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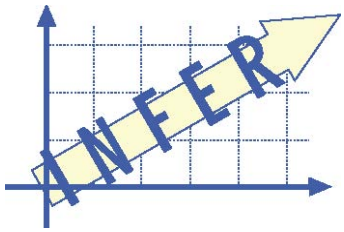

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Degree of Openness and Inflation Targeting Policy: Model of a Small Open Economy

by

Bousrih Jihene

(University of Rennes 1)

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Bousrih Jihene *

UNIVERSITY OF RENNES 1

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Abstract

In this paper, we present the dynamics of a Neo-Keynesian model applied to a small open economy in order to study the impact of openness on the choice of the appropriate inflation targeting policy. In the event of exogenous shocks, we can use either a CPI inflation targeting policy or a domestic inflation targeting policy.

We conclude that there is a relation between the degree of openness of the economy and the type of inflation targeting policy. By considering a domestic shock, when the economy is more open towards outside, we may find that the adoption of CPI inflation targeting is benefical. Whereas in the event of foreign shock, the optimal rule would be the domestic inflation targeting. By considering the criteria of social welfare, we find that for an important degree of openness, the policy of CPI inflation targeting remains the optimal monetary rule.

J.E.L classification: E31, E37, E52, F41

Keys words: Monetary policy, Domestic Inflation, CPI Inflation, Pass-Through, Degree of openness

*University of Rennes 1, 7 Place Hoche - CS 86514 35065 Rennes Cedex, Corresponding author: jihen.bousrih@univ-rennes1.fr; Tel:+33(0)2.23.23.33.24

1 Introduction

Bernanke and Mishkin (1997) define the inflation targeting as a framework of monetary policy characterized by:

1. Public announcement of an official quantitative objective for the rate of inflation over one given period of time.

2. Official announcement to the public that the principal goal of long run of the monetary policy is a low and stable inflation.

3. The responsibilisation of the central bank to reach its objectives.

The inflation targeting policy became popular toward 90's years, since this date several developed and emergent economies started to adopt this new monetary strategy.
The literature trying to explain the various aspects of the inflation targeting is abundant, we can cite Ben Bernanke et al. (1999), Amato and Gerlach (2002), Truman (2003), Giannoni and Woodford (2003), Martin et al. (2004), Carare and Stone (2006) and Sanchez-Fung (2008).
Why the countries target inflation? The reasons are varied: First, it contain inflation and make it converge towards a target value, second, it increase the credibility of the monetary authorities, third it anchor inflationary anticipations of the economic agents and ensure a stable economic environment for a constant expansion and finally it eliminate the difficulties resulting from the monetary targeting.

2 Degree of Openness and Inflation Targeting policy

2.1 Degree of Openness and Inflation

Taking into account a high degree of openness [1] in the emerging markets and the sensitivity of these economies to the import and export of some goods, the variations of exchange rate can have very fast effects on inflation. Calvo and Reinhart (2001) estimate that the transmission of exchange rate fluctuations to the domestic prices is four times more important in the emerging markets than in the developed ones. Ho and Mac Caulley (2003) compiled a several empirical studies undertaken over the period 1980-2000, they showed that the degree of pass-through, related to an important degree of openness, is higher in the emerging markets.
Nevertheless, we can say that a high degree of openness have some ambiguous effects. On

[1] the degree of openness is measured by the Ratio: Imports/GDP in Volume, Romer (1993)

one side, a higher degree of openness means that the economy is strongly influenced by the transmission of exchange rate variations to prices, which brings us to a positive correlation between the degree of openness and inflation.

But on the other side, by considering the economies adopting inflation targeting the continual search of credibility leads to a weak inflation in the most open countries. That can be explained by the interest of the central bank to minimize the variability of price level, which limits transmission of exchange rate variations to consumer good's prices.

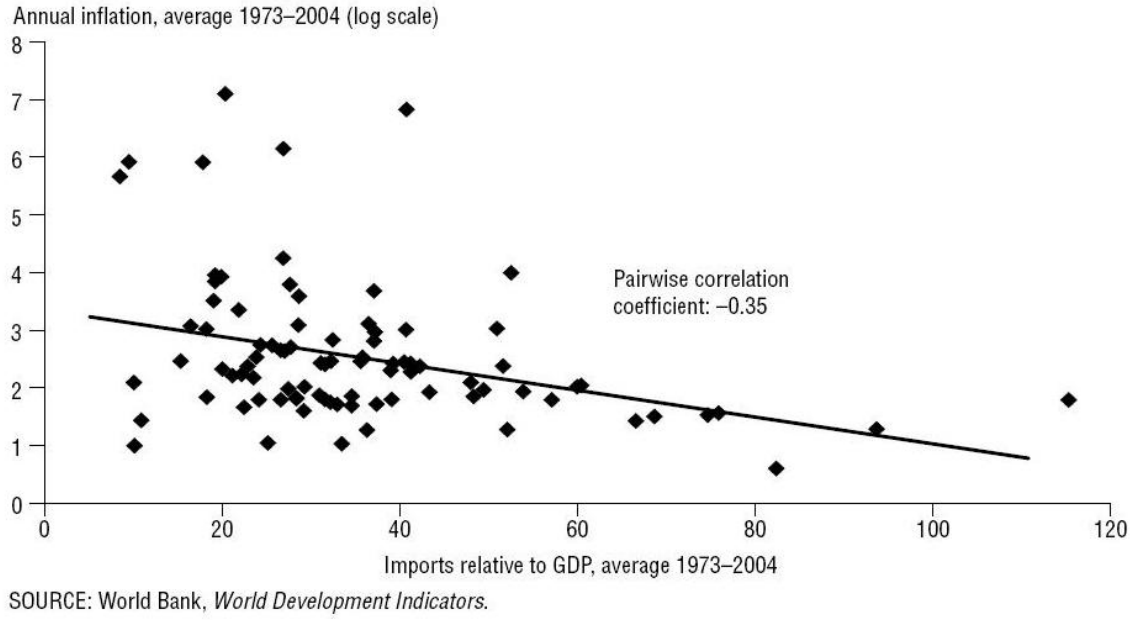

Figure 1: Relation between Inflation and Degree of openness
Source: Wynne et Kersting (2007)

Figure (1) illustrates the negative relation between the degree of openness and the level of inflation. Inspired by Kydland and Prescott's research (1977), the paper of Romer (1993) illustrates the relation which binds inflation with the degree of openness, it shows according to an empirical study relating to 114 OECD countries, that in the case of absence of a well defined monetary policy, a high degree of openness involves important variations in the inflation rate. Whereas in the presence of an explicit monetary rule centered on the control of prices, Romer (1993) shows that there exists a negative relation between the degree of openness and the variability of inflation.

The aim of this paper is to study, in case of exogenous shocks, the relation between the degree of openness of the economy and the variable that we should target(CPI Inflation or Domestic Inflation). So, we will try to study the impact of an important degree of economy's

openness on key variables such as inflation, output gap, exchange rate and interest rate when we adopt several inflation targeting policies. Then, we will check whether the choice of the variable to be target is influenced by the nature of the exogenous shocks in an open economy, or not.

2.2 Domestic Inflation Targeting and CPI Inflation Targeting: Which alternative for a small open economy?

The choice of which variable to target has been for a long time discussed in the literature. The variability of exchange rate can have a direct or an indirect effects on prices through the change in the price of the imported consumer goods. In the case of small open economies, dependence towards the rest of the world through the imports, plays a very important rule to sustain domestic economy. In this case we have a consumption basket largely composed of imported goods, implying that the degree of openness influences in a remarkable way the price's variations. In other words, the more the economy is open towards outside, the more the prices will be sensitive to a change of exchange rate, leading to more complicated control of inflation. Consequently the central bank face two choice: targeting CPI inflation which precisely includes the degree of openness in a complete way through the imported consumer goods, or targeting domestic inflation which also includes the variations of exchange rate but in an incomplete way through the price of the intermediate imported goods.

	Date of I.T	Target Adopted	Current Inf	Degree of Openness
Rep Tcheque	1997Q1	CPI excl Indirect Taxes	5.5(+/-1)	0,4
New zealand	1990Q1	CPI excl Indirect Taxes, varř Termes of Trade	1//3	0,366
Canada	1991Q1	CPI excl food, Energy and Indirect Taxes	1//3	0,36
United Kingdom	1992Q4	CPI excl Mortgage Interests	2//0	0,324
Finland	1993Q1	CPI Formel	2(+/-1)	0,365
Australia	1993Q2	CPI excl F and V, Petrol, Mortgage Interests	2//3	0,237
Israel	1991Q1	CPI	8//11	0,3
Chile	1999Q3	CPI	2//4	0,29

Source: Guender (2001)

Table 1: **Inflation target adopted in some countries**

Table (1) shows us that the policy generally adopted by the developed or emergent economies is CPI inflation targeting which includes at the same time the price of domestic and foreign goods.

The adoption of CPI inflation targeting is always prefered by the monetary authorities compared to domestic inflation targeting policy, the reason comes from the stabilising caracteristics

of the CPI inflation targeting policy. This is due to the nature of this monetary rule which takes into account the degree of economy's openness, consequently with a control of exchange rate variations, we have a less important volatility of key economic variables such as output gap, real exchange rate and nominal interest rate [2].
Nevertheless, Svensson (2000) find that a strict CPI inflation targeting uses the direct channel of exchange rate to stabilize short-term CPI inflation, involving important fluctuations of real exchange rate, nominal interest rate and terms of trade.
We also find some partisans of domestic inflation targeting policy, Conway et al. (1999) stress that the domestic inflation targeting does not include the direct effects of exchange rate variations, involving a reduction in the variability of real output, nominal interest rate, foreign exchange rate and domestic price. Gali and Monacelli (1999) and Clarida et al. (2001) suggest also that an optimal monetary policy must be focused on domestic inflation. But on another side, Adolfson (2001), McCallum and Nelson (2001) show that an optimal monetary policy must be centered on CPI inflation. Inspired by this divergence of opinion evoked in the literature, we try throughout this paper to explain the monetary authoritie's choice of policy that should be adopted.

The goal of this paper will be first, to formulate a NK model applied to a small open economy and to use it in order to study the macroeconomic characteristics of the adoption of differents inflation targeting policies. Finally, we will try to study which inflation targeting rule would be optimal, in terms of social welfare.

Our article will be organized as follows: in the first part, we will present our model with microeconomic fundations which includes a representative household, a firm, a government and a monetary authority. In a second part, we will try to solve the model with the method of Blanchard and kahn (1980), by considering the case of Chile as an example of small open economy. And finally, in the last part we will report our results and our conclusion.

3 The Model

Our model presents an adaptation of a Neo-Keynesian model applied to a small open economy. The starting point of our analysis is a model with stochastic growth which includes monopolistic competition and nominal prices rigidity, Calvo(1983). The adoption of price rigidity model allows to have more important dynamic effects of the monetary policy than a model with

[2] Guender (2001)

flexibles prices, commonly used in modeling of a small open economies.
The model describes the worldwide economy as a set of small open economies of which the number is normalized to 1. Each economy has a negligible size and thus cannot influence the rest of the world, these economies share the same preferences, technologies and markets structures.

First,we focus on study of consumers and producers behavior in one of these economies considering several inflation targeting rules. But before starting our analysis, we make a short remark on the notation we adopt throught this article. Our interest focus on the study of a small open economy and its interaction with the rest of the world, therefore the not indexed variables will refer to the modelled economy. The other variables indexed by $i \in [0.1]$ refer to one of the economies which constitute the rest of the world and finally the variables with an asterisk correspond to the rest of the whole world.

The modelled economy is represented by a central bank, a tax authority which is the government, a representative consumer and a competitive producer. Time is considered as discret.

3.1 Households

Our small open economy is inhabited by a representative consumer k whose utility function is given by;

$$E_t[U_s(k,j)] = E_t[\sum_{s=t}^{\infty} \beta^{s-t} \left\{ \frac{C_s(k,j)^{1-\sigma}}{1-\sigma} - \frac{L_s(k,j)^{1+\psi}}{1+\psi} \right\}], \tag{1}$$

with; $0 < \beta < 1$ is the discount rate, $C_t(k,j)$ consumption of consumer k for good j, ψ the frishien elasticity and $L_t(k,j)$ the labor provide by the consumer k to produce a good$j$.

The budget constraint of an individual household is given by;

$$P_t C_t + G_{t,t+1} B_{t+1} = (1-\tau) W_t L_t + B_t + TR_t, \tag{2}$$

with B_{t+1} is the repayment of the period t+1 for debts contracted at the period t, W_t is the nominal wage, TR_t is transfer of the gouvernment, $G_{t,t+1} = (1+i_t)^{-1}$ is the factor of actualization between the period t and the period t+1 and τ is the wage's tax imposed by the gouvernment.

In order to maximize his utility the representative consumer chooses to optimize his con-

sumption C_t and the quantity of labor L_t under the budget constraint formulated by the equation (2), we obtain the following first order conditions ;

$$\beta E_t[\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right)] = G_{t,t+1}, \tag{3}$$

$$L_t^{\psi} C_t^{\sigma} = (1-\tau)\frac{W_t}{P_t}. \tag{4}$$

The expression (3) represents the Euler equation for consumption whereas the expression (4) corresponds to the Euler equation for labor. The index of total consumption C_t is defined by;

$$C_t = [(1-\gamma)^{1/\eta}(C_{H,t})^{(\eta-1)/\eta} + \gamma^{1/\eta}(C_{F,t})^{(\eta-1)/\eta}]^{\eta/(\eta-1)}, \tag{5}$$

with $\eta > 1$ is the elasticity of substitution between the domestic goods and the foreign goods and γ corresponds to the proportion of the domestic consumption allocated to the imported goods.

The index of domestic goods consumption $C_{H,t}$ is defined by Dixit and Stiglitz (1977);

$$C_{H,t} = [\int_0^1 C_{H,t}(j)^{(\theta-1)/\theta} dj]^{\theta/(\theta-1)},$$

with; $j \in [0.1]$ indicates the variety of the consumed good. [3]

The index of imported goods consumption $C_{F,t}$ is expressed,

$$C_{F,t} = [\int_0^1 (C_{i,t})^{(\zeta-1)/\zeta} di]^{\zeta/(\zeta-1)},$$

with; $C_{i,t}$ is the index of the quantity of goods imported of countries i and consumed by the domestic households, it is defines by the function,

$$C_{i,t} = [\int_0^1 C_{i,t}(j)^{(\theta-1)/\theta} dj]^{\theta/(\theta-1)},$$

[3]Each economy produces a continuum of differentiated good represented by the unit interval

with θ is the elasticity of substitution between the various varieties of the goods in the same economy and ζ the elasticity of substitution between goods produced in the different foreign economies.

The optimal allocation for the various goods allows us to deduce the demand functions for each category of goods,

$$C_{H,t}(j) = [\frac{P_{H,t}(j)}{P_{H,t}}]^{-\theta} C_{H,t} \quad C_{i,t}(j) = [\frac{P_{i,t}(j)}{P_{i,t}}]^{-\theta} C_{i,t},$$

for all $i, j \in [0.1]$, with $P_{H,t} = (\int_0^1 P_{H,t}(j)^{1-\theta} dj)^{1/1-\theta}$ is the domestic price index and $P_{i,t} = (\int_0^1 P_{i,t}(j)^{1-\theta})^{1/1-\theta}$ is the price index of the imported goods of country i expressed in domestic currency.
It is followed from there that the optimal allocation for imported goods is,

$$C_{i,t} = [\frac{P_{i,t}}{P_{F,t}}]^{-\zeta} C_{F,t},$$

for all $i \in [0.1]$, $P_{F,t} = (\int_0^1 P_{i,t}^{1-\zeta} di)^{1/1-\zeta}$ is the price index of the imported goods expressed in domestic currency.
Taking the equation (5), we have the optimal allocation for the various goods,

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

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

with $P_t = [(1-\gamma) P_{H,t}^{(1-\eta)} + \gamma P_{F,t}^{(1-\eta)}]^{1/(1-\eta)}$ is the total consumption price index (CPI).

3.2 Firms

We suppose a fixed number of firms with monopolistic competition held by the households, their number is standardized to 1. Each firm produces a differentiated good and use the same technology. The production requires one factor of production which is labor,

$$Y_t(j) = Z_t L_t(j), \tag{8}$$

with Z_t represent an exogenous factor of technology, and $L_t(j)$ is the quantity of labor used to produce a good j.

The model include price rigidity as in Calvo (1983) we suppose that only a fraction of firms is authorized to adjust its prices each period. For this period, each firm is face to the probability $(1-\alpha)$ correspondent to the adjustment of his price, independently of the last period in which the firm has adjusted its price.

we note $\overline{P}_{H,t}(j)$ the fixed price by the firm at the period t, under the assumption of Calvo (1983), $P_{H,t+k}(j) = \overline{P}_{H,t}(j)$ with a probability α^kpour k=0.1.2... .

The producers are a monopolistic competitors, so each firm have a demand function expressed by:

$$Y_{t+k}(j) = [\frac{\overline{P}_{H,t}(j)}{P_{H,t+k}}]^{-\theta}(C_{H,t+k} + \int_0^1 C_{H,t+k}(i)di), \tag{9}$$

The profit function of firm will be noted;

$$Max[\sum_{k=0}^{\infty} \alpha^k E_t \left\{G_{t,t+k}[Y_{t+k}(\overline{P}_{H,t} - MC^n_{t+k})]\right\}, \tag{10}$$

with α is the probability that the producing consumer maintains the same price of the previous period and $MC^n_t = \frac{(1-\tau)w_t}{Z_t}$ is the nominal marginal cost [4].

The problem of the producer will be to find the price $\overline{P}_{H,t}(j)$ which maximizes the profit function(10) under demand constraint(9).

The first order condition is given by:

$$\sum_{k=0}^{\infty} \alpha^k E_t\{G_{t,t+1} Y_{t+k}(\overline{P}_{H,t} - \frac{\theta}{\theta-1} MC^n_{t+k})\} = 0, \tag{11}$$

from where we deduce the expression of the optimal price (in log) for a representative firm which adjusts his price at the period t,

$$\overline{p}_{H,t} = \mu + (1-\beta\alpha)\sum_{k=0}^{\infty} \beta\alpha^k E_t\{\hat{mc}_{t+k} + p_{H,t}\}, \tag{12}$$

with $\overline{p}_{H,t}$ is (log) domestic price, $\mu = log(\frac{\theta}{\theta-1})$ corresponds to (log) of the mark-up at the

[4]Monetary Policy and Exchange Rate Volatility in a Small Open Economy, Monacelli (2005)

stationary state and $\hat{mc}_{t+1}$ is (log) of the marginal cost at the stationary state.

Equation (12) shows us that the decision of fixing prices is Forward-Looking. The reason is that the firms at the time when they adjust their prices suppose that this price will be valid during a given number of period and thus they adjust it like a mark-up of anticipated marginal cost's average and not only current marginal cost.

3.3 Government

We suppose that the government adjust its budget each period. The budget constraint of the government is given by:

$$\tau P_{H,t} Y_{H,t} - TR_t = 0. \tag{13}$$

This equation shows that the transfer of the gvernment equalizes the domestic income on which we applies a tax rate τ, this latter eliminates the distortions on the market related to the monopolistic power of the firms (Flexible prices equilibrum and rigid prices equilibrum).

3.4 Relation between Domestic and Foreign Prices

3.4.1 Price level and Terms of Trade

Before beginning our analysis of equilibrum, we introduce certain definitions:
we define the term of trade between the domestic economy and country i by: $S_{i,t} = \frac{P_{i,t}}{P_{H,t}}$. The effective term of trade will be noted $S_t = \frac{P_{F,t}}{P_{H,t}}$, the log linearization of this equation gives us $s_t = logS_t = p_{F,t} - p_{H,t}$. While replacing in the expression of the price index P_t, there we obtain a linearized expression of the price level CPI:

$$p_t = (1-\gamma)p_{H,t} + \gamma p_{F,t} = p_{H,t} + \gamma s_t. \tag{14}$$

Thus, we can define the log of CPI inflation,

$$\pi_t = (1-\gamma)\pi_{H,t} + \gamma \pi_{F,t}. \tag{15}$$

It follows from this expression,

$$\pi_t = \pi_{H,t} + \gamma \triangle s_t. \tag{16}$$

with $\pi_{H,t} = p_{H,t} - p_{H,t-1}$ is the domestic inflation and $\pi_{F,t} = p_{F,t} - p_{F,t-1}$ is the foreign inflation.

The equation (16) link the two measure of inflation (Domestic and CPI) through the terms of trade and the coefficient γ which define the degree of economy's openness.

3.5 Financial Market

we suppose in this article that the international financial markets are complete. [5]. This important assumption enables us to say that in such a case we don't need an international diversification of our portfolio, therefore the transitory shocks do not have permanent consequences, which simplifies considerably our analysis.

We formulate the Euler equation as:

$$\beta E_t[\left(\frac{C^i_{t+1}}{C^i_t}\right)^{-\sigma}\left(\frac{P^i_t}{P^i_{t+1}}\right)\left(\frac{E_{i,t}}{E^i_{t+1}}\right)] = G_{t,t+1}, \tag{17}$$

with $E_{i,t}$ is nominal exchange rate between the domestic economy and country i.

By combining the equations (3) and (17) we obtain:

$$C_t = \kappa C^i_{i,t} Q^{\sigma^{-1}}_{i,t}, \tag{18}$$

with $Q_{i,t} = E_{i,t}P^i_t/P_t$ is real exchange rate and $\kappa = \frac{C_{t+1}}{C^i_{t+1}Q^{\sigma^{-1}}_{i,t+1}}$ is a constant term. We will suppose for the rest of this article that we have an identical environment and thus we don't have to hold foreign assets, therefore $\kappa = 1$. The assumption of complete markets [6] is translated through the equation (18), which associates domestic and foreign consumption with the real exchange rate.

By aggregating the expression (18) for the whole of the economies, we lead to the following expression:

$$c_t = c^*_t + \frac{1}{\sigma}q_t \tag{19}$$

$$c_t = c^*_t + \left(\frac{(1-\gamma)s_t}{\sigma}\right). \tag{20}$$

[5] Cole (1991), Monacelli (1999)

[6] The assumption of complete market has the advantage of eliminating foreign assets movements of the dynamics of economy. As a result, the stationary state is unique considering consumption independent of the last shocks. From where, the model can be linearized around a single stationary state, that not being possible with other standard models of the small open economies.

3.5.1 Uncovered Interest Parity

Under the assumption of a complete financial market, the domestic price of a foreign good is given by the uncovred interest parity:

$$G_{t,t+1}[i_t - i_t^i(E_{i,t+1}/E_{i,t})] = 0,$$

with $G_{t,t+1} = \frac{1}{1+i_t}$ is the factor of actualization for period *t+1*. We take a linear form of the preceding expression and agregate it on the whole of small economies i, we find the expression of uncovered interest parity:

$$i_t - i_t^* = E_t\{e_{t+1}\} - e_t. \tag{21}$$

4 Aggregation of the Model

The modelled economy is defined as a sequence of quantities,

$$\{Q_t\}_{t=0}^{\infty} = \left\{Y_t, C_t, C_{H,t}, C_{H,t}^*, C_{F,t}, L_t\right\}_{t=0}^{\infty}$$

a sequence of price,

$$\{P_t\}_{t=0}^{\infty} = \{P_t, P_{F,t}, P_{H,t}, P_t^*, W_t, Q_t, S_t, E_t\}_{t=0}^{\infty}$$

and an interest rate rule, i_t.

Equilibrium on goods and services market

$$Y_t(j) = C_{H,t}(j) + \int_0^1 C_{H,t}(i,j)di$$

$$= C_{H,t} + C_{H,t}^*$$

$$Y_t^* = C_t^*$$

Equilibrium on labor market

$$\int_k L^s(k)dk = \int_j L^d(j)dj$$

$$L_t = (C_t^{-\sigma}\frac{(1-\tau)W}{P})^{1/\psi}$$

4.1 Model at steady state

We resolve our model by supposing that: $Z = 1$, $PmL = \frac{W}{P}$,$P_{H,t} = P_{F,t} = P_t = P_t^* = Q_t = 1$, $\eta = \theta = 1$, $C = C^i = C^*$.

$Y = C;$	$\beta^{-1} - 1 = r$
$L = (\frac{(1-\tau)(\theta-1)}{\theta(Z)^\sigma})^{\frac{1}{\psi+1}}$	
$C = Z^{\frac{-\sigma}{\psi+1}+1}\left[\frac{(1-\tau)(\theta-1)}{\theta}\right]^{\frac{1}{\psi+1}}$	
$C^{ss} = Y^{ss} = Z^{\frac{-\sigma}{\psi+1}+1}\left[\frac{(1-\tau)(\theta-1)}{\theta}\right]^{\frac{1}{\psi+1}}$	
$C_H = (1-\gamma)C;$	$C_F = \gamma C$

Table 2: **Equations at steady state**

4.2 Aggregate Demand

The equilibrium on goods and services market, requires a level of production for all $j\epsilon[0.1]$, which satisfies the following condition:

$$Y_t(j) = C_{H,t}(j) + \int_0^1 C_{H,t}(i,j)di, \tag{22}$$

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\theta}\left[(1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}C_t + \gamma\int_0^1\left(\frac{P_{H,t}}{E_{i,t}P^i_{F,t}}\right)^{-\zeta}\left(\frac{P^i_{F,t}}{P^i_t}\right)^{-\eta}C_t(i)di\right], \tag{23}$$

with; $C_{H,t}(i,j)$ is demand of country i for good j produced in the domestic economy. Combining equation (18) with the definition of aggregate output $Y_t = \left[\int_0^1 Y_t(j)^{1-1/\theta}dj\right]^{\theta/\theta-1}$, we obtain:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta}C_t\left[(1-\gamma) + \gamma\int_0^1(S^i_t S_{i,t})^{\zeta-\eta}Q_{i,t}^{\eta-\frac{1}{\sigma}}di\right], \tag{24}$$

with: S^i_t is the effective term of trade of country i, whereas $S_{i,t}$ is term of trade between the domestic and the foreign economy. Using the form of the expression (24) at the steady state we find:

$$y_t = c_t + \frac{\gamma\omega}{\sigma}s_t, \tag{25}$$

with $\omega = \sigma\zeta + (1-\gamma)(\sigma\eta - 1)$. An analogical condition for country i allows us to write the following expression: $y_t^i = c_t^i + \frac{\gamma\omega}{\sigma} s_t^i$. Aggregating the latter for the rest of the world [7], we obtain:

$$y_t^* = \int_0^1 y_t^i di = c_t^*, \tag{26}$$

with y_t^* is the foreign output and c_t^* is the foreign consumption of the rest of the world.

Combining (19), (25) and (26), we obtain the expression of domestic demand:

$$y_t = y_t^* + \frac{1}{\sigma_\gamma} s_t, \tag{27}$$

with $\sigma_\gamma = \frac{\sigma}{(1-\gamma)+\gamma\omega} > 0$.

If we replace the equation of output (25) into the Euler equation of consumption, we obtain the expression of the aggregate demand:

$$y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma_\gamma}(i_t - E_t\{\pi_{H,t+1}\} + \gamma\Theta E_t\left\{\triangle y_{t+1}^*\right\}, \tag{28}$$

with: $\Theta = (\sigma\zeta - 1) + (1-\gamma)(\sigma\eta - 1)$, i_t is the nominal interest rate, $\pi_{H,t+1}$ is the domestic inflation at the period t+1 and y_{t+1}^* is the foreign output at the same period.

4.3 Aggregate Supply

Taking the expression of the price obtained by maximization of the profit function of firm, we obtain the expression of domestic inflation which represent a formulation of the Phillips curve of new Keynesian (NKPC):

$$\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + k_\gamma x_t, \tag{29}$$

with $k_\gamma = \lambda(\sigma_\gamma + \rho_z)$,$\lambda = \frac{(1-\beta\alpha)(1-\alpha)}{\alpha}$ and $x_t = y_t - y^{flex}$ is the output gap which is the difference between the domestic output y_t and the output obtained at flexible price equilibrum y^{flex}.

At this stage, we notice that the degree of openness of the economy γ affects the dynamics of inflation through the slope of Philips curve in other term through its impact on output gap.

The expression of domestic inflation combined with (16) allows us to find the expression of

[7] We suppose that $\int_0^1 s_t^i di = 0$

a phillips curve for CPI inflation:

$$\pi_t = \beta E_t\{\pi_{H,t+1}\} + k_\gamma x_t + \gamma(s_t - s_{t-1}). \tag{30}$$

4.4 Monetary Policy

We consider a simple Taylor rule according to which the central bank adjust nominal interest rate in response to anticipated inflation and delayed interest rate. Svensson (1997) considers that the monetary authorities when they target inflation, they always have an even implicit target of production. Our choice for a simple policy of Taylor, which includes inflation and interest rate, implicitly includes an adjustment of output through the expression of aggregate supply presented more in details in the previous part. The monetary policy is given, then, by the following expression:

$$i_t = \rho i_{t-1} + (1-\rho)\left(E_t[\pi_{t+1}] - \overline{\pi}\right) + \epsilon_t, \tag{31}$$

with: ρ_i is the degree of smoothing of interest rate, i_{t-1} is delayed nominal interest rate and $\overline{\pi}$ is the inflation target fixed by the central bank. The selected monetary rule will vary according to the variable of inflation which the central bank seeks to target, then we have two types of monetary rules:

- CPI inflation targeting policy :

$$i_t = \rho i_{t-1} + (1-\rho)\left(E_t[\pi_{t+1}] - \overline{\pi}\right) + \epsilon_t, \tag{32}$$

- Domestic inflation targeting policy :

$$i_t = \rho i_{t-1} + (1-\rho)\left(E_t[\pi_{H,t+1}] - \overline{\pi}\right) + \epsilon_t. \tag{33}$$

For the rest of this paper we take as a reference the framework of Gali and Monacelli (2005), we suppose that the domestic inflation targeting policy guarantee at the same time a stabilization of domestic price level and output gap . This result is confirmed by Rotemberg and Woodford's resarch (1999) which suppose that if there are a transfer ratio of the government τ which is constant, that makes it possible to counterbalance the distortions associated with the monoplistic power of firms on the market and consequently these firms will adjust price by considering the case of equilibrum at flexible price. While adopting a domestic inflation

targeting policy, prices of domestic goods will be consequently constant, which involves that the real marginal costs equalize the reverse of the mark-up [8]. The intuition is that by fixing the mark-up and thus the marginal cost at their flexibles price equilibrum, the firm do not may find it beneficial any more to adjust their prices and thus the domestic prices remain constant [9].

With flexible prices, the relation between the output gap x_t and the marginal cost $\hat{mc}_t$ is formulated as follows [10]:

$$\hat{mc}_t = (\psi + \sigma_\gamma)x_t$$

When the marginal cost is stabilized on its equilibrum level, the expression combined above with equation (29) of the model shows that the output gap will be consequently constant, Gali (2003).

5 Social Welfare

In order to evaluate the social welfare while considering the two policies of inflation targeting, we have recourse to approximate the second order of utility function of consumer. The social loss then will be dependant on deviation of inflation and deviation of output compared to its stationary state. We refere as a starting point to Gali(2007) and Beningo and Woodford (2005)'s works , we derive the function of social loss from utility of the representative agent, what lead us to the following expression:

$$L_t = -\frac{(1-\gamma)}{2}\sum_{t=0}^{\infty}\beta^t[\frac{\theta}{\lambda}\pi_t^2 + (1+\rho)x_t^2] \tag{34}$$

we consider now the unconditional anticipations of the equation (34) and we suppose that $\beta \to 1$, the expression of social loss will be expressed in terms of variances of inflation and the output.

$$L_t = -\frac{(1-\gamma)}{2}[\frac{\theta}{\lambda}var(\pi_t) + (1+\rho)var(x_t)] \tag{35}$$

[8] we suppose that in flexible price equilibrum, the marginal cost (log) equalizes the reverse of the mark-up(log); $\hat{mc}_t = -\mu = -log(\frac{\theta}{\theta-1})$

[9] Corsetti and Pesenti (2001) and Gali (2003)

[10] For more details, see Appendix-A

The analysis of the criteria of social welfare will be done according to three cases, the first will be our situation of reference γ_0, then we will see the effect of a variation of this degree of openness, γ_1 and γ_2, on the social loss variation, considering the two alternatives inflation targeting rules.

6 Resolution and Calibration of the Model

6.1 Method of Resolution of the Model

The resolution of the model is carried out by the method of Blanchard and Kahn (1980) which is a method of resolution of linear systems. In matric form, our system can be written:

$$E_t\left[k_{t+1}\right] = Ak_t + Bv_t$$

with k_t is the vector of endogenous variables, A and B are the matrix of coefficients and v_t is the matrix containing the variables of shock.

Blanchard and Kahn stipulate that if the number of the eigenvalues of matrix A, smaller than 1, is equal to the number of predicated variables, in our case 2 variable: i_{t-1} and s_{t-1}, and that the number of the eigenvalues of this same matrix, higher than 1, equal to the number of the variables anticipated, in our case 3 variables: C_{t+1}, π_{t+1} and $\pi_{H,t+1}$, then we can determine a single and steady state for our matrix system.

6.2 Calibration

The choice of the variables of calibration for Chile, is based on standard values used in the literature. The choice for Chile is du to the fact that this small open economy is considered as one of the emergents economies which succeeded its inflation targeting policy in comparison to the other countries. In spite of its inflationary past, Chile could reach very low levels of inflation during very short time by ensuring a great credibility of its monetary policy. Its dependence on outside did not prevent it to keep stable its level of inflation and from thus ensuring the good behavior of its economy. Table (3) recapitulates the various parameters used in the calibration of our model.

Parameters of Chile	
β	0,99
γ_0	0,29
γ_1	0,2
γ_2	0,6
α	0,75
θ	4,33
η	1,5
ψ	0,63
τ	0,25
σ	1
ρ_i	0,8
ρ_z	0,8
ρ_{yfo}	0,8

Table 3: **Parameters of Calibration**

The discount factor is $\beta = 0.99$. The degree of openness of the economy or the proportion of the domestic consumption allocated to the imported goods is measured by the ratio of the imports to the GDP over the period 1998-2000, [Parrado (2004)]. This parameter will be in a first case of reference equal to $\gamma_0 = 0.29$ then we vary it, $\gamma_1 = 0.2$ and $\gamma_2 = 0.6$, in order to see the effect of an increase in the degree of openness on the choice of the monetary policy.
This economy who is open toward outside is caracterised by an elasticity of substitution between the domestic goods and the foreign goods equal to $\eta = 1.5$.

The elasticity of substitution between the various varieties of goods in the same economy is $\theta = 4.33$ [Parrado (2004)], which implies a mark-up at the stationary state $\mu = 26\% - 27\%$. According to [Moyen and Sahuc (2008)], the reverse of Frishienne elasticity is $\psi = 0.63$.
The parameter responsible of the nominal rigidity of the prices is $\alpha = 0.75$ for Chile, which corresponds to only one annual adjustment of the prices.
Finally, the parameters of the interest rate rule and the autoregression process of the exogenous shocks are $\rho_i = 0.8$, $\rho_Z = 0.8$ and $\rho_{yFo} = 0.8$.

7 Results

The simulation of our model gives us the following results, we start by using the parameters of Chile without bringing any modification , then we modify the parameter γ which reflects the degree of openness of the Chilean economy and we study the impulse response which we will have following the exogenous shocks.

7.1 CPI Inflation Targeting

We suppose first, that the Chilean monetary authorities target the CPI inflation which includes at the same time domestic inflation and imported inflation through the foreign consumer goods.

7.1.1 Productivity shock

The simulation of our model gives us the following graphs which illustrate the impulse response of different variables, following a shock of productivity: CPI inflation, Domestic inflation, Output gap, Nominal interest rate, Real exchange rate, Terms of exchange, CPI price level and Domestic price level.

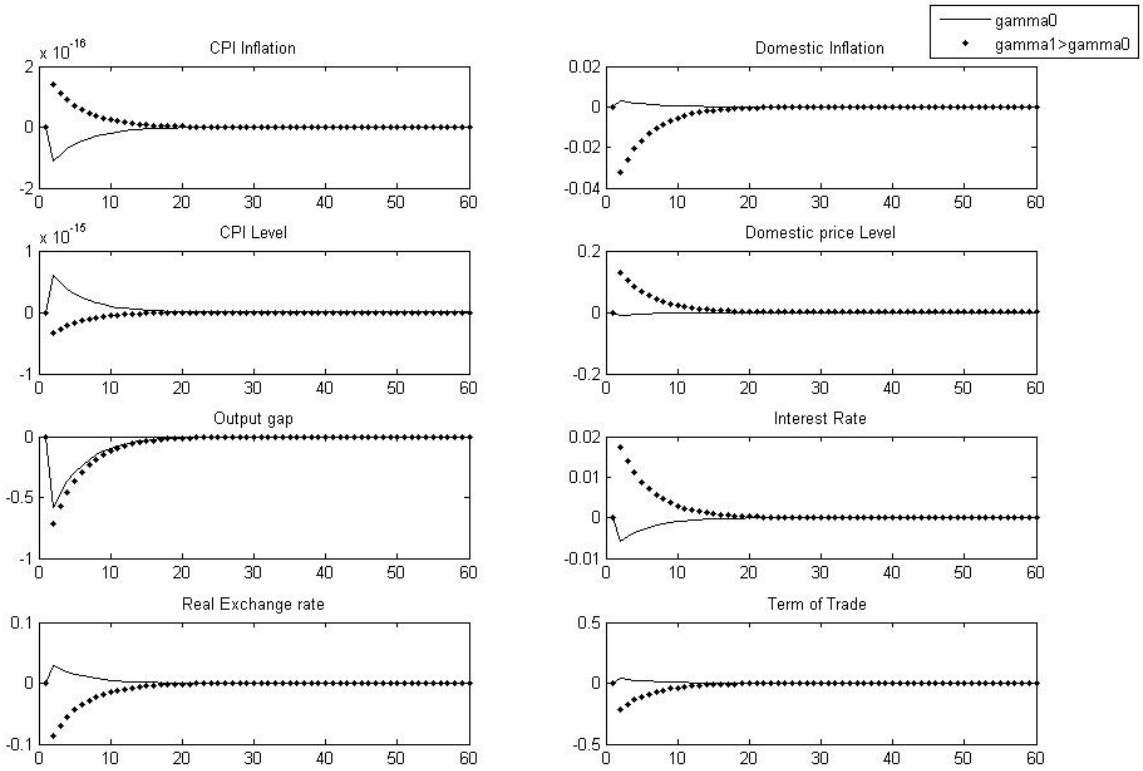

Figure 2: Impulse Responses to a shock of Productivity

The major goal of the monetary authorities when they adopt a CPI inflation targeting policy is to stabilize the CPI price level as well as the level of corresponding inflation.
Following a positive shock of productivity of 1 %, domestic inflation varies but in a small proportion, whereas CPI inflation remains constant. The improvement of the productivity involves a persistent reduction in the nominal interest rate which will influence favorably the consumption and the output. The figure (2) shows us that on the one hand the increase in domestic inflation involves a real appreciation whereas on the other hand, the fall of the

domestic price level involves an increase in the terms of trade.

By increasing $\gamma_1 > \gamma_0$, we notice that the adjustment of the variables is modified. Although CPI inflation remained constant when we consider the CPI inflation targeting, the other variables became much more volatile in comparison with the situation of reference γ_0. The variability of the degree of openness influences the aggregate supply, a modification of γ affect the slope of the curve through the output gap, which according to the equation (29) of the model implie a fall of the output gap, which generates consequently a contractionnary monetary policy that increase the interest rate.

A more important openness degree results in an increase in the imports of the foreign goods what causes an improvement in the demand of imported goods and consequently a fall in the reciprocal demand for domestic goods, which makes them less competitive for the consumers. The equation (16) which connects two measurements of inflation through the terms of trade, shows us that an increase in the degree of openness, involves a fall of domestic inflation. This effect is still confirmed, the raise in prices of the domestic goods involves a fall of the terms of trade, which implies a real appreciation of domestic currency (Equation (14)).

At this stage we can underline, that according to the impulse response of the various variables, we note that the increase in the degree of economy openness involves a greater variability translated through nominal interest rate, the terms of trade and real exchange rate.

7.1.2 Foreign GDP Shock

A shock on foreign variables generally have a very important impact by considering the small open economies, considering in most case that economies are very dependant on outside. So a variation of the foreign GDP is quickly transmitted on the national aggregates.

The impulse response of the figure (3) are a little different from those which preceding. An improvement of the foreign GDP of 1 % involves a rise in the domestic inflation accompanied by a stable level of CPI inflation and corresponding price level, this result is foreseeable considering the monetary policy adopted by the central bank which is the CPI inflation targeting. Following an increase in the supply of foreign goods, the monetary authorities will adopt an expansionnary monetary policy by lowering nominal interest rate in order to support the domestic output, which generates a positive output gap, which means that the level of production will be higher than the level in equilibrum state.

On another side, the fall of the domestic price level involves an increase in the terms of trade combined with an increase in real exchange rate explaining by the raise of domestic inflation.

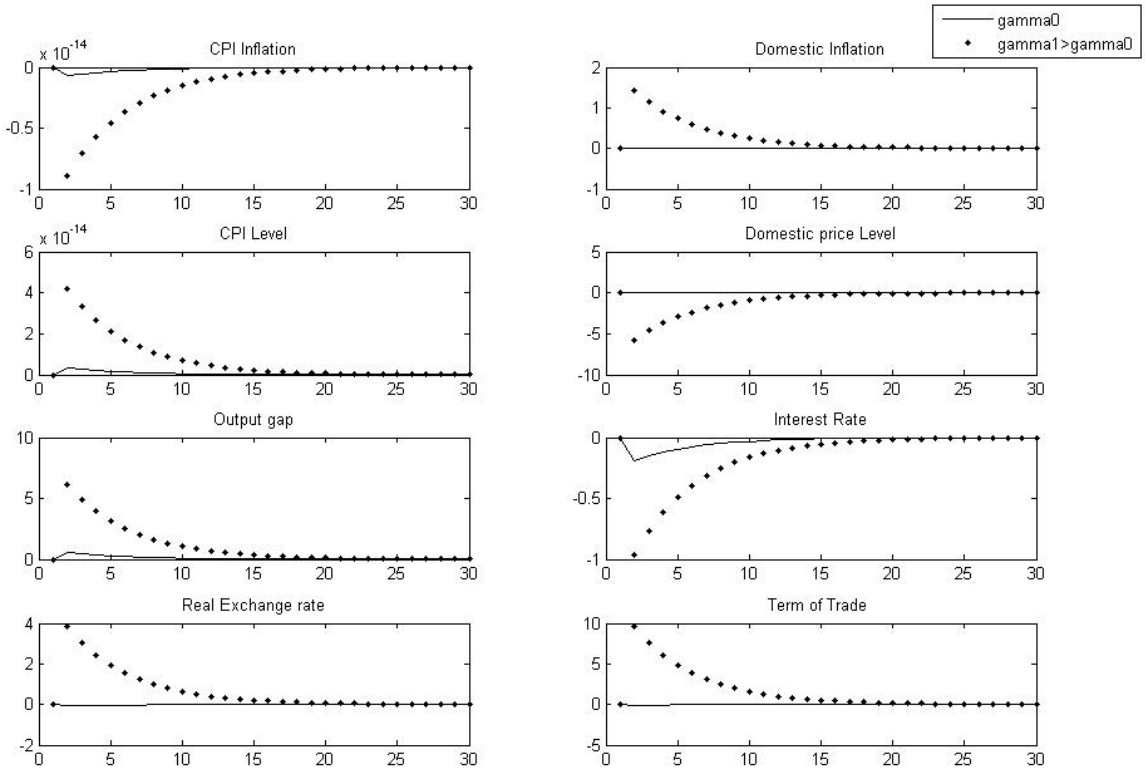

Figure 3: Impulse Responses to a foreign GDP shock

This increase in exchange rate involves a depreciation of the domestic currency encouraging exports and dissuading the imports.

This effect is amplified by increasing the degree of openness, the volatility of the variables increases in a very important way. The output gap, the terms of trade and the real exchange rate reach a volatility of 5 %. This important volatility is due to the increase in the demand of foreign goods which initially affect the price of the imported goods and considering the increase of γ, will modify the composition of CPI price level in favor of imported goods.

We could conclude at this level that a foreign GDP shock allows to an increase of the proportion of imported goods in the domestic consumption basket increasing the degree of Pass-Through towards domestic goods prices, which induces a greater volatility of economic variables, in spite of CPI inflation targeting.

7.2 Domestic Inflation Targeting

We applie in this part the same model but we suppose this time that the monetary authorities of Chile adopt a policy of domestic inflation targeting.

7.2.1 Productivity Shock

We start by applying a shock of productivity by distinguishing between our situation of reference γ_0 and the adjusted situation $\gamma_1 > \gamma_0$.

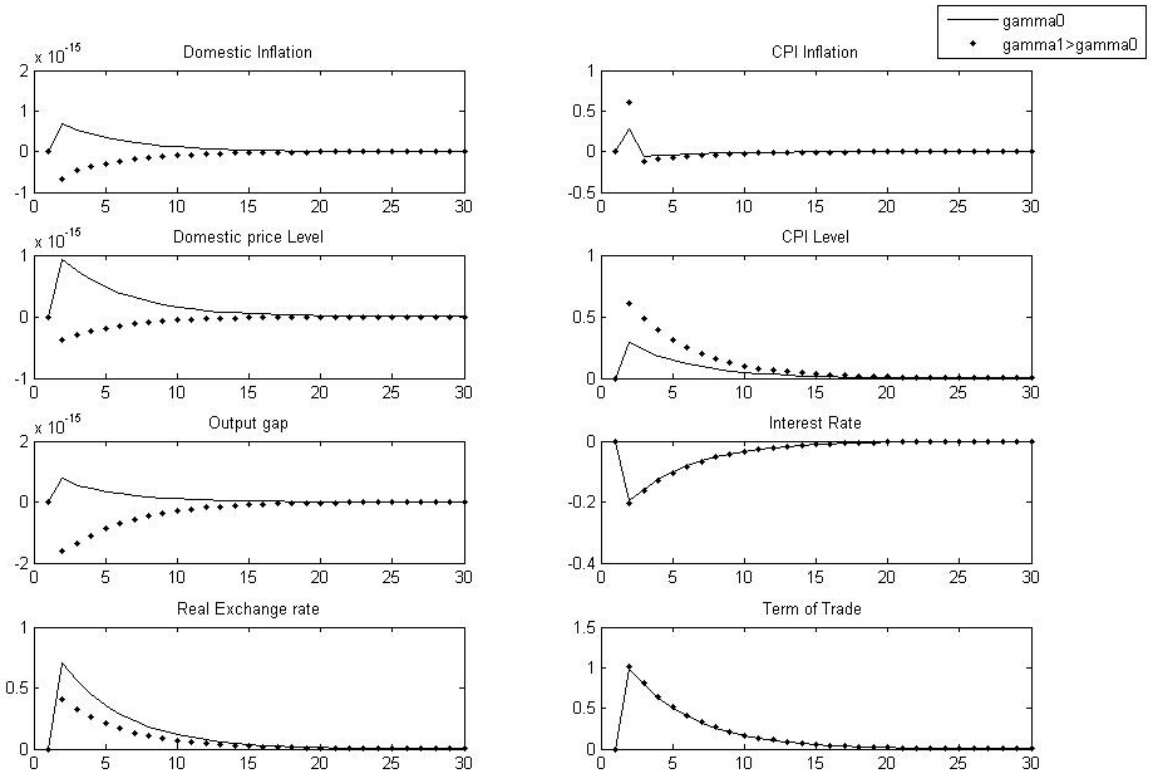

Figure 4: Impulse Responses to a shock of Productivity

Considering a domestic inflation targeting, the adjustment profile of the variables is a little bit modified. The goal of monetary authorities, in this case, will be to stabilize the domestic corresponding inflation and price level.

The level of the output gap is constant by considering the rule of domestic inflation targeting, which confirms the results of Gali and Monacelli (2005).

We notices a drop in the level of nominal interest rate, thus it involve implicitly an increase of consumption and output. This increase in output is not reflected through the output gap which remains constant following the shock, that is due to the fact that by adopting a target of domestic inflation, the central bank leads an implicit target of output gap and then tends to bring closer the level of domestic production of the level of equilibrum of long run, [Svensson (1997)].

Following a positive shock of productivity, the parity of interest rate can be presented as an explanation of the reaction of real exchange rate, . The fall of nominal interest rate involves a

depreciation of the national currency and thus increases exports what explains in its turn the rise of the production.

Gali and Monacelli (2005) still underline, that in the event of domestic inflation targeting, a depreciation of the national currency, due to a shock of productivity, involves an increase in CPI inflation.

By increasing the degree of openness of the economy, we can say that the adjustment of the variables is made in the same manner but we notice an important volatility compared to the situation of reference. Nevertheless, this idea is not valid for real exchange rate, the terms of trades and nominal interest rate. The explanation is simple, when we consider a domestic inflation targeting policy, a variation of γ lead to a variation of CPI inflation without influencing the level of terms of trade.

We notice that the level of real exchange rate will drop on a level lower than in the case of γ_0. Finally, the stability of output gap, even with an increase of γ makes interest rate nominal insensitive to this variation of the degree of openness.

We can conclude that when we consider a shock of productivity, we notice that by comparing the volatility of variables with two different targeting monetary rules, we can stress that the degree of transmission of the exogenous variations is more important with a domestic inflation targeting policy. In addition, with a CPI inflation targeting policy, we find that the Pass-Through is less important and thus the reaction of the variables to an increase of γ, is less marked with a volatility on average not exceeding 0.5 %, [Flamini (2007)].

7.2.2 Foreign GDP Shock

We present in this part the impulse response of Chile with a domestic inflation targeting policy to a shock of foreign GDP. We compare, as mentioned above, a first case γ_0 to a second case in which we have $\gamma_1 > \gamma_0$.

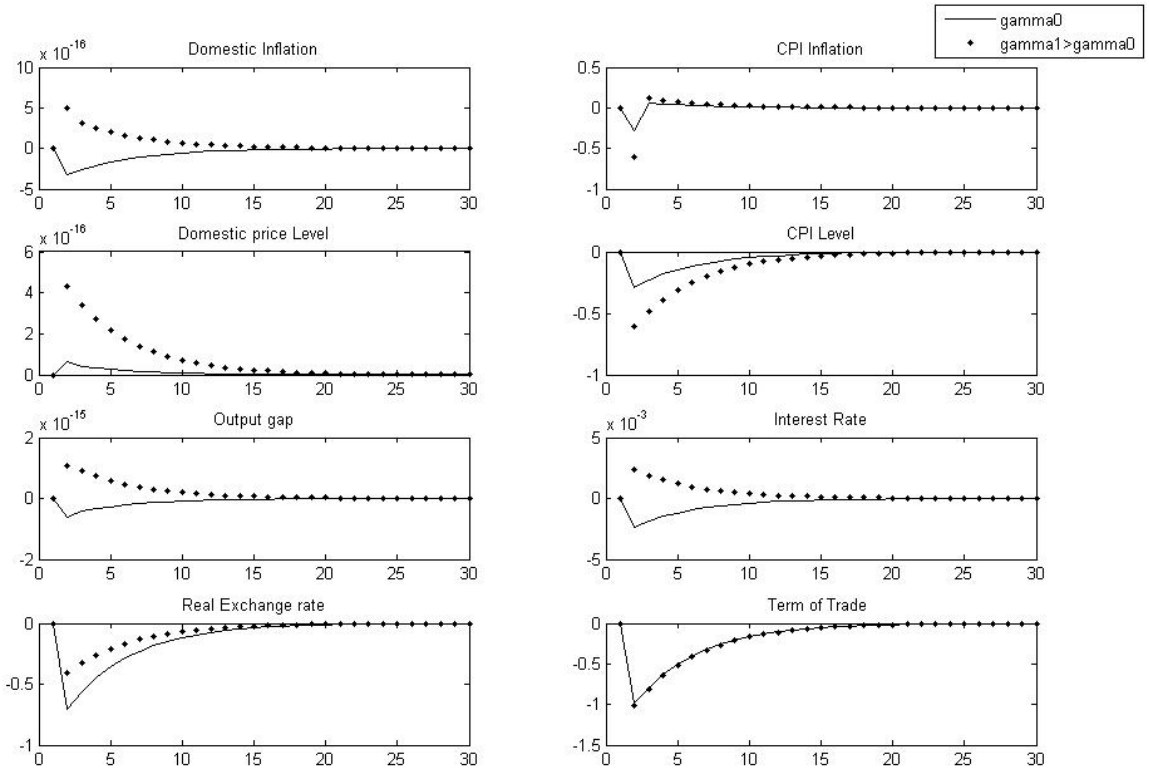

Figure 5: Impulse Responses to a foreign GDP shock

We find a constant level of domestic level of inflation, of output gap and domestic price, compatible with the objective of the central bank. Nevertheless, when we consider the same shock of foreign GDP but under the two monetary policies, we find different results.

The first remark that we can notice by comparing the impulse response for an increase in the foreign GDP, it is that volatility is much less important with a high degree of openness , this is valid for a domestic inflation targeting rule. In fact, when we target domestic inflation, the domestic goods price does not vary and thus the variations of terms of trades are very small. The stability of the output gap is accompanied with a small variation of interest rate compared to the situation where we have a monetary rule centered on CPI inflation.

We can say at this level, that by considering a foreign shock, the domestic inflation targeting policy offers more stabilizing characteristics for the domestic price level, the level of inflation corresponding and the output gap what, in the event of increase of γ, does not influence in an important way the behavior of the economic variables.

While referring to the preceding results, we say that when we consider the case of reference γ_0, it is more optimal for Chile to adopt a CPI inflation targeting policy in the event of domestic or foreign shock. Whereas by increasing the degree of openness, the choice of monetary policy becomes dependant of the nature of the exogenous shock. For a domestic shock such as an

improvement of the productivity, the optimal rule is the CPI inflation targeting, whereas for a foreign shock such as the increase in the demand of the imported goods the optimal rule would be the domestic inflation targeting.

7.3 Social Welfare

In this part, we try to evaluate the social welfare in case of CPI inflation targeting and domestic inflation targeting, by highlighting the impact of the variation in the degree of openness.

	CPI Inflation Targeting		**Domestic Inflation Targeting**	
	Productivity shock	**Foreign GDP shock**	**Productivity shock**	**Foreign GDP shock**
		$\gamma_0 = 0.29$: Baseline		
var(Inflation)	0,0000	0	0,0561	0,0554
var(output)	0,1500	0,1422	0	0
var(Loss)	**0,0959**	**0,0908**	**1,0047**	**0,9921**
		$\gamma_1 = 0.2$: Lower openness		
var(Inflation)	0,0000	0	0,0387	0,0382
var(output)	0,1657	0,2766	0	0
var(Loss)	**0,1193**	**0,1992**	**0,7809**	**0,7713**
		$\gamma_2 = 0,6$: Upper openness		
var(Inflation)	0,0000	0	0,1188	0,1171
var(output)	0,1857	1,597	0	0
var(Loss)	**0,0669**	**0,5749**	**1,1988**	**1,1816**

Table 4: **Variance Analysis of Social Welfare**

Table (4) report the results of variance analysis for the welfare loss function associated with two monetary policies of inflation targeting, these results are gathered in three groups each one treat a particular case. In the first case we take as reference $\gamma_0 = 0.29$, we find that for a CPI inflation targeting, the variance of CPI inflation is equal to zero, which is explained by the adopted policy, whereas with a domestic inflation targeting policy, the variance of CPI inflation become significant. Nevertheless when we target the domestic inflation, the situation is reversed for the output gap, the variance becames near to zero, which confirmed by Gali and Monacelli (2005). The loss in social welfare however is much important by considering this monetary policy. For the second case $\gamma_1 < \gamma_0$, we notice that the variability of output gap increases as well as the degree of social loss. This remark is reversed by considering the domestic inflation targeting policy, more the degree of openness is lower, more the loss in social

welfare as well as the variance of inflation decrease. In the last case $\gamma_2 > \gamma_0$, we notice that for a CPI inflation targeting policy, the variance of the social loss evolves in opposite direction with the degree of openness, whereas the output varies in the same direction as the openness of the economy. For $\gamma_2 = 0.6$, the variance of the social loss is equal to 0.0669 against a variance equal to 0.1193 for $\gamma_1 = 0.2$. Whereas, the output variance for γ_2 is equal to 0.1857 compared to 0.1657 for $\gamma_1 = 0.2$. The situation is reversed by considering the domestic inflation targeting policy.

We conclude that an open economy may find beneficial to adopt a CPI inflation targeting policy because it offers a more important profit in social welfare, by minimizing the variance of the social loss function and CPI inflation.

8 Conclusion

We tried throught this paper to study the impact of a high degree of openness on the choice of the inflation targeting policy which should be adopted by the central bank. We applied a neo-keynesian model caracterised by nominal rigidities and monopolistic competition, we take the case of Chile as a reference. We find on the one hand that there is a significant difference in the impulse response when we consider the two inflation targeting policies (Domestic and CPI inflation targeting). And in the other hand, there is a link between the adopted monetary policy and the nature of the exogenous shocks. By taking the case of reference γ_0 in which we did not modify the Chile's parameters, we find that the optimal policy adopted by the monetary authorities would be the CPI inflation targeting, which includes at the same time the variations of the domestic prices and the variations of foreign exchange rate, this result is valid by considering a domestic or a foreign shock. Now, when we consider the case where we modifie the degree of openness of the economy $\gamma_1 > \gamma_0$, the choice of the optimal policy becomes dependant on the nature of the exogenous shock. With a positive shock of productivity, we notice that the degree of Pass-Through towards the economy is controlled much more with a CPI inflation targeting policy than with a domestic inflation targeting one. Whereas, while considering a foreign GDP shock, the choice of a rule centered on domestic inflation becomes more optimal because it ensures at the same time a stability of the domestic goods price level, corresponding inflation and the output gap level.

By considering the criteria of social welfare, we conclude that the increase in the degree of openness of the economy allows profits in social welfare when we consider a CPI inflation targeting.

References

Adolfson, M. (2001). Monetary policy with incomplete exchange rate pass-through, *Working Paper Series in Economics and Finance, Stockholm School of Economics* **476**.

Amato, J. D. and Gerlach, S. (2002). Inflation targeting in emerging market and transition economies: Lessons after a decade, *European Economic Review* **46(4-5)**: 781–790.

Ben Bernanke, S., Thomas, L., Frederic, M. and Adam, S, P. (1999). *Inflation Targeting: Lessons from The International experience*, Princeton University Press.

Bernanke, B. S. and Mishkin, F. S. (1997). Inflation targeting: A new framework for monetary policy?, *Journal of Economic Perspectives* **11(2)**: 97–116.

Blanchard, O. J. and Kahn, C. (1980). The solution of linear difference models under rational expectations, *Econometric Society* **48(5)**: 1305–11.

Calvo, G. and Reinhart, C. (2001). Fixing for your life, *University Library of Munich, Germany* **13873**.

Carare, A. and Stone, M. (2006). Inflation targeting regimes, *European Economic Review* **50(5)**: 1297–1315.

Clarida, R., Gali, J. and Gertler, M. (2001). Optimal monetary policy in closed versus open economies: An integrated approach, *National Bureau of Economic Research* **8604**.

Conway, P., Drew, A., Hunt, B. and Scott, A. (1999). Exchange rate effects and inflation targeting in a small open economy: A stochastic analysis using fps, *Reserve Bank of New Zealand Discussion Paper Series* .

Flamini, A. (2007). Inflation targeting and exchange rate pass-through, *Journal of International Money and Finance* **26(7)**.

Gali, J. and Monacelli, T. (1999). Optimal monetary policy and exchange rate volatility in a small open economy, *Boston College Working Papers in Economics* **1908**.

Gali, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy, *National Bureau of Economic Research* .

Giannoni, M. P. and Woodford, M. (2003). Optimal inflation targeting rules, *National Bureau of Economic Research* .

Guender, A. (2001). Inflation targeting in the open economy: Which rate of inflation to target?, *Working paper of University of Canterbury - Christchurch, New Zealand* .

Ho, C. and Mac Caulley, R. (2003). Living with flexible exchange rates: issues and recent experience in inflation targeting emerging market economies:, *Working Paper* **130**: http://www.bis.org/publ/work130.htm.

Martin, C., Arghyrou, M. and Milas, C. (2004). Nonlinear inflation dynamics: evidence from the uk, *Money Macro and Finance Research Group* .

McCallum, B. T. and Nelson, E. (2001). Monetary policy for an open economy: An alternative framework with optimizing agents and sticky prices, *CEPR Discussion Papers* **2756**.

Moyen, S. and Sahuc, J.-G. (2008). Le modéle d'équilibre général de la " nouvelle synthèse": quelles hypothèses retenir?, *Economie et Prévision* **2-3**: 15–34.

Parrado, E. (2004). Inflation targeting and exchange rate rules in an open economy, *IMF working Paper* **04/21**.

Sanchez-Fung, J. R. (2008). Inflation targeting and monetary analysis in chile and mexico, *Quantitative and Qualitative Analysis in Social Sciences* **1**: 40–62.

Svensson, L. (1997). Optimal inflation targets, 'conservative' central banks, and linear inflation contracts, *National Bureau of Economic Research* **5251**.

Svensson, L. (2000). Open economy inflation targeting, *Journal of International Economics* **50**: 117–153.

Truman, E. M. (2003). *Inflation Targeting in The world Economy*, Peterson Institute for International Economics.