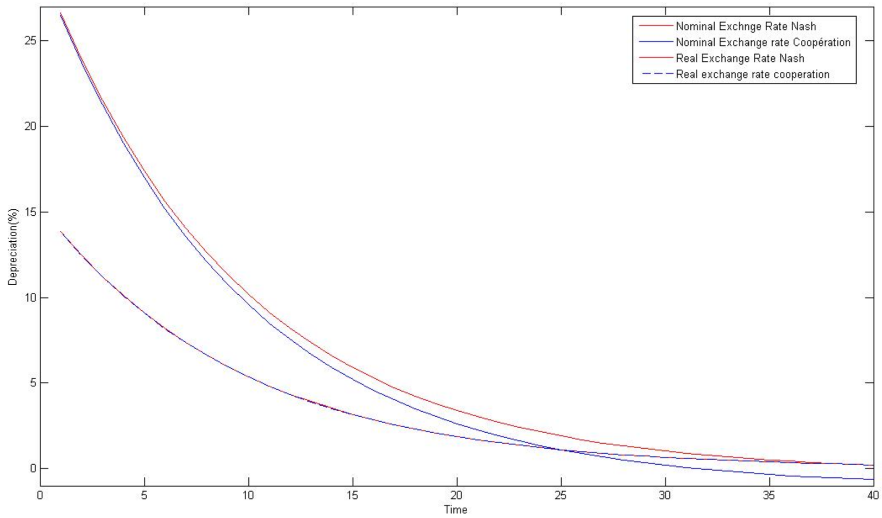

Figure 4: Nominal and real exchange rate reaction to a technological shock

	Nash Equilibrium	Cooperative Equilibrium
US current account	-6,5425	-6,5314
EA current account	7,0877	7,0757
US output	3,0135	3,0083
EA output	-1,8598	-1,8567
US consumption	-3,2423	-3,2369
EA consumption	4,9173	4,9089
US real interest rate	-0,8941	-0,97228
EA real interest rate	-2,0207	-2,097

Table 6: Nash vs Cooperative equilibrium: instant deviation of main variables (%)

5 Concluding remarks

We have built a two-country model in order to analyse the impact of international monetary cooperation in case of a current account adjustment resulting of a shock to the terms of trade. Our work is based on Ramsey optimal rules obatined using microfunded loss functions for the central banks. The result is that in the cases presented above, the two countries experimented loss of welfare but in a different scale. We have shown that international cooperation have little effects on the nominal and real exchange rates variability but have important repercussion on welfare whatever the shock we consider is. In the case of a cost push shock, cooperation is benefic for the Home country, reducing the cost of the adjustment for the country facing the shock, but inceasing it for the other one. However, cooperation should not be implemented if the shock we consider is a technological one. Indeed, we have seen, that in that situation, international monetary cooperation induces bigger losses than the those experimented if the economies act in a Nash way.

International monetary cooperation can be defined as a non cooperative game as the Foreign

	United States	Euro Area
Welfare correction under the Nash case (%)	0,0103	0,0003
Welfare correction under cooperation (%)	0,264	0,7657

Table 7: Matrix of Welfare corrections

country has always interest in implementing the Nash interest rule. It's difficult in this framework to see how cooperation can be naturally sustained, even in a cost push shock coniguration. It can be manage if there is incitation coming from the Home country leading its commercial partner to stay under the cooperation system. These incitations can be a kind of threat as, for example, the fact that the United States will not interfere to stop the fall of the dollar. Actually, historically speaking, the USA faced a current account adjustment in the eighties. Cooperation was implemented with the Plazza and Louvre Agreemments[14], but this situation was unic. The United States had declared that they were not the only one that had to interfere in the adjustment process and theaten the other economy of letting the dollar depreciation go. It succeeds but can we be sure that it will be the case today? Nothing is secure due to the important changes implemented in the European Union over the last decade. Its monetary unification changes the game.

Some extensions can be made to this work. Concerning the monetary policy reaction, we can implemented different monetary rules such as Taylor rules expressed as a function of the CPI orf domestic inflation in order to compare the results to the optimal reaction of the central bank[15]. In the current account adjustment direction, we can extend this framework to fiscal policy and see how it can manage to reduce the cost of the adjustment, and in this line, extend the model to the case of a European Union country.

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A Welfare Loss function microfunded in the Nash and Co-operative Equilibrium

A.1 The Nash case

A.1.1 The optimal level of subsidy

As we can see, the household's utility function is additively seprable, so let us defined :

$$U(C,N) \equiv U(C) - V(N)$$

where $U(C)$ and $V(N)$ represent respectively the consumption utility and the labor desutility experienced by the representative household.

The first thing to do is to set the value of the optimal subsidy that is to say the subsidy that maximise the utility fonction under the constraint $C_t = (A_t N_t)^{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}} (Y^*)^{\frac{\alpha\omega\sigma_\alpha}{\sigma}}$. The optimal condition we obtain, using the fact that $A_t = 1$, is

$$V'(N_t)\, N_t = \left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right) C_t U'(C_t) \tag{53}$$

This condition allow us to ensure that the only remaining perturbations in our economy are due to the pricing *a la Calvo*.

A.1.2 The micro-funded loss function

We're going to proceed in three steps[16]. First, we make an aprroximation of the utility of consumption, then of the labor desutility, and finally, we put all together and get the loss function of the central bank in the Nash equilibrium.

The consumption utility approximation We approximate the utility function $U(C_t)$ about the value of consumption that would have been reach under a flexible price equilibrium. As we're in the non-cooperative case, we take foreign variables as given. We get

$$U(C_t) = U(\bar{C}_t) + U'(\bar{C}_t)\bar{C}_t \left[\tilde{c}_t + \frac{1}{2}(1-\sigma)\,\tilde{c}_t^2\right] + o\left(\|a\|^3\right) \tag{54}$$

obtained by using the fact that $\frac{U''(C_t)C_t}{U'(C_t)} = (1-\sigma)$. Using the definition of the term of trade and the market clearing condition[17], can express the approximation

$$U(C_t) = U(\bar{C}_t) + U'(\bar{C}_t)\bar{C}_t \left[\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{y}_t + \frac{1}{2}(1-\sigma)\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{y}_t^2\right] + o\left(\|a\|^3\right) \tag{55}$$

In the meantime, the linearization of $U'(\bar{C}_t)C_t$ around the steady states yields

$$\begin{aligned} U'(\bar{C}_t)C_t &= U'(C)C + \left[U''(C)C + U(C)\right] C\bar{c}_t + o\left(\|a\|^2\right) \\ &= U'(C)C + U'(C)C(1-\sigma)\bar{c}_t + o\left(\|a\|^2\right) \end{aligned}$$

[16] We follow WOODFORD (2001) and Clarida, Gali and Gertler (2002)

[17] We obtain the following expression : $c_t = \left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right) y_t + \frac{\alpha\omega\sigma_\alpha}{\sigma} y_t^*$

where $\bar{c}_t \equiv log\left(\frac{\bar{C}_t}{C}\right)$ is the deviation of flexible price consumption from its steady state level, in percent. Combining the previous expressions :

$$U(C_t) = U'(C)C\left[\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{y}_t + \frac{1}{2}(1-\sigma)\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)^2\tilde{y}_t^2 + (1-\sigma)\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\bar{c}\tilde{y}_t\right] \quad (56)$$

Using the linearized version of the first order condition of the household relative to the worked hour, the market clearing condition and the optimal price setting rule under flexible equilibrium [18], we get the expression of the consumption utility approximation

$$U(C) = U'(C)C\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left[\tilde{y}_t + \frac{1}{2}(1-\sigma)\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{y}_t^2 + (1+\varphi)\bar{n}_t\tilde{y}_t\right] + t.i.p + o\left(\|a\|^3\right) \quad (57)$$

An approximation of labor desutility There is no change in comparison at the approximation of Woodford (2001) or Clarida, Gali and Gertler (2002). We use the same method. The main steps are presented below. We obtain

$$V(N_t) = V(\bar{N}) + V'(\bar{N}_t)\bar{N}_t\left[\tilde{n}_t + \frac{1}{2}(1+\varphi)\tilde{n}_t^2\right] + o\left(\|a\|^3\right) \quad (58)$$

$$V'(\bar{N}_t)\bar{N}_t = V'(N)N + V'(N)N(1+\varphi)\bar{n}_t + o\left(\|a\|^2\right) \quad (59)$$

Combining this two equations, we get

$$V(N_t) = V'(N_t)N\left[\tilde{n}_t + \frac{1}{2}(1+\varphi)\tilde{n}_t^2 + (1+\varphi)\bar{n}_t\tilde{n}_t\right] + t.i.p. + o\left(\|a\|^3\right) \quad (60)$$

Using an approximation of the agregate production function, $\tilde{n}_t = \tilde{y}_t + v_t$, where $v_t = log\int_0^\infty \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\xi} di$, then it yields

$$V(N_t) = V'(N)N\left[\tilde{y}_t + \frac{\xi}{2}\sigma_{p,t}^2 + \frac{1+\varphi}{2}\tilde{y}_t)^2 + (1+\varphi)\bar{n}_t\tilde{y}_t\right] + t.i.p. + o\left(\|a\|^3\right) \quad (61)$$

This expression is obtained using the following Lemma [19]: Let $\sigma_{p,t}^2 = \int_0^\infty (p_{H,t}(j) - p_{H,t})^2 di$ be the cross sectional dispersion of prices in the Home economy. Up to a second order approximation, $v_t \approx \frac{\xi}{2}\sigma_{p,t}^2$.

The second order approximation of the Central Bank objective function Recalling the first order condition of the optimal subsidy (53), we get the following approximation of the household's utility at period t

$$U(C_t) - V(N_t) = -\frac{1}{2}U'(C)C\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left[\kappa\tilde{y}_t 2 + \frac{\xi}{2}\pi_{H,t}^2\right] + t.i.p. + o\left(\|a\|^3\right) \quad (62)$$

where $\kappa \equiv (1-\sigma)\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right) - (1+\varphi)$

[18] leading to $\sigma\bar{c}_t + \varphi\bar{n}_t + \alpha\bar{s}_t = a_t$

[19] Proof: see Gali and Monacelli (2005)

Taking this equation in an intertemporal dimension, and using a second lemma[20] which implies that $\sum_{t=0}^{t=\infty} \beta^t \sigma_{p,t}^2 = \frac{1}{\lambda} \sum_{t=0}^{t=\infty} \beta^t \pi_{H,t}^2$, the objective function of the Home central bank, expressed in term of steady state consumption percent, is

$$W^N = -\frac{1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}}{2} \Lambda E_0 \left\{ \sum_{t=0}^{t=\infty} \beta^t \left[\pi_{H,t}^2 + \chi \tilde{y}_t^2 \right] \right\} \tag{63}$$

where $\Lambda = \frac{\xi}{\lambda}$ and $\chi = \frac{\kappa\lambda}{\xi}$. A similar objective function holds for the Foreign economy.

A.2 Cooperative equilibrium and objective function of the central bank

In this case, the central bank acts as if there is only one worldwilde economy. In consequence, the joint objectif function of the central bank takes into account the foreign variables so that

$$U(C_t) - (1 - \frac{\alpha\omega\sigma_\alpha}{\sigma})V(N_t) - \frac{\alpha\omega\sigma_\alpha}{\sigma} V(N_t^*)$$

Note that under the specific case of $\eta = \sigma = 1$ we find the results presented in Clarida, Gali and Gertler (2002) where $U(C_t) = (1-\alpha)V(N_t) - (1-\alpha)V(N_t^*)$.

A.2.1 the optimal rules of setting the subsidy

In addition, the subsidy is chosen in a cooperative way. The latter is chosen to maximised the objective function above under the constraint $C_t = N_t^{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}} (N_t^*)^{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}}$. The first order condition here is $V'(N_t)N_t = U'(C_t)C_t$, with $A_t = A_t^*$.

Variables with double upper bars denote the values under the global flexible prices equilibrium. Double tilde represents deviation of the variable from the latter equilibrium. We use the same equations as the Nash equilibrium but we keep the foreign variable in the terms depending of the policy.

A.2.2 The second order approximation of the household's utility

Approximation of consumption utility The approximation of the consumption utility leads us to the following result

$$\begin{aligned} U(C_t) &= U(\bar{\bar{C}}_t) + U'(\bar{\bar{C}}_t)\bar{\bar{c}}_t \left[\tilde{\tilde{c}}_t + \frac{1}{2}(1-\sigma)\tilde{\tilde{c}}_t^2 \right] + o\left(\|a\|^3 \right) \\ &= U(\bar{\bar{C}}_t) + U'(\bar{\bar{C}}_t)\bar{\bar{C}}_t \left[\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right) \tilde{\tilde{y}}_t + \left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right) \tilde{\tilde{y}}_t^* \right] \\ &\quad + \frac{U'(\bar{\bar{C}}_t)\bar{\bar{C}}_t}{2}(1-\sigma) \left[\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)^2 \tilde{\tilde{y}}_t^2 + \left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)^2 \left(\tilde{\tilde{y}}_t^*\right)^2 + 2\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right) \tilde{\tilde{y}}_t^* \tilde{\tilde{y}}_t \right] + o\left(\|a\|^3 \right) \end{aligned}$$

We make the same linearization of $U'(\bar{\bar{C}}) = U'(C)C + U'(C)C(1-\sigma)\bar{\bar{c}}_t + o\left(\|a\|^2\right)$, where $\bar{\bar{c}} = log\left(\frac{\bar{\bar{C}}}{C}\right)$ the deviation from the global steady state of consumption (in percent). Combining

[20]proof: see Woodford, NBER WP8071, pp 22-23

with the previous equation, we obtain

$$\begin{aligned} U(C_t) &= U'(C)C\left[\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t+\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t^*\right] \\ &+\frac{U'(C)C}{2}(1-\sigma)\left[\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)^2\tilde{\tilde{y}}_t^2+\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)^2\left(\tilde{\tilde{y}}_t^*\right)^2+2\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t^*\tilde{\tilde{y}}_t\right] \\ &+U'(C)C(1+\varphi)\bar{\bar{n}}_t\left[\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t+\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t^*\right]+t.i.p.+o\left(\|a^*\|^3\right) \qquad (64) \end{aligned}$$

Labor desutility Here, we follow the same way as the Nash case. The expression stay the same. So we have, for both economies

$$V(N_t) = V'(N)N\left[\tilde{\tilde{y}}_t+\frac{\xi}{2}\sigma_{p,t}^2+\frac{1+\varphi}{2}\tilde{\tilde{y}}_t^2+(1+\varphi)\bar{\bar{n}}_t\tilde{\tilde{y}}_t\right]+t.i.p.+o\left(\|a\|^3\right) \qquad (65)$$

$$V(N_t^*) = V'(N^*)N^*\left[\tilde{\tilde{y}}_t^*+\frac{\xi}{2}(\sigma_{p,t}^*)^2+\frac{1+\varphi}{2}(\tilde{\tilde{y}}_t^*)^2+(1+\varphi)\bar{\bar{n}}_t\tilde{\tilde{y}}_t^*\right]+t.i.p.+o\left(\|a^*\|^3\right) \qquad (66)$$

Agregation Then we have to combine equations (64), (65) and (66) to get the expression of the objective at the period t. We get

$$\begin{aligned} \frac{U(C_t)-(1-\frac{\alpha\omega\sigma_\alpha}{\sigma})V(N_t)-\frac{\alpha\omega\sigma_\alpha}{\sigma}V(N_t^*)}{U'(C)C} &= -\frac{1}{2}\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left[\kappa\tilde{\tilde{y}}_t^2+\xi\sigma_{p,t}^2\right] \\ &-\frac{1}{2}\frac{\alpha\omega\sigma_\alpha}{\sigma}\left[\kappa^*\tilde{\tilde{y}}_t^*+\xi\left(\sigma_{p,t}^*\right)^2\right] \\ &+(1-\sigma)\frac{\alpha\omega\sigma_\alpha}{\sigma}\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\tilde{\tilde{y}}_t\tilde{\tilde{y}}_t^*+t.i.p.+o\left(\|a\|^3\right) \end{aligned}$$

Using the second lemma for $\sigma_{p,t}^2$ and $\left(\sigma_{p,t}^*\right)^2$, we get the central bank objective function in the cooperative case in term of foreign and domestic outpug gap and inflation volatility

$$W^C = -\frac{1}{2}\Lambda E_0\sum_{t=0}^{t=\infty}\beta^t\left[\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(\pi_{H,t}^2+\chi\tilde{\tilde{y}}_t^2\right)+\frac{\alpha\omega\sigma_\alpha}{\sigma}\left(\pi_{F,t}^2+\chi^*\left(\tilde{\tilde{y}}_t^*\right)^2\right)-2\Phi\tilde{\tilde{y}}_t\tilde{\tilde{y}}_t^*\right] \qquad (67)$$

where $\Gamma=\frac{\xi}{\lambda}$, $\chi=\frac{\lambda\kappa}{\xi}$, $\chi^*=\frac{\lambda^*\kappa^*}{\xi}$ and $\Phi=\frac{\lambda(1-\sigma)\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)}{\xi}$.

B Optimal policy rules

B.1 Under Nash Equilibrium

The central bank maximise

$$W^N = -\frac{1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}}{2}\Lambda E_0 \left\{ \sum_{t=0}^{t=\infty} \beta^t \left[\pi_{H,t}^2 + \chi \tilde{y}_t^2\right] \right\} \tag{68}$$

where $\Lambda = \frac{\xi}{\lambda}$ and $\chi = \frac{\kappa\lambda}{\xi}$, under the constraint

$$\pi_{H,t} = \beta E_t \left\{\pi_{H,t+1}\right\} + \kappa_\alpha \tilde{y}_t$$

This leads to the following first order conditions

$$2\pi_{H,t} = -\Phi$$
$$2\xi\tilde{y}_t = \kappa_\alpha \Phi$$

where Φ is the Lagrange multiplier. Combining these equations, we obtain a relationship between the ouput gap and the level of domestic inflation

$$\tilde{y}_t = -\frac{\kappa_\alpha}{\chi}\pi_{H,t}$$

Substituing it in the IS curve, and we get the optimal interest rules

$$r_t^{Nash} = r\bar{r}_t + \frac{\sigma_\alpha \kappa_\alpha}{\chi}\pi_{H,t} + \left(1 - \frac{\sigma_\alpha \kappa_\alpha}{\chi}\right) E_t \left\{\pi_{H,t+1}\right\}$$

B.2 Cooperative Case

We consider here that the two countries are in fact a single economy. We need to determine a new flexible price equilibrium taking this into account. We note $\tilde{\tilde{y}}_t = y_t - \bar{\bar{y}}_t$ the output gap in this configuration and $\bar{\bar{y}}_t$ the worldwilde flexible price equilibrium which is defined in the same way as $\bar{y}$. We have

$$\bar{\bar{y}}_t = \Omega + \Gamma a_t + \Psi \bar{\bar{y}}_t^*$$
$$\bar{\bar{y}}_t^* = \Omega^* + \Gamma^* a_t^* + \Psi^* \bar{\bar{y}}_t$$

Re-introduced in the definition of the output gap, we get

$$\begin{aligned}
\tilde{\tilde{y}}_t &= y_t - \Omega + \Gamma a_t + \Psi \bar{\bar{y}}_t^* \\
\tilde{\tilde{y}}_t &= y_t - \Omega + \Gamma a_t + \Psi \bar{y}_t^* - \Psi \bar{y}_t^* + \alpha \Psi \bar{\bar{y}}_t^* \\
\tilde{\tilde{y}}_t &= \tilde{y}_t - \Psi \tilde{\tilde{y}}_t^*
\end{aligned}$$

The same relation hold for the foreign economy $\tilde{\tilde{y}}_t^* = \tilde{y}_t^* - \Psi^* \tilde{\tilde{y}}_t^*$.
We can now express the New Keynesian Phillips Curve in term of $\tilde{\tilde{y}}_t$ and $\tilde{\tilde{y}}_t^*$ to make the new constraints. The central bank seek to minimise the loss function

$$W^C = -\frac{1}{2}\Lambda E_0 \sum_{t=0}^{t=\infty} \beta^t \left[\left(1 - \frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(\pi_{H,t}^2 + \chi \tilde{\tilde{y}}_t^2\right) + \frac{\alpha\omega\sigma_\alpha}{\sigma}\left(\pi_{F,t}^2 + \chi^* \left(\tilde{\tilde{y}}_t^*\right)^2\right) - 2\Phi \tilde{\tilde{y}}_t \tilde{\tilde{y}}_t^*\right]$$

where $\Gamma = \frac{\xi}{\lambda}$, $\chi = \frac{\lambda\kappa}{\xi}$, $\chi^* = \frac{\lambda^*\kappa^*}{\xi}$ and $\Phi = \frac{\lambda(1-\sigma)\left(\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)}{\xi}$.
under the new Phillips Curves

$$\begin{aligned}\pi_{H,t} &= \beta E_t\{\pi_{H,t+1}\} + \kappa_\alpha \tilde{\tilde{y}}_t + \kappa_\alpha \Psi \tilde{\tilde{y}}_t^* \\ \pi_{F,t} &= \beta^* E_t\{\pi_{F,t+1}\} + \kappa_\alpha^* \tilde{\tilde{y}}_t^* + \kappa_\alpha^* \Psi^* \tilde{\tilde{y}}_t\end{aligned}$$

Combining the first order conditions, we obtain

$$\begin{aligned}\tilde{\tilde{y}}_t &= -\frac{\kappa_\alpha \xi}{\chi\left(\frac{\sigma_\alpha\omega\alpha}{\sigma}\right)}\varpi\left[\chi^*\frac{\alpha\omega\sigma_\alpha}{\sigma} - +\Psi\Phi\right]\pi_{H,t} - \frac{\xi^*}{\lambda^*}\varpi\left[\frac{\chi^*\Psi^*}{\chi\Xi} + \frac{\Phi}{\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\chi}\right]\pi_{F,t} \\ \tilde{\tilde{y}}_t^* &= -\frac{\xi^*\kappa_\alpha\chi^*}{\lambda^*\chi\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)}\varpi\left[\chi\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right) + \Phi\Psi^*\right]\pi_{F,t} - \frac{\xi\kappa_\alpha}{\lambda\frac{\alpha\omega\sigma_\alpha}{\sigma}}\varpi\left[\chi\Psi\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right) - \Phi\right]\pi_{H,t}\end{aligned}$$

Using the relation between $\tilde{y}_t$ and $\tilde{\tilde{y}}_t$, we get an expression for $\tilde{y}_t$ in term of $\pi_{H,t}$ and $\pi_{F,t}$. Finally, using the IS-curve, it follows the optimal interest rule

$$r_t^{Coop} = r\bar{r}_t + E_t\{\pi_{H,t+1}\} - \frac{\xi\kappa_\alpha\sigma_\alpha}{\lambda}(\chi^* - \chi\Psi\Xi)\varpi\left[E_t\{\pi_{H,t+1}\} - \pi_{H,t}\right] \tag{69}$$

$$-\frac{\sigma_\alpha\xi^*}{\lambda^*}\left[\frac{\Psi^*}{\chi\Phi} + \frac{\Phi}{\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\chi} - \kappa_\alpha\Psi + \frac{\kappa_\alpha\Phi\Psi\Psi^*}{\left(1-\frac{\alpha\omega\sigma_\alpha}{\sigma}\right)\chi}\right]\varpi\left[E_t\{\pi_{F,t+1}\} - \pi_{F,t}\right] \tag{70}$$

where $\varpi = \frac{1}{\kappa_\alpha\chi^* - \Phi(1-\sigma)}$ and $\Xi = \frac{1-\frac{\alpha\omega\sigma_\alpha}{\sigma}}{\frac{\alpha\omega\sigma_\alpha}{\sigma}}$.

The same kind of rule holds for the Foreign economy

C Figures, evolutions and IRF graphs

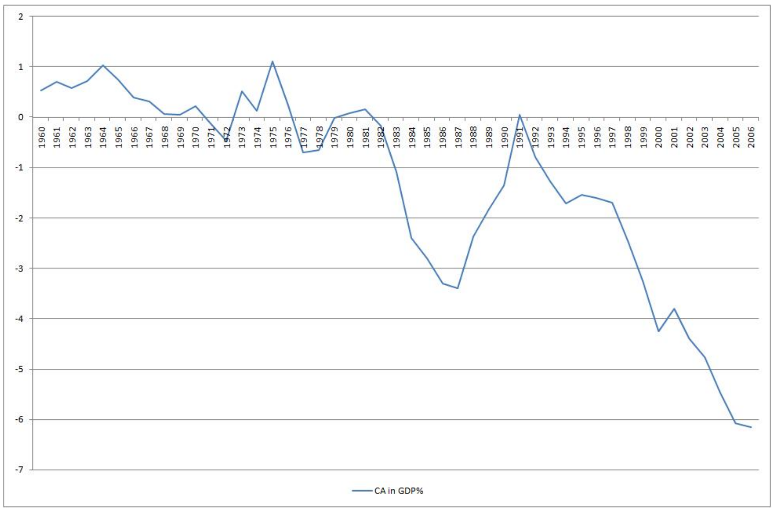

Figure 5: US current account since 1960

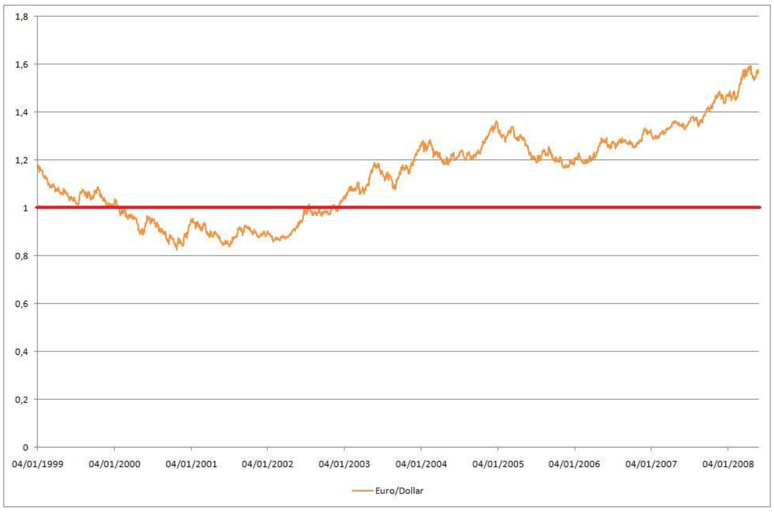

Figure 6: Euro/Dollar exchange rate

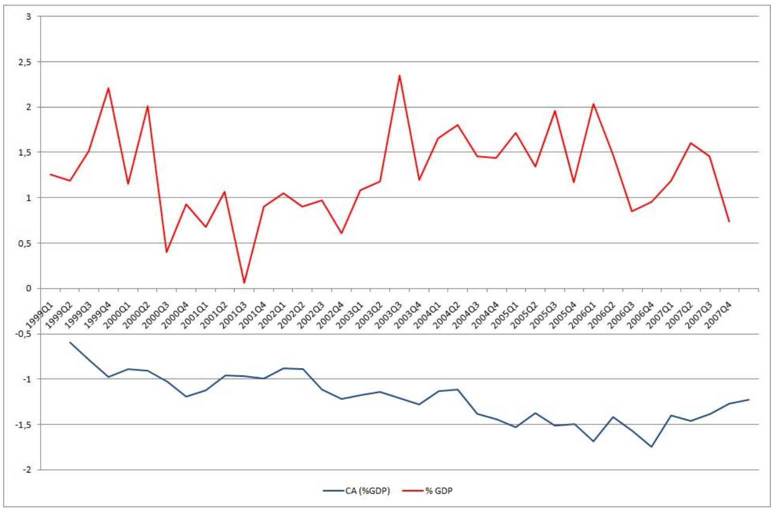

Figure 7: GDP and Current Account evolution (United States)

Figure 8: GDP and Current Account in Euro Area

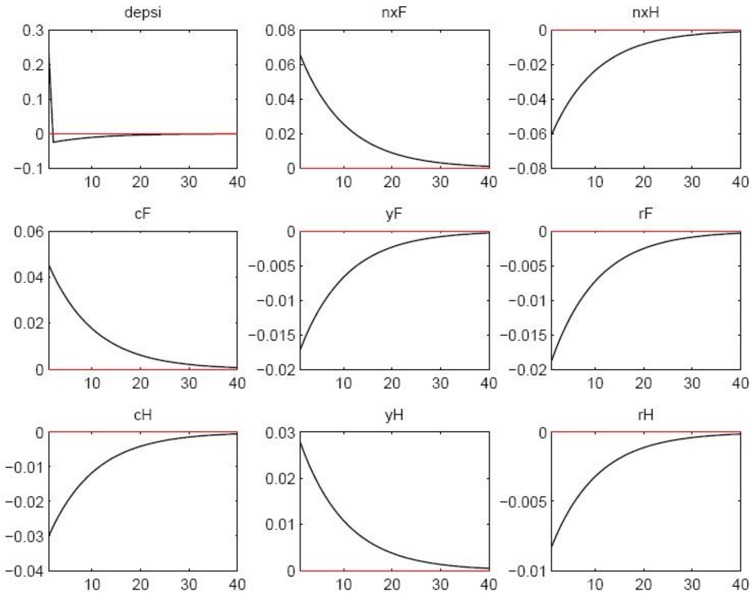

Figure 9: IRF under the Nash case, cost push shock

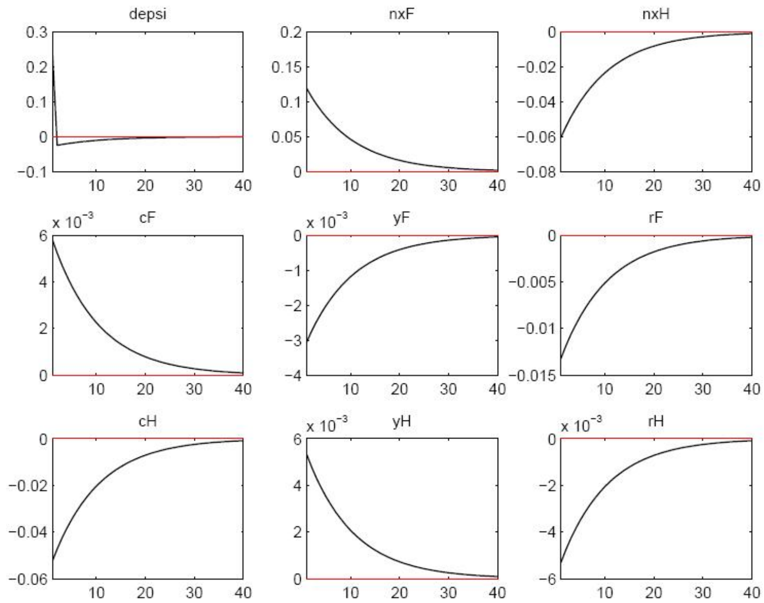

Figure 10: IRF under the cooperative case, cost push shock

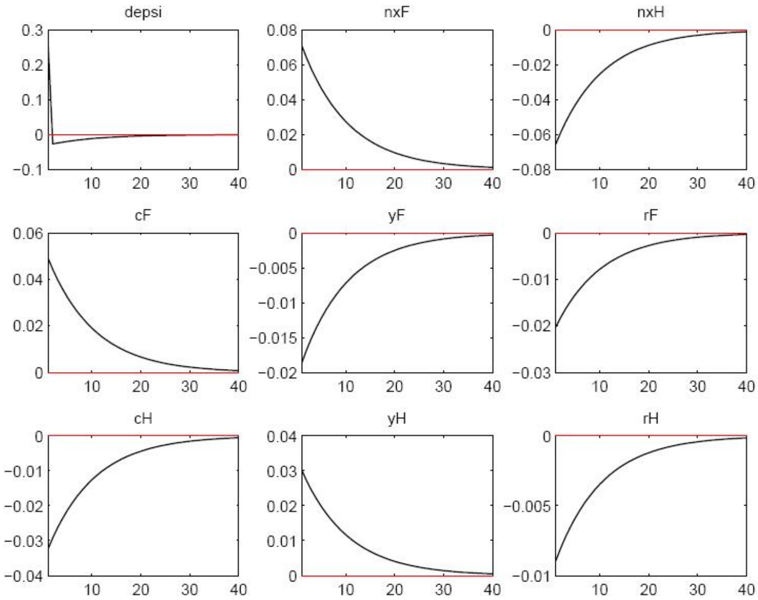

Figure 11: IRF under the Nash cas, Technological shock

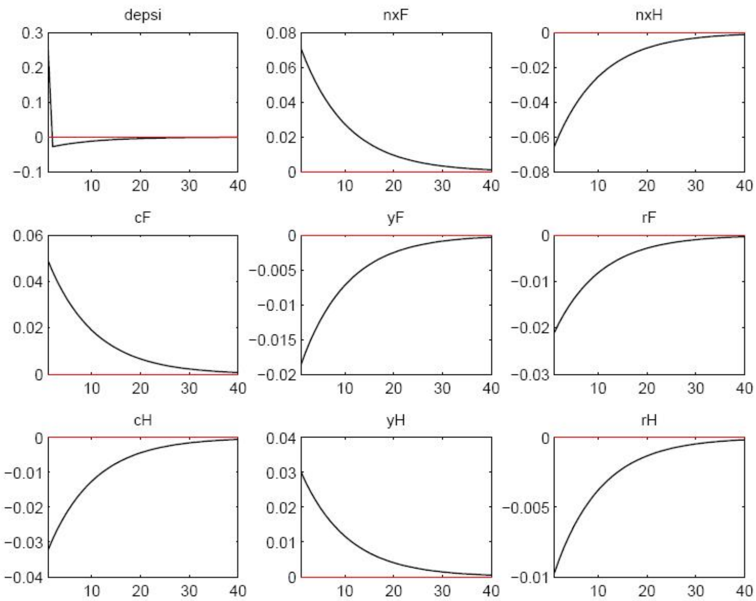

Figure 12: IRF under the cooperative case, technological shock