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Product Market Frictions, Bargaining and Pass-Through

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ABSTRACT

Empirical evidence shows that the pass-through of cost shocks to prices is very low, and delayed. This is in stark contrast with the standard framework of monopolistic competition used in macro models, which, absent nominal rigidities, implies complete pass-through of cost shocks to prices. This paper develops a model of pricing dynamics in business to business relationships where incomplete pass-through arises endogenously. The model is based on two assumptions. First, both retailers and wholesalers invest resources to form new, long-term, business relationships. Second, once a business relationship is formed, the prices and the quantities of the intermediate good exchanged are set in a bilateral bargaining between wholesalers and retailers. The repeated nature of the interactions between firms raises the question of whether wholesale prices are allocative. We show that wholesale prices still play an allocative role in the model, but this role is likely to be quite limited.

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Abstract

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JEL classification: E10, E30

Keywords: price dynamics, product market frictions, price bargain, customer relations, real rigidities, incomplete pass-through.

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1 Introduction

A number of empirical studies documents that marginal cost shocks are not fully passed through to prices at the firm level and that prices are substantially less volatile than costs[1]. This is in stark contrast with the standard framework of monopolistic competition used in macro models, the one developed by Dixit and Stiglitz (1977), which implies a complete pass-through of cost to prices. There are many theoretical reasons proposed as to why prices are more stable than marginal costs[2]. The most recent literature, trying to explain the low pass-through to prices of exchange rate shocks, has mainly focused on three factors: the existence of local distribution costs, markup adjustments (due, for instance, to a variable elasticity of demand), and pure nominal rigidities (menu costs).

In this paper we propose a novel explanation based on the presence of product market imperfections in the relationship between wholesalers and retailers.[3] In our model incomplete pass-through arises endogenously as a consequence of two key assumptions. First, both retailers and wholesalers spend resources to form new long term business relationships. Second, once a business relationship is formed, the wholesale prices and the quantities of the intermediate good exchanged are determined in a bilateral bargaining between wholesalers and retailers.

There is a vast empirical evidence on the importance of business to business (B2B) long term relationships and product market imperfections. For example, Blinder et al. (1998) find that, in the US, 85% of firms surveyed engage mainly in long term relationships with their customers, and that 77% of their customers are other firms. These long-term relationships are mainly covered by contracts, and these contracts typically last one year. Surveys for other industrialized economies usually corroborate these findings (See e.g. Fabiani et al. (2006) for the Euro Area or Apel et al. (2005) for Sweden). As noted by Matha and Pierrard (2011) firms allocate a non-negligible amount of resources in the search of customers or suppliers. The need for advertising, marketing, promotions etc. provided almost 600,000 jobs in 2006 in the US. This represents almost 0.5% of total US employment. A similar amount of people were engaged in purchasing and buying occupations. Moreover, total annual expenditure in all media advertising represents on average 2,5% of US GDP over the last decade.

Negotiations among retailers and wholesalers seem to be the rule rather than the exception. Zbaracky et al. (2004) find that customer communications and price negotiation costs account for almost 75% of the total price adjustment cost and are 20 times bigger than the size of the menu costs. Fabiani et al. (2006) find, on the basis of surveys conducted by nine Eurosystem national central banks, that the existence of implicit and explicit contracts with customers is considered as the most important explanation for rigid prices. Friberg and

[1]See, for instance, Hellerstein (2008) for the beer industry, Nakamura and Zerom (2010) for the coffee industry, Goldberg (1995) for the automobile industry and Kadiyali (1997) for the photographic industry.

[2]Examples include implicit contracts, social customs, customer markets and theories of countercyclical markups (See, e.g., Ball and Romer (1990) and the references therein).

[3]The model can also be interpreted in terms of relationships between upstream and downstream firms.

Wilander (2008) report that the invoicing currency for export is predominantly set through a negotiation between the exporter and the importer.

Very recent findings of Nakamura (2008), Gopinath and Itskhoki (2010) and Nakamura and Zerom (2010) suggest that delayed pass-through mostly occur at the wholesale rather than at the retail level. Nakamura (2008) studies a large panel data set of retailers in the US to analyse the pass-through of costs to wholesale and retail prices. Her results suggest that most of the observed price variation arises from retail-level[4] rather than manufacturer-level demand and supply shocks: wholesale prices seem to be more sticky than retail prices. Gopinath and Itskhoki (2010) review the closed and open economy empirical literature on real rigidities and reveal a consistent finding across studies: the variable markup channel for real rigidities plays little role for retail prices but appears to be quite important for wholesale prices.[5] Nakamura and Zerom (2010) study the pass-through of commodity price shocks in the coffee industry. They find that both for wholesale and retail prices, a 1% increase in coffee commodity costs lead to an increase in prices of approximately 0.3% over the subsequent 6 quarters. This again indicates that the majority of incomplete pass-through arises at the level of wholesale prices. Based on these findings, they argue that "it is wholesale price rigidity that matters" and that "studies that focus exclusively on retail prices may be incomplete in an important way".[6]

In this paper we investigate the implications of B2B long term relationships and bargaining for the response of prices and quantities to cost shocks. The central element of the model is the introduction of search and matching frictions a' la Diamond-Mortensen-Pissarides in the relationship between wholesalers and retailers. Following Matha and Pierrard (2011), we assume that both retailers and wholesalers face search and matching costs to form new business relationships. Wholesalers invest resources (marketing, advertising and sale managers) to find new customers; retailers produce effort (purchase agents) to form new business relationships with wholesalers. The total amount of trade of intermediate goods depends on two margins: an extensive margin (the number of customers) and an intensive margin (the quantity exchanged in each match). The presence of search costs governs the response of the extensive margin and creates a surplus related to each business relationship. Retailers and wholesalers bargain over this surplus and set wholesale prices and quantities according to their relative bargaining power.

We show that the model, despite its simplicity, has the potential to explain the low and delayed pass-through of cost shocks to wholesale and retail prices. Incomplete pass-through stems from two main features. On the one side, the presence of search frictions implies that firms find it difficult to rapidly adjust the production and distribution process to shocks, as

[4] Temporary sales are the main determinant of these variations.

[5] After reviewing the literature, Gopinath and Itskhoki (2010) use unpublished international price data and exchange rate shocks to evaluate the importance of real rigidities in price setting. They show that the pass-through of import prices to exchange rate shocks, even conditionally on changing, is very low and delayed. This suggests the presence of important real rigidities in the wholesale sector.

[6] Nakamura and Zerom (2010), p. 1193.

to increase production they need to establish new business relationships, which is a costly and time-consuming process. As a consequence retail prices and quantities do not change as easily as in a frictionless world. On the other side, the introduction of bilateral bargaining between firms implies that the responsiveness of wholesale prices to shocks depends crucially on the negotiation capabilities of the parties involved.

More generally, we find three factors to be crucial in explaining the degree of pass-through to wholesale and retail prices: (1) the relative bargaining power of retailers in the negotiations, (2) the persistence of the cost shock and (3) the elasticity of the demand of retailers for wholesale goods along the intensive margin. Interestingly, while retailers' bargaining power has a strong and monotonic effect on the pass-through to wholesale prices, its influence on retail prices and consumption is rather limited. The reason is that bargaining power mainly affects the distribution of the rents related to a business relationship, while the reaction of retail prices ultimately depends on the costs of rapidly adjusting the marketing and distribution infrastructure needed to sell the final goods.

The repeated nature of the interactions between firms points towards an intriguing issue: observed wholesale prices may not be allocative, in the sense that they may not affect the retail prices faced by consumers nor their consumption decisions. This issue is very relevant, especially at the light of the recent empirical evidence, which suggests that nominal price stickyness arises mainly at the wholesale rather than at the retail level. As recognized at least since Barro (1977), in fact, the stabilizing role of monetary policy when prices are sticky crucially depends on prices being allocative. The business to business model provides a natural laboratory to address this issue.

We show that wholesale prices have no direct influence on the intensive margin of trade, but affect the value of business relationships and thus the incentive to engage in search activities. For this reason, the allocative power of wholesale prices depends on the perceived persistence of the price change, and on the efficiency of the matching process. If wholesale price changes are long-lasting and search externalities are substantial, then wholesale prices still retain a large, and very persistent, allocative role. In all the other circumstances, the allocative power of wholesale prices is likely to be small, much smaller than in the standard monopolistic competition model.

The rest of the paper is structured as follows. Section 2 discusses the related literature. In Section 3 we derive the benchmark model. In Section 4 we analyse the effect of trading frictions and bargaining on the pass-through of cost shocks to wholesale and retail prices. Based on the findings, Section 5 addresses the issue of the allocative power of wholesale prices. Section 6 concludes.

2 Related literature

Recent research has started to investigate the role of long term relationships in the interaction between firms and customers. Notable examples are Hall (2008), Arseneau and Chugh (2007), Kleshchelski and Vincent (2009) and Ravn et al. (2010). Hall (2008) develops a model of consumers' search and seller recruiting where firms invest heavily in advertising in order to attract final consumers. He focuses on the magnitude and distribution of the rents associated with customer relationships and on the tightness of the retail markets under alternative distributions of the rents. Arseneau and Chugh (2007) derive a similar model of retailer-consumer relationships and explore the effects of different bargaining assumptions. They show that in the presence of search frictions prices play a distributive as well as an allocative role, and explore how concerns for fairness influence price dynamics. Both Hall (2008) and Arseneau and Chugh (2007) focus on the relationship between final consumers and firms, and not on business to business relationships between firms, as we do here. This is conceptually an important difference, since a bilateral bargaining between firms is arguably more realistic than between retailers and consumers.

Of these papers, the ones more closely related to ours are Kleshchelski and Vincent (2009) and Ravn et al. (2010), as they both provide theoretical explanations of the low pass-through of cost shocks to prices. Kleshchelski and Vincent (2009) construct a model in which firms care about the size of their consumer base, because consumers incur costs to switch sellers. Consequently, firms face an intertemporal trade-off between increasing current profits and building market shares for the future. Ravn et al. (2010) provide a theoretical explanation of the incomplete pass-through of marginal costs disturbances to prices based on a relative deep-habit demand for retail goods. When habits are formed at the level of individual goods, following a cost increase firms find it optimal to narrow profits margins in the current period to limit the decline in future habitual demand triggered by the price increase. Kleshchelski and Vincent (2009) and Ravn et al. (2010) share with our approach the idea that firms form long-term relationships, but differ in two key respects: they focus on retail firms-consumer relationships, and do not allow for bilateral negotiations between buyers and sellers.

From a modeling perspective, our paper builds on the work of Drozd and Nosal (2010) and Matha and Pierrard (2011). Drozd and Nosal (2010) propose an international business cycle model where international trade takes place only through matches between retailers and producers. The model is found to perform well in replicating the movements of international prices and quantities. Matha and Pierrard (2011) extend a standard real business cycle model allowing for search and matching frictions between firms and bargaining. They investigate the cyclical properties of such a model, and find that this is able to produce hump-shaped dynamics for all variables, a highly persistent output and a realistic representation of the product market variables such as search and prices. The present paper differs from Drozd and Nosal (2010) and Matha and Pierrard (2011) on three main dimensions. First, we study a different issue, as we investigate the implications of business to business relationships and

bargaining for pricing dynamics and for the allocative power of wholesale prices. Second, we focus on industry dynamics. This approach has the advantage of analytical tractability and allows a closer match with the empirical literature on cost pass-through. Finally, we carefully analyse the effect of the intensive margin of adjustment on pricing dynamics, unveiling its crucial role in explaining the degree of pass-through of cost shocks to prices.

More recently, Gopinath and Itskhoki (2010) developed a static bargaining model between one final good producer and a number of intermediate good suppliers. The model is used to provide a micro-foundation for a quantitative model with variable markups at the wholesale level but constant markups at the retail level. Our paper shares with Gopinath and Itskhoki (2010) the idea that introducing negotiations between firms is important to understand pricing dynamics, but differs in many important aspects. Most importantly, our model is dynamic, and takes into account the need for firms to invest in building new long term business relationships.

3 The model

In this section we develop a tractable model of business to business relationships where firms invest in long term relationships and set prices by bargaining. We focus on a generic industry where goods are produced by wholesalers, transformed by retailers and consumed by households. Retailers sell the final good to consumers in a perfectly competitive environment. Trade frictions are present in the relationship between wholesalers and retailers. The model builds on the Diamond-Mortensen-Pissarides search and matching model and adapts its basic concepts to business to business relationships.

3.1 Demand for retail goods

The economy is composed of a continuum of sectors, each producing a good indexed by i. In each sector, there is an infinite number of retail firms, each selling a different brand r. Following Kleshchelski and Vincent (2009), we assume that while goods i are imperfect substitutes, brands are homogeneous and perfectly substituable.[7]

The demand for the good produced in industry i is given by

$$c_t^i = \left(\frac{p_t^i}{P_t}\right)^{-\phi} C_t$$

where ϕ is the elasticity of substitution between the goods produced in different industries. P_t and C_t denote respectively the aggregate price and consumption levels. Following Ravn et al. (2010), since we focus on industry dynamics taking as given P_t and C_t, we simplify the demand function for the good i to:

$$c_t = A\left(p_t\right)^{-\phi}$$

[7] In this paper we use the term sector and industry interchangeably.

where A is a positive constant. Notice that in the rest of the paper, to simplify the notation, we drop the industry superscript i.

3.2 Wholesale firms

The industry is composed of a continuum of wholesale firms. In order to sell their products, wholesale producers need to establish customer relationships with retailers. We assume the aggregate number of business to business relationships in the industry, T_t, follows the law of motion:

$$T_{t+1} = (1-\delta)(T_t + M_t)$$

where δ is the rate at which business relationships are destroyed, which we take as exogenous. M_t, the number of new B2B relationships, is a constant return to scale function of the search effort of retailers d_t (e.g., from purchase managers) and the search effort a_t (advertising and marketing) by wholesalers:

$$M_t = \tilde{m} a_t^{\xi} d_t^{1-\xi}$$

where $\tilde{m} > 0$. Total trade volumes depend on the number of relationships T_t (extensive margin) and the units bought for each relationship q_t (intensive margin). Wholesalers take as given $k_t^a = \frac{M_t}{a_t} = \tilde{m}(\theta_t)^{-(1-\xi)}$, the number of new matches per unit of effort. $\theta_t = \frac{a_t}{d_t}$ is the product market tightness of industry i, defined as the ratio of advertisement effort per purchasing effort.

Firms are assumed to discount future profits at the constant rate $\beta \in (0,1)$[8]. The law of motion of the customer base for wholesaler j is:

$$T_t(j) = (1-\delta)\left(T_{t-1}(j) + a_{t-1}(j) k_{t-1}^a\right) \tag{1}$$

Notice that $T_t(j)$ is a state variable, as it takes time (one month, under our calibration) to establish a business relationship. The marginal cost of producing one intermediate variety, $mc_t(j)$, is assumed to be exogenous and independent of scale. Moreover, wholesale firms face a search cost to establish new business relationships that is convex in the search intensity of wholesalers $x_{wt}(j) = \frac{a_t(j)}{T_t(j)}$:[9]

$$\frac{\gamma}{2}(x_{wt}(j))^2 T_t(j)$$

[8] In a full-fledged general equilibrium model, the discount factor of the firm would be an endogenous variable given by the representative household's intertemporal marginal rate of substitution. See also Ravn et al. (2010).

[9] This specification of search costs, which has been used in the labor search literature by Gertler and Trigari (2009) and Thomas (2008), greatly simplifies the bargaining problem because it implies that the bargained price does not depend on the number of B2B relationships that each firm has in place. It thus permits to avoid the problem that in labor economics is known as intrafirm bargaining.

Wholesalers maximize the expected present value of future profits[10]

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left[p_{Wt}(j) - mc_t(j) \right] q_t(j) T_t(j) - \frac{\gamma}{2} \left(x_{wt}(j) \right)^2 T_t(j) \right\}$$

subject to the law of motion of the customer base (1). At the beginning of the period the firm chooses the advertising effort $x_{wt}(j)$; wholesale prices $p_{Wt}(j)$ and quantities $q_t(j)$ are decided after the successful match in a bilateral bargaining between wholesalers and retailers.

The solution to the maximization problem gives the following first order conditions:

$$\gamma \frac{x_{wt}(j)}{k_t^a} = \beta (1-\delta) E_t W_{t+1}(j) \tag{2}$$

$$W_t(j) = \left[p_{Wt}(j) - mc_t(j) \right] q_t(j) + \frac{\gamma}{2} \left(x_{wt}(j) \right)^2 + \beta (1-\delta) E_t W_{t+1}(j) \tag{3}$$

The first condition equates the expected search cost of an additional match (the left hand side), to its expected benefit, which is given by the expected value of a business relationship. $W_t(j)$ is the value of an existing business relationship for a wholesale firm, which consists of the total profit from an established relationship, plus the savings in the costs of establishing a new match, $\frac{\gamma}{2} \left(x_{wt}(j) \right)^2$, plus the expected continuation value. Notice that the introduction of search frictions transforms the wholesale problem into an intertemporal problem, as both the search intensity and the value of an existing relationship depend on the expected future value of a business relationship.

3.3 Retail firms

In sector i, there is a continuum of retailers buying tradable goods from wholesalers and selling them to households. As wholesalers, retailers choose at the beginning of the period the amount to invest in forming business relationships, captured by the search rate $x_{Rt}(r) = \frac{d_t(r)}{T_t(r)}$. Retailers take as given the rate at which search effort leads to a new match, defined as:

$$k_t^R = \frac{M_t}{d_t} = \tilde{m} \theta_t^{\xi}$$

and the search cost to establish new matches, that is convex in the search intensity $x_{Rt}(r)$:

$$\frac{\gamma}{2} \left(x_{Rt}(r) \right)^2 T_t(r)$$

Once matched with wholesalers, each retailer r has a technology which transforms wholesale goods into retail goods. It is important to specify at this point that in order to introduce a meaningful intensive margin of adjustment, we need to introduce a cost of changing the quantity sold per match. If changing $q_t(r)$ were costless, firms would find it optimal to have few matches (since it is costly to establish long-term relationships) and satisfy changes

[10] Notice that we implicitely assume symmetry among the matches of each wholesaler j.

in demand with changes in $q_t(r)$. This would go against the spirit of our model, which is meant to be one in which firms *must* engage in search and matching in order to expand their production, and would make the problem not well-defined.

To address this aspect, we introduce costs in changing the quantity sold per match through the production function of retailers. Specifically, we assume that for each match k, retailers have a technology that transforms $q_t(k)$ units of the wholesale good into $(q_t(k) - \omega_t(k))$ units of retail goods, where $\omega_t(k) = \frac{\psi}{2}(q_t(k) - \bar{q})^2$ is an adjustment cost in the units bought per match. Intuitively, $\bar{q}$ is the quantity per match that maximizes the technical efficiency of the production process of retailers. Deviations from this optimal amount decrease the marginal productivity of the intermediate good variety. The aggregate production of retailer r is thus given by:[11]

$$\begin{aligned} y_t(r) &= \int_0^{T_t(r)} (q_t(k) - \omega_t(k))\, dk \\ &= (q_t(r) - \omega_t(r))\, T_t(r) \end{aligned} \tag{4}$$

where we have imposed symmetry among matches. This production function has three main attractive features. First, it displays diminishing returns to q_t for deviations from the technically optimal level $\bar{q}$ both upwards and downwards. Second, it introduces an incentive for retailers to buy from different wholesalers (similar to a love for varieties). Third and most importantly, it is very flexible, in that it includes both the linear case and the extensive-margin-only case as special cases. More precisely, for $\psi \to 0$, the production function is linear in $q_t(k)$ and retailers can adjust their production on the intensive margin very easily. For $\psi \to \infty$, $q_t(k) = \bar{q}$ for all t, the intensive margin is closed, and firms can adjust production only by establishing new business relationships.

Each retailer maximizes the expected present value of future profits

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ p_t y_t(r) - p_{Wt}(r)\, q_t(r)\, T_t(r) - \frac{\gamma}{2}(x_{Rt}(r))^2\, T_t(r) \right\}$$

[11] A natural alternative would be to endogenize the intensive margin by assuming that each retailer buys differentiated goods from a range of wholesalers and has a “love of variety” motive (common in the trade literature) that leads him to value buying from many wholesalers in itself. The production function of retailers would be:

$$y_t = \left[\int_0^{T_t} q_{it}^{\rho}\, di \right]^{1/\rho}$$

with $\rho < 1$. The main reason why we chose a different specification is that the production function (4) is more flexible, since it nests both the linear case ($\psi \to 0$) and the extensive-margin-only case ($\psi \to \infty$) as special cases. This allows us to analyse more neatly the role of the intensive margin of trade adjustment for the cost pass-through.

subject to the law of motion of the customer base

$$T_t(r) = (1-\delta)\left(T_{t-1}(r) + d_{t-1}(r)\, k_{t-1}^R\right) \tag{5}$$

and the production function (4). Notice that since retail firms sell the final good in a perfectly competive market, they take the final price of the retail good, p_t, as given in the maximization problem. The solution to the problem gives:

$$\begin{aligned} \gamma \frac{x_{Rt}(r)}{k_t^R} &= \beta(1-\delta)\, E_t J_{t+1}(r) \\ J_t(r) &= p_t\left(q_t(r) - \omega_t(r)\right) - p_{Wt}(r)\, q_t(r) + \frac{\gamma}{2}\left(x_{Rt}(r)\right)^2 + \beta(1-\delta)\, E_t J_{t+1}(r) \end{aligned}$$

The first condition equates the expected search costs of an additional match, to its expected benefit, which is given by the expected value to a retailer of a business relationship. The second equation determines the value of a business relationship for a retailer, $J_t(r)$, which consists of the gross profits from an established relationship $p_t(q_t(r) - \omega_t(r)) - p_{Wt}(r)\, q_t(r)$, plus the savings in the costs of establishing a B2B relationship, plus the expected continuation value.

3.4 The bargaining problem

The presence of a surplus associated with existing long-term relationships implies that many wholesale prices and quantities are consistent with equilibrium (see, e.g., Hall 2005, 2008). Existing B2B relationships are privately efficient as long as they generate a positive surplus for both the parties involved in the bargaining. Therefore, any price path such that $W_t(j) \geq 0$ and $J_t(r) \geq 0$ for all t is consistent with equilibrium. This has interesting implications because, as emphatized by Hall (2007), it admits the possibility of equilibrium sticky prices in customer markets.[12]

In this paper, we follow the labor market literature and assume that the surplus sharing is a solution to a Nash (1950) bargaining problem. In Nash bargaining, each wholesaler j and retailer r jointly choose wholesale prices and quantities to maximize the Nash product $S_t(j,r)$ according to their relative bargaining power:

$$S_t(j,r) = \left[\left(W_t(j)\right)^{1-\eta}\left(J_t(r)\right)^{\eta}\right]$$

where η is the bargaining power of retailers. The solution to the maximization problem with respect to the wholesale price gives the optimal sharing rule

$$\eta W_t(j) = (1-\eta)\, J_t(r) \tag{6}$$

[12] See also Blanchard and Galì (2010) for a similar argument in the context of a labor search model. Arseneau and Chugh (2007) exploit this insight and analyse the implications of different pricing schemes on the price dynamics in a model with consumer search.

which implies:

$$p_{Wt}(j,r) = \eta \{mc_t(j) - \Omega_{Wt}(j,r)\} + (1-\eta)\left\{p_t\left(1 - \frac{\omega_t(j,r)}{q_t(j,r)}\right) + \Omega_{Rt}(j,r)\right\} \qquad (7)$$

where $\Omega_{Wt}(j,r) = \frac{\gamma}{2}\frac{(x_{wt}(j))^2}{q_t(j,r)}$ and $\Omega_{Rt}(j,r) = \frac{\gamma}{2}\frac{(x_{Rt}(r))^2}{q_t(j,r)}$ are the savings per unit in the costs of forming a business relationship for wholesalers and retailers respectively.

The wholesale price depends not only on the costs of producers, but also on the valuation of retailers. The bargained price is a weighted average between two terms. The first, $mc_t(j) - \Omega_{Wt}(j,r)$, represents the minimum amount that wholesalers are willing to accept, which depends on marginal costs and on the savings in the cost of forming another business relationship. The second term, $p_t\left(1 - \frac{\omega_t(j,r)}{q_t(j,r)}\right) + \Omega_{Rt}(j,r)$, represents the maximum price that retailers can accept, which is the sum of the marginal revenue obtained in the retail market and the savings in the costs of establishing another B2B relationship for retailers. The weights on the two terms depend on the bargaining power of the two parties. If wholesalers have no bargaining power ($\eta = 1$), retailers get the entire surplus from a business relationship and $p_{Wt}(j,r)$ is strictly related to marginal costs. Vice versa if wholesalers have all bargaining power ($\eta = 0$), they get all the surplus from a relationship and $p_{Wt}(j,r)$ follows closely the evolution of retail prices.

The optimal sharing rule (6) also implies:

$$\eta \frac{\gamma}{k_t^a} x_{wt}(j) = (1-\eta)\frac{\gamma}{k_t^R} x_{Rt}(r)$$

Aggregating across all firms, this gives, in terms of log deviations:

$$\hat{a}_t = \hat{d}_t \text{ and } \hat{\theta}_t = 0$$

The assumption of complete symmetry between the search problem of wholesalers and retailers thus implies a one to one relationship between changes in search effort by retailers $\left(\hat{d}_t\right)$ and wholesalers ($\hat{a}_t$). As a consequence, the product market tightness $\hat{\theta}_t$ is invariant to marginal cost shocks.[13]

While the bargained price is set in a way to split the surplus between the two parties in proportion to their bargaining power, wholesalers and retailers choose $q_t(j,r)$ in a way to maximize the total surplus from a long term relationship. Specifically, the solution of the maximization problem with respect to quantities gives:

$$p_t \psi (q_t(j,r) - \bar{q}) = p_t - mc_t(j) \qquad (8)$$

which states that the marginal benefit of an additional unit sold in the retail market, which is given by the total profit margin $p_t - mc_t(j)$, needs to be equal to the marginal cost of

[13]The bargaining power shock that we study in Section 5 will break this tight link.

increasing the quantity per match $q_t(j,r)$ above $\bar{q}$, which is an increasing function of the adjustment cost parameter ψ.

To get further intuition, we can rewrite (8) as:

$$q_t(j,r) = \bar{q} + \frac{1}{\psi}\left(\frac{\mu_t^{tot}(j,r) - 1}{\mu_t^{tot}(j,r)}\right) \tag{9}$$

where $\mu_t^{tot}(j,r) = \frac{p_t}{mc_t(j)}$ is the total gross mark-up of retail prices over marginal costs. The volume of trade per match is an increasing function of the total profit margin of retailers and wholesalers. As long as $\mu_t^{tot}(j,r) > 1$, the bargained $q_t(j,r)$ is set *above* $\bar{q}$ because retailers and wholesalers agree on a production strategy that exploits the market power related to the presence of search frictions. More importantly, notice that, since wholesalers and retailers decide together $q_t(j,r)$ in order to maximize the total surplus of a match, the units traded in each match depend directly on the final retail price but are set independently from the wholesale price. This rises the important question of whether wholesale prices play a role in the allocation of resources in the economy; a question to which we will return later.

3.5 Aggregations

Industry level relations are found by aggregating across all retailers r and wholesalers j under the assumption of complete symmetry across firms. For instance, the aggregate consumption of the final good of industry i is:

$$c_t = \left[\int_0^1 c_t(r)\,dr\right] = A(p_t)^{-\phi} = y_t = \left[\int_0^1 y_t(r)\,dr\right]$$

All other equations are identical to the individual firm's case and are therefore not repeated here.

3.6 Search externalities and the constrained efficient allocation

In a decentralized equilibrium, wholesalers and retailers decide their search intensity taking as given k_t^a and k_t^R, the rates at which additional effort leads to a new match. Each firm thus sets its optimal amount of search without internalising the effects on other firms, with the result that the sum of all individual decisions is conducive to an aggregate suboptimal outcome.

The constrained efficient allocation can be found by solving the problem of a benevolent social planner who faces the same technological constraints and search frictions that are present in the decentralized economy. The solution of the social planner's problem leads to the following result, which is further explained in the appendix[14].

[14] To derive the constrained efficient allocation in a partial equilibrium setup, we follow Hosios (1990). See also Matha and Pierrard (2011) for a similar analysis in a general equilibrium setting.

Proposition 1 *The decentralized equilibrium is constrained efficient only if the Hosios condition $\eta = 1 - \xi$ holds.*

Proof. In the Appendix. ■

Proposition 1 requires that each firm's social and private gain from participating in the matching process be equal. When the retailers' bargaining power, η, is larger than the elasticity of the matching function with respect to retailers' search activities, $1 - \xi$, retailers' private gains from participating into the matching process are too large, and retailers overinvest in forming new business relationships, while wholesalers underinvest in it. The opposite happens for $\eta < 1 - \xi$. Only when $\eta = 1 - \xi$ firms internalize the congestions that they create in the product market in a way that leads to an efficient matching process.

3.7 The mark - up in the long run

The presence of search frictions makes the mark-up endogenous and time varying. If we define the gross mark-up of the retail price over marginal production costs as $\mu_t^{tot} = \frac{p_t}{mc_t}$, its long run level is an increasing function of the search costs of retailers and wholesalers

$$\mu^{tot} = \frac{q}{(q-\omega)} + \frac{\gamma}{mc\,(q-\omega)} \left\{ \tilde{b}\left(\frac{x_w}{k^a} + \frac{x_R}{k^R}\right) - \left(\frac{x_w^2}{2} + \frac{x_R^2}{2}\right) \right\}$$

where $\tilde{b} = \frac{\{1-(1-\delta)\beta\}}{\beta(1-\delta)}$ and, for reasonable calibrations, $\left\{ \tilde{b}\left(\frac{x_w}{k^a} + \frac{x_R}{k^R}\right) - \left(\frac{x_w^2}{2} + \frac{x_R^2}{2}\right) \right\} > 0$. Notice that, because of product market imperfections, wholesalers and retailers enjoy a mark-up even though final goods are perfect substitutes. As we show in the following section, this mark-up is decreasing in the steady state value of q while it is concave in the bargaining power of retailers η.

The gross surplus from an existing relationship is split between retailers and wholesalers according to their relative bargaining power. Wholesalers get:

$$\mu^W = \frac{p_W}{mc} = \eta \left\{ 1 - \frac{\gamma x_w^2}{2mcq} \right\} + (1-\eta) \left\{ \frac{p}{mc}\frac{(q-\omega)}{q} + \frac{\gamma x_R^2}{2mcq} \right\}$$

which is increasing in the bargaining power of wholesalers $(1-\eta)$, while retailers get

$$\mu^R = \frac{p}{p_W} = \frac{\mu^{tot}}{\mu^W}$$

which is increasing in η.

3.8 Calibration and steady state

The model is calibrated at the monthly frequency. The discount rate β is 0.996. The elasticity of substitution across industries is set to the standard value $\phi = 6$, as in Ravn et al. (2010). The parameter determining the adjustment costs along the intensive margin is set to $\psi = 1$.

The elasticity of the matching function to the marketing effort by wholesalers, ξ, and the bargaining power of retailers, η, are set to 0.5, which imply complete symmetry between wholesalers and retailers. We choose the efficiency of the matching technology $\tilde{m}$ so that the monthly rate at which search effort leads to new business relationships is $k^R = 0.2$. This rate corresponds, approximately, to a quarterly rate of 0.5, the value used by Matha and Pierrard (2011). The separation rate δ is 0.10, which implies a quarterly rate slightly higher than the value $\delta = 0.25$ used by Matha and Pierrard (2011). The search effort parameter γ is chosen such that, under the baseline calibration, the total mark-up on the final good is 1.10. This gives a value $\gamma = 0.3457$.

Two crucial parameters in the determination of the steady state are ψ, which captures the curvature of the demand of retailers for the variety produced by each wholesaler, and η, which represents the bargaining power of retailers. Table 1 shows how the steady state changes for different values of these parameters.[15]

Consider first the impact of the adjustment costs along the intensive margin. For $\psi = 100000$ the intensive margin is closed, $q = \bar{q} = 1$ and the total markup of retail prices over marginal costs is 10.5 percent. Lowering ψ to 1 the model displays both an intensive and an extensive margin of adjustment. Firms optimally trade-off the costs of increasing production along the extensive margin (paying the search and matching cost) with the costs of increasing production along the intensive margin. The steady state stock of business relationships decreases while the quantity sold per match increases to $q = 1.091 > \bar{q}$. The higher q depresses prices and markups, which are now (slightly) smaller. If we set the adjustment costs ψ close to zero ($\psi = 0.00001$) firms lose any incentive to engage in B2B relationships, as they find it optimal to have very few matches and satisfy changes in demand with changes in q_t. The steady-state stock of B2B relationships goes down to $T = 0.007$ while the quantity per match goes to $q = 144.50$. The increase in q depresses prices and reduces markups, which are now close to zero. This demonstrates the need to have some frictions along the intensive margin in order to explain why firms spend resources in building business relationships.

Consider now the role of the bargaining power of retailers, η. In the baseline calibration, wholesalers and retailers have the same bargaining power ($\eta = 0.5$), the number of B2B relationships is relatively high, and the total mark-up on a final product is around 10 percent. Intuitively, since in the market there are many buyers and many sellers searching for new customers ($\theta = \frac{a}{d} = 1$), the product market is fluid and this facilitates the formation of new matches. Technically, the fact that we impose the retailers' bargaining power to be equal to the elasticity of retailers' search intensity in the matching function, i.e. $\eta = 1 - \xi$, implies that the search externalities are internalized and that the matching process is Pareto efficient. As soon as we move η away from $1 - \xi = 0.5$, the stock of business relationships decreases while the quantity exchanged per match and the total mark-up μ^{tot} increase. This higher

[15] To perform the steady state analysis, we set $\gamma = 0.3457$ as in the baseline calibration, and let the number of B2B relationships, the units sold per match and the wholesale and retail prices adjust endogenously to changes in ψ and η.

mark-up reflects the inefficiencies in the matching process. When wholesalers have most of the bargaining power ($\eta = 0.1$), they get most of the surplus from a business relationship and have a strong incentive to invest in advertising and marketing activities. At the same time, the incentive of retailers to spend resources in searching new suppliers is very low. As a consequence, the product market is very 'tight' ($\theta = 3$), the process of matching becomes sclerotic and the steady state number of B2B relationships decreases. Something similar - even though on the opposite side of the market - happens when retailers have most of the bargaining power ($\eta = 0.9$). Interestingly, the assumption of complete symmetry between the search problem of retailers and wholesalers implies that symmetric deviations from $\eta = 0.5$ upwards and downwards have identical effects on the stock of relationships and on the final retail price. The main difference lies in the evolution of the wholesale price: when η is high, wholesale prices are low and most of the profits go to retailers; when η is low, wholesale prices are high and wholesalers get most of the rents.

4 Trading frictions, bargaining and pass-through

The pass-through of marginal cost shocks is complete if a one percent increase in marginal costs leads to a 1 percent increase in prices; otherwise, if prices increase less than marginal costs, the pass-through is said to be incomplete. To determine whether in our model pass-through is incomplete, we characterize the impulse responses of wholesale and retail prices to innovations in the marginal costs of wholesalers. We assume that the marginal cost shock is industry-specific and follows an AR process of order 1

$$\widehat{mc}_t = \lambda \widehat{mc}_{t-1} + \varepsilon_t \tag{10}$$

where variables with hat denote log deviations from steady state, $\lambda \in [0, 1)$ is the serial correlation of marginal costs and ε_t is an i.i.d. shock.[16]

We proceed in two steps. We initially restrict attention to purely transitory cost shocks ($\lambda = 0$), for which it is possible to find simple analytical solutions. We then study the response to persistent cost shocks.

4.1 Transitory cost shocks

When the marginal cost shock is purely transitory ($\lambda = 0$), it is possible to find a simple solution to the model, which is summarized in the following proposition.

[16] Our strategy follows Ravn et al. (2010).

Proposition 2 *If marginal cost shocks $\widehat{mc}_t$ are purely transitory, i.e. $\lambda = 0$, the solution of the model is:*

$$\begin{aligned}
\hat{T}_t &= 0 \\
\hat{q}_t &= -B_q \widehat{mc}_t \\
\hat{y}_t &= \hat{T}_t + \kappa \hat{q}_t = -\kappa B_q \widehat{mc}_t \\
\hat{p}_t &= -\frac{1}{\phi}\hat{y}_t = \frac{\kappa}{\phi} B_q \widehat{mc}_t \\
\hat{p}_{Wt} &= \eta \frac{mc}{p_W}\widehat{mc}_t + (1-\eta)\frac{p(q-\omega)}{p_W q}\hat{p}_t - A_q \hat{q}_t \\
&= \left\{ \eta \frac{mc}{p_W} + (1-\eta)\frac{p(q-\omega)}{p_W q}\frac{\kappa}{\phi}B_q + A_q B_q \right\} \widehat{mc}_t
\end{aligned}$$

where $B_q = \frac{1}{\psi \mu^{tot} q + \frac{\kappa}{\phi}}$ captures the elasticity of $\hat{q}_t$ to changes in the total profit margin, $\kappa = \frac{q}{q-\omega}(1-\psi(q-\bar{q}))$ captures the increase in retailers' production related to an increase in $\hat{q}_t$, and $A_q = \left\{(1-\kappa)(1-\eta)\frac{p(q-\omega)}{p_W q} + (1-\eta)\frac{\Omega_R}{p_W} - \eta \frac{\Omega_W}{p_W}\right\} \in [0,1)$ represents the elasticity of the wholesale price to changes in $\hat{q}_t$.[17]

Proof. In the Appendix. ■

The key to understand the previous proposition is to notice that when the shock is expected to disappear in the future, firms do not have incentives to adjust along the extensive margin and the problem becomes static (i.e. $\hat{x}_{wt} = \hat{x}_{Rt} = \hat{T}_t = 0$). In this case, the response of retail quantities and prices depends on the adjustment costs along the intensive margin. The lower is the adjustment cost ψ, the easier it is for retailers to adjust their production and distribution structure, the larger is the elasticity of $\hat{q}_t$ to changes in $\widehat{mc}_t$. In turn, a strong reduction in the production of retail goods increases retail prices with an elasticity that depends on ϕ, the elasticity of the demand for the good produced in the industry. Ceteris paribus, the lower is ϕ, the higher the pass-through to retail prices. The pass-through to retail prices is complete only if the adjustment along the intensive margin is completely frictionless, i.e. if $\psi \to 0$, otherwise it is incomplete.

Wholesale prices are affected by three channels. First, there is the direct 'marginal cost channel', captured by $\eta \frac{mc}{p_W}$ in the proposition above. This term captures the direct influence of the marginal costs of wholesalers on the bargained price and increases with the bargaining power of retailers. The second channel is related to the retailers' reservation price and is captured by $(1-\eta)\frac{p(q-\omega)}{p_W q}\frac{\kappa}{\phi}B_q$. This term is larger, the more retail prices react to cost shocks or the higher is the bargaining power of wholesalers. The final term captures the 'bargained quantity effect' and is represented by $A_q B_q$. This term is related to the fact that wholesalers are willing to offer to retailers a lower price if retailers accept to buy more units of the intermediate good. An increase in marginal costs provokes a reduction in $\hat{q}_t$, which

[17] B_q is decreasing in ψ and increasing in ϕ and $B_q \to 0$ if $\psi \to \infty$. A_q is decreasing in ψ and η and converges to 0 for $\psi \to \infty$ and for $\eta \to 1$. κ is decreasing in ψ and $\kappa \to 1$ for $\psi \to 0$.

leads, through the 'bargained quantity effect', to an increase in the wholesale price $\hat{p}_{Wt}$. This effect is stronger the lower are ψ and η. The combined effect of these three channels implies that the pass-through to wholesale prices is complete when two conditions are met: (1) when the adjustment costs go to zero, $\psi \to 0$ or (2) when retailers have all the bargaining power, $\eta \to 1$.

Importantly, wholesale prices in this case play only a *distributive* but not an *allocative* role. Notice in fact that the dynamics of the prices and quantities of the retail goods ($\hat{p}_t = -\frac{\kappa}{\phi}\hat{q}_t$ and $\hat{y}_t = \kappa\hat{q}_t$) do not depend on the evolution of wholesale prices, which only play the role of distributing the rents among wholesalers and retailers.

Corollary *When $\lambda = 0$, we have:*

(i) the pass-through to retail prices converges to 1 for $\psi \to 0$.

(ii) the pass-through to wholesale prices converges to 1 when one of the following conditions is met: 1) $\psi \to 0$; 2) $\eta \to 1$.

(iii) wholesale prices play only a distributive role, not an allocative one.

An interesting special case refers to the situation in which adjustment costs are prohibitively large and intermediate trade can only take place along the extensive margin, i.e. for $\psi \to \infty$. In this case, following a purely transitory cost shock the model implies *zero* pass-through to retail prices and a pass-through to wholesale prices that is proportional to the bargaining power of retailers η:

$$\begin{aligned} \hat{p}_t &= 0 \\ \hat{p}_{Wt} &= \eta \frac{mc}{p_W} \widehat{mc}_t \end{aligned}$$

The zero pass-through result stems directly from the presence of search frictions. When firms can only increase production by forming new business relationships, output becomes a state variable, that can change only with one month delay. Since through the demand function there is a one to one relationship between consumption and prices, the presence of matching frictions prevents consumption and retail prices to move on impact. At the same time, if the marginal cost shock is completely transitory, firms have no incentive to create/destroy B2B relationships by changing the search effort level, and they absorb the shock completely through mark-up movements. The wholesale price shares the burden of the markup adjustment between wholesalers and retailers according to their relative bargaining power. Hence, in an environment where firms are hit by idiosyncratic cost shocks, our model can yield complete price rigidity and time-varying markups.

4.2 Persistent cost shocks

In the previous section we saw that following a transitory shock, firms are reluctant to engage in costly search activity and prefer to absorb the shock through mark-up adjustments.

However, when the cost shock is expected to persist over time, the results change considerably.

Table 2 displays the response of marginal costs, prices and mark-ups to a mildly persistent marginal cost shock ($\lambda = 0.5^{\frac{1}{3}}$) under our baseline calibration[18]. To help the comparison with existing models, we also include in Table 2 the results obtained in a standard Dixit-Stiglitz model and in the "pricing to habit" model proposed by Ravn, Schmitt-Grohe and Uribe (2010, denoted as R-SG-U in the Table).[19]

In the Dixit-Stiglitz monopolistic competition model, prices move one for one with marginal costs and markups are unaffected by the disturbance: cost pass-through is complete.

In the "pricing to habit" model, firms increase retail prices but proportionally less than the increase in marginal costs. The pass-through is incomplete, but still very high, especially on impact. Incomplete pass-through in Ravn et al. (2010) is the consequence of an intertemporal tradeoff: increasing current prices prevents a strong decline of current profit margins but, at the same time, it leads to a decline in current sales and to a reduction in the stock of habitual demand, which weakens the strength of future demand.

Pricing dynamics in the B2B model with long-term relationships are quite different. In the period of impact, firms reduce both the units sold per match and their advertising and marketing activities (captured in Table 2 by a_t). Retail prices increase due to the reduction of the units sold per match, while the pass-through to wholesale prices is almost proportional to the bargaining power of retailers. Starting from the second period, the disinvestment in long term relationships provokes a persistent reduction in the stock of B2B and in the total production of the industry, which induce a persistent reaction of wholesale and retail prices. The pass-through to retail and wholesale prices, however, remains quite low, and most of the cost shock is absorbed through mark up movements.

Notice that the low degree of pass-through to retail prices stands in stark contrast with both the Dixit-Stiglitz model, where the pass-through is complete, and the "pricing to habit" model by Ravn et al. (2010), where the pass-through is almost complete. Such a low pass-through is not far from empirical estimates. For example Hellerstein (2008) find that, in the beer industry, firms pass-through an average of 11 percent of a foreign-cost shock to their retail prices. Nakamura and Zerom (2010) find that, in the coffee industry, the pass-through of a persistent cost shock to retail prices is around 10 percent in the first quarter and around 25 percent after six quarters.

4.3 Factors behind low pass-through

What explains such a low pass-through in the business to business model? To answer this question, we analyze the dynamics of the model following a persistent marginal cost disturbance. We focus the analysis on three factors, which are essential to explain the degree of

[18] The persistence parameter λ is chosen such that our results are comparable to the ones obtained by Ravn et al. (2010).

[19] All variables are measured in percent deviations from their respective steady-state values. The values for the "pricing to habit" model are taken by Ravn et al. (2010).

pass-through to retail and wholesale prices: (1) the relative bargaining power of retailers in the negotiations, (2) the elasticity of the demand of retailers for wholesale goods along the intensive margin and (3) the persistence of the cost shock itself.

4.3.1 The role of the persistence of the shock

Figure 1 shows the impact of marginal cost shocks for different values of the persistence parameter λ. The degree of pass-through and - especially - the persistence of the price increase are strongly increasing in the persistence of the cost shock. The more persistent the shock is, the larger the incentive for firms to react by reducing the advertising and marketing effort. If the shock is transitory, firms are reluctant to reduce their advertising and marketing effort, as they expect costs to go back quickly to their normal level. The response of prices and consumption is, in this case, very short-lived. If the shock is persistent, firms do not mind losing business relationships, because cost conditions are expected not to be favorable for many periods. This causes a strong decline in B2B relationships and consumption, and induces a strong and persistent increase in retail and wholesale prices.

For the same reason, the persistence of the shock determines crucially whether firms are willing to absorb the disturbance through the intensive or the extensive margin. When the shock is temporary, most of the adjustment goes through the intensive margin. The higher the persistence of the shock, the more the adjustment goes through the extensive margin.[20]

4.3.2 The role of adjustment costs on the intensive margin

Figure 2 shows the effect of production adjustment costs on the dynamics of the model following a persistent marginal cost shock. Consistent with the findings of Nakamura and Zerom (2010) that cost shocks in the coffee industry are highly persistent, we set $\lambda = 0.95$.[21]

We present three cases. For $\psi = 100000$, firms are allowed to adjust production only along the extensive margin. For $\psi = 0.1$, retailers can adjust production easily along the intensive margin. $\psi = 1$ presents a situation in which firms use both margins to adjust production.

The degree of pass-through to wholesale and retail prices is profoundly affected by the curvature of retailers' demand on the intensive margin, as captured by ψ. Pass-through to wholesale and retail prices is low - and delayed - for medium to high level of adjustment costs ($\psi = 1$ or $\psi = 100000$) while it increases considerably when adjusting the quantity traded per match is relatively cheap. The introduction of an intensive margin allows firms to adjust production much faster to marginal cost shocks and thus increases the responsiveness of retail prices (and consequently of wholesale prices) to cost disturbances. Notice however that, for

[20] This is consistent with the empirical evidence of Ruhl (2008), who finds that the extensive margin of trade responds to permanent but not to transitory shocks.

[21] Nakamura and Zerom (2010) find that, in the coffee industry, a Dickey-Fuller test for the hypothesis of a unit root cannot be rejected at the 5% level. For simplicity, we focus here on very persistent, but stationary, cost processes.

reasonable calibrations, introducing an intensive margin is not enough to generate complete pass-through: pass-through to retail prices remains below 0.6 even when $\psi = 0.1$.[22]

4.3.3 The role of bargaining power

To understand the effects of bargaining power on the dynamics of the model, Figure 3 draws the cost pass-through to wholesale and retail prices for different values of η. In the first graph of Figure 3 the pass-through is computed as the *impact* response of prices to a one percent change in marginal costs. In the second, the pass-through is computed as the response of prices to a marginal cost shock *after one year*.

The bargaining power of retailers affects differently the pass-through to wholesale and retail prices. The pass-through to wholesale prices is increasing in η, both on impact and after one year. The pass-through to retail prices, instead, is non-monotonic in η: it is maximum when the Hosios condition is met, and decreases symmetrically as we move away from $\eta = 1 - \xi$.

At first sight, the idea that the reaction of wholesale prices to shocks to the marginal cost of wholesalers *increases* with the bargaining power of retailers may seem counterintuitive. One may have expected in fact that retailers would force wholesalers to absorb the shock without changing the bargained price p_{Wt}. To shed some light on this result, consider the evolution of the bargained wholesale price:

$$\hat{p}_{Wt} = \eta \left\{ \frac{mc}{p_W} \widehat{mc}_t - \frac{\Omega_W}{p_W} \hat{\Omega}_{Wt} \right\} + (1-\eta) \left\{ \frac{p}{p_W q} (q - \omega) \{ \hat{p}_t - (1-\kappa) \hat{q}_t \} + \frac{\Omega_R}{p_W} \hat{\Omega}_{Rt} \right\}$$

The wholesale price depends on the reservation price of wholesalers and the reservation price of retailers. When wholesalers have most of the bargaining power, i.e. for $\eta \to 0$, they get most of the surplus from a business relationship and the wholesale price becomes strictly related to the retailers' valuation of the wholesale good. At the limit, marginal cost shocks do not affect, at least directly, wholesale prices. When retailers have most of the bargaining power, i.e. for large values of η, the wholesale price becomes strictly related to the marginal cost of production of the wholesale good, $\frac{mc}{p_W} \widehat{mc}_t$. The reaction of wholesale prices to marginal cost shocks is in this case much stronger. At the limit, for $\eta \to 1$ we have $\frac{mc}{p_W} = 1$ and the pass-through to wholesale prices is complete.

The pass-through to retail prices depends instead on how easy it is to adjust production along the intensive and extensive margins:

$$\hat{p}_t = -\frac{1}{\phi} \left(\hat{T}_t + \kappa \hat{q}_t \right)$$

The bargaining power η affects $\hat{p}_t$ only through its effects on the efficiency of the matching

[22] In our model there are two ways to achieve complete pass-through to both retail and wholesale prices. The first way is to eliminate the curvature on q, i.e. let $\psi \to 0$. The second way is to eliminate search frictions, i.e. let $\gamma \to 0$.

process and thus on $\hat{T}_t$. The inverted-u shape is explained by the presence of search externalities.[23] When $\eta = 1 - \xi = 0.5$, the search externalities are internalized and the matching process is Pareto efficient. The large variation along the extensive margin is what leads to a larger pass-through to retail prices. When retailers have most of the bargaining power ($\eta = 0.9$), instead, the product market is tight, the process of matching is sclerotic and the variation along the extensive margin is more expensive. Similarly, when wholesalers have most of the bargaining power ($\eta = 0.1$), too many sellers chase too few buyers. Overall, however, the effect of η on the pass-through to retail goods is small compared with its effect on the pass-through to wholesale prices. This raises again questions about the allocative role of wholesale prices in our model.

5 Are wholesale prices allocative?

The previous results point towards an interesting issue: observed wholesale prices may not be allocative, in the sense that they may not affect the final prices faced by consumers nor their consumption decisions. This issue is likely to have important policy implications, given that, as first recognized by Barro (1977), the stabilizing role of monetary policy when prices are sticky crucially depends on prices being allocative.

In our model, the allocative power of wholesale prices depends on the persistence of the price change. When the price change is purely transitory, wholesale prices play only a distributive but not an allocative role. When the price change is expected to last into the future, instead, wholesale prices potentially play an allocative role on top of the distributive role. This happens because the incentives for firms to engage in costly search activities depend on the expected benefits of a B2B relationship, which are in turn influenced by the future expected wholesale price. The questions that remain to be addressed are: how does it work, and how big is this allocative role of wholesale prices?

To answer these questions, we analyse the response of retail prices and final consumption following an exogenous increase in wholesale prices. In the B2B model, this shock has a nice natural interpretation, as it can be interpreted as a shock to the bargaining power of the parties. In fact, the introduction of a bargaining shock $\hat{\eta}_t$ in the model only affects the evolution of the wholesale price, which is now determined as

$$\hat{p}_{Wt} = \eta \left\{ \frac{mc}{p_W} \widehat{mc}_t - \frac{\Omega_W}{p_W} \hat{\Omega}_{Wt} \right\} + (1-\eta) \left\{ \frac{p\,(q-\omega)}{p_W q} \left(\hat{p}_t - (1-\kappa)\, \hat{q}_t \right) + \frac{\Omega_R}{p_W} \hat{\Omega}_{Rt} \right\} - A_\eta \hat{\eta}_t$$

where $A_\eta = \frac{J}{p_W q} \left\{ 1 - \beta\,(1-\delta)\,\lambda_\eta \right\}$.[24] An increase in the bargaining power of wholesalers (i.e. a reduction of $\hat{\eta}_t$) raises $\hat{p}_{Wt}$ and is thus equivalent to an exogenous shock to wholesale

[23] See Figure 4.

[24] Notice that the persistence of the bargaining power shock λ_η reduces, ceteris paribus, the response of wholesale prices to the bargaining power shock. This is a consequence of the repeated nature of the interactions between firms which leads firms to take into account, in the negotiations, the expected continuation value of a match. Retailers, for instance, are willing to accept a higher wholesale price today if they expect to get a

prices.

Figure 5 compares the effects of wholesale price increases in the B-2-B model with the ones obtained in the Dixit-Stiglitz (1977) monopolistic competition model. $\hat{\eta}_t$ is assumed to follow an AR(1) process with persistence $\lambda_\eta = 0.95$. In order to facilitate the comparison of the results, in the B2B model the bargaining shock is scaled such that, independently of the calibration, wholesale prices increase by one percent on impact, as in the Dixit-Stiglitz (1977) model.[25]

In the standard monopolistic competition model, an increase in wholesale prices lead to a proportional increase in retail prices (the pass-through is complete) and to a strong reduction in final consumption $\hat{y}_t$. In the B2B model, instead, the response of retail prices and consumption depends crucially on the initial conditions of the product market, as captured by the initial bargaining power of retailers, η. When wholesalers have most of the bargaining power ($\eta = 0.1$), the increase in wholesale prices leads to a reduction in consumption and an increase in retail prices, as in the Dixit-Stiglitz model. On the contrary, when retailers are the dominant party in the negotiations ($\eta = 0.9$), an increase in wholesale price induces an *increase* in consumption and a *reduction* of retail prices - the opposite than in the Dixit-Stiglitz model. Finally, under complete symmetry ($\eta = 0.5$) wholesale price shocks do not affect neither retail prices nor final consumption, i.e. they do not play any allocative role.

These, perhaps surprising, results are explained by the search externalities in the product market. A persistent increase in wholesale prices raises the expected value of business relationships to wholesalers while reduces the one to retailers. For this reason, wholesalers increase their search intensity while retailers reduce it; but the strength of these responses changes with the initial bargaining power of the parties. When wholesalers have most of the bargaining power ($\eta = 0.1 < 1 - \xi$), the product market is very tight on the side of wholesalers, and the bargaining power shock only worsens the situation, leading to a drop-out of a significant fraction of searching retailers. The formation of new matches is strongly reduced, and is only partially offset by the increase in the units sold per match. Total consumption decreases and the pass-through to retail prices is positive, but delayed. On the contrary, when wholesalers are the weak party in the negotiations ($\eta = 0.9 > 1-\xi$), the wholesale price shock reduces the tightness of the market, and improves the efficiency of the matching process. The number of business relationships increases, leading to an *increase* in consumption and to a *reduction* of retail prices. When the Hosios condition is verified ($\eta = 0.5 = 1 - \xi$), the additional search effort by wholesalers exactly offset the reduction of retailers' search effort, and the stock of business relationships, final consumption and retail prices are unaffected.[26]

high share of the surplus in the future.

[25] To determine the response of prices under monopolistic competition, notice that in the Dixit-Stiglitz (1977) model the pass-through of wholesale price shocks to retail prices is complete, i.e. $\hat{p}_t = \hat{p}_{Wt}$. Consumption is then obtained using the sectorial demand condition $\hat{c}_t = -\phi\hat{p}_t = -\phi\hat{p}_{Wt}$. The evolution of wholesale prices, $\hat{p}_{Wt}$, in the Dixit-Stiglitz model is modeled as an AR(1) process with persistence λ_η. This is identical to the evolution of $\hat{p}_{Wt}$ in the B-2-B model when $\eta = 0.5$.

[26] See also Figure 6.

These results suggest two conclusions regarding the allocative power of wholesale prices. First, persistent wholesale price changes still retain some signalling power also in the presence of long-term contracts and efficient bargaining, but this effect works entirely through the incentives for firms to engage in costly advertising and purchasing activities. For this reason, the effect is considerably delayed and much more persistent than in the standard monopolistic competition model. Second, the effect of wholesale price changes depends on the presence and evolution of search externalities: when $\eta < 1 - \xi$ wholesale price changes lead to an increase in retail prices and a reduction in final consumption, as in the standard monopolistic competition model; when $\eta > 1 - \xi$, instead, an increase in wholesale prices *reduces* retail prices and *increases* final consumption.

6 Conclusion

This paper has developed a simple model of pricing in business relationships based on the presence of dynamic frictions of building long term contracts. The model is based on two assumptions with strong empirical support: First, firms need to spend resources in forming new long term relationships in order to expand trade. Second, firms bargain over the prices and quantities of the intermediate good exchanged. Despite its simplicity, the model has the potential to explain both the low and delayed pass-through of cost shocks to wholesale prices, and the almost complete pass-through of wholesale prices to retail prices. Moreover, the model is a natural laboratory to address questions related to the allocative power of wholesale prices in the presence of long term contracts. Our results suggest that wholesale prices still retain some allocative power into the model, but this effect works through a different channel - the incentive to invest in new long term relationships - and it is likely to be small unless shocks are very persistent, and search externalities are large.

Our analysis can be extended along several dimensions. For instance, it would be interesting to incorporate negotiation costs into the bargaining problem, or allow for infrequent negotiations. This would be coherent with the evidence that most contracts among firms have a duration of 1 year, and would naturally lead to real effects of nominal shocks. Moreover, the model can be easily incorporated in full-fledged general equilibrium models. This would allow us to study how long-term contracts and bargaining between firms affect the dynamics of modern economies. Finally, it would be interesting to extend the model to an open economy setting, by assuming for instance that home wholesalers trade with both home and foreign retailers. It is straightforward to show that the presence of trade frictions and bargaining set the stage for pricing to market and can explain wide and persistent deviations from the law of one prices, both in the long run and in the short run.[27]

[27] Results are available on request. See also Drozd and Nosal (2010).

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Steady State Analysis								
	T	q	θ	p	p_W	μ^R	μ^W	μ^{tot}
Adjustment costs								
$\psi = 100000$	0.551	1.000	1.000	1.105	1.052	1.050	1.052	1.105
$\psi = 1$	0.519	1.091	1.000	1.100	1.048	1.050	1.048	1.100
$\psi = 0.00001$	0.007	144.50	1.000	1.001	1.000	1.001	1.000	1.001
Bargaining power								
$\eta = 0.1$	0.358	1.140	3.000	1.163	1.138	1.022	1.138	1.163
$\eta = 0.5$	0.519	1.091	1.000	1.100	1.048	1.050	1.048	1.100
$\eta = 0.9$	0.358	1.140	0.333	1.163	1.015	1.145	1.015	1.163

Table 1: Adjustment costs, bargaining power and the steady state

Month	mc_t	Dixit -Stiglitz		R-SG-U (2010)		B2B Model						
		p_t	μ_t	p_t	μ_t	p_{Wt}	μ_{Wt}	p_t	μ_{Rt}	q_t	T_t	a_t
0	1	1	0	0.99	-0.01	0.57	-0.43	0.11	-0.46	-0.74	0	-1.27
3	0.5	0.5	0	0.36	-0.14	0.30	-0.20	0.10	-0.21	-0.34	-0.28	-0.67
6	0.25	0.25	0	0.13	-0.12	0.17	-0.08	0.08	-0.09	-0.14	-0.35	-0.36
9	0.125	0.125	0	0.05	-0.08	0.10	-0.03	0.06	-0.03	-0.05	-0.33	-0.19

Table 2: Persistent marginal cost shock and pass-through

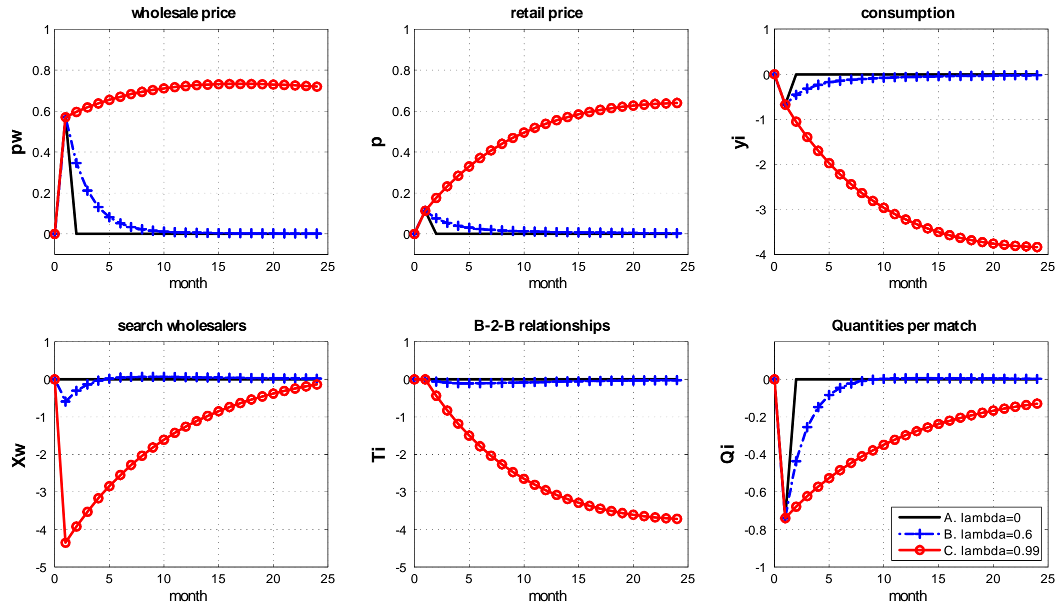

Figure 1: Persistence and pass-through

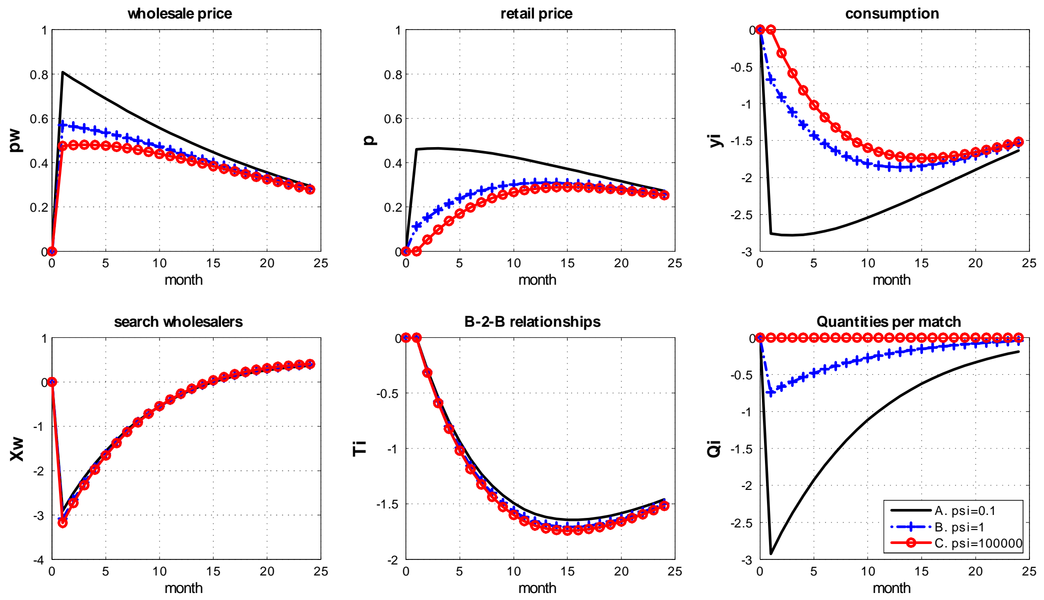

Figure 2: Intensive margin and pass-through

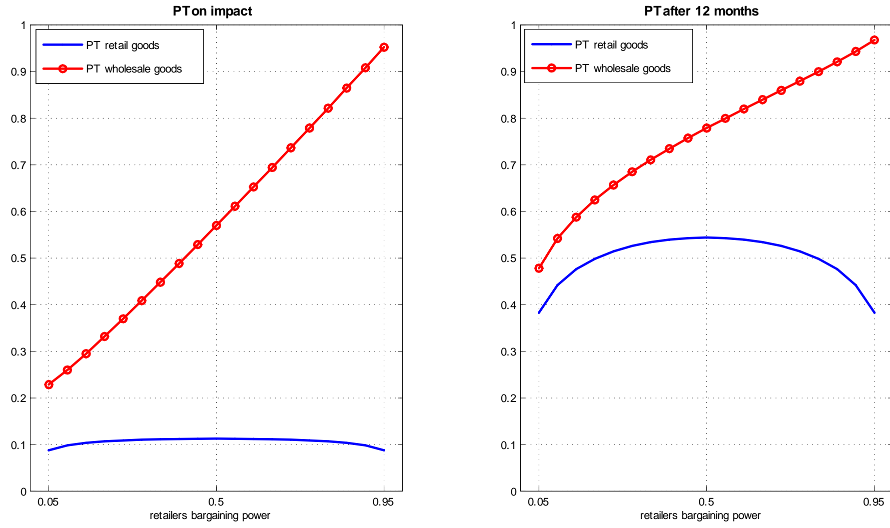

Figure 3: Bargaining power and pass-through

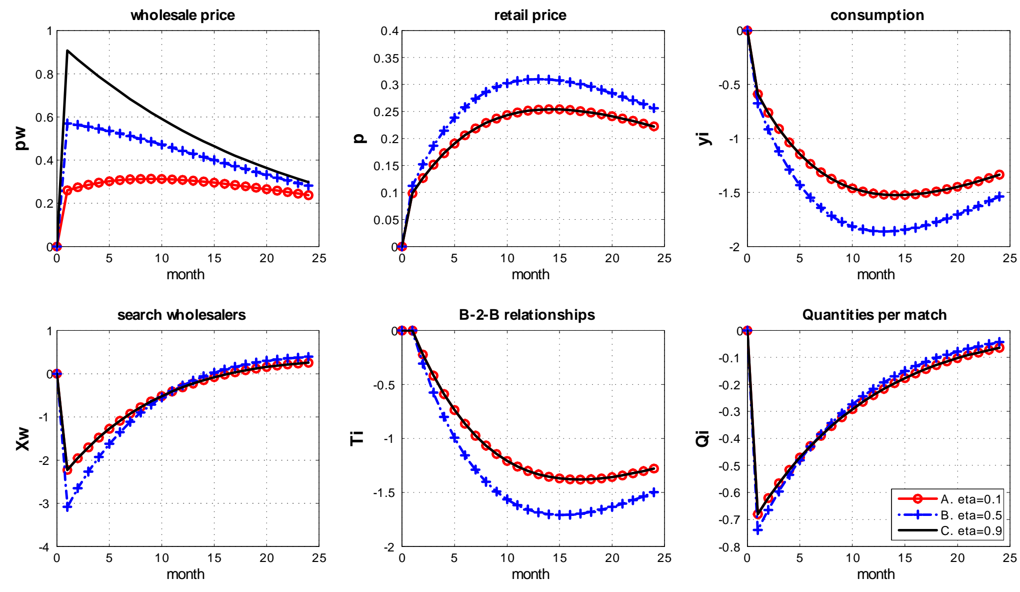

Figure 4: Bargaining power and the response to a persistent marginal cost shock

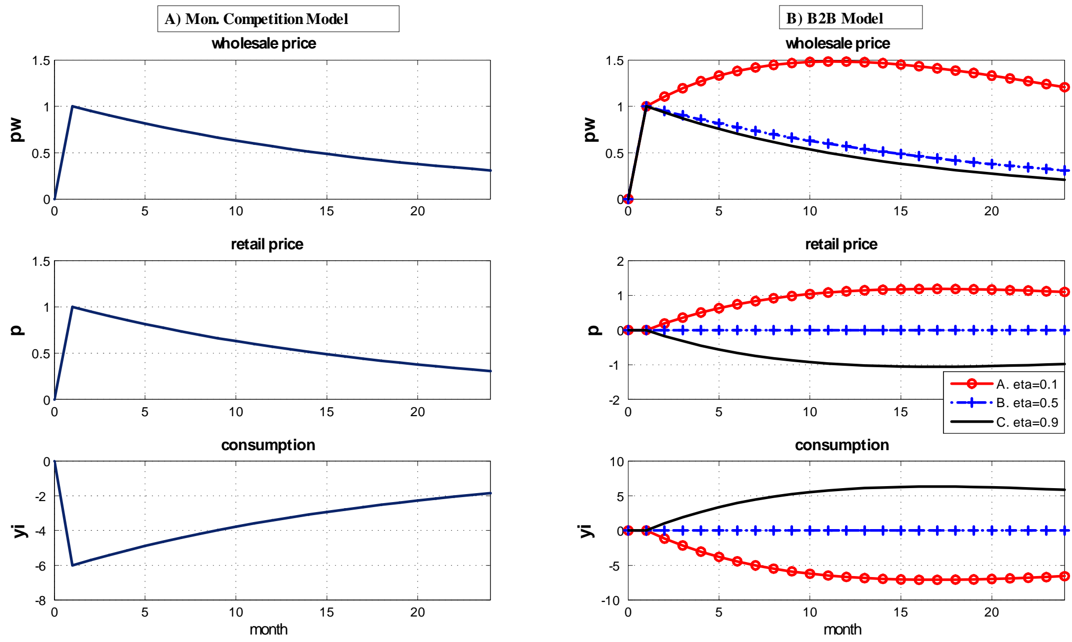

Figure 5: Allocative power of wholesale prices: monopolistic competition model vs. B-2-B model

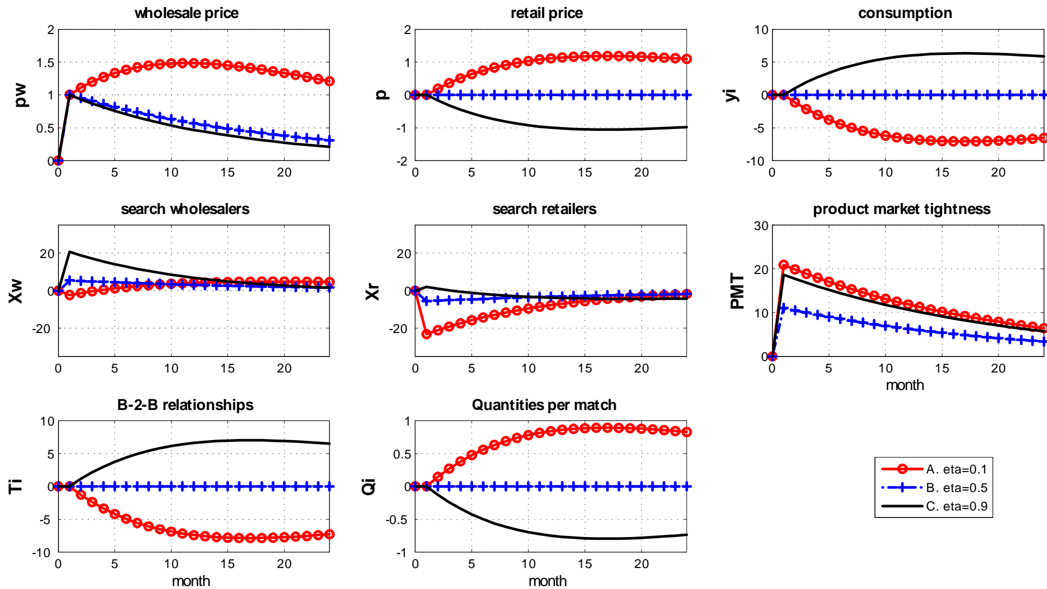

Figure 6: Response to a persistent wholesale price shock in the B-2-B model

Appendix

A. Constrained Efficient Allocation

To derive the constrained efficient allocation in a partial equilibrium setup, we follow Hosios (1990). We define the constrained efficient allocation as the optimal allocation a social planner may achieve as a market equilibrium[28]. This allocation can be found by solving the problem of a benevolent social planner who faces the same technological constraints and search frictions that are present in the decentralized economy. The implicit assumption is thus that the social planner is not able to circumvent the search frictions required to form a match; he can however internalize the effect of variations in product market tightness on search costs and on the resource constraint.

Proposition 1 *The decentralized equilibrium is constrained efficient only if $\eta = 1-\xi$ (Hosios condition).*

Proof. The social planner chooses $\{y_t, q_t, T_t, a_t, d_t\}$ to maximize

$$\max_{\{y_t,q_t,T_t,a_t,d_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ p_t y_t - mc_t q_t T_t - \frac{\gamma}{2}\left(\frac{d_t}{T_t}\right)^2 T_t - \frac{\gamma}{2}\left(\frac{a_t}{T_t}\right)^2 T_t \right\} \tag{11}$$

subject to the technological constraints on the extensive (matching frictions) and intensive margin (adjustment costs):

$$\begin{aligned} T_t &= (1-\delta)\left(T_{t-1} + \tilde{m} a_{t-1}^{\xi} d_{t-1}^{1-\xi}\right) \\ y_t &= \left(q_t - \frac{\psi (q_t - \bar{q})^2}{2}\right) T_t \end{aligned}$$

Notice that in (11) we have used the fact that, given symmetry in preferences and technology, efficiency requires that identical quantities of each good be produced by each wholesaler and retailer. The social planner problem gives the following first order conditions:

$$p_t \psi (q_t - \bar{q}) = p_t - mc_t \tag{12}$$

$$\tau_t = p_t \left(q_t - \frac{\psi (q_t - \bar{q})^2}{2}\right) - mc_t q_t + \frac{\gamma}{2} x_{Rt}^2 + \frac{\gamma}{2} x_{wt}^2 + \beta (1-\delta) \tau_{t+1} \tag{13}$$

$$\frac{\gamma x_{Wt}}{\tilde{m} \theta_t^{-(1-\xi)}} = \xi \beta ((1-\delta)) \tau_{t+1} \tag{14}$$

$$\frac{\gamma x_{Rt}}{\tilde{m} \theta_t^{\xi}} = (1-\xi) \beta (1-\delta) \tau_{t+1} \tag{15}$$

where τ_t captures the social value of a match. We can now compare it with the first order

[28] See also Mas-Colell, Whinston and Green (1995).

conditions of the decentralized solution, which can be rewritten as:

$$p_t\psi\left(q_t-\bar{q}\right) = p_t - mc_t \tag{16}$$

$$\tau_t = p_t\left(q_t-\frac{\psi\left(q_t-\bar{q}\right)^2}{2}\right) - mc_t q_t + \frac{\gamma}{2}x_{wt}^2 + \frac{\gamma}{2}x_{Rt}^2 + (1-\delta)\beta\tau_{t+1} \tag{17}$$

$$\frac{\gamma x_{Wt}}{\tilde{m}\theta_t^{-(1-\xi)}} = \beta(1-\delta)W_{t+1} = (1-\eta)\beta(1-\delta)\tau_{t+1} \tag{18}$$

$$\frac{\gamma x_{Rt}}{\tilde{m}\theta_t^{\xi}} = \beta(1-\delta)J_{t+1} = \eta\beta(1-\delta)\tau_{t+1} \tag{19}$$

where $\tau_t = W_t + J_t$. Comparing (12) – (15) with (16) – (19), it is easy to show that the condition $1-\eta=\xi$ is necessary and sufficient for the equivalence of the constrained efficient and the decentralized solution. ■

B. The benchmark model in log deviations

The model is solved log-linearizing around the steady state. The resulting system of equation can be reduced to the following:

- Wholesale prices

$$\begin{aligned}\hat{p}_{Wt} &= \eta\left\{\frac{mc}{p_W}\widehat{mc}_t - \frac{\gamma x_{wt}^2}{p_W q}\hat{x}_{Wt}\right\} \\ &\quad + (1-\eta)\left\{\frac{p(q-\omega)}{p_W q}\hat{p}_t + \frac{\gamma x_R^2}{p_W q}\hat{x}_{Rt}\right\} - A_q\hat{q}_t\end{aligned} \tag{20}$$

  where $A_q = \left\{(1-\kappa)(1-\eta)\frac{p(q-\omega)}{p_W q} + (1-\eta)\frac{\Omega_R}{p_W} - \eta\frac{\Omega_W}{p_W}\right\}$.

- Bargained quantities

$$\hat{q}_t = \frac{1}{\psi}\frac{mc}{pq}\left(\hat{p}_t - \widehat{mc}_t\right) = \frac{1}{\psi}\frac{mc}{pq}\left(\hat{\mu}_t^{tot}\right) \tag{21}$$

- Law of motion business to business relationships:

$$\hat{a}_t - (1-\xi)\hat{\theta}_t = \frac{1}{\delta}\hat{T}_{t+1} - \frac{(1-\delta)}{\delta}\hat{T}_t$$

- Market clearing condition

$$-\phi\hat{p}_t = \hat{T}_t + \kappa\hat{q}_t = \hat{y}_t \tag{22}$$

  where $\kappa = \frac{q}{q-\omega}\left(1-\psi\left(q-\bar{q}\right)\right)$.

- Product market tightness and search intensities

$$\begin{aligned}\hat{\theta}_t &= \hat{a}_t - \hat{d}_t = \hat{k}_t^R - \hat{k}_t^W = \hat{x}_{Wt} - \hat{x}_{Rt} \\ \hat{x}_{Wt} &= \hat{a}_t - \hat{T}_t \\ \hat{x}_{Rt} &= \hat{d}_t - \hat{T}_t\end{aligned}$$

- Wholesalers: search condition

$$\hat{x}_{Wt} - \hat{k}_t^W = \hat{x}_{Wt} + (1-\xi)\,\hat{\theta}_t = E_t \hat{W}_{t+1}$$

- Retailers: search condition

$$\hat{x}_{Rt} - \hat{k}_t^R = \hat{x}_{Rt} - \xi\hat{\theta}_t = E_t \hat{J}_{t+1}$$

- Wholesalers: value of a match

$$W\hat{W}_t = p_W q \hat{p}_{Wt} - mcq\widehat{mc}_t + (p_W - mc)\, q\hat{q}_t + \gamma x_w^2 \hat{x}_{Wt} + (1-\delta)\,\beta W E_t \hat{W}_{t+1}$$

- Retailers: value of a match

$$\begin{aligned} J\hat{J}_t &= -p_W q \hat{p}_{Wt} + p\,(q-\omega)\,\hat{p}_t + \gamma x_R^2 \hat{x}_{Rt} + (1-\delta)\,\beta J E_t \hat{J}_{t+1} \\ &\quad - (p_W q - p\,(q-\omega)\,\kappa)\,\hat{q}_t \end{aligned}$$

C. Proof of Proposition 2

Consider the complete log-linearized model in Appendix B. If the marginal cost shock is purely transitory, i.e. $\lambda = 0$, it is possible to find recursively a relatively simple solution to the model. When the shock is purely transitory, in fact, it does not affect the expected future value of a business relationship and thus wholesalers and retailers do not have incentives to vary their search intensity ($\hat{x}_{wt} = E_t\hat{W}_{t+1} = \hat{x}_{Rt} = E_t\hat{J}_{t+1} = 0$). This in turn implies that the number of B2B relationships is not affected by the shock ($\hat{T}_t = 0$). In other words, a purely transitory shock does not lead to intertemporal substitution and the model becomes static.

From (22) we can write:

$$\hat{p}_t = -\frac{1}{\phi}\left(\hat{T}_t + \kappa\hat{q}_t\right) = -\frac{\kappa}{\phi}\hat{q}_t \tag{23}$$

where $\kappa = \frac{q}{q-\omega}\left(1 - \psi\,(q - \bar{q})\right)$ captures the curvature of the production function of retailers with respect to $\hat{q}_t$. Introduce (23) into (21) to get:

$$\hat{q}_t = \frac{1}{\psi}\frac{mc}{pq}\left(\hat{p}_t - \widehat{mc}_t\right) = -B_q\left(\widehat{mc}_t\right) \tag{24}$$

where $B_q = \frac{\Phi_q}{1+\frac{\kappa}{\phi}\Phi_q}$ captures the elasticity of $\hat{q}_t$ to changes in the total profit margin and $\Phi_q = \frac{1}{\psi\mu^{tot}q}$ is a decreasing function of ψ.

Using this, we get

$$\hat{p}_t = -\frac{\kappa}{\phi}\hat{q}_t = \frac{\kappa}{\phi}B_q\left(\widehat{mc}_t\right) \tag{25}$$

where $\frac{\kappa}{\phi}B_q$ is decreasing in ψ and ϕ.

Finally use (24) and (25) into (20) to get:

$$\hat{p}_{Wt} = \left\{\eta\frac{mc}{p_W} + (1-\eta)\,\frac{p\,(q-\omega)}{p_W q}\frac{\kappa}{\phi}B_q + A_q B_q\right\}\widehat{mc}_t$$

where A_q captures the elasticity of wholesale prices to changes in $\hat{q}_t$, and is decreasing in ψ.