INSTITUT NATIONAL DE LA STATISTIQUE ET DES ETUDES ECONOMIQUES
Série des Documents de Travail du CREST
(Centre de Recherche en Economie et Statistique)

n° 2009-03

The New Keynesian Phillips Curve with Non Zero Steady State Inflation and Entry of Firms

L. BLOCH[1]

[1] CREST-INSEE, T. J310, 15 Boulevard Gabriel Péri, 92245 Malakoff Cedex, France. Tel : +33 (0)1 41 17 60 34. Email : laurence.bloch@ensae.fr

The New Keynesian Phillips Curve with Non Zero Steady State Inflation and Entry of Firms

Laurence Bloch[1][2][3]

April 2009

Abstract

Over the last years, a few authors have assumed a non zero steady state inflation in the derivation of the new Keynesian Phillips curve (NKPC) based on Calvo price setting with staggered prices. This has led to the theoretical result that the slope of the NKPC decreases with trend inflation, in contrast with stylized facts showing its decline since the 1980s.

In this paper, we develop an enlarged NKPC allowing for endogenous entry of firms with previously assumed non zero steady state inflation. Pricing complementarities are introduced on the demand side. This NKPC exhibits the following properties: 1) its slope, though decreasing with the trend of inflation, also decreases with the trend of the number of varieties; therefore, this NKPC reconciles theory with stylized facts in an environment of low inflation and globalization; 2) in the long run, real average marginal cost and real activity not only decrease with inflation, but also increase with the number of varieties; 3) disinflation and deregulation in the product market (a lowering of the entry costs for firms) have complementary effects in the long run: disinflation implies more growth for lower levels of product market regulation.

Keywords: Firm entry, new Keynesian Phillips curve, non zero Steady State Inflation.

Résumé

Durant ces dernières années, quelques auteurs ont fait l'hypothèse d'une inflation stationnaire non nulle lors de la dérivation de la courbe de Phillips dans les nouveaux modèles keynésiens fondée sur un mécanisme de fixation des prix pour plusieurs périodes (à la « Calvo »). La pente de cette courbe diminue alors avec l'inflation tendancielle, résultat théorique à l'opposé des faits stylisés selon lesquels la pente de la courbe de Phillips aurait diminué depuis les années 1980.

Dans ce papier, nous introduisons une hypothèse de libre entrée des firmes sur le marché des produits dans un nouveau modèle keynésien et développons, dans ce cadre, une courbe de Phillips tenant compte aussi d'une inflation stationnaire non nulle. Des complémentarités de prix sont introduites dans la demande. Nous montrons que cette courbe de Phillips élargie présente les propriétés suivantes : 1) sa pente, bien que décroissante avec l'inflation tendancielle, diminue aussi avec le nombre de produits en tendance ; cette courbe permet ainsi de réconcilier la théorie avec les faits stylisés dans un environnement de faible inflation et de mondialisation croissante ; 2) dans le long terme, le coût marginal réel moyen et l'activité réelle non seulement diminuent avec l'inflation, mais augmentent aussi avec le nombre de produits ; 3) désinflation et dérégulation du marché des produits (une réduction des coûts d'entrée pour les firmes) ont des effets complémentaires à long terme : la désinflation implique plus de croissance lorsque les coûts d'entrée sur le marché des produits sont plus faibles.

Mots clés : Entrée de firmes, Courbe de Phillips dans les nouveaux modèles keynésiens, inflation stationnaire non nulle.

JEL Classification: E31.

[1] CREST-INSEE, TJ310, 15, boulevard Gabriel Péri - 92245 Malakoff Cedex - France, tel:+33 (0)1 41 17 60 34, Email: laurence.bloch@ensae.fr.

[2] We thank Pierre Cahuc, Guillaume Chevillon, Huw Dixon, Stéphane Grégoir, Hubert Kempf, Guy Laroque, Thomas Le Barbanchon, Hervé Le Bihan, Sébastien Roux, Jean-Guillaume Sahuc, Olivier Simon, and participants in the Macroeconometrics CREST, Macroeconomics CREST and Banque de France Seminars and in the AFSE Congress 2008 for useful discussions.

[3] This version is a modified version of a preliminary draft "Product Market Regulation, Trend Inflation and Inflation Dynamics in the new Keynesian Phillips curve" (September 12, 2008) presented at the AFSE Congress 2008.

1 Introduction

The New Keynesian framework has emerged as the workhouse for the analysis of monetary policy and its implications for inflation and economic fluctuations. It combines intertemporal optimization and rational expectations, key features of Real Business Cycles models, with imperfection competion and nominal rigidities. As a consequence of the presence of nominal rigidities, monetary policy is not neutral in the short run. The new Keynesian Phillips curve (NKPC) constitutes one of the key building block of the basic New Keynesian model, assuming zero steady state inflation and a continuum of firms with no entry/exit of firms, for reasons of simplicity. In its basic form, the NKPC relates inflation to expectation of inflation and fluctuations of real marginal costs of production (or output gap). Changes in the slope of the NKPC - the sensitivity of inflation to fluctuations of real marginal costs of production - mostly concern policy makers when assessing the cost of disinflation. Moreover, the steady state of the basic New Keynesian model is very simplifyed: real marginal cost is constant and equal to the inverse of the market power of firms, aggregate output is constant and monetary policy is neutral. In this paper, we investigate how more realistic assumptions for steady state inflation and entry of firms affect the NKPC and the steady state.

Our departure point is the new Keynesian Phillips curve (NKPC) with a non zero steady state inflation. Since King and Wolman (1996), a few authors - Ascari (2004), Sahuc (2006), Bakhshi and al. (2007) and Cogley and Sbordone (2008) - have derived a NKPC based on the standard Calvo (1983) price setting with staggered prices while incorporating a non zero steady state inflation, different from a zero inflation steady state usually assumed when log-linearizing. The presence of non zero steady state inflation alters the structure of the NKPC: the coefficients on past and expected future inflation as well as the slope of the NKPC become functions of trend inflation. The NKPC then includes an additional forward-looking inflation variable with a complex structure. Furthermore, the slope of the NKPC decreases with trend inflation. This implication sits oddly with the stylized fact from the traditional Phillips curve literature and the conventional wisdom that Phillips curves are flatter at low inflation levels. To avoid these implications, Sahuc (2006) and Bakhshi and al. (2007) showed that partial backward indexation of prices for firms, which do not reoptimize their prices in the Calvo price-setting, can weaken, even offset, the decrease of the slope with trend inflation. Moreover, Bashki and al. (2007) showed that if the frequency of price adjustment (Calvo price adjustment signal) becomes an endogenous feature of the economy and a function of the trend inflation rate, then the decrease in the slope of the NKPC with trend inflation can be inverted. Besides, King and Wolman (1996), Goodfriend and King (1997) and Ascari (2004) explored the long run properties of this NKPC: the super-neutrality of money is no more satisfied in the long run; in other words, there is a trade-off between inflation and real average marginal cost or real activity. In addition, Khan and al. (2003) and Yun (2005) analyze the normative implications of relative price distortion for monetary policy, putting forward that relative price distortion is implied by trend inflation in a sticky price model with Calvo-type staggered price setting. In the same vein, Kiley (2007) and Ascari and Ropele (2007) addressed the question of how optimal monetary policy is affected by positive trend inflation.

Another strand of literature has recently studied the endogenous link between product creation (firm entry) and the usual monopolistic competition assumption in the New Keynesian models of business cycle. Bergin and Corsetti (2005), Lewis (2006), and Bilbiie and al. (2007a, 2007b) allowed entry of firms and a variable number of varieties, assuming a one to one identification between a producer, a differentiated good product and a firm. The introduction of nominal rigidity in the model has been usually addressed in a symmetric way in order to avoid heterogeneity in prices within and across cohorts of firms. For example, Bergin and Corsetti (2005) assumed that all the entrant firms preset the price of their product for the period of production; Lewis (2006) introduced nominal rigidities through a Calvo-type wage setting, assuming that each worker has monopoly power in supplying a different labour type; Bilbiie and al. (2007a) incorporated nominal rigidity in the form of a quadratic cost of adjusting prices over time (Rotemberg, 1982); they appealed to symmetry across firms and assumed that a new entrant, at the time of its first price setting takes the average product price last period in its cost of adjusting price. As Bilbiie and al. (2007a) put forward, net entry of firms induces an extra term linked to the fluctuations of the number of firms (or varieties) in any traditional NKPC. They argued that this variable takes a part of the observed persistence in the dynamics of product price inflation in the NKPC. Furthermore, a few authors focused on the impact of globalization on inflation: an increase in competitive pressures and in the elasticity of substitution between goods generated by an increase in the number of varieties would contribute theoretically to flatten the slope of the Phillips curve. However, empirical investigations focusing on the impact of globalization on the slope of the Phillips curve are rather inconclusive or provide contradictory conclusions (see Ball (2006), Borio and Filardo (2007), Ihrig and al. (2007) and Sbordone (2008)).

In this paper, using the framework of the New Keynesian model with monopolistic competition and nominal rigidity, we allow for both endogenous entry of firms and non zero steady state inflation. We assume sunk entry costs: firms entry occurs until the firm value - the discounted sum of expected profits - is equalized with the cost of entry. In addition, we introduce demand side pricing complementarities through translog preferences[1]: the increase in the number of varieties increases the elasticity of substitution between goods and by implication the elasticity of demand faced by firms; at the same time, it enhances competitive pressures. Firms set prices as in the sticky price model of Calvo. Thus, both because of steady state inflation and entry of firms, heterogeneity in prices within cohorts of firms can't be neglected and induces relative price dispersion distortion.

We argue that when allowing for endogenous entry of firms and increasing elasticity of demand with the number of varieties, the long-run and short-run properties of the NKPC derived with non zero steady state inflation are changed in comparison with only non zero steady state inflation: 1) in the long run, because of the link between monopolistic competition and entry of firms, the level of the real average marginal cost (the inverse of the average markup in the economy), or real activity, henceforth becomes an increasing function of the number of varieties; 2) as with no entry of firms, the real average marginal cost decreases with inflation in the long run, but this effect is enhanced in an economy where the cost of entry for firms is low. Indeed, in case of no entry of firms, expectations of trend inflation, amplified by the elasticity of demand faced by firms, curtail expectations of future profits and hence spur a rational price setting firm which sets or resets its price optimally only at some intervals of time (as in the Calvo setting price model) to raise its markup (marginal markup). After aggregation, and taking into account of the inverse movements of relative price and price dispersion with trend inflation, the average markup increases slightly with trend inflation. In a model with endogenous entry of firms, this effect is amplified by the non constancy of the elasticity of demand with the number of firms: at a given cost of entry, a larger number of varieties increases this elasticity and thus enhances the positive effect of inflation on marginal markup. Therefore, at a given cost of entry, when trend inflation is null the number of firms is fully determined, mainly by the cost of entry; when trend inflation is positive, the entry of firms is favoured by the positive effect of trend inflation on the marginal markup, enhanced by the number of varieties. The induced increase of the number

[1] See Feenstra (2003) for a detailed presentation of translog preferences.

of firms reinforces the positive effect of trend inflation on the marginal markup. Finally, the less the cost of entry, the larger the number of varieties and the larger the effect of inflation on average markup and on real activity. In other words, disinflation and deregulation in the product market (a lowering of the entry cost for firms) appear to generate complementary effects on real average marginal cost and aggregate output in the long run; 3) finally, in the short run, the slope of the NKPC, though decreasing in the trend of inflation, also decreases in the trend of the number of varieties mainly because the elasticity of demand faced by firms increases in the number of varieties. Hence, this NKPC reconciles theory with stylized facts, without invoking backward indexation of prices or endogenous frequency of price adjustment.

The next section presents the model and extends the Calvo price setting and the derivation of the NKPC to the case of non zero steady state inflation with endogenous entry of firms and with increasing substitution in the demand with the number of varieties. Section 3 characterizes the steady state and explores the short-run and long-run properties of this NKPC through numerical examples.

2 The Model

We develop a New Keynesian model allowing endogenous number of producers of goods. There is free entry in the product market, but firms face fixed entry costs to start production of a particular variety. The entry costs consist of labor employed in developing the good and setting up the production line. Entry occurs until the firm value is equalized to the entry cost. Monopolistic competition in the goods market is introduced by assuming that each firm produces a differentiated good for which it sets its price. Nominal rigidities are introduced in the form of staggered price setting by firms using the formalism due to Calvo (1983), assuming that only a fraction of firms can reset their prices in any given period. The NKPC is then derived, under entry of firms and in addition with elasticity of demand and competitive pressures increasing with the number of firms; the log-linearization around the steady state takes into account the non zero steady state inflation.

The model economy is made of a single infinitely-lived representative household, a continuum of monopolistically competitive firms and a government authority. The government is assumed to set monetary policy with a long-run inflation target, to distribute labor subsidies financed with lump-sum taxes. We abstract from government consumption expenditure.

Because of the steady state inflation and of entry of firms in a staggered price setting of the Calvo-type, we pay a particular attention to the heterogeneity of prices within and across cohorts of firms.

We derive the NKPC and the steady state of the model and compare them with their derived counterparts in case of steady state inflation with no entry of firms. We give here a very succinct presentation of the model, focused on firms' behavior, derivation of the NKPC and steady state (the rest of the model is in appendix).

2.1 Firms

2.1.1 Technology and Sunk Entry Cost

There is a continuum of monopolistically good producers $i \in \Omega$, each producing one specific differentiated good $y_t(i)$, using specific labour input $l_t(i)$, with A_t the common labor productivity:

$$y_t(i) = A_t l_t(i)^{1-a} \tag{1}$$

The number N_t of differentiated goods produced, and thus the subset of goods $\Omega_t \subset \Omega$, is endogenously determined by the model. An increase in N_t corresponds to both the introduction of new varieties and the creation of new firms. There is free entry in the goods sector.

We assume that to start the production of a new variety i, a firm needs to employ $\frac{f_{Et}}{A_t}$ hours of labour and thus faces a sunk entry cost equal to $\frac{W_t}{P_t}\frac{f_{Et}}{A_t}$ in units of the consumption goods, with W_t nominal wage rate and P_t aggregate price index. This sunk entry cost is the same for any prospective entrant. There are no fixed production costs. Hence, all firms that enter the economy produce in every period until they are hit with a death shock which occurs with probability $\delta \in [0,1]$. The entrants meet this sunk entry cost, one period in advance of producing and setting price for a differentiated variety.

The number N_t of producing firms in period t is:

$$N_t \equiv (1-\delta)(N_{t-1} + N_{Et-1}) \tag{2}$$

with N_{Et-1} the number of new entrants in period $t-1$.

Entry occurs until the firm value $v_t(i)$ (in unit of consumption goods) is equalized with the entry costs, leading to the free entry condition:

$$v_t(i) = \frac{W_t}{P_t}\frac{f_{Et}}{A_t} \tag{3}$$

with $v_t(i) \equiv E_t \sum_{s=t+1}^{\infty} q_{t,t+s} div_s(i)$, where $div_s(i)$ is the operating profit of the firm i (not taking into account entry costs) in units of consumption goods at period s and $q_{t,t+s}$ is the discount factor in real terms between time t and $t+s$ [2]. The free entry condition (3) holds so long as the number N_{Et} of entrants is positive.

2.1.2 Aggregate Price Dynamics

We introduce nominal rigidities in the good producers sector using the formalism due to Calvo (1983). For simplicity, we assume that when a new entrant makes its first price setting decision, it operates as all pre-existing producers do, subject to the same nominal rigidity.

In any given period t, each producing firm may set (or reset) its price only with probability $1-\alpha$. Thus, in each period, a fraction $1-\alpha$ of producing firms (pre-existing firms and new entrants of the previous period) reset (or set) their prices $p_t(i)$ optimally, while the remaining firms adjust their price on lagged general price inflation.

If the firm i does not reoptimize its price, it updates it according to the rule:

$$p_t(i) = p_{t-1}(i)\Pi_{t-1}^{\varrho} \tag{4}$$

where $\Pi_{t-1} = P_{t-1}/P_{t-2}$ is the lagged gross inflation rate of the aggregate price level and $\varrho \in [0,1]$ measures the degree of indexation to past inflation. The rule is the same for a new entrant: if it doesn't set its price optimally, it takes the symmetric price of pre-existing firms

[2] $q_{t,t+s} = [\beta(1-\delta)]^s \frac{U\prime_c(C_{t+s},L_{t+s})}{U\prime_c(C_t,L_t)} = [\beta(1-\delta)]^s \frac{C_t}{C_{t+s}}$ with C_t the consumption bundle, L_t the number of hours supplied and β the subjective discount rate (see appendix for more details).

corresponding to the general price P_{t-1} on the subset of goods Ω_{t-1}, i.e $P_{t-1}N_{t-1}^{\gamma}$, adjusted on lagged general price inflation.

With θ the elasticity of intratemporal substitution between the differentiated goods (see appendix), the aggregate price level can be expressed as:

$$\begin{aligned}
P_t^{1-\theta} &\equiv \frac{1}{B_t^{1-\theta}}\int_{i\in\Omega_t} p_t^{1-\theta}(i)di \\
&= \frac{1}{B_t^{1-\theta}}(\alpha\int_{i\in\Omega_{t-1}} p_{t-1}^{1-\theta}(i)\Pi_{t-1}^{\varrho(1-\theta)}di + \alpha\int_{i\in\Omega_t-\Omega_{t-1}} P_{t-1}^{1-\theta}N_{t-1}^{\gamma}\Pi_{t-1}^{\varrho(1-\theta)}di \\
&\quad +(1-\alpha)\int_{i\in\Omega_t} p_t^{*1-\theta}(i)di)
\end{aligned}$$

Denoting the optimizing firms' relative price by $x_t = \frac{p_t^*}{P_t}$ (i.e the ratio of the new price charged by firms that are free to set their prices optimally to the general price level), we obtain:

$$x_t^{1-\theta} = \frac{N_t^{\gamma(1-\theta)} - \alpha\Pi_t^{\theta-1}\Pi_{t-1}^{\rho(1-\theta)}N_{t-1}^{\gamma(1-\theta)}}{(1-\alpha)}$$

The steady state expression of the optimizing firms' relative price x_t is:

$$\overline{x} = \overline{N}^{\gamma}\left(\frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}{1-\alpha}\right)^{\frac{1}{(1-\theta)}} \tag{5}$$

A price adjustment gap emerges. On the one hand, it reflects the fact that in any model with sticky prices positive inflation mechanically erodes the relative prices of firms which are not adjusting optimally or, equivalently, there will be higher relative prices for those firms that are adjusting optimally (erosion inflation effect). On the other hand, it also reflects the decrease of the welfare-relevant consumer price index with the number of varieties for a given product price level (consumer taste for variety effect).

Furthermore, defining the stationary variables $\widetilde{\pi}_t = \frac{\Pi_t}{\overline{\Pi}}, \widetilde{x}_t = \frac{x_t}{\overline{x}}$,... where a bar over a variable indicates its value in steady state, and hat variables by $\widehat{x}_t = log\widetilde{x}_t \simeq \frac{x_t-\overline{x}}{\overline{x}}$, the log-linear approximation around its steady state gives the following expression relating $\widehat{x}_t$ to $\widehat{\pi}_t$, $\widehat{\pi}_{t-1}$, $\widehat{N}_t$ and $\widehat{N}_{t-1}$:

$$\widehat{x}_t = \frac{\gamma}{1-\alpha\Pi^{(1-\varrho)(\theta-1)}}\widehat{N}_t + \frac{1}{\varphi_0}(\widehat{\pi}_t - \varrho(\widehat{\pi}_{t-1} - \widehat{g}_t^{\pi}) - \gamma(\widehat{N}_{t-1} - \widehat{g}_t^{N})) \tag{6}$$

with $\varphi_0 = \frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}{\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}$.

2.1.3 Optimal Price Setting

A firm i reoptimizing in period t will choose the optimal nominal price $p_t^*(i)$ that maximizes its expected discounted sum of profits:

$$\underset{p_t^*}{MaxE_t}\sum_{j=0}^{\infty}\alpha^j Q_{t,t+j}(p_t^*(i)y_{t+j,t}(i)-CC_{t+j,t}(i))$$

subject to the sequence of demand constraints:

$$y_{t+j,t}(i)=B_{t+j}^{\theta-1}\left(\frac{p_t^*(i)\psi_{tj}}{P_{t+j}}\right)^{-\theta}Y_{t+j}$$

where $Q_{t,t+j}\equiv[\beta(1-\delta)]^j\frac{C_t}{C_{t+j}}\frac{P_t}{P_{t+j}}\equiv q_{t,t+j}\frac{P_t}{P_{t+j}}$ is the discount factor between time t and $t+j$ for nominal payoffs, $Y_{t+j}$is the aggregate ouput in period $t+j$, $y_{t+j,t}(i)$ is the production in period $t+j$ of the firm i reoptimizing in period t, $CC_{t+j,t}(i)$ is the cost function in period $t+j$ of the firm i reoptimizing in period t.

The variable ψ_{tj}, defined as ψ_{tj} ={1 if $j=0$, $\prod_{k=0}^{j-1}\Pi_{t+k}^{\rho}$ if $j\geq 1$, captures the fact that if the firm does not reoptimize its price, it updates it according to (4).

The first order condition takes the form:

$$E_t\sum_{j=0}^{\infty}\alpha^j Q_{t,t+j}Y_{t+j}P_{t+j}^{\theta}\psi_{tj}^{1-\theta}(p_t^*(i)-\frac{\theta}{\theta-1}MC_{t+j,t}(i)\psi_{tj}^{-1})=0$$

where $MC_{t+j,t}(i)$ is the nominal marginal cost at the period $t+j$ of the firm i that last re-optimized its price at t.

2.2 The NKPC with non zero steady state, entry of firms and demand side pricing complementarities

At equilibrium, $MC_{t+j,t}(i)$ the nominal marginal cost at period $t+j$ of a firm i that last re-optimized its price at t differs from the economy's average nominal marginal cost MC_{t+j} through firm-specific labor input and the measure of price dispersion D_{t+j} (see appendix), with

$$D_{t+j}\equiv B_{t+j}^{\theta-1}\left[\int_{i\in\Omega_{t+j}}\left(\frac{p_{t+j}(i)}{P_{t+j}}\right)^{\frac{-\theta}{(1-a)}}di\right]^{1-a}\tag{7}$$

The parameter $\omega=\frac{a}{1-a}$, with $1-a$ the labor share in the production function, is the elasticity of firm's marginal cost to its own output and measures the extent of strategic complementarity[3].

$$MC_{t+j,t}(i)=MC_{t+j}(\frac{y_{t+j,t}(i)}{Y_{t+j}})^{\omega}D_{t+j}^{\frac{-1}{1-a}}=MC_{t+j}(B_{t+j}^{\theta-1})^{\omega}(\frac{p_t^*\psi_{tj}}{P_{t+j}})^{-\theta\omega}D_{t+j}^{\frac{-1}{1-a}}\tag{8}$$

with MC_{t+j} the average nominal marginal cost at $t+j$ expressed as:

$$MC_{t+j}\equiv\frac{W_{t+j}}{(1-a)}\left(\frac{Y_{t+j}D_{t+j}}{A_{t+j}}\right)^{1/(1-a)}\frac{1}{Y_{t+j}}\tag{9}$$

[3]See Woodford (2003) for more details when capital is firm-specific and therefore cannot be instantaneously reallocated across firms.

From the definition of the relative price dispersion D_t (7) and the Calvo-type staggered price setting, we derive a law of motion for the relative price distortion[4] and its steady state expression, $\overline{D}^{\frac{1}{(1-a)}} = \overline{B}^{\frac{\theta-1}{1-a}} N \overline{x}^{\frac{-\theta}{(1-a)}} \frac{(1-\alpha)}{(1-\alpha\overline{\Pi}^{(1-\varrho)\frac{\theta}{1-a}})}$, and using the steady state expression (5) of the relative price $\overline{x}$ we obtain:

$$\overline{D} = \overline{N}^{-(\gamma+a)} \left(\frac{1-\alpha}{1-\alpha\overline{\Pi}^{(1-\varrho)\frac{\theta}{1-a}}} \right)^{1-a} \left(\frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}{1-\alpha} \right)^{\frac{\theta}{(\theta-1)}} \tag{10}$$

The component $\left(\frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}{1-\alpha} \right)^{\frac{\theta}{(\theta-1)}}$ evolves as the relative price and decreases with steady state inflation $\overline{\Pi}$, this effect being amplified through θ. The other component $\left(\frac{1-\alpha}{1-\alpha\overline{\Pi}^{(1-\varrho)\frac{\theta}{1-a}}} \right)^{1-a}$ increases with steady state inflation $\overline{\Pi}$, this effect being amplified through θ. Finally, the level of the relative price distortion in the steady state $\overline{D}$ is mainly set up by $\overline{N}^{-(\gamma+a)}$ (named variety effect) and decreases with the number of varieties $\overline{N}$. It increases with $\overline{\Pi}$ at a higher speed when θ is higher (see Figure 1[5] in appendix).

Thus, the first order condition is rewritten as:

$$E_t \sum_{j=0}^{\infty} \alpha^j Q_{t,t+j} Y_{t+j} P_{t+j}^{\theta} \psi_{tj}^{1-\theta} (p_t^{*(1+\theta\omega)} - \frac{\theta}{\theta-1} MC_{t+j} D_{t+j}^{\frac{-1}{1-a}} (B_{t+j}^{\theta-1})^{\omega} \psi_{tj}^{-(1+\theta\omega)} P_{t+j}^{\theta\omega}) = 0 \tag{11}$$

In the limiting case of no price rigidity ($\alpha = 0$), and no strategic complementarity ($\omega = 0$), the previous condition collapses to the familiar price-setting condition under flexible prices $p_t^* = \frac{\theta}{\theta-1} MC_{t,t}$.

In addition to entry of firms, we assume an increasing elasticity of substitution $\theta(N_t)$ with the number of varieties N_t and thus a decreasing monopoly power of firms $\mu(N_t) \equiv \mu_t \equiv \frac{\theta(N_t)}{\theta(N_t)-1}$ and a decreasing taste for variety $\gamma(N_t)$ (for example taking translog preferences, see Table 1 in annex).

The steady state expression of the relative price coming from the aggregate price level (expression (5)) is the same as previously but with θ and γ evaluated at the steady state $\theta(\overline{N})$ and $\gamma(\overline{N})$ (expression (5')).

In the expression of the first order condition of the optimal price setting (11), the desired markup at each period $t+j$, $\mu \equiv \frac{\theta}{\theta-1}$, must be replaced with μ_{t+j} and will be defined by $\mu_{t+j} \equiv K(\frac{p_t^* \psi_{tj}}{P_{t+j}})^{-\theta_{t+j}})^{\xi_{t+j}}$, with an increasing elasticity of substitution $\theta_{t+j} \equiv \theta(N_{t+j})$ with

[4] Same types of calculations for the relative price dispersion D_t as for the aggregate price level P_t (see 2.1.2) lead to the expression (F):

$$\left(\frac{D_t}{B_t^{\theta-1}} \right)^{1/(1-a)} = \left[\alpha \Pi_t^{\theta/(1-a)} \Pi_{t-1}^{-\varrho\theta/(1-a)} \left(\frac{D_{t-1}}{B_{t-1}^{\theta-1}} \right)^{1/(1-a)} + ... \right.$$

$$\left. ... \alpha(N_t - N_{t-1}) N_{t-1}^{-\gamma\theta/(1-a)} \Pi_t^{\theta/(1-a)} \Pi_{t-1}^{-\varrho\theta/(1-a)} + (1-\alpha) x_t^{-\theta/(1-a)} N_t \right]$$

(F)

[5] In Figure 1, θ is assumed to vary with $\overline{N}$ (translog preferences with $\theta(1) = 10$).

the number of varieties and a decreasing elasticity of the monopoly power ξ_{t+j} with regard to the relative sales which decreases with the number of varieties. In all the calculations, θ will be replaced with $\theta(N_{t+j})$, γ with $\gamma(N_{t+j})$ and the elasticity ω representing the strategic complementarity with $\omega + \xi(N_{t+j})$.

The first order condition implies in steady state:

$$\overline{x}^{1+\overline{\theta}(\overline{N})(\omega+\xi(\overline{N}))} = K\overline{mc}\,\overline{N}^{(\gamma(\theta(\overline{N})-1)-1)\omega}\overline{D}^{\frac{-1}{1-a}} \left(\frac{1-\alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)(\overline{\theta}(\overline{N})-1)}}{1-\alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)\overline{\theta}(\overline{N})(1+\omega+\xi(\overline{N}))}} \right) \tag{12}$$

with K expressed as $K\overline{x}^{-\overline{\theta}(\overline{N})\xi(\overline{N})} = \frac{\theta(\overline{N})}{\theta(\overline{N})-1}$ and $\overline{mc}$ the real marginal cost (inverse of marginal markup) in steady state.

Combining expression (5') of the relative price coming from the aggregate level price in steady state, and expression (12) of the marginal markup coming from the optimal price setting in steady state, we derive the following expression for the economy's average marginal markup $1/\overline{mc}$ (the inverse of the real average marginal cost) in the steady state:

$$(1/\overline{mc}) = \left[\left(\frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}{1-\alpha} \right)^{\frac{1-\theta(\overline{N})}{1+\theta(\overline{N})\omega}} \right] \left[\frac{\theta(\overline{N})}{\theta(\overline{N})-1} \left(\frac{1-\alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}{1-\alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)\theta(\overline{N})(1+\omega+\xi(\overline{N}))}} \right) \right] \ldots$$

$$\ldots \left[\overline{D}^{\frac{-1}{(1-a)}} N^{-\gamma(\overline{N})(1+\omega)-\omega} \right] \tag{13}$$

The economy's average marginal markup ($1/\overline{mc}$) embodies the inflation-erosion effect ($\overline{P}/\overline{p^*}$ in the first bracket, already described in 2.1.2), the expected inflation effect ($\overline{p^*}/\overline{MC}$, in the second bracket, see the description of marginal new markup below) and relative price dispersion augmented with the number of varieties (in the third bracket) since it is simply the product.

The marginal new markup mmk - the ratio of newly set relative price x (p^*/P) and real marginal cost mmc,with $mmc = mc.x^{-\theta\omega}N^{\gamma(\theta-1)\omega-\omega}$ without taking into account the dispersion - rises in steady state as the level of steady state inflation increases. Confronted with a situation of higher expected steady state inflation, a rational price setting firm has an incentive to raise its marginal markup to try to offset the erosion of future profits that higher expected inflation automatically creates (expected inflation effect). This effect is strengthened (through the powers of $\overline{\Pi}$) by the increase in the elasticity of demand with the trend in the number of varieties. On the contrary, this effect is lowered by the degree of indexation on past prices. The level of the marginal new markup is determined with the number of varieties through the competitive pressures $\frac{\theta(\overline{N})}{\theta(\overline{N})-1}$ (see Figure 2[6] in appendix).

The relative price dispersion effect is a decreasing function of $\overline{\Pi}$ with a higher speed when N increases.

Finally, the economy's average marginal markup ($1/\overline{mc}$) increases slightly with steady-state inflation $\overline{\Pi}$ and this effect is strengthened (through the powers of $\overline{\Pi}$) by the increase in the elasticity of demand with the trend in the number of varieties. On the contrary, this effect is lowered by the degree of indexation on past prices. Henceforth, the economy's average marginal

[6] In Figure 2, θ is assumed to vary with $\overline{N}$.

markup ($1/\overline{mc}$) level decreases with the number of varieties through the competitive pressures $\frac{\theta(\overline{N})}{\theta(\overline{N})-1}$ (see Figure 3[7] in appendix). In comparison with a model with non zero steady state inflation but no entry of firms, the number of firms reinforces the effect of $\overline{\Pi}$ through the powers of Π and it plays on the level of competitive pressures through $\frac{\theta(\overline{N})}{\theta(\overline{N})-1}$.

After log-linearization of the first order condition of the optimal price setting around the steady state (expression (12)), and after use of the expression (6) (which results from the log-linearization of the aggregate price dynamics), we derive the following version of the NKPC[8]:

$$\widehat{\pi}_t = (\varrho\widehat{\pi}_{t-1} - \varrho\widehat{g}_t^{\pi} + \gamma(\widehat{N}_{t-1} - \widehat{g}_t^{N}) - \frac{\gamma\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}\widehat{N}_t + \varphi_2\varrho E_t\widehat{g^{\pi}}_{t+1} - \gamma\varphi_2(\widehat{N}_t - E_t\widehat{g^{N}}_{t+1}) + ...$$

$$... \frac{\gamma\varphi_2\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}} E_t\widehat{N}_{t+1} + \varphi_4\widehat{mc}_t + \varphi_4((\gamma(\theta(\overline{N})-1)-1)(\omega+\xi(\overline{N}))\widehat{N}_t - \frac{\varphi_4}{(1-a)}\widehat{D}_t$$

$$... + \widetilde{\beta}_1 E_t\widehat{\pi}_{t+1} + \widetilde{\beta}_2 E_t\sum_{j=2}^{\infty}\varphi_1^j\widehat{\pi}_{t+j} + \beta_3 E_t\sum_{j=0}^{\infty}\varphi_1^j(\widehat{q}_{t+j,t+j+1} + \widehat{g^{y}}_{t+1+j}))/\Delta \qquad (14)$$

with $\varphi_4 = \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}(1-\alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)\theta(\overline{N})(1+\omega+\xi(\overline{N}))})$ and
$\Delta = 1 + \varrho\varphi_2(1+\varphi_0) + \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)\varrho\varphi_1$.

See expressions of coefficients in appendix.

As shown by Ascari (2004), Sahuc (2006) and Cogley and Sbordone (2008), in case of only non zero steady state inflation, the NKPC includes an additional forward-looking inflation variable The NKPC also includes extra terms related to the fluctuations of the number of firms around their steady state (see Bilbiie et al.(2007a)).

The slope of the NKPC (coefficient before $\widehat{mc}_t$) is a decreasing function of the steady state inflation $\overline{\Pi}$ and is mainly impacted by $\overline{N}$ through the multiplicative coefficient $\frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}$, decreasing with $\overline{N}$ because the effect of the increase of the elasticity of demand $\theta(\overline{N})$ with the number of varieties outweighs the inverse effect of the decrease of the elasticity of the monopoly power $\xi(\overline{N})$ with the number of varieties[9]. Moreover, because the gross trend inflation $\overline{\Pi}$ is no more assumed equal to 1, the other coefficients of the NKPC (coefficients of the forward expectation of inflation and of the expectations farther in the future), except the one of the lag variable $\widehat{\pi}_{t-1}$, are now depending on $\overline{N}$, in particular through the powers of $\overline{\Pi}$ and through $\theta(\overline{N})$ (the case for β_1 and β_2).

[7] In Figure 3, θ is assumed to vary with $\overline{N}$; the augmented dispersion effect is equal to $\overline{D}^{\frac{-1}{(1-a)}}\overline{N}^{-\gamma(1+\omega)-\omega}$.

[8] Specifically, $\widehat{mc}_t = \ln(mc_t/\overline{mc}_t), \widehat{D}_t = \ln(D_t/\overline{D}_t)$ $\widehat{g}_t^{\pi} = \ln(\overline{\Pi}_t/\overline{\Pi}_{t-1})$, $\widehat{g}_t^{y} = \ln(g_t^y/\overline{g}^y)$, $\widehat{q}_{t,t+1} = \ln(q_{t,t+1}/\overline{q}_{t,t+1})$ with $q_{t,t+1}$ the real discount factor between time t and $t+1$; see the appendix for details of derivation.

[9] This result is always true with translog preferences, independently of the value of $\overline{N}$, assuming a constant strategic complementarity; in case of Kimball preferences and with the strategic complementarity ω decreasing with $\overline{N}$, Sbordone (2008) showed that the slope declines only for values of $\overline{N}$ superior to 1.05-1.10.

3 Steady State, NKPC and Numerical Examples

3.1 The Steady State under Exogenous Positive Trend Inflation and Sunk Entry Costs

From the equilibrium (see annex), the steady state is summarized through five equations which determine the steady state number of firms $\overline{N}$, real average marginal cost $\overline{mc}$, aggregate output $\overline{Y}$, real wage $\frac{\overline{W}}{\overline{P}}$and relative price dispersion $\overline{D}$ in function of steady state inflation $\overline{\Pi}$, sunk entry costs $\overline{f_E}$, productivity $\overline{A}$ and labor subsidy rate $\overline{\tau}$ and parameters of the model.

The first one (15) is mainly induced by the aggregate free entry condition:

$$\overline{mc} = \frac{1}{1-a}(1 - \frac{\overline{W}}{\overline{P}}\frac{\overline{f_E}}{\overline{A}}(1-\beta(1-\delta))\frac{\overline{N}}{\overline{Y}}) \tag{15}$$

The second equation is the steady state expression of the economy's average marginal markup (13).

The thirth and fourth ones ((16) and (17)) are derived from labor supply and market clearing in labor market (see appendix):

$$\overline{mc} = \frac{\chi}{(1-a)(1+\overline{\tau})}\left[(\frac{\overline{YD}}{\overline{A}})^{1/(1-a)} + \overline{N_E}\frac{\overline{f_E}}{\overline{A}}\right]^{\varphi}(\frac{\overline{YD}}{\overline{A}})^{1/(1-a)} \tag{16}$$

with $\overline{N_E} = \frac{\delta}{(1-\delta)}\overline{N}$.

$$\frac{\overline{W}}{\overline{P}} = \overline{mc}(1-a)\frac{\overline{Y}}{(\frac{\overline{YD}}{\overline{A}})^{1/(1-a)}} \tag{17}$$

The last equation is the expression of the relative price dispersion in the steady state (expression (10)).

In the steady state (assuming $a = 0$ and thus $\omega = 0$, for simplicity[10]), in case of steady state gross inflation $\overline{\Pi}$ equal to 1 and no entry of firms, the relative price dispersion $\overline{D}$ is equal to 1, the real average marginal cost $\overline{mc}$ is equal to $\frac{1}{\theta/(\theta-1)}$, then equations (16) and (17) give $\overline{Y}$ and $\frac{\overline{W}}{\overline{P}}$.

In case of non zero steady state inflation and when the elasticity θ and the market power μ are not varying with the number of varieties $\overline{N}$, the economy's average marginal cost $\overline{mc}$ is mainly a decreasing function of the steady state inflation $\overline{\Pi}$ - the expected inflation effect outweighing the inflation erosion effect - and does not depend on the number of varieties $\overline{N}$ except through the very slight effect of $\overline{D}$. Thus, when the steady state inflation is null, the economy's average marginal cost $\overline{mc}$ is equal to the inverse of the market power $\frac{1}{\frac{\theta}{\theta-1}}$; when the steady state inflation increases, the evolution of $\overline{mc}$ is mainly determined by the steady state inflation $\overline{\Pi}$ one's through the equation (13). The real wage $\frac{\overline{W}}{\overline{P}}$ is then related to the average marginal cost $\overline{mc}$ (equation 17). Then, the aggregate output $\overline{Y}$ is mainly determined by the labour supply equation (16), as an increasing function of $\overline{mc}$ ($\overline{mc}$ at the power $\frac{1+\varphi}{1-a}$). Finally, the number of varieties $\overline{N}$ is mainly set up by the sunk entry cost $\overline{f_E}$ (in units of labour) (equation

[10] $a \neq 0$ or $\omega \neq 0$ may generate multiple equilibria.

(15)), and to a weaker extent by the average marginal cost $\overline{mc}$ (whose it is a decreasing function) and thus by the steady state inflation $\overline{\Pi}$ (whose it is an increasing function) (see Figure 4 in appendix).

When the elasticity θ and the market power μ are varying with the number of varieties $\overline{N}$, at a given sunk entry cost $\overline{f_E}$, higher expected inflation raises the marginal new markup (through the terms $\overline{\Pi}^{\theta(\overline{N})}$)[11] and thus the average markup (the inverse of the average marginal cost) (equation (13)). It gives incentives to firms to enter the market (equation (15)). This increase in the number of firms strenghtens the positive effect of higher expected inflation on marginal markup and thus on the average markup (equation (13)). In other words, it enhances the decrease of the average marginal cost with inflation, which strenghtens the increase of the number of firms. Finally, the less the cost of entry is, the larger the initial number of varieties (without any inflation) is, the larger the final effect of steady state inflation on average markup, real activity and on number of varieties (see Figure 5 in appendix).

Finally, with no entry of firms, the steady state of the model is reduced to the last four equations. The number of firms is constant and its mass is equal to 1. The steady state exhibits two distortions. The first distortion is the presence of market power in the goods markets ($\mu = \frac{\theta}{\theta-1}$), exercised by monopolistically competitive firms. The second distortion results from the presence of staggered price setting in a context of steady state inflation: steady state inflation through the heterogeneity in relative prices that it induces acts as if it maintains a form of rigidity in the steady state. The effect of the infrequent adjustment of prices (rigidity coefficient α) doesn't anymore disappear in the steady state. Actually, this second distortion is present in the equilibrium in the basic New Keynesian model but disappears in the steady state in a context of zero steady state inflation (thus, $\overline{mc} = \frac{1}{\theta/(\theta-1)}$). Moreover, in a context of steady state inflation, the two distortions are related through the elasticity of demand θ: the higher θ is, the weaker the market power of firms μ is, the weaker the first distortion is, but the higher the positive impact of steady state inflation on the sticky prices distortion is.

The endogenous entry of firms reintroduces the link between the sunk cost of entry, the number of firms and the competitive pressures. On the one hand, at a given non zero steady state inflation, a lowering of sunk entry cost (for example, deregulation in the product market through reduction in entry barriers) will induce a higher number of firms and thus a weaker market power distortion, but it will also induce a larger sticky prices distortion and thus a larger number of firms and hence, it will weaken the market power distortion. On the other hand, at given entry costs, higher steady state inflation will induce a higher sticky price distortion and thus a larger number of firms and hence will weaken the market power distortion. Actually, in the presence of non zero steady state inflation, price stickiness distorts the total amount of labour supply and its allocation in favour of product creation instead of production of existing varieties, in comparison with zero steady state inflation.

3.2 The NKPC under Positive Trend Inflation and Exogenous Operating Costs

The coefficients of the NKPC (expression (14) and expression (43) in appendix) are sensitive to the steady state number of varieties not directly through the number of firms but only through the increases of competitive pressures and the decrease of the elasticity of demand with the number of varieties. Apart from the slope and the coefficient of past inflation, the different

[11] See explanations of the evolution of the marginal new markup in 2.2.

coefficients are functions of the steady state number of varieties through the powers of $\overline{\Pi}$, only because $\overline{\Pi}$ is not equal to 1.

The coefficient Δ is very close to $1+\varrho$, with ϱ the degree of indexation. It slightly increases with $\overline{\Pi}$ and decreases with the level of entry costs $\overline{f_E}$.

The coefficient on past inflation (before or after dividing by Δ) is almost completely governed by the degree of indexation and increases with it.

A higher trend inflation is associated with a lower slope of the NKPC. This implication, as mentioned earlier, is at odds with the stylized fact that Phillips curves are flatter in low inflation environment. Moreover, the slope of the NKPC (before dividing by Δ) increases slightly with the degree of indexation, but after dividing by Δ, decreases with the degree of indexation. Finally, the slope of the NKPC (before or after dividing by Δ) decreases in the trend in the number of varieties and thus increases in the level of the entry costs, partially because of the higher competition but mainly because of the increase of the elasticity of demand (see Figures 6a and 6b in appendix).

Both coefficients of the expectation of future inflation and of the expectations farther in the future decrease with the degree of indexation and become null when the indexation is complete. Similarly, they both increase not only with steady state inflation, but also with the steady state number of varieties through the powers of $\overline{\Pi}$ and the elasticity of demand $\theta(\overline{N})$ and thus decreases with entry costs (see Figures 7a and 7b in appendix).

4 Conclusion

In this paper, we have derived the NKPC in a new Keynesian model allowing for endogenous entry of firms and assuming a non zero steady state inflation. Our main findings can be summarized as follows: first, in the long run, because of the reintroduced link between monopolistic competition and entry of firms, the level of the real average marginal cost (the inverse of the average markup in the economy), or real activity, henceforth becomes an increasing function of the number of varieties; second, as with no entry of firms, the real average marginal cost decreases with inflation in the long run; this effect is enhanced in an economy where the cost of entry for firms is low, because both non zero inflation and low cost of entry strengthen the number of firms; third, the increase of the slope with decreasing trend inflation can be alleviated, even inverted, by the decrease of the slope in the tendency of the number of varieties because of increasing elasticity of substititution of demand with the number of varieties, without referring to an increase in partial indexation or an endogenous price rigidity. The impact of expectations of inflation farther in the future is enhanced not only as trend inflation increases but also with the tendency of the number of varieties. Therefore, in a context of decreasing trend inflation, the coefficients of the NKPC can be stabilized through the increase in competitive pressures and in the elasticity of demand faced by the firms, both implied by an increase in the tendency in the number of varieties.

This paper opens on different possible research avenues. First, we put forward the complementary effects on output of disinflation and deregulation policies, but we treat long-run inflation target - the steady state inflation - as an exogenous process. Instead, we could complement our model with a modelling of the long run inflation target, whose movements could be the outcome of exogenous shifts in the structure of the economy or of exogenous supply shocks (including deregulating shock in the product market). One plausible story could be that the central bank updates its target policy rule as it learns about the structure of the economy and that shifts in the inflation target are an outcome of this learning process. However, the empirical learning literature remains rather inconclusive on this subject[12]. Another story could be that the true source of movements in the Fed's inflation target are exogenous supply-shocks hitting the economy. For example, Orphanides and Wilcox's (2002) suggested that since 1980 the Fed has acted "opportunistically" to bring inflation back down in the aftermath of more favourable supply-side disturbances. Bomfim and Rudebusch (2000) compared the cost in economic terms of deliberate and opportunistic disinflation policies and showed that the results depend on the credibility of the central bank, and hence on assumptions to be made about expectations held by agents. On his part, Rogoff (2003, 2006) argued, that in a global environment central banks have less incentives to inflate the economy. Finally, Ireland (2007) tried to draw inferences about the behavior of the Fed's unobserved inflation target. His main empirical conclusions are that a model where inflation target movements are deliberate policy response to exogenous supply side shocks turns out to be statistically indistinguishable from a model where movements in inflation target are purely random. At last, more work is needed to understand the origins of movements in long-run inflation target.

Second, the empirical relevance for inflation dynamics of the derived enlarged NKPC could be investigated. This NKPC would be associated with a steady state restriction between average marginal cost, inflation and number of firms (or costs of entry). Cogley and Sbordone (2008) estimated an enlarged NKPC taking into account a time-varying inflation trend, but without including the number of firms. They put forward that a purely forward-looking version of the model fits the data well: observed inflation persistence seems to be mainly due to shift in long-run trend component of inflation. Recently, Bloch (2008) addressed the empirical evidence of a NKPC close to the one derived here, allowing for entry of firms. Preliminary results pointed out that the introduction of a product market regulation variable - using an OECD indicator characterized by persistent fluctuations in its underlying trend, could be a micro-founded means to capture a part of the observed inflation persistence during the last thirty years for both the US and France.

[12] See for example Cogley and Sargent (2005), Milani (2007), Primiceri (2006), Sargent, Williams and Zha (2006), Schorfheide (2005), Sims and Zha (2006).

5 Appendix

Here, we complete the presentation of the model: intratemporal consumption choice, intertemporal optimization and equilibrium. Details of calculation for the derivation of the NKPC are then given.

5.1 Household Preferences and the Intratemporal Consumption Choice

We consider a cashless closed economy as in Woodford (2003) and Gali (2008). The representative household is infinitely lived and maximizes its expected intertemporal utility:

$$E_0 \sum_t \beta^t \left(\log C_t - \chi \frac{{L_t}^{1+\varphi}}{1+\varphi} \right) \tag{18}$$

where C_t is the consumption bundle, $0 < \beta < 1$ denotes the subjective discount factor, L_t is the number of hours supplied and $\varphi \geq 0$ is the inverse of the Frisch labour-supply elasticity with respect to real wages.

At time t, the household consumes the basket of goods C_t defined over the continuum of goods Ω indexed by i (see preference specifications below):

$$C_t = B_t \left[\int_{i \in \Omega} c_t(i)^{1/\mu} di \right]^{\mu} \tag{19}$$

where $B_t \equiv N_t^{1+\gamma-\mu}$ and $c_t(i)$ is the demand for differentiated goods of type i.

At any given time t, only a subset of goods $\Omega_t \subset \Omega$ is available, and thus C_t is restricted to Ω_t. N_t is the mass of Ω_t.

The household minimizes the total cost of differentiated goods, taking as given their nominal prices $p_t(i)$. Cost-minimization then gives a demand curve for the differentiated product i of the form:

$$c_t(i) = B_t^{\theta-1} \left(\frac{p_t(i)}{P_t} \right)^{-\theta} C_t \tag{20}$$

where P_t is the welfare-based consumer price index, defined as the minimum expenditure required to purchase one unit of the basket C_t:

$$P_t \equiv \frac{1}{B_t} \left[\int_{i \in \Omega_t} p_t(i)^{1-\theta} di \right]^{1/(1-\theta)} \tag{21}$$

We consider two alternative preference specifications (see Table 1): in the first one, the consumption aggregator is the CES (Constant Elasticity of Substitution) variant introduced by Benassy (1996) which disentangles monopoly power, measured by the markup μ and the consumer taste for variety captured by $\gamma \geq 0$. The consumer taste for variety γ (in elasticity form) corresponds to the marginal utility gain derived from spreading a given amount of consumption on a basket that includes one additional variety. The parameter μ is inversely related to the elasticity of intratemporal substitution between the differentiated goods: $\mu \equiv \frac{\theta}{\theta-1}$, with $\theta > 1$. This preference specification is used when only the number of goods N_t varies, but not the elasticity of substitution θ. It includes the case of constant elasticity of substitution (CES) between goods, put forward by Dixit and Stiglitz (1977), if $\gamma = \mu - 1 \equiv \frac{1}{\theta-1}$. The second specification relies on the translog expenditure function, generalized by Feenstra (2003) when the number of goods varies, and used by Bergin and Corsetti (2005), and Bilbiie and al. (2007a, 2007b), where the elasticity of demand faced by firm is increasing with the number of varieties. The price elasticity of demand is $1+\sigma N_t, \sigma > 0$. As N_t increases, goods become closer substitutes and the elasticity of substitution increases. If goods are closer substitutes, then the markup $\mu(N_t)$ and the benefit of additional varieties in elasticity form $\gamma(N_t)$ decrease. Table 1 contains the expressions for the market power, relative price, and benefit of variety in elasticity form for each preference specification. It completely characterizes the effects of preferences in the model.

insert Table 1: Preference specifications and markups

5.2 Household Budget Constraint and Intertemporal Optimization

At each period t, the representative household entirely owns firms. It finances the fixed entry costs of N_{Et} new entrants firms, which consist of wages paid for the hours worked on developing the good and setting up the production line. In return, the household receives all the profits of the N_t operating firms at time t, earns labor income and pay taxes.

In each period t, the household chooses decision rules for consumption C_t, labor supply L_t and a nominal bonds portfolio BO_t to maximize (1) subject to a sequence of period budget constraints:

$$C_t + \frac{BO_t}{P_t} + N_{Et}\frac{W_t}{P_t}\frac{f_{Et}}{A_t} = \frac{BO_{t-1}R_t}{P_t} + (1+\tau_t)\frac{W_t}{P_t}L_t + Div_t - T_t \tag{22}$$

where R_t is the gross consumption-based nominal interest at period t on holdings of bonds between $t-1$ and t, W_t is the nominal wage rate, and Div_t are the operating profits (in unit of consumption goods) aggregated on the N_t producing firms. $N_{Et}\frac{W_t}{P_t}\frac{f_{Et}}{A_t}$ are the entry costs of the N_{Et} new entrants firms (in unit of consumption goods). The labor market is perfectly competitive and wages are fully flexible. τ_t is the labor subsidy rate and T_t is a real lump-sum tax.

The first-order conditions for the household's optimization are then given by:

$$(1+\tau_t)\frac{W_t}{P_t} = \chi L_t^{\varphi} C_t \tag{23}$$

and by the Euler equation:

$$\beta R_t E_t \left[\frac{C_t}{C_{t+1}}\frac{P_t}{P_{t+1}}\right] = 1 \tag{24}$$

5.3 Equilibrium

◦ **Market clearing in the good market** requires[13]:

$y_t(i) = c_t(i)$ for all $i \in [0,1]$ and all t. Letting aggregate output be defined as $Y_t \equiv B_t\left[\int_{i\in\Omega_t} y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$, it follows that:

$$Y_t = C_t \tag{25}$$

must holds for all t.

[13] We abstract from government consumption expenditure.

∘ **Market clearing in the labor market** requires:
$L_t = \int_{i\in\Omega_t} l_t(i)di + N_{Et}\frac{f_{Et}}{A_t}$. The representative household supplies labor in a competitive market both for firms' production activities and start-up.

Using (1),

$$L_t = \int_{i\in\Omega_t} (\frac{y_t(i)}{A_t})^{\frac{1}{1-a}} di + N_{Et}\frac{f_{Et}}{A_t} = (\frac{Y_t}{A_t})^{\frac{1}{1-a}} B_t^{\frac{\theta-1}{1-a}} \int_{i\in\Omega_t} \left(\frac{p_t(i)}{P_t}\right)^{\frac{-\theta}{(1-a)}} di + N_{Et}\frac{f_{Et}}{A_t} \tag{26}$$

∘ Resulting from (28), the **aggregate production function** is:

$$Y_t = \frac{A_t}{D_t}(L_t - N_{Et}\frac{f_{Et}}{A_t})^{1-a} \tag{27}$$

where $D_t \equiv B_t^{\theta-1}\left[\int_{i\in\Omega_t}\left(\frac{p_t(i)}{P_t}\right)^{\frac{-\theta}{(1-a)}} di\right]^{1-a} \equiv \frac{1}{B_t}\left[\int_{i\in\Omega_t}\left(\frac{p_t(i)}{P_tB_t}\right)^{\frac{-\theta}{(1-a)}} di\right]^{1-a}$ (7) is a measure of price (and, hence, output) dispersion across firms. It can be shown that D_t increases with inflation and diminishes with the number of varieties. In case of no dispersion and no inflation $D_t = N_t^{-(\gamma+a)}$.

∘ **Aggregate budget identity**. Imposing the equilibrium conditions $BO_{t-1} = BO_t = 0$ in the household budget constraint and assuming the equilibrium of government budget ($T_t = -\tau_t\frac{W_t}{P_t}L_t$) yields the aggregate accounting identity:

$$C_t + N_{Et}\frac{W_t}{P_t}\frac{f_{Et}}{A_t} = \frac{W_t}{P_t}L_t + Div_t \tag{28}$$

Total expenditure on consumption and investment in new firms must be equal to total income (labour income plus dividend income).

∘ **Aggregate free entry condition**. The aggregate value of firms in the economy is equal to their entry costs:

$$\int_{\Omega_t} v_t(i)di = N_t\frac{W_t}{P_t}\frac{f_{Et}}{A_t} \tag{29}$$

insert Table 2: Benchmark Model, Summary

The model is closed by specifying a rule for nominal interest rate setting the monetary policy which determines R_t. The model determines the unknown variables, N_t, P_t, $\frac{W_t}{P_t}, Y_t, C_t, Div_t, mc_t, L_t$, and p_t in function of the parameters and exogenous variables f_{Et}, A_t, and τ_t.

5.4 Derivation of the NKPC

We use the expression $MC_{t+j,t}(i) = MC_{t+j}(\frac{y_{t+j,t}(i)}{Y_{t+j}})^{\omega} D_{t+j}^{\frac{-1}{1-a}} = MC_{t+j}(B_{t+j}^{\theta-1})^{\omega}(\frac{p_t^*\psi_{tj}}{P_{t+j}})^{-\theta\omega} D_{t+j}^{\frac{-1}{1-a}}$ (8) relating optimizing firm's marginal cost $MC_{t+j,t}(i)$ to the economy's average marginal cost MC_{t+j}[14].

[14] In this section, we adapt the derivation of the NKPC with non stationary trend inflation proposed by Cogley and Sbordone (2008) to our purpose (with also entry of firms and price dispersion).

The first order condition (11) implies that

$$p_t^{*(1+\theta\omega)} = \left(\frac{\frac{\theta}{\theta-1} E_t \sum_{j=0}^{\infty} \alpha^j q_{t,t+j} Y_{t+j} P_{t+j}^{\theta(1+\omega)-1} \psi_{tj}^{-\theta(1+\omega)} MC_{t+j} D_{t+j}^{\frac{-1}{1-a}} (B_{t+j}^{\theta-1})^{\omega}}{E_t \sum_{j=0}^{\infty} \alpha^j q_{t,t+j} Y_{t+j} P_{t+j}^{\theta-1} \psi_{tj}^{1-\theta}} \right) \equiv \frac{U_t}{V_t} \tag{30}$$

Using the definition of ψ_{tj} in (5) we can express the functions U_t and V_t in recursive form, respectively

$$U_t = \frac{\theta}{\theta-1} Y_t P_t^{\theta(1+\omega)-1} MC_t D_t^{\frac{-1}{1-a}} (B_t^{\theta-1})^{\omega} + E_t \left[\alpha q_{t,t+1} \Pi_t^{-\varrho\theta(1+\omega)} U_{t+1} \right] \tag{31}$$

and

$$V_t = Y_t P_t^{\theta-1} + E_t \left[\alpha q_{t,t+1} \Pi_t^{\varrho(1-\theta)} V_{t+1} \right] \tag{32}$$

Deflating appropriately (31) and (32) we obtain:

$$\widetilde{U}_t \equiv \frac{U_t}{Y_t P_t^{\theta(1+\omega)}} = \frac{\theta}{\theta-1} mc_t D_t^{\frac{-1}{1-a}} (B_t^{\theta-1})^{\omega} + E_t \left[\alpha q_{t,t+1} g_{t+1}^{y} \Pi_{t+1}^{\theta(1+\omega)} \Pi_t^{-\varrho\theta(1+\omega)} \widetilde{U}_{t+1} \right] \tag{33}$$

$$\widetilde{V}_t \equiv \frac{V_t}{Y_t P_t^{\theta-1}} = 1 + E_t \left[\alpha q_{t,t+1} g_{t+1}^{y} \Pi_{t+1}^{\theta-1} \Pi^{\varrho(1-\theta)} \widetilde{V}_{t+1} \right] \tag{34}$$

where $mc_t \equiv \frac{MC_t}{P_t}$ and $g_{t+1}^y \equiv \frac{Y_{t+1}}{Y_t}$. Then

$$\frac{\widetilde{U}_t}{\widetilde{V}_t} = \left(\frac{p_t^*}{P_t} \right)^{1+\theta\omega} \equiv x_t^{1+\theta\omega} \tag{35}$$

From (35) and (36) evaluated at the steady state, we obtain:

$$\overline{\widetilde{U}} = \frac{\frac{\theta}{\theta-1} \overline{mc}\,\overline{D}^{\frac{-1}{1-a}} (\overline{B}^{\theta-1})^{\omega}}{1 - \alpha\overline{q} g_{\overline{y}} g_{\overline{b}}^{\theta-1} \overline{\Pi}^{(1-\varrho)\theta(1+\omega)}} \tag{36}$$

$$\overline{\widetilde{V}} = \frac{1}{1 - \alpha\overline{q} g_{\overline{y}} g_{\overline{b}}^{\theta-1} \overline{\Pi}^{(1-\varrho)(\theta-1)}} \tag{37}$$

and we obtain the following expression:

$$\overline{x}^{1+\theta\omega} = \frac{\overline{\widetilde{U}}}{\overline{\widetilde{V}}} \frac{\theta}{\theta-1} \overline{mc}\,\overline{D}^{\frac{-1}{1-a}} \overline{N}^{(\gamma(\theta-1)-1)\omega} \left(\frac{1 - \alpha\overline{q} g_{\overline{y}} g_{\overline{b}}^{\theta-1} \overline{\Pi}^{(1-\varrho)(\theta-1)}}{1 - \alpha\overline{q} g_{\overline{y}} g_{\overline{b}}^{\theta-1} \overline{\Pi}^{(1-\varrho)\theta(1+\omega)}} \right) \tag{38}$$

We derive a log-linear approximation of (35) and we obtain:

$$\widehat{\widetilde{U}}_t = \varphi_3 (\widehat{mc}_t + \frac{-1}{1-a} \widehat{D}_t + (\theta-1)\,\omega \widehat{B}_t) + \varphi_2 E_t \left[\widehat{q}_{t,t+1} + \widehat{g}_{t+1}^{y} + \theta(1+\omega)(\widehat{\pi}_{t+1} - \varrho\widehat{\pi}_t) \right] ... \tag{39}$$

$$... + \varphi_2 E_t \widehat{\widetilde{U}}_{t+1}$$

and

$$\widehat{\widehat{V}}_t = \varphi_1 E_t \left[\widehat{q}_{t,t+1} + \widehat{g}^y_{t+1} + (\theta-1)(\widehat{\pi}_{t+1} - \varrho\widehat{\pi}_t)\right] + \varphi_1 E_t \widehat{\widehat{V}}_{t+1} \tag{40}$$

where
$\varphi_1 = \alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)(\theta-1)}$
$\varphi_2 = \alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)\theta(1+\omega)}$
$\varphi_3 = 1 - \varphi_2$

The log-linearization of (35) yields then:

$$(1+\theta\omega)\widehat{x}_t = \widehat{\widehat{U}}_t - \widehat{\widehat{V}}_t \tag{41}$$

from which we can solve for $\widehat{\pi}_t$ using the expression (6):

$$\widehat{\pi}_t = (\varrho\widehat{\pi}_{t-1} - \varrho\widehat{g}^{\pi}_t) + \gamma(\widehat{N}_{t-1} - \widehat{g}^N_t) - \frac{\gamma\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}\widehat{N}_t + \varphi_2\varrho E_t \widehat{g^{\pi}}_{t+1} ... \tag{42}$$

$$... - \gamma\varphi_2(\widehat{N}_t - E_t\widehat{g^N}_{t+1}) + \frac{\gamma\varphi_2\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta-1)}}E_t\widehat{N}_{t+1} + \frac{\varphi_0}{(1+\theta\omega)}(\widehat{\widehat{U}}_t - \widehat{\widehat{V}}_t)$$

Finally, combining (39) and (40) to get an expression for $(\widehat{\widehat{U}}_t - \widehat{\widehat{V}}_t)$; then, using (42) and replacing θ with $\theta(\overline{N})$, γ with $\gamma(\overline{N})$ and the elasticity ω with $\omega + \xi(\overline{N})$, we obtain the following expression of the NKPC and the derived expression (14) in the text:

$$\widehat{\pi}_t - \varrho\widehat{\pi}_{t-1} = -\varrho\widehat{g}^{\pi}_t + \gamma(\widehat{N}_{t-1} - \widehat{g}^N_t) - \frac{\gamma\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}\widehat{N}_t + \varphi_2\varrho E_t\widehat{g^{\pi}}_{t+1} - \gamma\varphi_2(\widehat{N}_t - E_t\widehat{g^N}_{t+1}) + ...$$

$$... \frac{\gamma\varphi_2\varphi_0}{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}E_t\widehat{N}_{t+1} + \varphi_4\widehat{mc}_t + \varphi_4((\gamma(\theta(\overline{N})-1)-1)(\omega+\xi(\overline{N}))\widehat{N}_t - \frac{\varphi_4}{(1-a)}\widehat{D}_t$$

$$... + \beta_1 E_t(\widehat{\pi}_{t+1} - \varrho\widehat{\pi}_t) + \beta_2 E_t \sum_{j=2}^{\infty}\varphi_1^j(\widehat{\pi}_{t+j} - \varrho\widehat{\pi}_{t+j-1}) + \beta_3 E_t\sum_{j=0}^{\infty}\varphi_1^j(\widehat{q}_{t+j,t+j+1} + \widehat{g^y}_{t+1+j}) \tag{43}$$

The coefficients of (43) and (14) are defined by:
$\varphi_0 = \frac{1-\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}{\alpha\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}}$
$\varphi_1 = \alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)(\theta(\overline{N})-1)}$
$\varphi_2 = \alpha\overline{q}g_{\overline{y}}g_{\overline{b}}^{\theta-1}\overline{\Pi}^{(1-\varrho)\theta(\overline{N})(1+\omega+\xi(\overline{N}))}$
$\varphi_3 = 1 - \varphi_2$
$\beta_1 = \varphi_2(1+\varphi_0) + \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)\varphi_1$
$\beta_2 = \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)$
$\beta_3 = \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}\varphi_1$

$$\varphi_4 = \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\varphi_3$$

$$\Delta = 1 + \varrho\varphi_2(1+\varphi_0) + \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)\varrho\varphi_1$$
$$\widetilde{\beta}_1 = \frac{(1-\rho\varphi_1)\beta_1}{\varphi_1} = \varphi_2(1+\varphi_0) + \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)\varphi_1(1-\varrho\varphi_1)$$
$$\widetilde{\beta}_2 = \frac{(1-\rho\varphi_1)\beta_2}{\varphi_1} = \frac{\varphi_0}{(1+\theta(\overline{N})(\omega+\xi(\overline{N}))}\frac{(\varphi_2-\varphi_1)}{\varphi_1}(\theta(\overline{N})-1)(1-\varrho\varphi_1).$$

5.5 Numerical Examples

We assume:

$$\beta = 0.99, \delta = 0.025, \chi = 1, \tau_t = 0, A_t = 0, \varphi = 1, a = 0, \varrho = 0.$$

6 References

Ascari, Guido (2004): "Staggered Prices and Trend Inflation: some Nuisances", Review of Economic Dynamics 7, 642-667.

Ascari, Guido and Tiziano Ropele (2007): "Optimal Monetary Policy under Low Trend Inflation", Journal of Monetary Economics, 54 (8), 2568-2583.

Bakhshi, Hasan, Hashmat Khan, Pablo Burriel-Llombart, and Barbara Rudolf (2007): "The New Keynesian Phillips Curve Under Trend Inflation and Strategic Complementarity", Journal of Macroeconomics 29, 37-59.

Ball, L., 2006: "Has Globalization Changed Inflation ?", NBER,Working Paper n°12687.

Benassy, Jean-Pascal (1996): "Taste for Variety and Optimum Production Patterns in Monopolistic Competition", Economics Letters 52 (1996), 41-47.

Bergin, Paul R., and Giancarlo Corsetti (2005): "Towards a Theory of Firm Entry and Stabilization Policy", NBER Working Paper n°11821.

Bilbiie, Florin O., Fabio Ghironi, and Marc J. Melitz (2007a): "Monetary Policy and Business Cycles with Endogenous Entry and Product Variety", NBER Working Paper n°13199.

Bilbiie, Florin O., Fabio Ghironi, and Marc J. Melitz (2007b): "Endogenous Entry, Product Variety, and Business Cycles", NBER Working Paper n° 13646.

Bloch, Laurence (2008): "Product Market Regulation, Trend Inflation and Inflation Dynamics in the New Keynesian Phillips Curve", Crest-Insee Mimeo, November.

Bomfim, Antulio N. and Glenn D. Rudebusch (2000): "Opportunistic and Deliberate Disinflation under Imperfect Credibility", Journal of Money, Credit and Banking, vol. 32, n°4, 707-721.

Borio, C. ,and A. Filardo (2007): "New Cross-Country Evidence on the Global Determinants of Domestic Inflation", BIS Working Paper.

Calvo, Guillermo (1983): "Staggered Prices in a Utility-Maximizing Framework", Journal of Monetary Economics, 12 (3), 383-398.

Cogley, Timothy and Argia M. Sbordone (2008): "Trend Inflation, Indexation, and Inflation Persistence in the New Keynesian Phillips Curve", forthcoming in the American Economic Review.

Dixit, Avinash K., and Joseph E. Stiglitz (1977): Monopolistic Competition and Optimum Product Diversity", American Economic Review 67 (3), 297-308.

Feenstra, Robert C. (2003): " A Homothetic Utility Function for Monopolistic Competition Models, without Constant Price Elasticity", Economics Letters 78, 79-86.

Gali, Jordi (2008): *Monetary Policy, Inflation, and the Business Cycle. An Introduction to the New Keynesian Framework*, Princeton University Press.

Goodfriend, Marvin and Robert G. King (1997): "The New Neoclassical Synthesis and the Role of Monetary Policy", in B.S Bernanke and J.J Rotemberg (eds.) NBER Macoeconomics Annual, MIT Press, 231-283.

Ihrig, J., S.B Kamin, D. Lindner, and J. Marquez (2007): "Some Simple Tests of the Globalization and Inflation Hypothesis", Board of Governors, International Discussion Paper n°893.

Ireland, Peter N. (2007): "Changes in the Federal Reserve's Inflation Target: Causes and Consequences", Journal of Money, Credit and Banking, vol. 39, n°8, 1851-1882.

Kiley, Michael T. (2007): " Is Moderate-To-High Inflation Inherently Unstable ?", International Journal of Central Banking 3 (2), 173-201.

Khan, Aubhik, Robert G. King and Alexander L. Wolman (2003): "Optimal Monetary Policy", Review of Economic Studies (2003) 70, 825-860.

King, Robert G. and Alexander L. Wolman (1996): "Inflation Targeting in a St. Louis Model of the 21st Century", Federal Reserve Bank of St. Louis Review, May-June 1996.

Lewis, Vivien (2006): “Macroeconomic Fluctuations and Firm Entry: Theory and Evidence”, National Bank of Belgium Working Paper n°103.

Orphanides, Athanasios and David W. Wilcox (2002): “The Opportunistic Approach to Disinflation”, International Finance 5:1, 2002, 47-71.

Rogoff, Kenneth (2003): “Globalization and Global Disinflation”, Federal Reserve Bank of Kansas City Economic Review, Fourth Quarter 2003, 45-78.

Rogoff, Kenneth (2006): “Impact of Globalization on Monetary Policy”, Jackson Hole Symposium, August 24-26.

Sahuc, Jean-Guillaume (2006): “Partial Indexation, Trend Inflation, and the Hybrid Phillips Curve”, Economics Letters 90, 42-50.

Sbordone, Argia M. (2008): “Globalization and Inflation Dynamics: The Impact of Increased Competition”, Federal Reserve Bank of New York Staff Reports, n°324.

Yun, Tack (2005): “Optimal Monetary Policy with Relative Price Distortions”, American Economic Review, vol.95 n°1, 89-109.

Woodford, Michael (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, Princeton.

	CES-Benassy	CES-Dixit-Stiglitz	Translog
Symmetric price elasticity of demand	θ	θ	$1 + \sigma N_t$
Market power	$\theta/(\theta - 1)$	$\theta/(\theta - 1)$	$1 + 1/(\sigma N_t)$
Benefit of additional product variety: relative price p_t/P_t (*)	N_t^{γ}	$N_t^{1/(\theta-1)}$	$N_t^{1/(2\sigma N_t)}$
Consumer taste for variety γ**: relative price in elasticity form**	γ	$1/(\theta - 1)$	$1/(2\sigma N_t)$

Table 1: Preference specifications and markups

(*): in symmetric equilibrium

Number of firms	$N_t \equiv (1-\delta)(N_{t-1} + N_{Et-1})$	(2)
Intratemporal optimization	$(1+\tau_t)\frac{W_t}{P_t} = \chi L_t^{\varphi} C_t$	(23)
Euler equation (bonds)	$\beta R_t E_t \left[\frac{C_t}{C_{t+1}} \frac{P_t}{P_{t+1}}\right] = 1$	(24)
Aggregate budget identity	$C_t + N_{Et}\frac{W_t}{P_t}\frac{f_{Et}}{A_t} = \frac{W_t}{P_t} L_t + Div_t$	(28)
Clearing in the good market	$Y_t = C_t$	(25)
Aggregate free entry conditions	$\int_{\Omega_t} v_t(i)di \equiv E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^s \frac{C_t}{C_{t+s}} Div_s = N_t \frac{W_t}{P_t}\frac{f_{Et}}{A_t}$	(29)
Operating Profits (*)	$Div_t = (1 - mc_t)Y_t$	
Average markup	$\widehat{mc}_t =$ function of $(\widehat{\pi}_t, E_t\widehat{\pi}_{t+1}, ...)$,	NKPC (14) with (13)
Pricing	$mc_t = \frac{W_t}{P_t}\frac{(Y_t D_t/A_t)^{1/(1-a)}}{Y_t(1-a)}$	(17)
Dispersion	D_t related to N_t, Π_t, Π_{t-1}	through (F)

Table 2: Benchmark Model, Summary

(*): in unit of consumption goods

Expression (F):

$$\left(\frac{D_t}{B_t^{\theta-1}}\right)^{1/(1-a)} = \alpha \Pi_t^{\theta/(1-a)} \Pi_{t-1}^{-\varrho\theta/(1-a)} \left(\frac{D_{t-1}}{B_{t-1}^{\theta-1}}\right)^{1/(1-a)} + ...$$
$$...\alpha(N_t - N_{t-1}) N_{t-1}^{-\gamma\theta/(1-a)} \Pi_t^{\theta/(1-a)} \Pi_{t-1}^{-\varrho\theta/(1-a)} + (1-\alpha) x_t^{-\theta/(1-a)} N_t$$

Figure 1a-Steady state dispersion: global effect

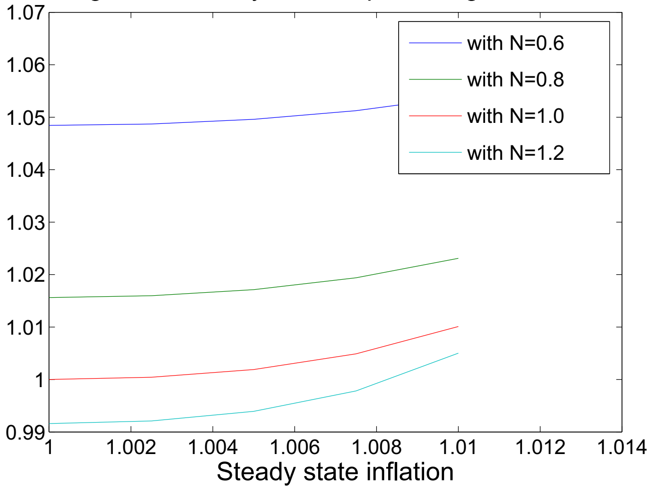


Figure 1b-Steady state dispersion: variety effect

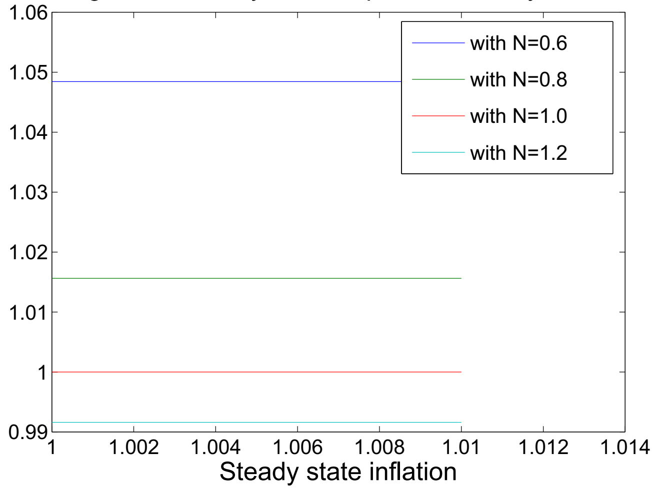


Figure 1c-Steady state dispersion: relative price component

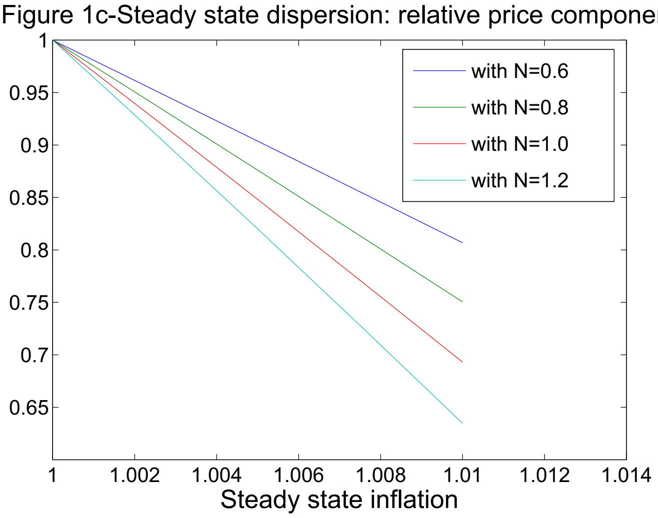
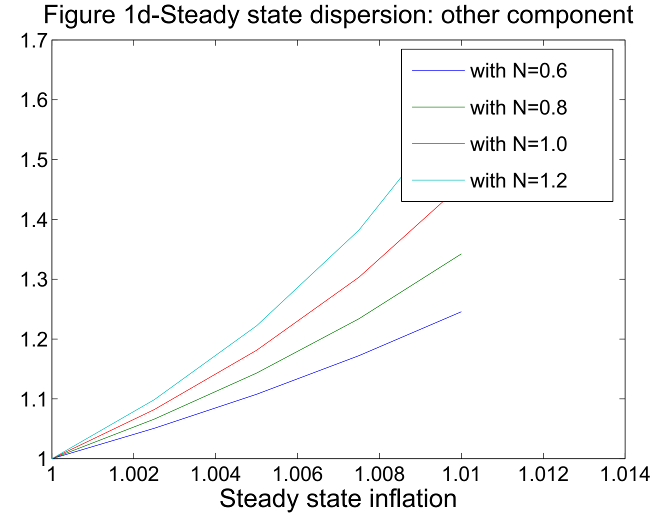


Figure 1d-Steady state dispersion: other component



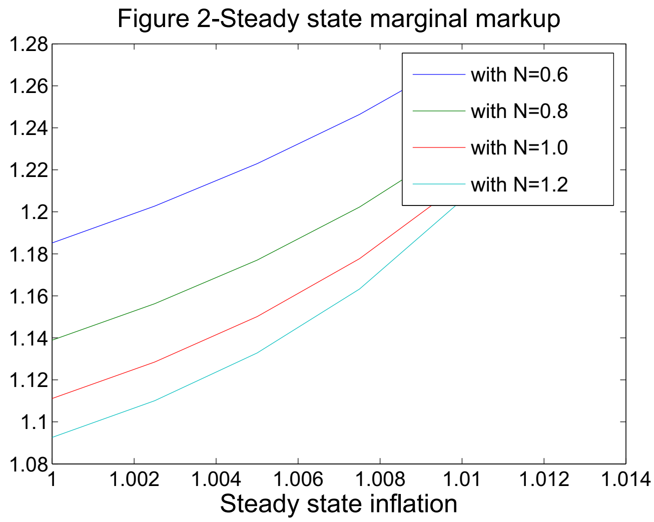


Figure 2-Steady state marginal markup
1.28
1.26
1.24
1.22
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1
1.002
1.004
1.006
1.008
1.01
1.012
1.014
Steady state inflation
with N=0.6
with N=0.8
with N=1.0
with N=1.2

Figure 3a-Steady state average marginal markup

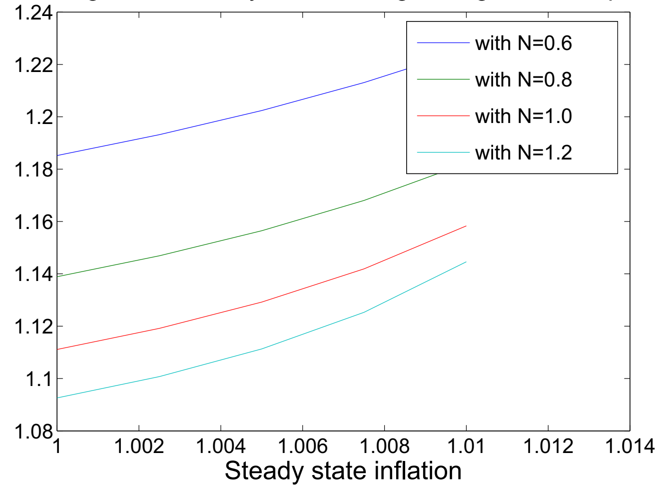


Figure 3b-Steady state marginal markup

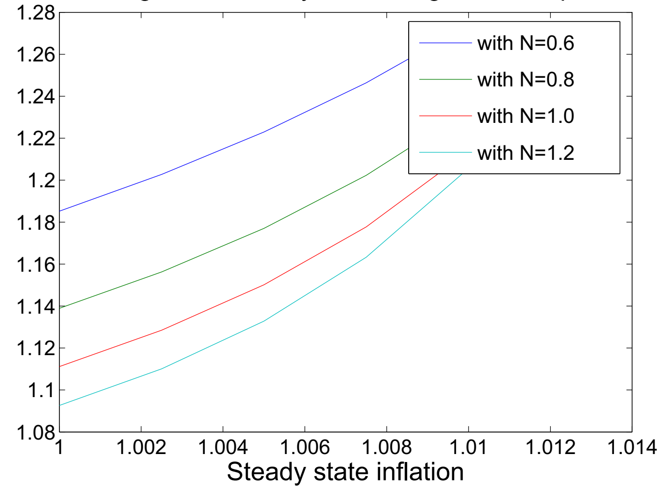


Figure 3c-Steady state relative price effect

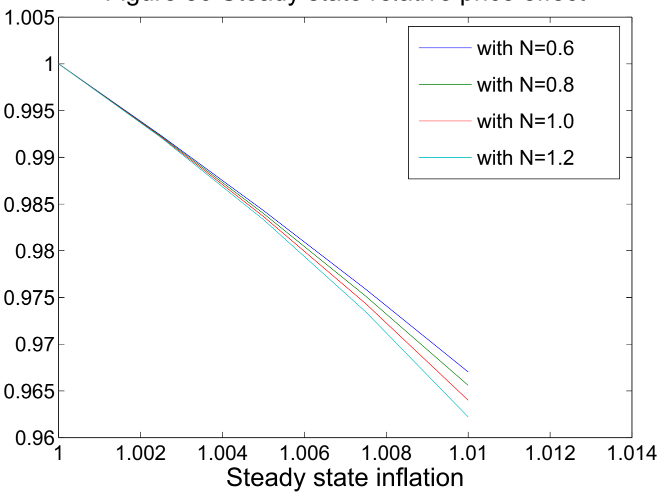
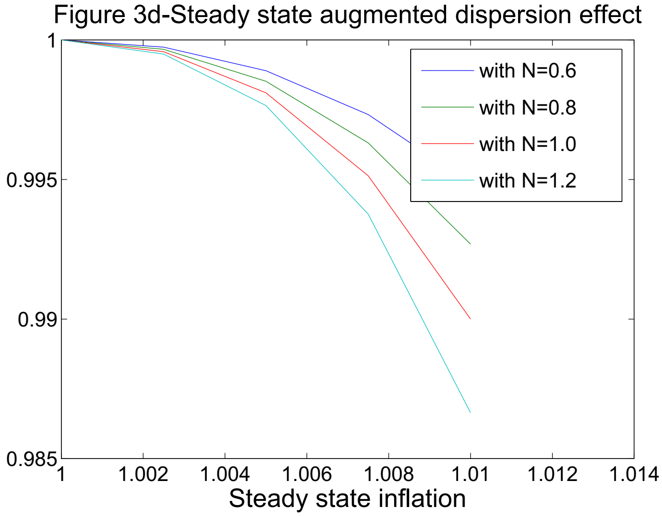


Figure 3d-Steady state augmented dispersion effect



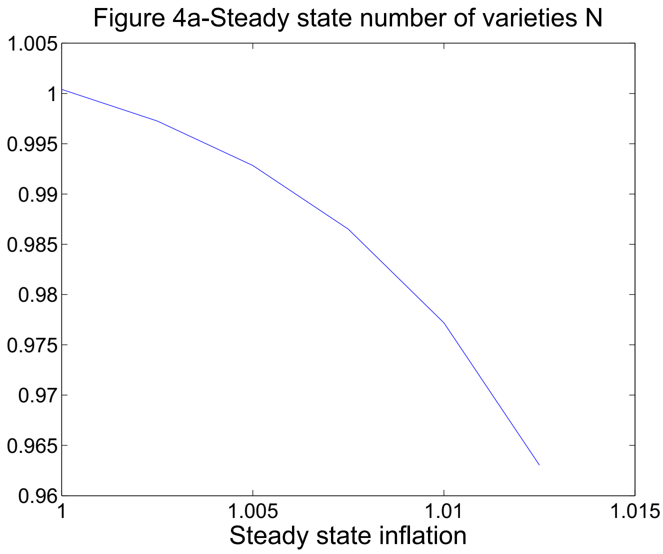


Figure 4a-Steady state number of varieties N
1.005
1
0.995
0.99
0.985
0.98
0.975
0.97
0.965
0.96
1
1.005
1.01
1.015
Steady state inflation

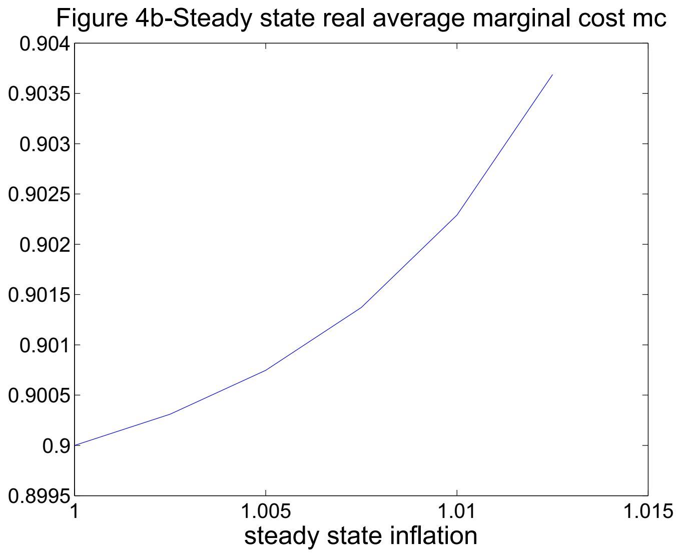


Figure 4b-Steady state real average marginal cost mc
0.904
0.9035
0.903
0.9025
0.902
0.9015
0.901
0.9005
0.9
0.8995
1
1.005
1.01
1.015
steady state inflation

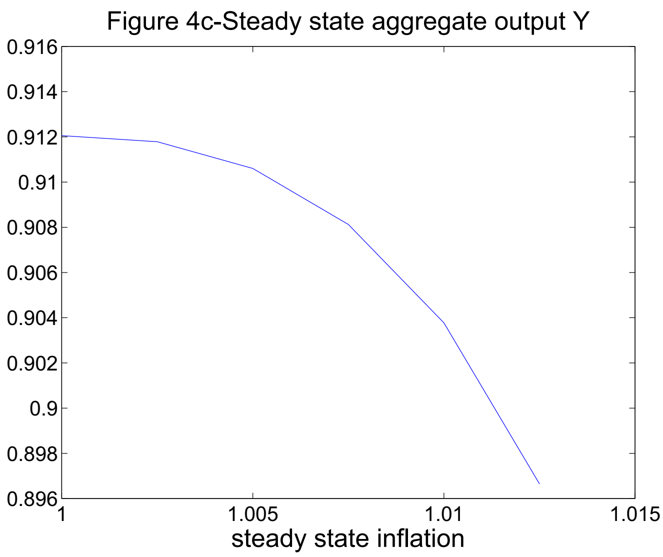


Figure 4c-Steady state aggregate output Y
0.916
0.914
0.912
0.91
0.908
0.906
0.904
0.902
0.9
0.898
0.896
1
1.005
1.01
1.015
steady state inflation

Figure 5a-Steady state number of varieties N

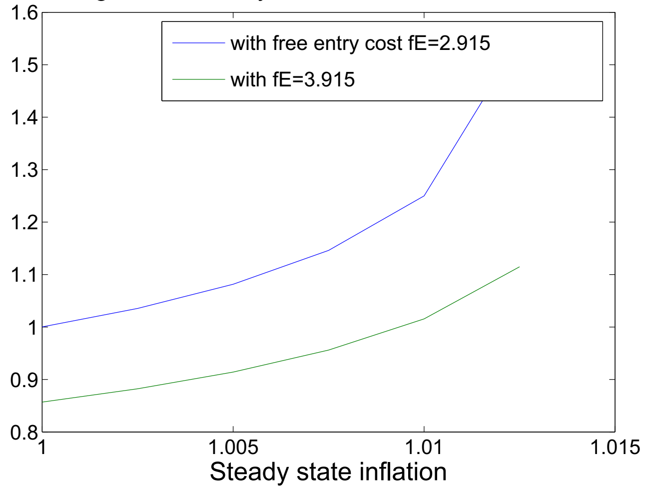


Figure 5b-Steady state real average marginal cost mc

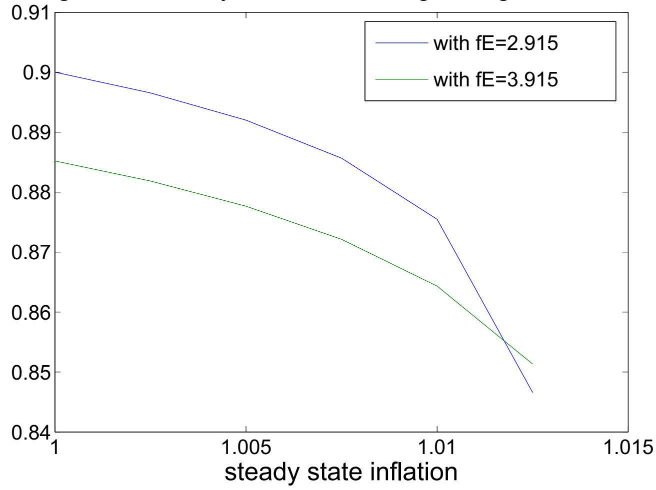


Figure 5c-Steady state aggregate output Y

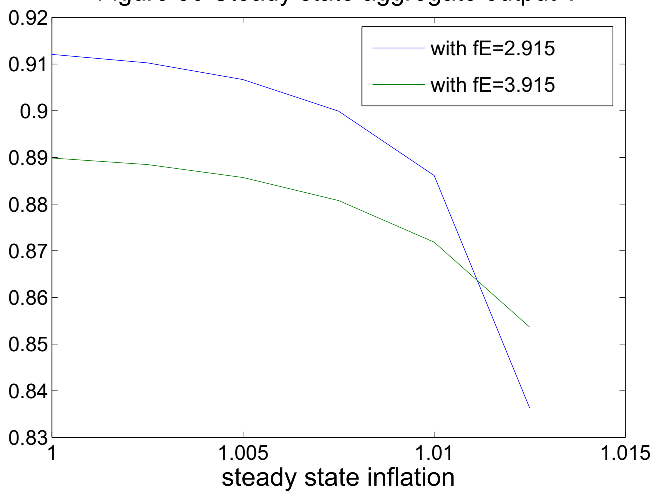


Figure 6a-Slope of the NKPC (in function of the steady state N)

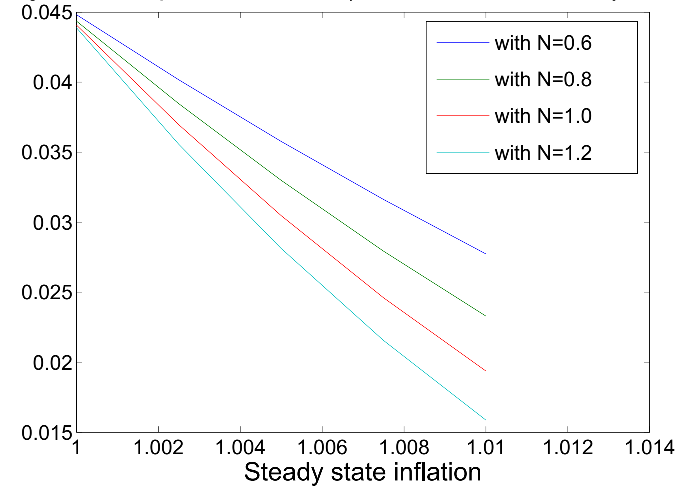


Figure 6b-Slope of the NKPC

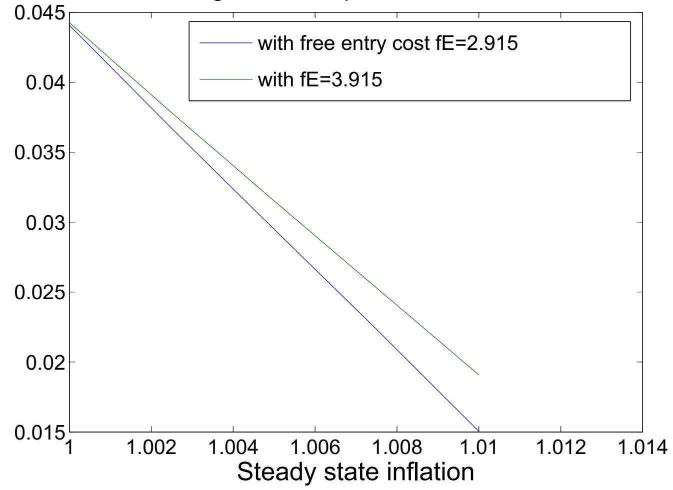


Figure 7a-Coefficient of the expectation of future inflation in the NKPC

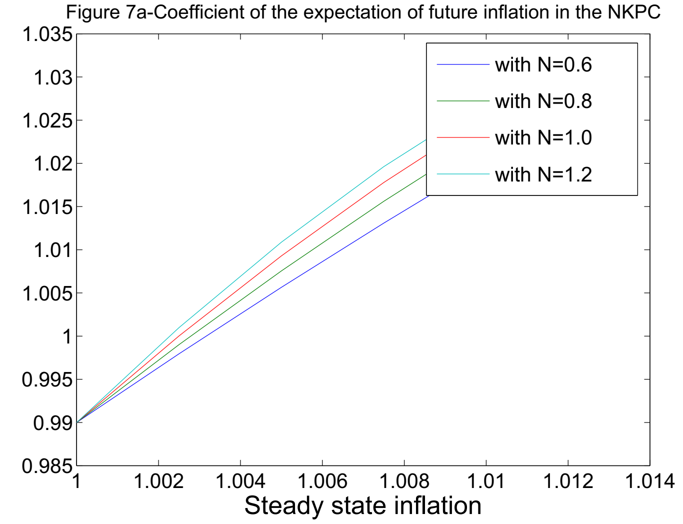


Figure 7b-Coefficient of the expectation of future inflation in the NKPC