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Abstract

How do monopolistically competitive industries react to shocks within the framework provided by a New Keynesian macro model? I link macroeconomics and trade theory through a consideration of market dynamics and use an analytically tractable model of a closed economy with endogenous firm entry to show the implications of market structure for the transmission of real shocks to aggregate variables and welfare. The sources of the shock have an important bearing on the results: thus, productivity shocks have an extensive impact on production, while innovation shocks have an intensive impact. A more patient population results in a more varied market, and is able to cushion the effects following an innovation shock.

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1 Introduction

Markets are dynamic and as such both the volume and range of goods supplied change from period to period, these changes being linked to macroeconomic foundations. Although macroeconomics and trade theory are closely interrelated, the former typically takes patterns of trade and market structures as given.

This paper develops a simple model of a closed economy to explore the responses of intensive (volume) and extensive (range of varieties) margins to real shocks. In so doing, it takes into account the fact that household welfare depends both on the quantity and diversity of consumption, i.e., a household prefers to consume a bit of everything rather than a lot of one homogeneous good. Krugman (1991), for example, has emphasized the role of product diversification on welfare in the context of spatial economics.

I distinguish between two technologies in the economy. The first determines the capacity to invent new varieties. Firms compete with their differentiated varieties in a monopolistic market. They devote one period to designing a variety and constructing a plant in which to produce it. Having done this, they then produce and sell this variety in the following period. However, the competition to offer new or improved varieties means that today's goods are obsolete after just one year of production. As such, firms are obliged to use their resources to invent new varieties every period. Thus, varieties should not be considered as haute couture fashion items but rather as manufactured goods that which need to be constantly adapted and improved. New models of computers or cameras and the latest fashions for the forthcoming season are just some examples of the "butterfly" varieties that make up long-lived goods. The second technology determines methods of production. Both technologies are homogeneous across firms and subject to external shocks. Here, a consideration of the two technologies has a considerable bearing on the results as each of them affects real variables, albeit in distinct ways.

New Keynesian models combine a stripped-down Dixit-Stiglitz model of industrial structure with intertemporal optimizing behaviour and rational expectations. They also generally impose a form of transitory nominal rigidity on product prices and labour costs. The advantage of these models is their capacity to combine these elements with a particular versatility for handling shocks and associated policy challenges in seeking to achieve short-term stabilization. One of their restrictions, however, is typically recognized as being the exogenization of the total number of firms. This is in contrast with the original Dixit-Stiglitz paper (Dixit and Stiglitz 1977), where the number of firms is endogenous and determined by a free entry-exit condition. This paper allows the number of firms to vary over time and while this is not an entirely innovative feature, few other papers conducted in the New Keynesian tradition do so. The obvious exception here is the inter-country allocation of firms undertaken in the Obstfeld-Rogoff papers (e.g. JPE 1995).

Corsetti, Martin and Pesenti (2007) explored these issues in the context of a pure static model. Here, I adhere closely to their paper by introducing a quasi-dynamic framework, in that I allow households to take intertemporal decisions, although I focus my attention primarily on comparative statics. It is reasonable to believe that the effects of real shocks will differ when we account for the future expectations of agents. Likewise, uncertainty may also play a crucial role in the maximizing behaviour of agents. In order to capture this as simply as possible, I introduce risk to firms via price rigidities. The introduction of nominal rigidities enables me to reflect on monetary policy and its optimal target.

As in Corsetti et al. (2007), drawing a distinction between two kinds of productivity (creation and production) is crucial. The former increases production via the extensive margin and, as a consequence, enlarges the size of firms. The latter has a negative impact on the number of varieties. A shock to the size of the population increases the number of firms, in what is known as the "home market" effect in the open-economy literature, i.e., a country exports the goods for which it offers a relatively large local demand. The presence of fixed costs generates dependence between the number of firms and household patience. When households are more patient, they save more. As a result, the economy houses a larger number of acting firms. However, this cushions any shock on the ability to create new varieties.

Moreover, nominal rigidities place the economy in a suboptimal point in terms of welfare. In comparison with the flexible-price scenario, prices rise to higher levels and the number of firms falls. As such a result might justify intervention, I explore here the role of a central bank. The monetary authority is able to correct these imperfections by implementing a monetary policy that is tied to the level of productivity in production. However, if the central bank fails to choose the most appropriate monetary policy, this can destabilize the economy. The consequences of this are discussed. Finally, although the paper does not specifically analyze the role of fiscal policy as a tool for addressing market imperfections, a brief discussion is included in the section examining price stickiness.

This paper is organized as follows: Section 2 presents a brief overview of the literature, while the sections that follow examine the possibilities of building analytical tools in a closed- economic setting. Section 3 establishes the general set-up for the basic model; Section 4 develops a flexible-price version; Section 5 incorporates the rigidities in the prices chosen by the firms and examines the impact of monetary policy and the problems generated by insufficient stabilization. Finally, Section 6 concludes. An appendix containing the algebraic details is available upon request from the author.

2 Literature Review

Although there were a number of obvious forerunners, most notably Svensson and van Wijnbergen (1989), it was Obstfeld and Rogoff's (1995) "Redux model" that triggered a flood of research on a new class of open economy macroeconomic models. This surge in the literature was characterised by a number of key distinguishing features: optimization-based dynamic general-equilibrium modelling; stochastic shocks; imperfect competition; nominal rigidities and the evaluation of monetary policies based explicitly on household welfare. This incorporation of microeconomic optimization has permitted a rigorous welfare analysis of policies and regimes, while the approach invites a rich analysis of alternative product, labour, and asset-market structures, bringing research that much closer to the complexities of reality.

Imperfect competition is a key ingredient in these new models.[1] Monopoly power brings the equilibrium of production below that of the social optimum, which is a distortion that can potentially be corrected by active monetary or fiscal policy intervention. Both nominal rigidities and market imperfections alter the transmission mechanism of shocks to real variables. By addressing issues of concern to policymakers, this new strand of research seeks to provide an analytical framework that is relevant for policy analysis. In fact, more recent contributions have sought to understand more fully the positive macroeconomic effects of uncertainty, as well as the normative implications for alternative international monetary regimes. As Obstfeld and Rogoff (1998) showed, important effects of uncertainty can compound or offset the more obvious welfare effects of variability, including effects on economic activity levels.

For many decades now international trade has been growing faster than GDP. For example, over the last thirty years, the share of imports in US GDP has more than doubled: rising from 4.8 percent in 1972 to 11.5 percent in 2002, while worldwide trade, measured as the value of trade as a fraction of the value of GDP, increased from 7.9 percent in 1950 to 15.4 percent in 1990, a 94.9 percent increase (See Bergoeing and Kehoe (2001)). Most theorists claim that this explosion in trade has its origin in three interrelated sources: the reduction in trade costs, the relaxation of capital controls, and the relative growth of many East Asian and other economies outside of the United States.

New trade theory provides insights for these stylized facts that are not so readily explicable when adopting the traditional trade approach. Helpman and Krugman (1987), for example, point out the need to introduce economies of scale and imperfect competition in conventional trade models, like the Ricardian model and the Heckscher-Ohlin model, to explain these facts. However, this vast body of "new-trade theory" literature often disregards the fact that US trade jumped from a range of 74,667 imported varieties in 1972 to 259,215 in 2001. Hence, the introduction of the endogenous entry and exit of firms may be a crucial feature in capturing the real world evolution.

In the theoretical literature, while virtually all studies predict large economies will export more in absolute terms than small economies, there is no agreement on how this is brought about. Models that assume Armington (1969) national differentiation emphasize the "intensive" margin, i.e., a country with double the resources will trade twice as much but will not trade a greater number of goods. Monopolistic competition models in the vein of Krugman (1980, 1981) stress the "extensive" margin for exports (i.e., economies twice the size will produce and export twice as many goods). Hummels and Klenow (2002), for instance, analyzed the exports in 1995 from 110 countries to 59 importers and decomposed the greater trade of larger economies into contributions from intensive and extensive margins. Their main finding was that the extensive margin ac-

[1] Median elasticity of substitution has decreased over time. Thus, trade goods have become increasingly more differentiated. See Broda and Weinstein (2003). Furthermore, when focusing on the increase in trade among industrialized countries, Markusen (1986) stressed the unequal income elasticity of demands resulting from non-homothetic preferences: demand for differentiated products is superior to that for homogeneous products.

counts for two-thirds of the greater exports of larger economies, and one-third of the greater imports of larger economies. Similar results are obtained by Funke and Ruhwedel (2001). However, Hummels and Klenow (2005) greatly extend the results of previous studies regarding the relationship between the size of an economy, international trade, and product variety, i.e., they shed considerable light on the empirical aspects of the home market effect.[2]

Luini and Mangani (2004) and Mangani (2007) report empirical analysis using cross-sectional data of an extensive increase in trade. To do so, they use an innovative source of data to estimate the variety of goods and services: namely, registered trademarks (the Community and the International trademarks protected by the World Intellectual Property Organization). While the use of trademarks potentially reduces the scope of the questions that can be addressed, it enables them to carry out a broad analysis of product variety. The main result to be derived from their research is that, by drawing on the aforementioned data, they are able to verify the findings of Hummels and Klenow (2005) that larger economies (in terms of GDP) not only produce and export more in absolute terms, but also produce and trade more goods. This implies that the strong relationship between larger economies and product variety is important as regards consumer welfare. However, the authors warn the reader to be cautious in interpreting their findings given the special characteristics of their data.

From a theoretical perspective, however, the traditional literature has always assumed that the number of firms is given or fixed. This has prevented experts from accurately determining the implications of different shocks on the range of varieties available in different countries and, consequently, on national and international welfare. Broda and Weinstein's (2003) empirical analysis offers an extensive discussion of the dramatic consequences this traditional set-up has for research findings. Notice that the import price index for models of this kind (without endogenous variety) is one that does not take into account any changes in the number of goods. Broda and Weinstein (2003), assuming that Krugman's (1980) model fits US data, show the mismeasurement caused by the use of an incorrect price index. They conclude that US welfare increased by 2.83 percent solely as a result of the expansion in varieties (from 1990-2001). These gains from variety are three to six times larger than the estimated gains from eliminating protectionism (e.g., Feenstra et al. (1992) and Romer (1994)) and around ten times larger than the estimated gains from eliminating business cycles (Alvarez and Jermann (2004)).

A number of "new open-economists" (including Ghironi and Melitz (2005) and Corsetti, Martin and Pesenti (2007)) have recently begun to take this essential characteristic into account. In this way, they are able to consider the relationship between the macroeconomic effects of the productivity differential and the substitutability or complementarity of goods, i.e., showing that elas-

[2] In fact, they found that countries with more workers export greater quantities to each market-category, but at prices that are no lower. This is consistent with a model in which larger countries avoid terms of trade deterioration by enlarging the set and/or increasing the quality of the goods they produce.

ticities matter when determining levels of production and allocations. Ghironi and Melitz's (2005) research is, as such, most closely in line with the analysis reported here of an open-economy scenario. Their approach differs from that adopted by Corsetti et al. (2007) in three main ways: a) they endogenize the tradability of goods instead of the creation of new varieties; b) they allow for heterogeneity of firms and, thus, are able to observe idiosyncratic shocks; and c) they incorporate dynamics on the understanding that firms must pay a sunk entry cost to start production.

This paper undertakes a closed-economy analysis with homogeneous firms. The model adopted incorporates dynamics a là Ghironi and Melitz (2005) and observes shocks to labour and innovation productivities. The objective is to understand the consequences of market structure dynamics within a country's borders.

3 The Model

I model an autarchy where external trade in goods or assets is not possible. The economy consists of L_t infinitely-lived households, an endogenously determined number of varieties, and a government. The only source of investment is that involved in the start-up cost for each new variety produced by a monopolistic firm.

3.1 Households

The economy is populated by L_t infinitely-lived households whose utility function is

$$E_t \sum \beta U = E \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\frac{1}{\psi}}}{1-\frac{1}{\psi}} - k\ell_t \right], \tag{1}$$

where C is the index of consumption defined below, ℓ is the labour supply which generates a constant disutility measured by k, ψ is the intertemporal elasticity of substitution and β is the subjective discount factor.

Households can be employed either in the creation and design of new varieties that will be supplied in the next period or in the production tasks of currently active firms. However, they are homogeneous and receive the same wage regardless of their occupation in the economy.

The index of consumption takes the usual form

$$C_t = \left[\int_{h=0}^{n_t} c_t(h)^{1-\frac{1}{\sigma}} dh \right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where σ is the elasticity of substitution between varieties, n_t is the number of varieties available for consumption in period t and $c_t(h)$ is the individual demand of variety h. Household preferences are assumed to be expressed for a very large set of goods, so that their utility is well defined (and increasing) for any new good introduced in the market, and for a given level of technology and labour endowment.

Consumers are restricted by their budget identity,

$$s_t I_t + B_t = s_{t-1} \int_{h=0}^{n_t} \Pi_t(h) dh + (1 + i_t) B_{t-1} + w_t \ell_t - \int_{h=0}^{n_t} p_t(h) c_t(h) dh - T_t, \quad (3)$$

where s are savings expressed as a proportion of total investment, B are riskless bonds and $\pi(h)$ are the profits generated by firm h. There are n monopolistic firms producing differentiated varieties, i is the nominal interest rate paid by the bonds, w represents the wage, $p(h)$ is the price for variety h, and T is a lump-sum tax paid each period. Finally, I_t denotes total investment, which is equal to

$$I_t = \left[\int_{h=0}^{n_{t+1}} q_t(h) dh \right] = q_t n_{t+1}, \quad (4)$$

where $q(h)$ is the cost incurred by a firm in order to create a new variety today that can be brought to the market tomorrow. So that, $s_t = \frac{1}{L_t}$ due to the homogeneity among households.

By deciding how much to invest, households indirectly affect the amount of labour devoted to the creation of new equipment for the production of new or improved varieties in the next period. This amount of labour effort is, hence, prevented from participating in the production of today's consumption goods.

3.2 Firms

A continuum of n_t monopolistic firms acts in the economy at t. Investment appears in the form of an exogenous start-up cost, q_t, that entrepreneurs need to incur, at time t, in order to develop their new variety. These varieties are produced and sold in the market at $t + 1$. This cost comprises the wages paid to the labour force allocated to the innovation tasks that have productivity ν_t. So that $q_t = \frac{1}{v_t}$. It is arguably more natural to assume that the design of a new variety requires some final goods that would otherwise have been used as consumption. Indeed, the use of part of the available homogeneous labour supply for creation, rather than for the production of consumption goods, is equivalent to this.

Investment is fully depreciated at the end of the productive period. As such, these two-period firms could be said to adhere to the "reinvent yourself or die" rule. Any firm wishing to survive in the market must necessarily incur constant costs of innovation. Successful firms, therefore, produce a renewed variety of their good and, in this model, they are considered "new firms/varieties" in the following period. Unsuccessful firms, by contrast, disappear and new firms enter the market during each period. The model does not, however, differentiate between old-renewed and brand-new firms. Simply it provides us with the total number of varieties supplied in the market during each period, which is the measure that in essence affects welfare.

Once set up, the firms produce a differentiated variety with a homogeneous and linear technology that requires only labour

$$y_t(h) = \alpha_t \ell_t(h), \tag{5}$$

where $y(h)$ is the production of variety h, α is the productivity parameter, which is completely exogenous and $\ell(h)$ is the amount of labour required for productive activities of variety h.

4 Equilibrium

4.1 The Flexible Price Regime

Let us first focus on an environment without nominal frictions. In this case, all contracts and prices are written in nominal terms and are completely flexible. Hence, we can solve for the real variables only and resort to a cashless economy.

4.1.1 The Household's Problem

The representative household makes decisions regarding consumption, labour supply and savings. To do so, it maximizes (1) subject to (3), which produces the following first-order conditions:

$$c_t(h) : c(h) = \left(\frac{p_t(h)}{P_t}\right)^{-\sigma} C_t, \tag{6}$$

$$C_t \; : \lambda_t = \frac{1}{P_t C_t^{\frac{1}{\psi}}}, \tag{7}$$

$$\ell_t : w = k P_t C_t^{\frac{1}{\psi}},$$

$$s_t : \lambda_t q_t n_{t+1} = \beta E_t \left[\lambda_{t+1} \Pi_{t+1} n_{t+1}\right], \tag{8}$$

$$B_t : \lambda_t = \beta \left(1 + i_t\right) E_t \lambda_{t+1}, \tag{9}$$

where P is the welfare-based price index and λ is the Lagrangian operator.

Observe that the first-order condition for s_t implies free entry in the goods market. This condition provides us with a result for n_{t+1}. It also informs us that new firms will be set up until the expected discounted profits of the marginal firm (i.e., the present value of the firm) are equal to the costs of creating it. By using the definition

$$\mu_t = P_t C_t^{\frac{1}{\psi}}, \tag{10}$$

the free entry condition can be rewritten as follows:

$$q_t = E_t \beta \frac{\mu_t}{\mu_{t+1}} \Pi_{t+1}, \tag{11}$$

where μ must be interpreted as the monetary policy.

As for portfolio choice, there is no borrowing or lending in the equilibrium, so that $B_t = 0\ \forall t$. Moreover, each homogeneous household has an equal share of equities, $s_t = \frac{1}{L_t}$. However, notice that in the case in which we allow for population growth, it has to be controlled for. The equal-share result can be retained by introducing a redistributive scheme with lump-sum taxes and transfers so that the government budget becomes

$$T + \int_{a=0}^{\infty} T_a = \int^{n} G(h), \tag{12}$$

where $G(h)$ is public consumption of variety h and T_a is a positive transfer for the generations already working and a negative transfer for the new generation that owns no shares in the firms. This transfer program is self-financed, so that $\int_{a=0}^{\infty} T_a = 0$. The subscript a refers to the age of the individual.

In this context, the welfare-based price index is

$$P_t = n_t^{\frac{1}{1-\sigma}} p_t, \tag{13}$$

which is decreasing in the number of varieties. Finally, for the sake of simplicity we assume that the government's public demand is similar to the private demand derived in (6) for each specific variety. Hence,

$$G_t(h) = \left(\frac{p_t(h)}{P_t}\right)^{-\sigma} G_t, \tag{14}$$

where G_t is total public expenditure.

4.1.2 The Firms' Problem

The productively homogeneous firms operating in this economy produce differentiated goods. They enjoy some monopolistic power and maximize their profits with respect to price and labour and subject to the technology constraint. Profits are a function of n_{t+1} via the expression for the consumer price index (CPI). That is,

$$\Pi_{t+1} = \frac{1}{\sigma} \frac{p_{t+1}^{1-\sigma}(h) L_{t+1} \mu_{t+1}^{\psi}}{n_{t+1}^{\frac{\psi-\sigma}{1-\sigma}}} + \frac{1}{\sigma} p_{t+1}(h) G_{t+1}(h). \tag{15}$$

The sign of the effects of the number of acting firms on profits depends on the level of substitutability or market power, determined by σ and the intertemporal elasticity of substitution ψ. In general, profits are not as high in markets in which competition is stronger. In equation (15) this condition holds for $\frac{\psi-\sigma}{1-\sigma} > 0$. I assume $\varphi \leq 1 < \sigma$. Indeed, the literature typically parameterises $1/2 \geqslant \varphi \geqslant 1$. The most appropriate choice for σ is less obvious, although it is typically set above 1 and values between 2 and 10 are common.

Under perfect foresight, n_{t+1} is the solution to the free entry condition:

$$q_t = \beta \frac{\mu_t}{\mu_{t+1}} \left[\frac{1}{\sigma} \frac{p_{t+1}^{1-\sigma}(h) L_{t+1} \mu_{t+1}^{\psi}}{n_{t+1}^{\frac{\psi-\sigma}{1-\sigma}}} + \frac{1}{\sigma} p_{t+1}(h) G_{t+1}(h) \right], \tag{16}$$

where p_t is the optimal price obtained from the first-order conditions in the maximization problem. This takes the usual form of a constant mark-up over the marginal cost of production,

$$p_t = \frac{\sigma}{\sigma - 1} \frac{k\mu_t}{\alpha_t}. \tag{17}$$

The number of varieties supplied in the market is determined by the combination of the last two equations and the household's first-order conditions. This depends on the exogenous technology processes, the size of the population, fiscal policy and some parameters,

$$n_{t+1} = \left[\frac{\frac{k}{\nu_t} - \beta \frac{1}{\sigma-1} \frac{k}{\alpha_{t+1}} G_{t+1}(h)}{\beta \frac{1}{\sigma} \left[\frac{\sigma}{\sigma-1} \frac{k}{\alpha_{t+1}} \right]^{1-\psi} L_{t+1}} \right]^{\frac{\sigma-1}{\psi-\sigma}}. \tag{18}$$

The relationship between the number of active firms and the cost of creation lies in this equality. $\sigma > \psi$ is needed in order to ensure a decreasing effect of entry costs on the number of available varieties. This condition is required because an increase in the number of firms (which crucially would change expected profits) generates two effects on the consumption demand. First, the CPI falls, resulting in intertemporal substitution, represented by ψ, that consists in higher consumption today. Second, since there are more goods to consume, households split their income between them. This reallocation of private expenditure among all goods generates an intratemporal substitution away from existing goods, which is measured by σ. Notice that, in line with this reasoning, the inequality $(\sigma > \psi)$ becomes a necessary condition for the steady state equilibrium to be stable.

Due to the existence of in-advance investment, the subjective discount factor, β, affects the number of firms positively. When people are more patient they choose to save more and buy shares in the firm. In this way, an economy is supplied with a larger range of varieties. Obviously, the cost of creating new firms reduces the number of companies acting in the next period.

It is perhaps important at this juncture to stress the various implications of a change in the number of firms. First, consider that consumers have a love of variety. This means they prefer to consume a larger range of different goods rather than a large amount of just a few goods.[3] So, in principle, they should

[3] There is a body of literature that deals with this consideration and which explicitly separates the love of variety from the elasticity of substitution. See, for example De Groot and Nahuis (1998) and De Groot (2001).

be better off with more firms in the market. However, a greater number of firms means that more labour will be used in non-production activities. Each new company incurs a prior fixed cost which requires labour. And as this new company will not supply a new good until the second period, the workers employed to innovate during the first period are kept away from the production of goods already available for consumption. This is a traditional trade-off. Households must renounce present consumption in order to invest (with the fixed cost) in innovation and enjoy consumption tomorrow.[4]

Hence, decisions regarding savings that are dedicated to innovation ultimately determine the size of a firm that I call Z.

$$\begin{aligned} Z_t &= \frac{L_t \ell_t - \frac{n_{t+1}}{v_t}}{n_t} \qquad (19) \\ &= \frac{L_t C_t(\alpha_t) + G_t(\alpha_t)}{\alpha_t n_t}, \end{aligned}$$

where $n_t Z_t$ is the number of workers not employed in the creation of new firms at t; so that, it is the labour force available for the production of final goods today. Equation (19) represents the size of a firm producing at t. It indicates that an increment in the overall number of currently active firms, *ceteris paribus,* reduces the number of workers in each one as the larger number of firms must share the same number of workers. An increase in expected profits or a reduction in the costs of creation makes innovation more attractive and n_{t+1} higher. . Consequently, the labour force for the production of final goods is lost today in order to reach the new level of n. This causes a reduction in Z_t. Finally, if people experience a larger disutility for their labour effort and decide to increase their leisure time, either production per variety must be reduced or people must renounce future varieties. The second part of equation (19) shows that Z is a function of the GDP. However, it is not possible to analyze variations in Z because of the two simultaneous effects an increase on α_t generates. For a given demand, an increase in labour productivity, $\Delta\alpha_t$, would generate a reduction on firm's size due to the fact that less labour is required to produce the same amount of goods. Since n is given from previous period, the unique instantaneous effect of α_t improvement is via the reduction of the price index, which results in an increase in the demand that completely offsets the first impact of a movement in α_t.

4.2 Market Dynamics

If we differentiate the equilibrium condition (16) in the steady state defined above, take the assumption made in (14) and set public expenditure to zero

[4] A further consideration might be the existence of scale economies. In this case, the opportunity cost of enjoying a new variety would be much more important in the case of scale inefficiencies. But this analysis lies beyond the scope of the present paper.

$(G = 0)$, then the result is the following equation in differences:

$$\frac{\sigma - \psi}{\sigma - 1} \frac{dn_{t+1}}{n} = \frac{d\nu_t}{\beta} + (\psi - 1)\, d\alpha_{t+1} + dL_{t+1} + k \left(\frac{\sigma}{\sigma - 1} \right)^{\psi} n^{\frac{\psi}{1-\sigma}} dG_{t+1}. \quad (20)$$

Notice, first of all, that the sign of the effects crucially depends on the relation between σ and ψ. Under the initial assumption, $\psi \leq 1 < \sigma$, if there is an increase in the efficiency with which firms are created, i.e., as v_t rises, the number of firms also increases. By contrast, when firms become more productive, i.e., each firm is able to supply a larger amount of variety h with the same quantity of inputs $(\Delta\alpha)$, this productivity improvement discourages the creation of new firms. The reason for this is that a lower marginal cost forces firms to set prices accordingly, which is translated into smaller profits when the intertemporal elasticity of substitution is below 1 (i.e., $\psi < 1$).

Notice also the consequences of an overall productivity change, i.e., $d\alpha = dv$. Although these two shocks act in opposite directions, in the static model the dominant effect is unambiguously the positive impact of extra efficiency on the creation of new firms. The only exception is $\psi = 0$. In this case, one of the shocks balances the other exactly. However, under the present framework, this is not so clear. The relationship between the intertemporal elasticity of substitution ψ and the patience of the households β determines whether the total effect results in the entry or exit of firms. Based on the assumption $\psi < 1$ and assuming $0 < \beta \leq 1$, the dominant effect is, as in the static case, the improvement in v. In fact, this positive impact becomes stronger as β falls $(\forall \beta < 1)$. Hence, the greater the patience shown by the consumers, the smaller is the positive impact of a shock on the productivity of creation. The intuition behind this result is the following: on the one hand, when people are patient, they tend to invest more and so, in general, the economy produces a wider range of varieties than it does when consumers are impatient (notice that the derivative of (16) with respect to β is unambiguously positive). On the other hand, when consumers tend to save more, the demand for each variety falls and, so, the expected profits also fall. This serves as a disincentive to new market entrants. However, if $\psi < 1$ does not hold, the final result is uncertain.

Additionally, a larger market size, i.e., larger L, generates an increase in the number of firms.[5] More public expenditure means more total demand, which also leads to a greater range of varieties. Indeed, the fiscal authority has some scope for taking actions to restrict monopolistic power. Thus, it might offer a per unit subsidy to ensure that firms price at, and not above, their marginal costs. This fiscal expenditure can be recouped from lump-sum taxes so as to avoid generating a new distortion. This, today, is a recurrent theme in both modern industrial organization literature and advanced textbooks and so I do not tackle it any further here.

Finally, notice that the monetary stance μ is absent from the above equation, since monetary policy cannot have any impact on real variables when prices are completely flexible.

[5] Recall that I control for growth in L with redistributive transfers.

To sum up, while most of the conclusions concerning the effects of the endogenous variables on the number of varieties may be quite obvious to the reader, the crucial role of the explicit difference drawn between the two types of productivity should be borne in mind.

4.3 Consumer Price Index

As discussed above, household utility is derived from consumption; however, the household is concerned about both the quantity and variety of its consumer basket. Having analyzed the factors that can affect the diversity of goods in the market, let us turn to examine how household purchasing power is affected by prices. The differentiation of equation (13), the welfare-based CPI, results in the following expression:

$$\frac{dP_t}{P} = \frac{1}{1-\sigma}\frac{dn_t}{n} + d\mu_t - d\alpha_t. \tag{21}$$

If we once again assume $\sigma > 1$, the more firms that act in the market, the lower the price index P will fall. That is, as the number of firms in the market increases, competition becomes fiercer, pushing prices down. Likewise, P will fall more rapidly, as the substitutability between varieties increases, i.e., as the monopolistic power of the firms is weakened. An improvement in productivity also reduces the CPI, since production costs are lower. The implications of this have been widely studied in open economy models as it means that countries with better technology (i.e., more developed countries) experience deteriorating terms of trade (defined as the ratio between import and export prices). Finally, consideration needs to be given to the effects of the monetary policy, which, as expected, are positive.

4.4 Steady State Analysis

In order to define a steady state, let $\mu = 1$, $\alpha = \nu = 1$, $L = 1$. Thus, $w = k$ and

$$k = \beta\frac{1}{\sigma}\left[\left[\frac{\sigma}{\sigma-1}k\right]^{1-\psi}\frac{1}{n^{\frac{\psi-\sigma}{1-\sigma}}} + \left[\frac{\sigma}{\sigma-1}k\right]G(h)\right]. \tag{22}$$

Moreover, if I set $G = 0$, then

$$n = \left[\beta\frac{1}{\sigma k}\left(\frac{\sigma}{\sigma-1}k\right)^{1-\psi}\right]^{\frac{\sigma-1}{\sigma-\psi}}. \tag{23}$$

In the steady state, when firms are able to charge a high mark-up, entry is more attractive as they can expect higher profits. Given that investment is being made, in the form of the operating costs paid in advance, the subjective discount factor affects the number of varieties in equilibrium. The impact will be either positive or negative depending, again, on the relationship between σ and ψ. If $\psi > \sigma$ (i.e., goods are complements in the Edgeworth-Pareto sense), an increase in household patience leads to a reduction in the number of firms in equilibrium. However, if $\psi < \sigma$ (i.e., goods are substitutes), as assumed here, the greater the degree of household patience, the more likely people are to choose to save by investing in a firm's shares. This results in an increase in the number of varieties in equilibrium. By contrast, as the disutility of labour effort increases (Δk), consumers attach relatively more value to leisure than to consumption. Hence, the number of varieties is reduced as the labour supply decreases.

From equations (9) and (8) and the assumptions made for the steady state equilibrium, we find that

$$\beta = \frac{1}{1+i}. \tag{24}$$

For the rest of the endogenous variables we find:

$$p = \frac{\sigma}{\sigma - 1} k, \tag{25}$$

$$P = \left(\frac{\sigma k}{\beta}\right)^{\frac{1}{\sigma-\psi}} \left(\frac{\sigma k}{\sigma - 1}\right)^{\frac{\sigma-1}{\sigma-\psi}}. \tag{26}$$

In the steady state, individual prices depend positively on the monopolistic power of firms and their marginal costs, measured by $k = w$. The price index value is subject to the size of the mark-up and the level of patience of the households. The impact on the CPI of variations in these concepts differs depending on whether the goods are substitutes or complements. If they are substitutes, a high level of patience reduces the price index. In this case, people work to generate more differentiated varieties, which is to the detriment of P.

Consumption in equilibrium is

$$c = \frac{1}{\beta}(\sigma - 1), \tag{27}$$

$$C = \beta^{\frac{\psi}{\sigma-\psi}} (\sigma - 1)^{\frac{\psi(\sigma-1)}{\sigma-\psi}} (\sigma k)^{-\psi \frac{\sigma}{\sigma-\psi}}. \tag{28}$$

Consumption per variety is affected only by patience and the elasticity of substitution. From (23) it is known that the elasticity of substitution has a negative relationship with the number of firms in equilibrium (when goods are substitutes). As varieties become more substitutable, people are more reluctant to work towards creating new firms so as to simply achieve more of the same after paying the fixed cost. Hence, they decide to invest less and consume a larger amount of each (already) available variety. For this reason, σ has a positive effect on c. The effects of the parameters on C present exactly the opposite sign to those for CPI.

Finally,

$$Y = C, \tag{29}$$

$$\pi = \frac{k}{\beta} \text{ per firm.} \tag{30}$$

The first identity is a straightforward result of a closed economy without government consumption. Notice the extremely simplified form found for profits. As households suffer more from their labour effort, they will renounce the creation of more firms and so profits per firm will increase. By contrast, if the patience levels of consumers are high, present consumption will present a lower value, savings will be higher and the economy will be able to support more producers in equilibrium. However, such an outcome reduces profitability per firm. Finally, the last steady state equation is indicative of the level of labour supply.

$$\ell = C + n = \left(\frac{\sigma}{\sigma-1}k\right)^{-\psi} n^{\frac{\psi}{\sigma-1}} + n; \tag{31}$$

$$= \beta^{\frac{\psi}{\sigma-\psi}} (\sigma-1)^{\frac{\psi(\sigma-1)}{\sigma-\psi}} (\sigma k)^{-\psi\frac{\sigma}{\sigma-\psi}} + \left(\frac{\beta}{\sigma k}\right)^{\frac{\sigma-1}{\sigma-\psi}} \left(\frac{\sigma}{\sigma-1}k\right)^{(1-\psi)\frac{\sigma-1}{\sigma-\psi}} \tag{32}$$

As the population becomes more patient, the labour supply obviously undergoes an increment owing to the increase in n. Furthermore, an increase in the disutility of work reduces the labour supply. For values of σ larger than one, but which do not rise very high, labour supply decreases with substitutability. This is probably because of the decrease in the number of firms (fewer start-ups). However, if σ becomes very large, the labour supply of each individual is reduced. The reason for this is that, at this point, the positive effect of σ on c per variety - which increases total demand and hence, production - dominates the negative effect of the reduction in the number of firms.

4.5 Analysis of the Macro-Dynamics

Let us log-linearize all the relevant equations: first-order conditions, budget constraints and any equilibrium conditions for studying the model's dynamics. There are fourteen unknowns, i.e. endogenous variables: P, p, n, C, c, s, B, $G(h)$, ℓ, i, w, Y, I and π, and fourteen linearized equations.[6] This system can be reduce to the following rearranged expression for the free entry condition:

$$\left(\frac{1}{\psi}-\frac{1}{\sigma}\right)\frac{nk}{\varpi}\hat{n}_{t+2} = -\hat{v}_t - \eta\hat{\mathbf{P}}_{t+1} + \chi\hat{L}_{t+1} - \theta\hat{n}_{t+1} - \tag{33}$$

$$- \left(\frac{1}{\sigma}-\frac{1}{\psi}\right)\frac{k}{\varpi}\left[-\frac{n}{\beta}\hat{L}_t - \hat{\alpha}_{t+1} + n\hat{v}_{t+1}\right],$$

where $\varpi > 0$, $\theta > 0$, $\chi > 0$ for $0 < \beta$ and $\eta < 0$.[7]

Equation (33) is a first-order difference equation that depends on the endogenous variables n and P, the exogenous variables v, α and L and on the constant parameters contained also in ϖ, θ, η and χ.

Notice that, when the CPI deviates above its steady state value, it has a positive impact on the future number of firms. This is because higher prices are

[6] See the appendix for details.

[7] See the appendix for details of these parameter aggregates.

transformed in higher profits. Hence, firms will take advantage of this deviation and enter the market. Moreover, consumption becomes relatively expensive with respect to investment. People expect that P will return to its steady state value in the long term, so they prefer to wait for consumption. If n_{t+1} deviates from n (above), at $t+2$ the economy tends to correct that deviation by reducing the number of firms. The effects of v and L are also worth observing. Both exogenous variables appear in two lagged periods (t and $t+1$) and their effects work in opposite directions. An improvement in v_t increases n_{t+1}, but by a smaller proportion.[8] Hence, at $t+1$ there is already a high range of varieties available, i.e. in deviations, n is at a higher level than that of the steady state value. Here again, the negative effect on $\hat{n}_{t+2}$ is the correction of this "excessive" value. $\hat{L}_t$ is derived from the substitution of $\hat{C}_{t+1}$ in the budget constraint. Therefore, the impact is generated by the deviations of C. If the population was low during the last period, then people can expect to receive a larger proportion of the total profits generated by existing firms today. Hence, households can consume more. This higher demand acts as an incentive to businessmen and the number of firms created at $t+1$ rises. So, the deviation in $t+1$ is corrected in $t+2$.

To analyze the dynamic behaviour of the main variables, it is useful to organize the system so as to obtain a first-order difference equation. Notice that the unique endogenous variable with two-periods lag is the exogenous $\hat{v}_t$.[9]

$$\frac{kn}{\varpi}\hat{n}_{t+2} \simeq \vartheta_n \hat{n}_{t+1} + \gamma \hat{L}_{t+1} - \frac{kn}{\beta\varpi}\hat{L}_t + \frac{kn}{\varpi}\hat{v}_{t+1} + \Omega\frac{\sigma}{\sigma-1}\hat{v}_t + \vartheta_\alpha \hat{\alpha}_{t+1}.^{10} \quad (34)$$

For the accepted standard values of σ, ψ, β and k in the macro literature,[11] the intertemporal effects on n are the following: $\vartheta_n > 0$, i.e., positive deviations of n in t, increase the number of firms in the next period. The number of varieties in the market helps reduce the CPI, hence it is cheaper to consume and households agree to save more to create new firms. Variations in the size of the population have a longer term impact. First, since $\gamma > 0$, a larger population today provides more than one-to-one incentives for the creation of firms in the next period, since there is more labour available and expected profits are higher because of the extra demand. By contrast, $\hat{L}_t$ has a negative effect that is lower than one on $\hat{n}_{t+2}$, which helps correct the excess creation of firms. $\Omega < 0$ and $\varpi > 0$, so, as explained above, we find that once again the change in this

[8] Bear in mind that n_{t+1} is decided at t, which is why the relevant productivity of creation is v_t

[9] A further (numerical) analysis would require a study of the roots, considering L and ν as parameters of the characteristic polynomial, which would therefore depend on time. Here I adhere to a simple reasoning of the coefficients of the variables.

[11] The standard macroeconomic literature usually sets ψ, the risk aversion parameter, around or below 0.5, so that $\frac{1}{\psi} \simeq 2$ (see for instance, Greenwood, Hercovitz and Huffman (1988), Mendoza (1991) and Blankenau, Kose and Yi (2001)). The disutility of labor, k, in a linear technology is around 0.75. It is set in such a way that labour force participation matches the value of 66% reported by the BLS and the ILO (see, for example, Poschke (2009). β is close to 1 and $\sigma > 1$ (see Kollmann (2006)). The signs of the coefficients in the equation are stable for a large range of values above and below the standard values.

variable has opposite intertemporal effects. Finally $\vartheta_\alpha > 0$ for β is extremely close to one and negative otherwise. A positive deviation in the productivity of production today will result in more varieties tomorrow, if the population is patient. If not, then households will tend to consume more, since they expect to benefit, both in the current and in the following periods, from levels of α over its steady state, so they over-consume and the number of varieties at $t+1$ decreases.

5 Nominal Rigidities in Prices

The recent literature on macroeconomics and trade has often been concerned with nominal rigidities, seeing them as a possible, albeit partial, explanation for some of the more abstruse questions currently being addressed by the experts (the so called economic puzzles). In this section, I develop a version of the basic model which introduces rigidities in the prices of the varieties.

Corsetti and Pesenti (2007) and Obstfeld and Rogoff (2000) argue that sticky wages and flexible prices are a close reflection of reality. Yet despite this claim, if prices are set as a constant mark-up over marginal costs, then for certain applications it would not matter whether or not prices and wages were sticky.[12] The introduction of nominal rigidities means monetary policies can be analysed and the monetary authorities have the capacity to handle the distortions generated by such goods market frictions.

Although it lies beyond the scope of this paper, we cannot disregard completely the role of fiscal policies in the correction of the market imperfections that arise in this model: namely, those of monopolistic power and price stickiness. Indeed, modern advanced textbooks on Industrial Organization and the creative-destruction models of Aghion and Howitt discuss these issues at length. A benevolent planner may give a per unit subsidy to firms to ensure they price at, and not above, their marginal cost. To address the optimality of the extensive margin (i.e., the number of varieties supplied to the market) from society's point of view, the government may apply a subsidy or a tax on the fixed costs. In fact, markets with monopolistic competition may suffer from either too many or too few varieties. An increase in competition does not always result in a rise in welfare because it generates two opposite externalities. On the one hand, each new firm obtains its profits by depriving their competitors of some of their previous profits, i.e., a business-stealing effect. On the other hand, it raises consumer surplus. When firms have no fixed costs, the latter are always higher. However, when set-up costs are required, there is no guarantee that more firms will automatically generate more welfare (see Mankiw and Whinston (1986) for a detailed discussion).

What then is the role of the monetary authority in the context of our closed economy? Firms can no longer flexibly alter their prices in the face of a shock.

[12] Erceg, Henderson, and Levin (2000), however, provide an example of when it would matter - in a closed economy with both staggered price- and staggered wage-setting, the monetary authority can no longer replicate the flexible price equilibrium.

Rather, at the beginning of each period, they must sign contracts setting nominal prices for that period based on their expectations.[13] Prices crucially depend on expected μ. An expected monetary expansion raises the price level and nominal spending.

The government controls the path of short-term rates i, providing a nominal anchor for market expectations. A forward-looking monetary measure, μ is provided by equation (9) and the definition in (10). So that,

$$\frac{1}{\mu_t} = \beta \left(1 + i_t\right) E_t \frac{1}{\mu_{t+1}},$$

where $\frac{\mu_{t+1}}{\mu_t}$ represents the (gross) inflation target in a non-stochastic steady state.

5.1 Firms' Problem

Firms maximize their expected profits with respect to labour, ℓ, and the price, p. So that,

$$\underset{\ell,\, p}{Max}\ E_t \left[Q \left(p_{t+1} \left(L_{t+1} c_{t+1}(h) + G_{t+1}(h)\right) - \frac{w_{t+1}}{\alpha_{t+1}} \left(L_{t+1} c_{t+1}(h) + G_{t+1}(h)\right) \right) \right],$$

where Q is the discount factor. Thus, the first-order conditions yield the following expression for the optimal price of the differentiated variety:

$$p_{t+1} = \frac{\sigma}{\sigma - 1} \frac{E_t \left(\frac{\beta k}{\alpha_{t+1}} \mu_{t+1}^{\psi} \right)}{E_t \left(\beta \mu_{t+1}^{\psi - 1} \right)}. \tag{35}$$

Considering the optimal choice of prices and assuming that public expenditure is zero, the free entry condition (FEC) becomes

$$\frac{k}{v_t} = \beta E_t \left(\frac{p_{t+1}}{\mu_{t+1}} - \frac{k}{\alpha_{t+1}} \right) L_{t+1} c_{t+1}(h). \tag{36}$$

[13] Today, a number n_{t+1} of firms (matching condition 11) has been created. These firms will start producing tomorrow only if the price they have fixed in the previous period is at least as high as their marginal cost, i.e.,

$$\begin{aligned} p_t - MC_t &= \frac{\sigma}{\sigma - 1} \frac{k P_t C_t^{\frac{1}{\psi}}}{\alpha_t} - \frac{w_t}{\alpha_t} \geq 0 \\ &= > \frac{\sigma k}{\sigma - 1} P_t C_t^{\frac{1}{\psi}} \geq w_t. \end{aligned}$$

In what follows, we need not concern ourselves with this condition as it is never violated under this current framework.

Equation (36) provides us with the number of varieties exchanged in the consumer goods market at time $t+1$ when prices are rigid, $n_{r,t+1}$. This is

$$\begin{aligned} n_{r,t+1}^{\frac{\sigma-\psi}{\sigma-1}} &= \frac{v_t}{k}\beta L_{t+1}\left(\frac{\sigma}{\sigma-1}\right)^{-\psi} k^{1-\psi} * \\ &*E_t\left[\begin{array}{c} \mu_{t+1}^{\psi-1}\frac{\sigma}{\sigma-1}\left(\frac{E_t\left(\frac{\mu_{t+1}^{\psi}}{\alpha_{t+1}}\right)}{E_t\left(\mu_{t+1}^{\psi-1}\right)}\right)^{1-\psi} - \\ -\frac{\mu_{t+1}^{\psi}}{\alpha_{t+1}}\left(\frac{E_t\left(\frac{\mu_{t+1}^{\psi}}{\alpha_{t+1}}\right)}{E_t\left(\mu_{t+1}^{\psi-1}\right)}\right)^{-\psi} \end{array}\right]. \end{aligned} \tag{37}$$

Hence, households consume

$$c_{r,t}\left(h\right) = n_t^{\frac{\sigma-\psi}{1-\sigma}}\left(\frac{\mu_t}{\frac{\sigma}{\sigma-1}\frac{\beta k E_{t-1}\left(\frac{\mu_t^{\psi}}{\alpha_t}\right)}{\beta E_{t-1}\left(\mu_t^{\psi-1}\right)}}\right)^{\psi} \tag{38}$$

of each variety when prices are rigid. In this scenario, the real variables n_t and c_t are tied to the expected behaviour of the monetary authorities and the expected shocks to productivity of processes of production. Thus, the credibility of the government becomes a relevant factor.

5.2 The monetary policy

Economic policies may seek to stabilize economic cycles and so correct market imperfections. This paper restricts itself to comparative statics, so that this section examines the capability of monetary policy to solve the imperfection generated by nominal stickiness. Here a government can aim to close the output gap and replicate the flexible-price situation. The flexible-price scenario is better in terms of welfare given that it has only to suffer the monopolistic power imperfection. The monetary authority should commit itself to a monetary policy μ, whereby the number of firms in the case of rigidities, $n_{r,t+1}$, equals the number of firms in the flexible-price situation, $n_{f,t+1}$. Once again, the authorities may have to deal with an important trade-off: it may not be true that by simply closing the output gap the economy will simultaneously attain the consumption of the flexible set-up. In other words, although the output gap might be narrowed, the consumption gap could well remain.

To achieve the same number of firms as in the flexible-price scenario, the monetary authority would need to set a monetary policy $\mu = \alpha$, taking the CPI as given. This policy rule involves committing itself to providing a nominal anchor for the economy and deviating from such a stance only when productivity shocks shake the economy and destabilize marginal costs. By so doing, the policy eliminates uncertainty in marginal costs and in profits.

Let us verify the implications of this monetary policy on output. After plugging the optimal policy in (37), $n_{r,t+1}$ becomes exactly equal to $n_{f,t+1}$:

$$\begin{aligned} n_{r,t+1}^{\frac{\sigma-\psi}{\sigma-1}} &= \frac{v_t}{k}\beta L_{t+1}\left(\frac{\sigma}{\sigma-1}\right)^{-\psi}\left(\frac{1}{\sigma-1}\right)k^{1-\psi}E_t\left[\mu_{t+1}^{\psi-1}\right] = \\ &= \left[\frac{\nu_t}{k}\beta k^{1-\psi}L_{t+1}\frac{1}{\sigma-1}\left(\frac{\sigma}{\sigma-1}\right)^{-\psi}\left[\frac{1}{\alpha_{t+1}}\right]^{1-\psi}\right] = n_{f,t+1}^{\frac{\sigma-1}{\sigma-\psi}}. \end{aligned} \tag{39}$$

Notice that the authority is able to fix both the output and consumption levels of the flexible-prices regime by using the defined policy. Consumption, (38), becomes $c_{r,t}(h) = n_t^{\frac{\sigma-\psi}{1-\sigma}}\left(\frac{k\sigma}{\sigma-1}\right)^{-\psi}\alpha_t^{\psi}$, which is the same as it was in the flexible version. Moreover, in the steady state,

$$n_r = \left(\beta\left(k\sigma\right)^{-\psi}\left(\sigma-1\right)^{\psi-1}\right)^{\frac{\sigma-1}{\sigma-\psi}}.$$

5.2.1 The Costs of Insufficient Stabilization

Although benevolent, the monetary authority may fail to choose the correct policy. What, therefore, would be the consequences of adopting a sub-optimal monetary policy? Logically, we can predict that welfare would be damaged by such macroeconomic uncertainty, since insufficient stabilization results in suboptimal prices and a suboptimal number of varieties.

Let us assume that the authority incorrectly sets a monetary policy $\mu = \alpha^{\Gamma}$ where $0 \leq \Gamma \leq 1$ ($\Gamma = 1$ would be the suitable policy for a flexible-price replication). For any value of Γ different from one, the policy response to shocks will be inefficient in relation to the government's target. Thus, now

$$p_{t+1} = \frac{\sigma k}{\sigma-1}\frac{E_t\left(\alpha_{t+1}^{\Gamma\psi-1}\right)}{E_t\left(\alpha_{t+1}^{\Gamma(\psi-1)}\right)}.$$

Applying Jensen's inequality, it is known that $E_t\left(\alpha_{t+1}^{\Gamma\psi-1}\right) \geq E_t\left(\alpha_{t+1}\right)^{\Gamma\psi-1}$ and

$E_t\left(\alpha_{t+1}^{\Gamma(\psi-1)}\right) \geq E_t\left(\alpha_{t+1}\right)^{\Gamma(\psi-1)}$. Without any loss of generality, I choose $\Gamma = 0$ and verify the effect of insufficient stabilization. The consequence is undoubtedly higher prices:

$$p = \frac{\sigma k}{\sigma-1}E_t\left(\frac{1}{\alpha}\right) > \frac{\sigma k}{\sigma-1}. \tag{40}$$

Uncertainty about marginal costs tends to reduce expected discounted profits. This is because people are risk averse and prefer a certain amount of income x rather than an expected average income of x. In order to make discounted profits less sensitive to shocks, firms raise their preset prices. In this way, the economy suffers higher price levels[14] and, consequently, lower levels of consumption.

Moreover, if the government tends to adopt monetary policies that do not completely offset the productivity shock, investors, who are risk averse, will tend to feel uncertain about their future profits and so create fewer firms:

$$
\begin{aligned}
& n_{r,t+1}^{\frac{\sigma-\psi}{\sigma-1}}\left(\mu=\alpha^{\Gamma}\right)-n_{r,t+1}^{\frac{\sigma-\psi}{\sigma-1}}\left(\mu=\alpha\right)= \\
& \delta\left[\frac{\sigma}{\sigma-1}E_t\left(\alpha_{t+1}^{\Gamma(\psi-1)}\right)-E_t\left(\alpha_{t+1}^{\Gamma\psi-1}\right)\right]-\delta\left[\frac{\sigma}{\sigma-1}E_t\left(\alpha_{t+1}^{(\psi-1)}\right)-E_t\left(\alpha_{t+1}^{\psi-1}\right)\right] \\
= \quad & \frac{\sigma}{\sigma-1}\left[\underbrace{E_t\left(\alpha_{t+1}^{\Gamma(\psi-1)}\right)-E_t\left(\alpha_{t+1}^{(\psi-1)}\right)}_{(-)}\right]+\left[\underbrace{E_t\left(\alpha_{t+1}^{\psi-1}\right)-E_t\left(\alpha_{t+1}^{\Gamma\psi-1}\right)}_{(-)}\right],
\end{aligned}
$$

where $\delta=\frac{v_t}{k}\beta L_{t+1}\left(\frac{\sigma}{\sigma-1}\right)^{-\psi}k^{1-\psi}$. To sum up, when monetary authorities fail to use the replication policy,[15] the economy is characterised by prices that are too high and a number of varieties that is too low. Moreover, the surplus of consumers is seriously damaged in both it dimensions: first, the level of consumption is affected by reduced purchasing power, and, second, there is very little variety of differentiated goods, i.e., people are unable to satisfy their love of variety.

As discussed above, as regards its fiscal policy, the government could intervene to remove the imperfections of monopoly power. For instance, it could use a subsidy to reduce the marginal costs of production.

6 Conclusions

This paper has presented a dynamic general-equilibrium model of a closed economy and has analysed full price flexibility and the simplest case of nominal price rigidities. The paper shows the relevance of intertemporal decisions and uncertainty in determining the level of economic activity. Thus, on the one hand, a change in the degree of patience manifest by the consumer moves the economy to a steady state, so that the greater the consumer's patience, the greater the product diversity enjoyed by that society. On the other hand, when a society faces nominal rigidities, firms tend to set higher prices to (partially) offset the losses they can expect to suffer in the case of a negative shock to productivity (of production). At the same time, managers tend to create fewer firms as profits are no longer certain.

The different types of productivity shock have effects of opposite signs on the extensive margin of production: an improvement to the technology of creation increases the number of varieties, while an increase in the productivity of

[14] This result coincides with the conclusion reached in related studies. See, for instance, Corsetti and Pesenti (2005).

[15] In other words, the monetary policy that matches the solution in a flexible-price framework.

operational firms reduces the number of goods supplied. Finally, an increase in market size has a positive impact on the number of varieties.

In the present paper, as in most of the literature, the elasticity of substitution between goods and the love of variety are perfectly tied together (in the set-up presented here, love of variety equals the firms' mark-up). It may, however, be of interest to relax this assumption and to consider their explicit separation. De Groot and Nahuis (1998) claim that the disentanglement of the two elasticities might have important implications for economic growth and welfare.

Finally, it is worth stressing the current dearth of empirical research. Establishing a separation between the two kinds of productivity empirically is by no means a straightforward task, and while Debaere and Lee (2004) report an initial attempt at identifying them separately, there remains much work to be done.

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