Online Appendix to "On Price Dynamics with Search and Bargaining in the Product Market"

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A Data

To construct an empirical proxy for the search effort of wholesale firms, we use data from the Occupational Employment Statistics (OES) survey of the U.S. Bureau of Labor Statistics (BLS). In particular, we use the following statistics: national data for the employment and hourly wage of the *sales representatives, wholesale and manufacturing*; industry-specific data for the employment and hourly wage of all the occupations in *manufacturing* and *wholesale trade*; national-level employment data for *advertising managers*, *marketing managers* and *sales managers*. All of these are annual data and span the period 2004-2018. Our sample starts in 2004 because this is the first year for which the industry-level data for manufacturing and wholesale trade are available.

The data used for computing the business cycle moments are at quarterly frequency and expressed in 2012 dollars whenever applicable. Data for GDP, personal consumption, fixed investment are chained volume, seasonally adjusted data from the Bureau of Economic Analysis (BEA). Data for nonfarm employment, nonfarm real wages (real compensation per hour) and the producer price index (PPI) are from the BLS database and are seasonally adjusted. The series for real producer prices is the PPI for intermediate demand in the manufacturing sector (i.e., for goods supplied to manufacturing industries) deflated by the consumer price index (CPI). We use the CPI also for the estimation of the real interest rate; the interest rate series is the 3-month T-bill rate from the Federal Reserve Board. Since the seasonally-adjusted PPI is available only from 1978 onwards, the sample period used for computing the business cycle moments goes from 1978Q1 to 2018Q4.

Finally, to measure the persistence and volatility of the productivity shock in the model for this sample period, we use the updated utilization-adjusted total factor productivity (TFP) series of Fernald (2012). The original series is in terms of percentage changes. We first obtain a series in levels; then, as usual, we take logarithms, remove a linear trend and estimate an $AR(1)$ model.

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We adopt the utilization-adjusted series because the residuals of its $AR(1)$ fit are white noise, according to conventional tests.

A.1 Further Analysis of the PPI Data

Figure 1 and, among others, Table 3 show that, over the period 1978Q1-2018Q4, the PPI for intermediate demand in the manufacturing sector has been less volatile than GDP and slightly procyclical. The procyclical behavior displayed after the second half of the 1970s is true also for other PPI series, that span a longer historical period. Figure 1 shows one of such series, the PPI for finished products. The reason underlying the procyclicality is that the acyclical or procyclical behavior displayed by the US PPI from the late 1970s onwards dominates its countercyclical behavior during the early 1970s.

In this appendix, we show additional evidence in support of this conclusion by showing that it does not seem to be affected by the method used to extract the business cycles. Specifically, as an alternative to the Hodrick-Prescott (HP) filter, we have also used the Band Pass (BP) filter to extract the cyclical component of the US PPI. This is defined as the component with periods between 1.5 and 8 years. Figure 7 compares the HP-filtered series of Figure 1 (left diagram) with the BP-filtered ones (right diagram), which have been plotted after eliminating the initial 2 years as well as the final 2 years. We see that the fluctuations of the HP- and BP-filtered series are alike. Moreover, while the contemporaneous correlation of the PPI for intermediate demand in the manufacturing sector with GDP is 0.193 in the case of the HP filter, it is 0.204 in the case of the BP filter. That is, the difference is minimal.

B Proofs

B.1 Proof of Proposition 1

Following Hosios (1990), the constrained efficient allocation is the solution to the problem of a benevolent social planner, who is subject to the same technological constraints and search frictions that firms face in a decentralized equilibrium. The idea is that the social planner cannot circumvent the search frictions, but she can internalize the effect of changes in product market tightness on the costs of search and on the resource constraint.

The problem of the social planner is as follows:

$$v_p(T_t, mc_t) = \max_{q_t, T_{t+1}, a_t, d_t} \left\{ p_t y_t - mc_t q_t T_t - \frac{\gamma}{2} x_{R,t}^2 T_t - \frac{\gamma}{2} x_{\mathcal{W},t}^2 T_t + \beta \mathbb{E}_t v_p(T_{t+1}, mc_{t+1}) \right\} \quad (35)$$

$$\text{s.t. } T_{t+1} = (1-\delta_T)\left(T_t + \tilde{\mathcal{M}} a_t^{\xi} d_t^{1-\xi}\right) \quad (36)$$

$$y_t = \left[q_t - \frac{\psi (q_t - \bar{q})^2}{2} \right] T_t, \quad (37)$$

and given $T_0 > 0$. Equation (35) is based on the fact that, due to symmetry in preferences and technology, efficiency requires that identical quantities of each good be produced by each wholesaler and each retailer. The first order conditions are:

$$
\begin{aligned}
p_t \psi \left(q_t - \bar{q}\right) &= p_t - mc_t && (38)\\
V_t &= p_t \left[q_t - \frac{\psi \left(q_t - \bar{q}\right)^2}{2}\right] - mc_t q_t + \frac{\gamma}{2} x_{R,t}^2 + \frac{\gamma}{2} x_{\mathcal{W},t}^2 + \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1} && (39)\\
\gamma \frac{x_{\mathcal{W},t}}{\tilde{\mathcal{M}} \theta_t^{-(1-\xi)}} &= \xi \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1} && (40)\\
\gamma \frac{x_{R,t}}{\tilde{\mathcal{M}} \theta_t^{\xi}} &= \left(1 - \xi\right) \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1}, && (41)
\end{aligned}
$$

where $V_t \equiv \partial v_p \left(T_t, mc_t\right) / \partial T_t$ is the social value of the marginal match. To compare conditions (38)$-$(41) with those characterizing the decentralized equilibrium, we can combine the decentralized optimality conditions of wholesalers and retailers and write them as follows:

$$
\begin{aligned}
p_t \psi \left(q_t - \bar{q}\right) &= p_t - mc_t && (42)\\
V_t &= p_t \left(q_t - \omega_t\right) - mc_t q_t + \frac{\gamma}{2} x_{\mathcal{W},t}^2 + \frac{\gamma}{2} x_{R,t}^2 + \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1} && (43)\\
\gamma \frac{x_{\mathcal{W},t}}{f^{\mathcal{W}} \left(\theta_t\right)} &= \beta \left(1 - \delta_T\right) \mathbb{E}_t \mathcal{W}_{t+1} = \left(1 - \eta\right) \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1} && (44)\\
\gamma \frac{x_{R,t}}{f^{R} \left(\theta_t\right)} &= \beta \left(1 - \delta_T\right) \mathbb{E}_t J_{t+1} = \eta \beta \left(1 - \delta_T\right) \mathbb{E}_t V_{t+1}, && (45)
\end{aligned}
$$

where $V_t = \mathcal{W}_t + J_t$ and we have used the definitions of the probabilities of matching $f^{\mathcal{W}} \left(\theta_t\right)$ and $f^{R} \left(\theta_t\right)$ and of retailers' production adjustment costs ω_t. It is easy to see that the necessary and sufficient condition for the constrained efficient solution (38) $-$ (41) to be equivalent to the decentralized solution (42) $-$ (45) is $1 - \eta = \xi$. ■

B.2 Proof of Proposition 2

Firms do not invest in search when $\widehat{mc}_t = \epsilon_{mc,t}$ ($\lambda_{mc} = 0$) because new matches have zero expected future value ($\mathbb{E}_t \widehat{\mathcal{W}}_{t+1} = \mathbb{E}_t \hat{J}_{t+1} = 0$). Consequently, $\hat{T}_t = 0$ and the log-linearized market clearing condition (19) gives:

$$\hat{p}_t = -\frac{1}{\phi} \left(\hat{T}_t + \kappa \hat{q}_t\right) = -\frac{\kappa}{\phi} \hat{q}_t, \tag{46}$$

where $\kappa = \frac{q}{q-\omega} \left(1 - \psi \left(q - \bar{q}\right)\right)$ captures the curvature of the production function of retailers with respect to $\hat{q}_t$. Plugging (46) into the log-linearization of (17), we get:

$$\hat{q}_t = \frac{1}{\psi} \frac{mc}{pq} \left(\hat{p}_t - \widehat{mc}_t\right) = -B_q \left(\widehat{mc}_t\right), \tag{47}$$

where $B_q = \frac{mc/(\psi pq)}{1 + \frac{\kappa}{\phi}[mc/(\psi pq)]}$ captures the elasticity of $\hat{q}_t$ to changes in the total profit margin.

Using equation (47) back into (46), we then obtain

$$\hat{p}_t = \frac{\kappa}{\phi} B_q \left(\widehat{mc}_t\right). \tag{48}$$

Therefore, the pass-through of changes in the marginal cost to the retail price is complete for $\psi \to 0$:

$$\lim_{\psi \to 0} \frac{\kappa}{\phi} B_q = 1; \tag{49}$$

note in fact that $\lim_{\psi \to 0} \kappa = 1$ and $\lim_{\psi \to 0} B_q = \phi$. Otherwise, the pass-through is generally incomplete and decreasing in both ϕ and ψ. Moreover, equation (48) is independent of the dynamics of the wholesale price, which therefore plays no allocative role.

Combining (47) and (48) with the log-linearization of (16), we finally get:

$$\hat{p}_{\mathcal{W},t} = \left\{ \eta \frac{mc}{p_{\mathcal{W}}} + (1-\eta) \frac{p(q-\omega)}{p_{\mathcal{W}} q} \frac{\kappa}{\phi} B_q + A_q B_q \right\} \widehat{mc}_t, \tag{50}$$

where $A_q = \left[(1-\kappa)(1-\eta) \frac{p(q-\omega)}{p_{\mathcal{W}} q} + (1-\eta) \frac{\Omega_R}{p_{\mathcal{W}}} - \eta \frac{\Omega_{\mathcal{W}}}{p_{\mathcal{W}}} \right] \in [0,1)$ captures the elasticity of the wholesale price to changes in $\hat{q}_t$. It follows that:

$$\lim_{\eta \to 1} \left\{ \eta \frac{mc}{p_{\mathcal{W}}} + (1-\eta) \frac{p(q-\omega)}{p_{\mathcal{W}} q} \frac{\kappa}{\phi} B_q + A_q B_q \right\} = 1 \tag{51}$$

because, in the steady state, $\lim_{\eta \to 1} p_{\mathcal{W}} = mc$ and $\lim_{\eta \to 1} \Omega_{\mathcal{W}} = 0$. Moreover, we have that:

$$\lim_{\psi \to 0} \left\{ \eta \frac{mc}{p_{\mathcal{W}}} + (1-\eta) \frac{p(q-\omega)}{p_{\mathcal{W}} q} \frac{\kappa}{\phi} B_q + A_q B_q \right\} = 1 \tag{52}$$

because, in the steady state, $\lim_{\psi \to 0} p = mc$ and $\lim_{\psi \to 0} q = \infty$, which in turn implies that $\lim_{\psi \to 0} \Omega_{\mathcal{W}} = 0$ and $\lim_{\psi \to 0} \Omega_R = 0$. In sum, the pass-through to the wholesale price is complete for either $\eta \to 1$ or $\psi \to 0$ or both. ■

C Calibration

C.1 Construction of the Proxy for the Search Intensity

We obtain a proxy for the search effort of wholesale firms using the OES data. Gourio and Rudanko (2014) use these data for a similar purpose; in particular, they need these data to infer key parameters of a B2C matching scheme with directed search. However, due to the heterogeneity of the models, our strategy differs from theirs in many other aspects (information extracted from the OES survey, parameters to infer, etc.). Moreover, the OES data contains information that is specific to the B2B relationships, so we prefer it to other sources of evidence such as the data on advertising expenditures of the Newspaper Association of America and of the U.S. Census Bureau.[1] These data on advertising expenditures capture the costs of posting ads in newspapers, magazines and in the internet. Yet, even though these data measure advertising costs precisely, it does not seem clear how to separate these costs between those pertaining to relationships with businesses and those pertaining to relationships with consumers.

The proxy that we build captures the wholesaler's search effort as a percentage of the overall trade of intermediate goods: $\iota_{\mathcal{W}} \equiv a/(qT)$. To build it, we use the following information: a) the number of managers in charge of marketing and advertising as a ratio of the total number of managers working as advertising, marketing, and sales managers (the "managerial ratio"); b) the monthly wage bill paid to the *sales representatives for wholesalers or manufacturers*; c) the average of the monthly wage bills paid to all the workers in manufacturing and to all the workers in the wholesale sector.[2]

The wage bill of the sales representatives is a proxy for the dollar value of the effort made in selling goods to other firms. In fact, the task of the sales representatives for wholesalers or manufacturers is to sell goods *to businesses or groups of individuals*, which is logically related to what in the model are the sales of intermediate goods by wholesalers engaging in B2B relationships.

However, not all the sales are deals with new customers (Gourio and Rudanko, 2014). That is, dealing with new customers is not the exclusive duty of the sales representatives. We account for this by using the managerial ratio. The intuition for this is that the job of managers is, generally, that of guiding the work by means of business policies. The marketing managers recorded by the OES dataset do so to *identify potential customers* and ensure *customer satisfaction* (as part of the more general analysis of the demand for goods). That is, the marketing and advertising managers ratio can be interpreted as the emphasis given to customer care and the attraction of new customers relative to the policies designed for all the sales-related activities.

If we consider the marketing managers only, the managerial ratio is 34.7 percent on average over all the period for which data are available (2004-2018). Therefore, multiplied by this ratio, the wages of sales representatives selling goods to other businesses translate into a proxy for wholesalers' search effort a. We finally scale this search-effort proxy by the wage bill of all of the workers employed in manufacturing and wholesale sectors. In particular, we take the weighted average of the wage bills in the two sectors, where the weights are based on the relative number of workers in the two sectors.[3] This average is a measure for qT, in terms of income paid to the workers. Note that focusing only on the income paid to the workers guarantees consistency. Although we correct their wages for the importance of marketing and advertising, sales representatives are just one type

[1] See Hall (2014) and Matha and Pierrard (2011) for examples of calibrations based on the advertising data published by the Newspaper Association of America and the U.S. Census Bureau.

[2] Note that our managers and sales representatives data are aggregates of all the sectors. For example, the sales representatives are good-specific workers (i.e., experts at selling wholesale or manufacturing products) that are employed in the various sectors of the U.S. economy: agriculture and related activities, utilities, construction, etc. It is for this reason that our empirical target for the $\iota_{\mathcal{W}}$ ratio amounts to an economywide average.

[3] The justification for this is that the sales representatives sell either of the goods produced in manufacturing and wholesale trade, but the data are silent about the specific percentage of each product in total sales nationwide. Employment-based weights can thus give us a sense of the relative importance of the two sectors.

of occupation of just one input of production (labor). But the range of workers and inputs that firms deploy in marketing and advertising is presumably wider. For example, one can easily think that the sales representatives in our sample use computers and phones that are provided by their employers. However, our statistics do not capture either these types of inputs or others (nor other relevant types of jobs).

Since in the model the search effort of wholesale firms involves advertising as well, we construct an alternative managerial ratio by adding the number of advertising managers to that of marketing managers. The job of the first managers is to create *extra-interest in a good* to sell. With this addition, the median value of our target for $\iota_{\mathcal{W}}$ over the sample period is 9.34 percent; without the correction, the median is instead 8.36 percent. Given that advertising strategies are not entirely devoted to attracting the demand from new customers, we calibrate our model such that $\iota_{\mathcal{W}}$ matches the midpoint between these two percentages: 8.85 percent.

C.2 Partial Equilibrium: Solution of the Steady State

Given the efficiency conditions of the maximization problems of the wholesale firm and the retail firm (equations (6)-(7) and (12)-(13)), the equilibrium of steady state satisfies the following equation:

$$\frac{2(1-\beta)+\beta\delta}{2\beta\delta}\gamma\left[(\iota_{\mathcal{W}})^2+(\iota_R)^2\right]=\mu\frac{q-\omega}{q^2}, \tag{53}$$

where $\iota_R \equiv d/(qT)$ is the counterpart to the wholesaler's ratio $\iota_{\mathcal{W}}$ and μ is the total markup of the industry. Given $\iota_{\mathcal{W}}$, we get ι_R from the optimal sharing rule (equation (15)) coherently with the value chosen for the bargaining power η.[4] The markup μ follows instead from the sum of the search costs-to-output ratios—$(\gamma/2)\,x_{\mathcal{W}}^2T/y$ and $(\gamma/2)\,x_R^2T/y$—implied by the same two first order conditions underlying equation (53). As a result,

$$\mu \equiv p - mc\frac{q}{q-\omega}, \tag{54}$$

which is the profit per unit of industrial output of selling final goods to consumers relative to the costs of producing intermediate inputs.

Therefore, we solve for the steady state numerically using a target for μ and our empirical proxy $\iota_{\mathcal{W}}$. Specifically, we find the marginal cost mc and the search cost parameters γ that satisfy equations (53) – (54) and the bargained quantity per match from equation (17), which is

$$q_t = \bar{q} + \frac{1}{\psi}\left(1-\frac{mc}{p}\right), \tag{55}$$

[4] We obtain $d/(qT)$ from the optimal sharing rule of the Nash bargaining problem and the value assigned to η for two reasons. First, there is a data availability issue. The OES data capture specific aspects of the search effort made by wholesale businesses when trading with other firms or groups of individuals, but it does not contain comparably specific evidence of retailers' purchasing. Second, the interpretation of retailers in our model should not be confined to the retail trade sector; it extends to all the firms that buy intermediate goods from other firms and sell to final consumers, regardless of the sector where they operate.

under the following parametric restrictions: $p = 1$, $\mu = 0.12$ and $\iota_{\mathcal{W}} = 0.0885$. The determination of the matching efficiency $\tilde{\mathcal{M}}$ is then made possible by the rest of the steady state.

C.2.1 Pass-Through on Impact to the Retail Price

Since new B2B relationships affect the list of customers after one month, it follows from equation (20)-(21) that, on impact, the pass-through of changes in the marginal cost to the retail price is

$$\begin{aligned} \hat{p}_t &= \frac{\kappa}{\phi} B_q \widehat{mc}_t \\ &= \Gamma \widehat{mc}_t, \end{aligned} \tag{56}$$

where $\hat{p}_t = \ln(p_t/p)$ (and similarly for the other variables in this appendix) and $\Gamma = \kappa B_q/\phi$ as in equation (27). Since $B_q = \frac{mc/(\psi pq)}{1+\frac{\kappa}{\phi}mc/(\psi pq)}$, we target an impact pass-through $\Gamma = 0.25$ by choosing the parameter ψ, conditional on the elasticity ϕ set as in Ravn et al. (2010) and the numerical solution of the steady state.

C.3 General Equilibrium: Solution of the Steady State

We find the steady state numerically following the same approach described for the partial equilibrium. The only difference is that, in general equilibrium, the marginal cost is endogenous. Therefore, we solve for γ, mc, q and K with an augmented version of the system of equations used for the partial equilibrium. That is, in addition to equations (53) – (55), we employ the optimal capital-labor ratio (from equations (69) – (70)).

D Persistence of Marginal Cost Shocks

As in Kleshchelski and Vincent (2009), Menzio (2007) and Ravn et al. (2010), customer relationships affect prices when cost shocks are persistent. If this is not the case ($\lambda_{mc} = 0$), the extensive margin of trade does not play any role and marginal cost shocks affect prices only along the intensive margin. Proposition 2 summarizes the pass-through to prices for $\lambda_{mc} = 0$.

Here we present the results of a robustness exercise over λ_{mc}, while all the other parameters are as in the benchmark calibration (Table 1). We study how the reaction of the industry to a 1% increase in $\widehat{mc}_t$ is affected by λ_{mc}. We consider the following values for this parameter: 0, 0.75, 0.95, 0.99. Figure 8 shows the results. Take, for instance, the case of a mildly persistent shock ($\lambda_{mc} = 0.75$). On impact, firms agree to trade less within each match (q_t falls) and, at the same time, reduce their search effort. The fall in q_t leads to higher retail and wholesale prices. The pass-through to the wholesale price is larger than that to the retail price because the former does not play an allocative role along the intensive margin and, thus, is the only price that is directly affected by the shock. The effects of the reduction in search show up in the first period after the shock and are persistent over time, causing a prolonged reduction in the stock of B2B relationships and in total output. Thus, the reaction of the two prices is also persistent. But the degrees of pass-through are anyway incomplete for both prices, since the most of the cost shock is absorbed through movements in the markup.

The persistence of the responses of the two prices is larger, the larger λ_{mc} is. The dynamics are very short-lived for $\lambda_{mc} = 0$ and extremely persistent for $\lambda_{mc} = 0.99$. This is because the more persistent the cost shock, the higher the willingness of firms to absorb the shock by reducing their search intensities. Nonetheless, the responses of the two prices suggest that there is no λ_{mc} in our calibration that makes the pass-through of increases in the marginal cost complete.

In conclusion, provided that retailers do not face prohibitive costs of adjusting the quantity per match, the persistence of the shock influences the preference of the firms for adjusting along the intensive margin or along the extensive margin. When cost shocks are short-lived, firms tend to absorb the most of these shocks along the intensive margin. In contrast, in the case of fairly persistent shocks, the importance of adjusting along the extensive margin grows progressively over time. This is consistent with the empirical evidence by Ruhl (2008), who finds that the extensive margin of trade responds to permanent shocks but not to transitory shocks.

E General Equilibrium Models

E.1 An RBC Model with B2B

We introduce our framework with B2B relationships into a general equilibrium model without adding frictions or reasons for differentiation between retail goods. As a result, we obtain an otherwise standard real business cycle (RBC) model augmented with search and matching frictions, bargaining and two margins of intermediate goods trade.

The representative household's utility is given by $U(C_t, N_t) = \ln C_t - \zeta N_t^{1+\nu}/(1+\nu)$, and her objective is to maximize $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$ subject to the following constraints:

$$\frac{1}{P_t}\int_0^1 p_{i,t}c_{i,t}di + I_t = w_t N_t + (r_t + \delta_K)\mathcal{KS}_t - \chi_0 \frac{(u_{K,t})^{\chi_1} - 1}{\chi_1} K_t + \Upsilon_t \quad (57)$$

$$C_t = \left[\int_0^1 c_{i,t}^{(\phi-1)/\phi} di\right]^{\phi/(\phi-1)} \quad (58)$$

$$K_{t+1} = (1-\delta_K) K_t + I_t. \quad (59)$$

The FOCs are:

$$r_t + \delta_K = \chi_0 (u_{K,t})^{\chi_1 - 1} \quad (60)$$

$$1 = \mathbb{E}_t \beta_{t,t+1}\left[1 + r_{t+1}u_{K,t+1} + \delta_K (u_{K,t+1} - 1) - \chi_0 \frac{(u_{K,t+1})^{\chi_1} - 1}{\chi_1}\right] \quad (61)$$

$$w_t = \zeta N_t^{\nu} C_t \quad (62)$$

$$c_{i,t} = (p_{i,t})^{-\phi} C_t, \quad (63)$$

where $\beta_{t,t+1} \equiv \beta C_t / C_{t+1}$.

Wholesale firms rent capital and labor from the household, and each of them faces the following profit maximization problem:

$$
\begin{aligned}
\upsilon_{\mathcal{W}}\left(T_t, Z_t\right) &= \max_{N_t, \mathcal{KS}_t, a_t, T_{t+1}} \left\{\pi_{\mathcal{W},t} + \mathbb{E}_t \beta_{t,t+1} \upsilon_{\mathcal{W}}\left(T_{t+1}, Z_{t+1}\right)\right\} && (64)\\
\text{s.t. } \pi_{\mathcal{W},t} &= p_{\mathcal{W},t} q_t T_t - w_t N_t - \left(r_t + \delta_K\right) \mathcal{KS}_t - \frac{\gamma}{2}\left(x_{\mathcal{W},t}\right)^2 T_t && (65)\\
T_{t+1} &= \left(1-\delta_T\right)\left(T_t + a_t f^{\mathcal{W}}\left(\theta_t\right)\right) && (66)\\
q_t T_t &\leq Y_{\mathcal{W},t} && (67)\\
Y_{\mathcal{W},t} &= Z_t \mathcal{KS}_t^{\alpha} N_t^{1-\alpha}. && (68)
\end{aligned}
$$

All the equilibrium conditions for search and B2B relationships are as in partial equilibrium—with the only difference that they include the stochastic discount factor $\beta_{t,t+1}$ rather than the constant β. As for production, the constraint on sales binds in equilibrium, so the marginal input prices are not equal to the corresponding marginal products. Denoting the multiplier associated with the constraint on sales as τ_t, we formally have:

$$
\begin{aligned}
\frac{w_t}{\tau_t} &= (1-\alpha)\frac{Y_{\mathcal{W},t}}{N_t} && (69)\\
\frac{r_t+\delta_K}{\tau_t} &= \alpha \frac{Y_{\mathcal{W},t}}{\mathcal{KS}_t}. && (70)
\end{aligned}
$$

Intuitively, these equilibrium conditions are affected by the frictions of trading along both the extensive margin and the intensive margin, as these frictions affect the marginal cost:

$$
\tau_t \equiv mc_t = \frac{1}{Z_t}\left(\frac{r_t+\delta_K}{\alpha}\right)^{\alpha}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}. \qquad (71)
$$

The search costs associated with the formation of new B2B relationships motivate firms to agree on setting the bargained wholesale price above the marginal cost. In turn, the costs of adjusting trade along the intensive margin affect the responsiveness of the marginal cost to shocks.

The problem of retail firms is the same as in partial equilibrium: they purchase the intermediate goods from the wholesalers and transform it for final consumption, facing a cost ω_t of adjusting the quantity per match. In addition, also the solutions for the bargained wholesale price and the bargained quantity per match are as in partial equilibrium.

Finally, in the symmetric equilibrium $p_{i,t} = P_t = 1$, so $c_{i,t} = C_t$ and the condition for the goods market to clear is:

$$
Y_t = C_t + I_t + \chi_0 \frac{\left(u_{K,t}\right)^{\chi_1} - 1}{\chi_1} K_t + \frac{\gamma}{2}\left(x_{\mathcal{W},t}^2 + x_{R,t}^2\right) T_t, \qquad (72)
$$

where $Y_t = Y_{\mathcal{W},t} - \omega_t T_t$ is aggregate income.

E.2 Comparison with a Standard RBC Model

The B2B model introduces in the standard RBC model the frictions associated to engaging in business relationships. Therefore, we simply summarize what formally changes in absence of search, bargaining and the relationship between extensive and intensive margins of trade.

The profit maximization of the representative firm is

$$\max_{N_t, \mathcal{KS}_t} \tilde{Y}_t - w_t N_t - (r_t + \delta_K) \mathcal{KS}_t, \tag{73}$$

where $\tilde{Y}_t = Z_t \mathcal{KS}_t^{\alpha} N_t^{1-\alpha}$ is output, and the market clearing condition is

$$\tilde{Y}_t = C_t + I_t + \chi_0 \frac{(u_{K,t})^{\chi_1} - 1}{\chi_1} K_t. \tag{74}$$

Note that C_t now denotes consumption of a single good variety. For the rest, the RBC framework is the same as our model presented above.

E.3 Comparison with an NK Model

The representative household faces a problem that is similar to that of the representative household in the B2B and RBC models. Her budget constraint is

$$\frac{C_t}{P_t} + \frac{B_{t+1}}{P_t R_t} + I_t = \frac{B_t}{P_t} + w_t N_t + (r_t + \delta_K) \mathcal{KS}_t - \chi_0 \frac{(u_{K,t})^{\chi_1} - 1}{\chi_1} K_t + \tilde{\Upsilon}_t, \tag{75}$$

where P_t is the general price level, B_t/P_t is a real bond, R_t is the nominal interest rate and $\tilde{\Upsilon}_t$ is the sum of the profits of firms in the NK model. That is, bond holdings represent the only difference between the NK model and the previous ones. The corresponding FOC is

$$1 = R_t \mathbb{E}_t \frac{\beta_{t,t+1}}{\Pi_{t+1}}, \tag{76}$$

where $\Pi_t \equiv P_t / P_{t-1}$.

The representative retailer bundles differentiated wholesale goods as follows:

$$\tilde{Y}_t = \left[\int_0^1 Y_{\mathcal{W},t}(j)^{(\varepsilon-1)/\varepsilon} \, dj \right]^{\varepsilon/(\varepsilon-1)}, \tag{77}$$

where $Y_{\mathcal{W},t}(j)$ is the input received by wholesaler j and $\varepsilon > 1$ is the elasticity of substitution between inputs. The demand for input j that maximizes the profit of the retailer is

$$Y_{\mathcal{W},t}(j) = (\tilde{p}_{\mathcal{W},t}(j))^{-\varepsilon} \tilde{Y}_t, \tag{78}$$

where $\tilde{p}_{\mathcal{W},t}(j) \equiv P_t(j) / P_t$ is the (relative) wholesale price and the general price level is given by $P_t = \left[\int_0^1 P_t(j)^{1-\varepsilon} dj \right]^{1/(1-\varepsilon)}$.

The representative wholesaler chooses the optimal $P_t(j)$ that maximizes the present discounted value of future expected profits subject to equation (78) and the constraint that output $Y_{\mathcal{W},t}(j) = Z_t \mathcal{KS}_t^{\alpha}(j) N_t^{1-\alpha}(j)$. At any given time t, wholesale profits are

$$\tilde{\pi}_{\mathcal{W},t} = \left[\tilde{p}_{\mathcal{W},t}(j) - \frac{\psi_P}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - \Pi\right)^2\right] Y_{\mathcal{W},t}(j) - w_t N_t(j) - (r_t + \delta_K)\mathcal{KS}_t(j), \tag{79}$$

where ψ_P measures the size of the price adjustment costs (Rotemberg, 1982) and Π is steady-state inflation. The multiplier associated to output is $\tilde{\tau}_t(j) = mc_t(j)$, which is the optimal marginal cost of wholesaler j. These are equivalent to the equilibrium marginal cost of our B2B model for all $j \in [0,1]$. Formally, the optimal capital-labor ratio is also equal. The optimal price, instead, satisfies

$$\begin{aligned} \psi_P(\Pi_t(j) - \Pi)\Pi_t(j) &= (1-\varepsilon)\tilde{p}_{\mathcal{W},t}(j) + \varepsilon\left[mc_t(j) + \frac{\psi_P}{2}(\Pi_t(j) - \Pi)^2\right] \\ &\quad + \mathbb{E}_t\beta_{t,t+1}\psi_P(\Pi_{t+1}(j) - \Pi)\Pi_{t+1}(j)\left(\frac{Y_{\mathcal{W},t+1}(j)}{Y_{\mathcal{W},t}(j)}\right), \end{aligned} \tag{80}$$

where $\Pi_t(j) \equiv P_t(j)/P_{t-1}(j)$. Since in equilibrium firms behave symmetrically, they choose the same intermediate good price (i.e., $P_t(j) = P_t \; \forall j$) and produce the same quantity (i.e., $Y_{\mathcal{W},t}(j) = Y_{\mathcal{W},t} = \tilde{Y}_t \; \forall j$), this equation becomes:

$$\begin{aligned} 1 &= \tilde{\mu}\left[mc_t + \frac{\psi_P}{2}(\Pi_t - \Pi)^2\right] \\ &\quad - \frac{1}{\varepsilon - 1}\left[\psi_P(\Pi_t - \Pi)\Pi_t - \mathbb{E}_t\beta_{t,t+1}\psi_P(\Pi_{t+1} - \Pi)\Pi_{t+1}\left(\frac{\tilde{Y}_{t+1}}{\tilde{Y}_t}\right)\right], \end{aligned} \tag{81}$$

where $\tilde{\mu} \equiv \varepsilon/(\varepsilon - 1)$ is the markup. Note that, since $P_t(j) = P_t$, $\Pi_t = \Pi_t(j)$ for any j.

Log-linearizing equation (81) around a zero-inflation steady state (i.e., $\Pi = 1$) gives the familiar Phillips curve. The Taylor-type rule followed by the central bank to set the interest rate for the control of inflation and the output gap is instead

$$\frac{R_t}{R} = \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi}\left(\frac{\tilde{Y}_t}{\tilde{Y}_t^{flex}}\right)^{\phi_Y}\right]^{1-\lambda_R}\left(\frac{R_{t-1}}{R}\right)^{\lambda_R}, \tag{82}$$

where λ_R is the persistence of the interest rate, R is the steady-state interest rate and $\phi_\pi, \phi_Y > 0$ are the weights attributed to stabilizing inflation and the output gap, respectively. Note that the output gap is defined as the deviation of $\tilde{Y}_t$ from its flexible-price level ($\tilde{Y}_t^{flex}$), which corresponds to $\psi_P \to 0$, and that we abstract from monetary policy shocks. Indeed, the comparison with the B2B model is in terms of technology shocks leading to unexpected changes in the marginal cost.

Finally, the model is closed by the fact that the bonds are in zero net supply and that goods market clear when

$$\tilde{Y}_t \left[1 - \frac{\psi_P}{2} (\Pi_t - \Pi)^2\right] = C_t + I_t + \chi_0 \frac{(u_{K,t})^{\chi_1} - 1}{\chi_1} K_t. \tag{83}$$

F An Alternative Bargaining Protocol: Right-to-Manage Bargaining

To assess to what extent the results of the paper depend on the particular bargaining protocol chosen, in this section we compare the results obtained under Efficient Nash Bargaining (EB) to the ones obtained under Right-to-Manage (RTM) Bargaining.[5]

F.1 Partial Equilibrium

Under the bargaining scheme analyzed in the paper, prices and quantities are determined jointly by wholesalers and retailers as a solution of the same Nash bargain. Trigari (2006) refers to this bargaining protocol as Efficient Bargaining (EB) because the outcome of this bargain is privately efficient (and also socially efficient if the Hosios condition is satisfied). The solutions for prices and quantities are respectively:

$$p_{\mathcal{W},t} = \eta \left[mc_t - \Omega_{\mathcal{W},t}\right] + (1-\eta)\left[p_t\left(1 - \frac{\omega_t}{q_t}\right) + \Omega_{R,t}\right] \tag{84}$$

$$q_t = \bar{q} + \frac{1}{\psi}\left(\frac{p_t - mc_t}{p_t}\right) \tag{85}$$

where $\Omega_{\mathcal{W},t} = \gamma\left(x_{\mathcal{W},t}\right)^2 / (2q_t)$, $\Omega_{R,t} = \gamma\left(x_{R,t}\right)^2 / (2q_t)$ and, given symmetry, we have dropped the firm-specific indexes j and r.

In the Right-to-Manage (RTM) case, the wholesale price is set by bargaining, but retailers retain the right to set the unit sold per match unilaterally. Therefore, for a given bargained price, $p_{\mathcal{W},t}$, retailers choose the quantity bought per match to maximize the value of a B2B relationship:

$$\max_{q_t} \; J_t = p_t (q_t - \omega_t) - p_{\mathcal{W},t} q_t + \frac{\gamma}{2} x_{R,t}^2 + \beta (1 - \delta_T) \mathbb{E}_t J_{t+1},$$

with solution

$$q_t = \bar{q} + \frac{1}{\psi}\left(\frac{p_t - p_{\mathcal{W},t}}{p_t}\right). \tag{86}$$

Since retailers choose q_t unilaterally, the quantity per match now depends on the profit margin of retailers, $p_t - p_{\mathcal{W},t}$, instead of on the total profit of a B2B relationship, $p_t - mc_t$. This fact has two important implications. First, wholesale prices are now allocative along the intensive margin. Second, marginal cost shocks affect q_t only inasmuch as they translate into movements of $p_{\mathcal{W},t}$. Therefore, as long as the pass-through to wholesale prices is incomplete, the direct effect of the

[5] See Trigari (2006) for a discussion related to the labor market.

marginal cost on q_t is actually smaller than under Nash bargaining.

Before choosing the optimal quantity per match (86), firms choose the wholesale price so as to maximize the Nash product, taking as given the effect of wholesale prices on q_t. The solution for $p_{\mathcal{W},t}$ is very similar to the one under EB:

$$p_{\mathcal{W},t} = \chi_t \left[mc_t - \Omega_{\mathcal{W},t}\right] + (1-\chi_t)\left[p_t\left(1-\frac{\omega_t}{q_t}\right) + \Omega_{R,t}\right]. \tag{87}$$

As under EB, the bargained price is a weighted average of the reservation price of wholesalers and retailers. The difference is that now the weights are determined by an *effective* bargaining power,

$$\chi_t = \frac{\eta\Delta_{R,t}}{\eta\Delta_{R,t} + (1-\eta)\,\Delta_{\mathcal{W},t}}, \tag{88}$$

which depends not only on η, but also on the net marginal benefit from an increase in $p_{\mathcal{W},t}$ for the wholesaler, $\Delta_{\mathcal{W},t}$, and the retailer $\Delta_{R,t}$. These are, respectively:

$$\Delta_{\mathcal{W},t} = q_t - \frac{1}{\psi}\left(\frac{p_{\mathcal{W},t} - mc_t}{p_t}\right) \tag{89}$$

$$\Delta_{R,t} = q_t \tag{90}$$

Under RTM bargaining, wholesale prices play therefore both a distributive and an allocative role. Notice, however, that the allocation of resources within the match under RTM is inefficient, and that at least one of the two parties could be better off by bargaining over quantities as well as over prices.

The bargaining protocol does not affect the other equations of the model, which are identical in the two cases. This implies that the pass-through of cost shocks to retail prices still depend on the overall change in production along the intensive and extensive margin. In log deviations:

$$\hat{p}_t = -\frac{\kappa}{\phi}\hat{q}_t - \frac{1}{\phi}\hat{T}_t \tag{91}$$

Under EB, there is a direct effect of marginal cost shocks on the intensive margin of trade, while wholesale prices only affect the extensive margin of trade T_t:

$$\hat{p}_t = \frac{1}{1+\frac{\kappa}{\psi\phi}\frac{mc}{pq}}\left(\frac{\kappa}{\psi\phi}\frac{mc}{pq}\widehat{mc}_t - \frac{1}{\phi}\hat{T}_t\right). \tag{92}$$

Under RTM bargaining, instead, marginal cost shocks affect indirectly $\hat{p}_t$, through its effect on $\hat{p}_{\mathcal{W},t}$:

$$\hat{p}_t = \frac{1}{1+\frac{\kappa}{\psi\phi}\frac{p_{\mathcal{W}}}{pq}}\left(\frac{\kappa}{\psi\phi}\frac{p_{\mathcal{W}}}{pq}\hat{p}_{\mathcal{W},t} - \frac{1}{\phi}\hat{T}_t\right). \tag{93}$$

The response of the extensive margin $\hat{T}_t$ is, in both cases, mainly determined by the presence of search externalities and, more generally, by the efficiency of the matching process.

F.1.1 Calibration

The calibration strategy is the same as that developed for the baseline EB model. Therefore, once again we infer γ and $\tilde{\mathcal{M}}$ by imposing that the steady state matches a markup $\mu = 0.12$ and a wholesaler's search effort in percent of the overall trade of intermediate goods $\iota_{\mathcal{W}} = 0.0885$, whereas all the other parameters take the same values as in the EB case. See Table 6 for the calibrated parameters; the column for the EB case is a copy of the benchmark calibration in Table 1.

The calibration of the RTM case differs from that of the EB case only because, to solve for the steady state, we need to take into account the direct link created by the optimal quantity per match (equation (86)) between $p_{\mathcal{W},t}$, p_t and q_t. As a result, although there is again a non-linear system to solve, this system now involves more simultaneous equations than that used in the EB case. Specifically, we set $p = 1$ and find q, γ, mc, χ and $p_{\mathcal{W}}$, simultaneously, by solving equations (7), (53) – (54), (86) and (88). Table 6 shows the implied values of γ and $\tilde{\mathcal{M}}$.

F.1.2 Steady State

The main properties of the steady state are shown in Table 7. To simplify the comparison, in this tables there are also the results obtained with EB from Table 1.

It is easy to see that the behavior of the model under RTM bargaining is analogous to that of the EB model. What differs is that, under RTM, wholesale and retail firms are asymmetric. Therefore, for the calibration in Table 6, retailers receive the largest share of the total markup of the industry (i.e., $\mu_{\mathcal{W}}/\mu_R < 1$), which justifies their strong incentive to search for business partners ($d > a$). Compared to the EB case, this asymmetry leads to lower trade along the intensive margin, but a larger number of B2B relationships are established along the extensive margin. Nevertheless, by varying η and ψ, we find that the economic implications of the RTM model for search, trade and surplus sharing do not differ much from those of the EB model.

What is important is instead the implication of this robustness for the asymmetry between firms introduced by RTM bargaining. In particular, Table 7 shows that the asymmetry decreases as ψ rises and is completely ineffective for low values of η. In fact, if retailers face low costs of adjusting along the intensive margin (e.g., $\psi = 0.02$), they not only set the quantity traded with their business partners unilaterally, but also vary it easily to obtain any adjustment of the total trade volume (qT).[6] This power is instead substantially attenuated by an increase in ψ. Similarly, the potentially strong position of the retailers does not influence the equilibrium so much for $\eta = 0.25$ because, in this case, the wholesale price tends anyway to the reservation price of the retailers (see equations

[6] Note that, as in the EB case, the RTM model is feasible under an economically meaningful intensive margin of trade. See Sections 2.3 and B.2 (especially equation (52)) for an explanation in the EB case. To see this in the context of RTM bargaining, use equation (86) to find the ratio between prices:

$$\frac{p_{\mathcal{W},t}}{p_t} = 1 - \psi\left(q_t - \bar{q}\right).$$

This equation implies that $p_t = p_{\mathcal{W},t}$ for $\psi \to 0$. For technical reasons, however, the RTM model requires $\psi_L = 0.02$ as the lowest feasible value of ψ under our calibration; it is larger than the value used for the sensitivity analysis in the context of the EB model. See Table 7.

(84) and (87)), so that the wholesalers appropriate the most of the surplus.

F.1.3 Marginal Cost Shocks and Pass-Through to Prices

Figure 9 shows the dynamic reaction of selected variables to a marginal cost shock for different values of η. Overall, the dynamics of the RTM model are quite similar to the ones of the EB model. In both cases, the pass-through to prices is incomplete, being more so for wholesale prices than for retail prices and displays sluggish dynamics.

The effects of RTM bargaining arise for different values of the bargaining power η. In the EB model, the bargaining problem of retailers and wholesalers is symmetric. This symmetry translates into the matching process and implies that the responses of retail prices and consumption when $\eta = 0.9$ are identical to the responses when $\eta = 0.1$. On the contrary, in the RTM model the responses of retail prices and consumption are larger for $\eta = 0.9$ than for $\eta = 0.1$. Notice that this result is an implication of how $\hat{q}_t$ reacts to $\widehat{mc_t}$ under the asymmetry generated by RTM bargaining. In particular, when retailers have most of the bargaining power ($\eta = 0.9$), the reaction of the intensive margin is stronger because a higher η translates into a larger increase in $\hat{p}_{\mathcal{W},t}$ and, therefore, $\hat{q}_t$ drops by more. However, this larger reaction of the intensive margin is partially counteracted by a smaller reduction of the extensive margin, $\hat{T}_t$, which is a reflection of a very inefficient matching process. This inefficiency arises because when retailers have most of the bargaining power and have the right to choose unilaterally the units per match, wholesalers have very little incentives to invest in B2B relationships. As a consequence, the product market is very tight for retailers. On the other hand, when wholesalers have most of the bargaining power ($\eta = 0.1$), the reactions of wholesale prices and quantities are smaller, but the reaction of the extensive margin of adjustment is larger, partially counteracting the drop in $\hat{q}_t$. Indeed, after 15 months the responses of the retail price and quantity are very similar regardless of whether $\eta = 0.1$ or $\eta = 0.9$. As in the EB case, both the reaction of the extensive margin and the long-run pass-through to retail prices and quantities are larger for $\eta = 0.5$.

Note that all this remains true if additionally to varying η, we also lower ψ. As Tables 1 and 6 show, the EB model reproduces an impact (or short-run) pass-through to retail prices of 0.25 with a lower ψ than the RTM model. If we, thus, use the value of ψ found for the EB model (0.2181) in the RTM case, we obtain that a 1 percent increase in $\widehat{mc_t}$ provokes a larger reaction of retail prices and consumption, but the sensitivity of the model to η remains substantially the same as we have just described. This is consistent with our previous results from the analysis of the steady state (Table 7).

The reason why the extensive margin of trade reacts by more when $\eta = 0.1$ than when $\eta = 0.9$ is the inherent asymmetry introduced under the RTM protocol: since retailers have the right to manage quantities unilaterally, they have higher incentives than wholesalers—ceteris paribus—to invest in B2B relationships. Therefore, even when firms have the same bargaining power ($\eta = 0.5$) wholesalers are less willing to invest in marketing and advertising than retailers, and the product market will be tight on retailers' side ($\theta < 1$). For the same reason, the matching process is even more sclerotic when retailers have high bargaining power ($\eta = 0.9$) than when wholesalers are the dominant party in the negotiations ($\eta = 0.1$).

Despite these differences, and despite the rather different transmission mechanism of cost shocks, most of our results are not affected much by the use of this alternative bargaining protocol. Consider for instance Figure 10, which compares the pass-through of costs to prices for different values of η in the two models. The pass-through under RTM bargaining is quite similar to the one under EB, both on impact and after 1 year. Therefore, the disconnection between the pass-through to wholesale prices and the pass-through to retail prices is not driven only by the assumption of Nash bargaining. The presence of search frictions already creates a partial disconnection between retail and wholesale prices.

The differences between the RTM and EB models are visible only for small values of η. When η is small, a marginal cost shock leads to a strong reduction of the effective bargaining power χ_t. This, in turn, reduces the pass-through of cost shocks to wholesale prices. Moreover, since the quantity traded along intensive margin under RTM bargaining is directly related to $\hat{p}_{\mathcal{W},t}$ instead of $\widehat{mc}_t$, the pass-through to retail prices is also smaller than in the EB model.

For higher values of η, the differences between the two models get progressively smaller, and basically disappear for values of η above 0.8. When η is sufficiently high, the wholesale price is closely related to the marginal cost, and the elasticity of the effective bargaining power to marginal cost shocks converges to 0. As a consequence, the dynamics of the RTM model are almost indistinguishable from the ones of the EB model.

F.2 General Equilibrium

The general equilibrium version of the model with RTM bargaining is very similar to that of the B2B model with EB. In fact, the different bargaining protocol changes the form of only two equations. One is the equation for the units sold per match, which now depend only on the profit margin of retailers:

$$q_t = \bar{q} + \frac{1}{\psi}\left(1 - p_{\mathcal{W},t}\right). \tag{94}$$

The other is the equation for the bargained price of the wholesale good,

$$p_{\mathcal{W},t} = \chi_t\left(mc_t - \Omega_{\mathcal{W},t}\right) + \left(1 - \chi_t\right)\left(1 - \frac{\omega_t}{q_t} + \Omega_{R,t}\right), \tag{95}$$

where $mc_t = \frac{1}{Z_t}\left[\left(r_t + \delta_K\right)/\alpha\right]^{\alpha}\left[w_t/\left(1-\alpha\right)\right]^{1-\alpha}$ (i.e., the same as in equation (71)), χ_t is as in equation (88), $\Delta_{R,t}$ is as in equation (90) and $\Delta_{\mathcal{W},t}$ is given by

$$\Delta_{\mathcal{W},t} = q_t - \frac{1}{\psi}\left(p_{\mathcal{W},t} - mc_t\right). \tag{96}$$

As in the partial equilibrium version of the model, the "right to manage" of retail firms creates a direct link between the intensive margin and wholesale prices. Moreover, since this link is taken into account in the bargaining process, the effective bargaining power χ_t is state dependent. In particular, since χ_t is increasing in q_t, the effective bargaining power of retailers increases during periods in which their profit margin is larger, while it declines during periods of smaller profits.

F.2.1 Calibration

The calibration strategy is the same as that developed for the baseline EB model. Based on this, we conduct two types of exercises. One is to solve and simulate the model subject to TFP shocks with the same parameter values used for the model with EB. These are the values reported in column (1) of Table 2, and the corresponding results are given by Table 3 and Figure 5 (see Section 5.1.2). The other exercise is to solve the model with RTM bargaining in order to match all of the targets which form part of our calibration strategy. This involves finding the parameters η and ψ (in both the TFP-only case and the case of both TFP and mismatch shocks) and those of the shocks that allow the behavior of the TFP series by Fernald (2012) to be matched and second moments in the data (in the case of both TFP and mismatch shocks). We label this second type of exercise as *"Fitting RTM"*. The "Fitting RTM" calibration for the TFP-only case is reported in column (1) of Table 8, and the corresponding results are discussed in the next section to complement the explanation in Section 5.1.2. The "Fitting RTM" calibration for the model with TFP and mismatch shocks is reported in column (4) of Table 8 and the corresponding results are in Table 5 and Figure 6 (see Section 6).

For all these exercises, the steady state is determined with the same system of equations as that used for the partial equilibrium—equations (7), (53) – (54), (86) and (88). The only difference is that this system of five equations is now solved conditional on the fact that $p_t \to 1$ for any time t and that the marginal cost depends endogenously on the capital stock (i.e., (69) – (70) apply).

F.2.2 Results

Table 9 compares the results of the model subject to TFP shocks under both the baseline EB case (column (2)) and the RTM bargaining case (column (5)). In both cases, the parameters η and ψ are set to match the volatility of the intermediate goods price and investment relative to the output volatility. As the table shows, under this calibration, the two versions of the model perform almost in the same way. The difference between them lies only in the calibration. In particular, under RTM $\eta = 0.6516$ and $\psi = 2.0299$ (column (1) of Table 8), which are both smaller than values found for the EB model (0.6581 and 2.8678, respectively, from column (1) of Table 2). However, these differences are small.

These small differences in the calibrations needed to match the relative volatilities of the intermediate goods price and investment under different bargaining protocols are consistent with the findings discussed in Section 5.1.2. In this case, the simulation of the RTM bargaining model is based on the same calibration that allows the EB model to match the data. As a result, we have found that RTM bargaining increases the volatility of output by only 0.01 percentage points, while the relative volatility of intermediate prices increases from 0.70 (the value in the data) to 0.74.

These are small differences, and the effect of RTM bargaining on other variables is comparably small.

G Additional sensitivity analyses

G.1 Sensitivity of the Second Moments to γ and $\tilde{\mathcal{M}}$

In Section 5.1.2 we describe the propagation mechanism of TFP shocks generated by our RBC model with B2B relationships between firms. While in that section we stress the role of the two key parameters of our theory, in this section we provide additional information by studying the sensitivity of the results to the search costs and efficiency of the matching. The two parameters capturing these two aspects are, respectively, γ and $\tilde{\mathcal{M}}$.

Considering how changes in these two parameters affect the results is interesting because they are the parameters that we infer indirectly within our calibration strategy. Therefore, our sensitivity exercise involves lowering each of them at a time and see how the second moments predicted by the model under TFP shocks change. In doing so, we keep all the other parameters unchanged at the values displayed in column (1) of Table 2. The results are in columns (3) and (4) of Table 9.

Column (3) of this table shows the predictions of the model when $\tilde{\mathcal{M}}$ is 90 percent of its baseline value; specifically, when $\tilde{\mathcal{M}} = 0.4359$. This case lowers the productive capacity of the economy because, for given search costs, it is now less likely that a potential B2B relationship is successfully formed. Coherently, we find that the volatility of output declines relative to the baseline case, and this generally affects all the other second moments proportionally. The relative volatilities of the real intermediate price, consumption, investment, labor, real wage and real interest rate are almost all larger than in the baseline case, while the correlations of these variables with output gets smaller.

Column (4) of Table 9 shows the predictions of the model when γ is 90 percent of its baseline value, meaning that $\gamma = 7.7725$. Compared with the baseline case, it is now less costly for firms to search for business partners in the product market, and hence each unit of search effort is more efficient. Contrary to our results for a low $\tilde{\mathcal{M}}$, we find that the reduction of γ increases the volatility of output, lowers the relative volatility of the other variables and raises their procyclicality. There is only one exception, which is the relative volatility of the real wage; it rises as γ falls.

Note, nevertheless, that the quantitative effects of a 10 percent reduction in either $\tilde{\mathcal{M}}$ or γ are small. Moreover, γ influences the quantitative behavior of the model in a similar way as ψ. The only difference between the two parameters is that ψ produces far larger effects on the relative volatility of investment and on the correlation of the the real intermediate goods price with output than γ. Put differently, investment and the real intermediate goods price depend crucially on how firms can respond to shocks by trading along the intensive margin—as opposed to the extensive margin; in contrast, the efficiency of the extensive margin matters much less. Its effect is analogous to a *scaling* effect.

G.2 The Role of the Duration of the Matches

Our baseline assumption for the duration of the matches is that they last 19 months, so that the separation rate is $\delta_T = 0.05$. This choice is supported by empirical evidence (Blinder et al., 1998, Apel et al., 2005, Amirault et al., 2006, Heise, 2019) and previous models with B2B relationships (Mathä and Pierrard, 2011, Drozd and Nosal, 2012). In sum, these papers indicate that customer relationships that can be deemed long-term relationships have durations between roughly 1 year and 2.5 years. Therefore, 19 months represents roughly the midpoint of this range, and in this appendix we study the sensitivity of the results to increasing or lowering δ_T. This is an interesting exercise because δ_T is one of the two parameters affecting the indirect inference of γ and $\tilde{\mathcal{M}}$ within our calibration strategy; the other is η, to which we devote a large portion of our paper.

Specifically, to capture a duration of 1 year we set $\delta_T^{(H)} = 0.077$, and to capture a duration of 2.5 years we set $\delta_T^{(L)} = 0.0323$.

G.2.1 Partial Equilibrium

Although δ_T has a direct effect on γ and $\tilde{\mathcal{M}}$ (i.e., these parameters would both increase if we increased δ_T and re-determined the steady state entirely through our indirect inference strategy), we analyze the implications of increasing or lowering δ_T as we did in the case of η and ψ. That is, we keep all the parameters other than δ_T unchanged and in line with their benchmark values (see Table 6). The last two rows of Table 7 show the results for the steady state.

These results suggest that firms have to put more effort into search activities when the existing B2B relationships get separated more frequently (i.e., as δ_T increases). Although their search efforts rise, firms find it also more convenient to carry out a larger portion of trade along the intensive margin (i.e., q is larger) rather than along the extensive margin (i.e., T is smaller).

Figure 11 shows the responses to a 1 percent increase in the marginal cost. We find that, since, for a high δ_T, firms trade between each other mostly along the intensive margin in the steady state, this margin is also the least responsive to cost shocks. This is transferred to prices, consumption and search intensity, in the sense that all these variables tend to be less elastic to the marginal cost, the larger δ_T is. Finally, note that the increase in $\widehat{mc_t}$ is more closely associated with a larger increase in prices, the smaller δ_T is, but the effect on the pass-through to the wholesale price is tiny.

G.2.2 General Equilibrium

To study the sensitivity of the general equilibrium version of the model to the calibration of δ_T, we proceed in two ways. First, for the TFP-only case, we set the duration of the B2B relationships in line with either $\delta_T^{(H)} = 0.077$ or $\delta_T^{(L)} = 0.0323$ and keep η and ψ unchanged at their baseline values. The results are shown in columns (3)-(4) of Table 10. Second, we change δ_T and, simultaneously, use η and ψ to match second moments computed from the data. In the TFP-only case, η and ψ are chosen to replicate the relative volatilities of the real intermediate goods price and investment.

In the case of both TFP and mismatch shocks, η and ψ are chosen alongside $\sigma_{\tilde{\mathcal{M}}}$ to match the percentage volatility of output, the relative volatility of the real intermediate goods price and the correlation of this price with output. The calibration for this second type of exercise is given by Table 8 under the title "Fitting $\delta_T^{(H)}$" or "Fitting $\delta_T^{(L)}$". The implications for the second moments are shown in columns (5)-(6) and (8)-(9) of Table 10.

TFP Shocks. Columns (3)-(4) of Table 10 show that, as the duration of the B2B relationships declines (i.e., from the baseline δ_T to $\delta_T = \delta_T^{(H)}$), output becomes less volatile, whereas the real intermediate goods price and investment become relatively more volatile. Intuitively, firms involved in relationships that are just one year long tend to trade heavily along the intensive margin, and the elasticity of this margin to TFP shocks magnifies the responsiveness of the real intermediate goods price and investment. Therefore, to replicate their relative volatilities in the data, we need to assume that the intensive margin of trade is more elastic than it is in the case with the baseline δ_T. Specifically, we set $\psi = 0.8725$ and simultaneously adjust retailers' bargaining power (see column (3) of Table 8). As a result, we find that output is effectively less volatile for $\delta_T = \delta_T^{(H)}$ than for the baseline δ_T, and, interestingly, the real intermediate goods price is more negatively correlated with output (see column (6) of Table 10). Figure 12 shows that the decline in output volatility caused by an increase in δ_T is mostly due to $\widehat{mc}_t$ and $\hat{T}_t$, while the majority of the adjustment of intermediate goods trade after a decline in TFP is guaranteed by $\hat{q}_t$. Conversely, for $\delta_T = \delta_T^{(L)}$, trading along the intensive margin is rather costly (i.e., $\psi = 12.772$), output becomes more volatile and its negative comovement with the real intermediate goods price becomes rather small.

All these results suggest two conclusions. First, *long* B2B relationships shape production not only because, empirically, they account for the most of the trade (e.g., Eslava et al., 2015, and Heise, 2019), but also because the quantitative performance of our augmented RBC model worsens if we reduce the duration of the matches. Second, B2B relationships that are relatively long-lasting imply an important extensive margin of trade, which helps in understanding the cyclical behavior of the real intermediate goods price with respect to that of output.

TFP and Mismatch Shocks. Adding shocks to $\widehat{\tilde{\mathcal{M}}}_t$, we again find that the ability of the model to explain the data tends to improve with the duration of the matches. The quantitative performance of the model is shown in columns (8)-(9) of Table 10, and the underlying calibration is in columns (5)-(6) of Table 8.

For $\delta_T = \delta_T^{(L)}$, the model can replicate the volatility of output, the relative volatility of the real intermediate goods price and its correlations with output under the assumption that mismatch shocks are quite volatile ($\sigma_{\tilde{\mathcal{M}}} = 0.0303$, or 0.0425 per quarter) and the costs of trading along the intensive margin are quite high ($\psi = 2.848$). Both parameters are larger than those we find for the baseline δ_T, which are specifically $\sigma_{\tilde{\mathcal{M}}} = 0.017705$ and $\psi = 1.841$ (see column (2) of Table 2). The reason for this is simply that the extensive margin tends to dominate more the intermediate goods trade, the longer the duration of the B2B relationships is. Therefore, shocks that affect the likelihood of their formation, for given search costs, must be correspondingly stronger. For $\delta_T = \delta_T^{(H)}$, the opposite is true instead.

Importantly, the predictions of the model for other second moments, such as the relative volatilities of investment and labor, are closer to the data for $\delta_T = \delta_T^{(L)}$ than for $\delta_T = \delta_T^{(H)}$. This leads us to qualify the conclusions of our paper. The key role played by the extensive margin of trade in accounting for the second moments is due not only to costly adjustments of the quantity traded along the intensive margin and mismatch shocks, but also to the B2B relationships being sufficiently long-lasting.

G.3 Preference Shocks as Demand Shocks

Another question that arises from our analysis is whether standard demand shocks, such as preference shocks, can help the model to replicate the positive correlation between the PPI and output fluctuations that we observe in the data. If so, preference shocks would be simply capturing shocks that originate from the demand for final goods.

To answer this question, let us assume that consumers maximize the following objective function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t e^{\tilde{b}_t} \left(\ln C_t - \zeta \frac{N_t^{1+\nu}}{1+\nu} \right)$$

where $\tilde{b}_t$ is a shock to the discount of future utility and is given by $\tilde{b}_t = \rho_{\tilde{b}} \tilde{b}_{t-1} + \epsilon_{\tilde{b},t}$, with $\epsilon_{\tilde{b},t} \sim N(0, \sigma_{\tilde{b}})$. For comparability, we set the persistence of this shock, $\rho_{\tilde{b}}$, to obtain the same persistence as mismatch shocks after aggregating the monthly simulations at the quarterly frequency (i.e., 0.92). As a result, we obtain $\rho_{\tilde{b}} = 0.9691$. We then consider three possible values for the volatility of preference shocks, $\sigma_{\tilde{b}}$, and adjust the bargaining power to continue matching the relative volatility of the PPI. After the quarterly aggregation of the simulated data, the three values for the volatility of the preference shock are 0.5%, 1% and 1.5%.[7] All the other parameters are unchanged. Table 11 shows the results of this exercise.

As the table shows, preference shocks do not improve the ability of the model to match the second moments of output and PPI. A preference shock increases the volatility of output, but, at the same time, it strengthens the countercyclicality of the real intermediate goods price. Specifically, $corr(p_W, Y)$ goes from -0.30—i.e., the same value obtained in the baseline TFP-only case—for $\sigma_{\tilde{b}} = 0.5\%$ to -0.33 for $\sigma_{\tilde{b}} = 1.5\%$, while the volatility of output increases from 0.96% to 1.09%. Thus, it is impossible to choose the volatility of the shock to match the data for both output and the real intermediate goods price.

Moreover, preference shocks lead to counterfactual results also for other variables. In particular, the volatility of consumption tends to increase more than that of output, and to become countercyclical, in contrary to the data. Intuitively, the strong effects on consumption are due to the fact that, in our model, the preference shock affects not only the Euler equation for capital, as it is

[7] Specifically, we set: $\sigma_{\tilde{b}} = 0.00355$ and $\eta = 0.6581$; $\sigma_{\tilde{b}} = 0.0071$ and $\eta = 0.6445$; $\sigma_{\tilde{b}} = 0.0107$ and $\eta = 0.6276$.

usually the case, but also the first order conditions for searching and building business relationships. As preference shocks change the discounted future marginal value of the B2B relationships for both wholesalers and retailers, intermediate goods trade and final goods supply must react. It is through this adjustment of production that consumption reacts to the shock in a quantitatively stronger way than in DSGE models without B2B relationships.

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Parameter	Description	Benchmark	
		EB	RTM
β	Discount factor	0.996	0.996
δ_T	Separation rate	0.05	0.05
$\tilde{\mathcal{M}}$	Efficiency of matching	0.3566	0.4710
ξ	Elasticity of matching	0.5	0.5
γ	Search cost parameter	7.6837	9.9792
η	Retailers' bargaining power	0.5	0.5
ϕ	Substitution elasticity (consumption)	6.2	6.2
ψ	Retailers' adjustment cost	0.2181	0.3255
$\bar{q}$	Retailers' technical target	1	1
λ_{mc}	Persistence of mc	0.95	0.95
σ_{mc}	Volatility of shocks to mc	0.01	0.01

Table 6: Calibration of the RTM model in partial equilibrium. *Notes*: The column titled EB coincides with the benchmark calibration in Table 1.

	a	d	$\mu_{\mathcal{W}}/\mu_R$	T	q	χ
EB Case (Copy of Table 1)						
Benchmark	0.091	0.091	1.000	0.618	1.668	-
ψ_H (1.00)	0.127	0.127	1.000	0.860	1.178	-
ψ_L (0.01)†	0.024	0.024	1.000	0.162	6.314	-
η_H (0.75)	0.067	0.115	0.333	0.593	1.749	-
η_L (0.25)	0.115	0.067	3.003	0.593	1.749	-
RTM Bargaining Case						
Benchmark	0.089	0.096	0.860	0.828	1.216	0.537
ψ_H (1.00)	0.103	0.106	0.938	0.935	1.072	0.516
ψ_L (0.02)†	0.033	0.040	0.693	0.326	3.115	0.592
η_H (0.75)	0.063	0.113	0.311	0.757	1.341	0.763
η_L (0.25)	0.120	0.081	2.232	0.880	1.139	0.309
Sensitivity to Duration of Matches under EB						
$\delta_T^{(H)}$ (0.077)	0.111	0.111	1.000	0.474	2.293	-
$\delta_T^{(L)}$ (0.0383)	0.071	0.071	1.000	0.758	1.331	-

Table 7: Sensitivity of the steady state in partial equilibrium: sensitivity to duration of the matches and type of bargaining. *Notes*: We infer γ and $\tilde{\mathcal{M}}$ for the benchmark calibration of the EB or RTM case, and, then, keep them fixed to conduct all the other (sensitivity) exercises. †For the low-ψ case under RTM bargaining, we use a value which is larger than that for the EB model because of differences in the feasible numerical set for ψ under the two types of bargaining, given our calibration.

Parameter/Description	Shocks: Z_t			Shocks: Z_t, $\widetilde{\mathcal{M}}_t$		
	"Fitting RTM" (1)	"Fitting $\delta_T^{(L)}$" (2)	"Fitting $\delta_T^{(H)}$" (3)	"Fitting RTM" (4)	"Fitting $\delta_T^{(L)}$" (5)	"Fitting $\delta_T^{(H)}$" (6)
β : Discount factor	0.996	0.996	0.996	0.996	0.996	0.996
δ_T : Separation rate	0.05	0.0323	0.077	0.05	0.0323	0.077
$\tilde{\mathcal{M}}$: Efficiency of matching	0.4868	0.4843	0.4843	0.4618	0.4843	0.4843
ξ : Elasticity of matching	0.5	0.5	0.5	0.5	0.5	0.5
γ : Search cost parameter	8.7223	8.6361	8.6361	7.7553	8.6361	8.6361
η : Retailers' bargaining power	0.6516	0.6068	0.7355	0.6844	0.7015	0.748
ψ : Retailers' adjustment cost	2.0299	12.772	0.8725	1.5385	2.848	0.7138
$\bar{q}$: Retailers' technical target	1	1	1	1	1	1
α : Capital share	0.33	0.33	0.33	0.33	0.33	0.33
δ_K : Capital depreciation rate	0.00833	0.00833	0.00833	0.00833	0.00833	0.00833
ν : Labor elasticity coefficient	0.625	0.625	0.625	0.625	0.625	0.625
ζ : Labor disutility parameter	11.5045	11.6198	11.3205	11.5045	11.6109	11.337
χ_1 : Elasticity of capacity utilization	2.62	2.62	2.62	2.62	2.62	2.62
λ_Z : Persistence of Z	0.99305	0.99305	0.99305	0.99205	0.99265	0.99265
σ_Z : Volatility of shocks to Z	0.00504	0.00504	0.00504	0.00504	0.00504	0.00504
$\lambda_{\tilde{\mathcal{M}}}$: Persistence of $\tilde{\mathcal{M}}$	-	-	-	0.96858	0.9691	0.9691
$\sigma_{\tilde{\mathcal{M}}}$: Volatility of shocks to $\tilde{\mathcal{M}}$	-	-	-	0.017717	0.0303	0.00988

Table 8: Calibration for the robustness of the general equilibrium B2B model to a different bargaining protocol and different durations of the matches.

	Data	Baseline	Sensitivity		
			Low $\widetilde{\mathcal{M}}$	Low γ	"Fitting RTM"
	(1)	(2)	(3)	(4)	(5)
Volatility GDP (%)	1.27	0.94	0.88	0.97	0.95
Volatility relative to GDP					
Intermediate Price	0.70	0.70	0.77	0.67	0.70
Consumption	0.79	0.56	0.58	0.55	0.56
Investment	3.47	3.47	3.84	3.33	3.47
Labor	0.95	0.82	0.89	0.79	0.83
Wage	0.80	0.58	0.58	0.59	0.59
Interest Rate	0.38	0.01	0.01	0.01	0.01
corr(x,GDP)					
Intermediate Price	0.19	-0.30	-0.31	-0.29	-0.30
Consumption	0.85	0.82	0.80	0.82	0.82
Investment	0.90	0.57	0.48	0.62	0.58
Labor	0.80	0.17	0.12	0.20	0.17
Wage	-0.03	0.93	0.92	0.94	0.93
Interest Rate	0.06	0.68	0.63	0.70	0.67

Table 9: Second moments under shocks to the TFP: sensitivity to matching efficiency, search cost and bargaining protocol. *Notes*: The data span the period 1978Q1-2018Q4. We simulated samples of as many months as in the empirical sample, aggregated the data at the quarterly level and computed the summary statistics as averages over 500 replications. At each replication, there are 2000 initial datapoints, that we dropped before computing the moments. We HP-filtered both the empirical data and the simulated data (smoothing parameter of 1600).

	Data	Shocks: Z_t					Shocks: Z_t, $\widetilde{\mathcal{M}}_t$		
		Baseline	Sensitivity				B2B-ZM	Sensitivity	
			$\delta_T^{(L)}$	$\delta_T^{(H)}$	"Fitting $\delta_T^{(L)}$"	"Fitting $\delta_T^{(H)}$"		"Fitting $\delta_T^{(L)}$"	"Fitting $\delta_T^{(H)}$"
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Volatility GDP (%)	1.27	0.94	0.98	0.86	0.99	0.91	1.27	1.27	1.27
Volatility relative to GDP									
Intermediate Price	0.70	0.70	0.66	0.79	0.70	0.70	0.70	0.70	0.70
Consumption	0.79	0.56	0.57	0.55	0.55	0.55	0.47	0.47	0.47
Investment	3.47	3.47	2.86	5.28	3.47	3.47	4.11	3.76	4.56
Labor	0.95	0.82	0.77	0.95	1.00	0.58	0.86	0.92	0.73
Wage	0.80	0.58	0.59	0.58	0.63	0.56	0.73	0.71	0.72
Interest Rate	0.38	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
corr(x,GDP)									
Intermediate Price	0.19	-0.30	-0.32	-0.25	-0.08	-0.49	0.19	0.19	0.19
Consumption	0.85	0.82	0.83	0.76	0.70	0.90	0.81	0.76	0.84
Investment	0.90	0.57	0.73	0.38	0.75	0.36	0.78	0.84	0.70
Labor	0.80	0.17	0.17	0.19	0.32	0.12	0.57	0.56	0.63
Wage	-0.03	0.93	0.94	0.89	0.93	0.96	0.94	0.94	0.95
Interest Rate	0.06	0.68	0.68	0.67	0.70	0.77	0.80	0.79	0.83

Table 10: Second moments: sensitivity to different durations of the matches. *Notes*: The data span the period 1978Q1-2018Q4. We simulated samples of as many months as in the empirical sample, aggregated the data at the quarterly level and computed the summary statistics as averages over 500 replications. At each replication, there are 2000 initial datapoints, that we dropped before computing the moments. We HP-filtered both the empirical data and the simulated data (smoothing parameter of 1600).

	Data	Baseline	B2B with 2 Shocks			
			B2B-ZM	Sensitivity: Z_t, $\tilde{b}_t$ shocks		
				$\sigma_{\tilde{b}} = 0.5\%$	$\sigma_{\tilde{b}} = 1\%$	$\sigma_{\tilde{b}} = 1.5\%$
	(1)	(2)	(3)	(4)	(5)	(6)
Volatility GDP (%)	1.27	0.94	1.27	0.96	1.01	1.09
Volatility relative to GDP						
Intermediate Price	0.70	0.70	0.70	0.70	0.70	0.70
Consumption	0.79	0.56	0.56	0.72	1.05	1.37
Investment	3.47	3.47	4.11	4.00	5.20	6.51
Labor	0.95	0.82	0.86	0.84	0.90	0.99
Wage	0.80	0.58	0.73	0.67	0.86	1.06
Interest Rate	0.38	0.01	0.01	0.01	0.01	0.01
corr(x,GDP)						
Intermediate Price	0.19	-0.30	0.19	-0.30	-0.32	-0.33
Consumption	0.85	0.82	0.81	0.52	0.18	-0.04
Investment	0.90	0.57	0.78	0.58	0.58	0.62
Labor	0.80	0.17	0.57	0.22	0.32	0.43
Wage	-0.03	0.93	0.94	0.74	0.43	0.20
Interest Rate	0.06	0.68	0.80	0.67	0.62	0.55

Table 11: Second moments of the B2B model under TFP, matching efficiency and preference shocks. *Notes*: The data span the period 1978Q1-2018Q4. We simulated samples of as many months as in the empirical sample, aggregated the data at the quarterly level and computed the summary statistics as averages over 500 replications. At each replication, there are 2000 initial datapoints, that we dropped before computing the moments. We HP-filtered both the empirical data and the simulated data (smoothing parameter of 1600).

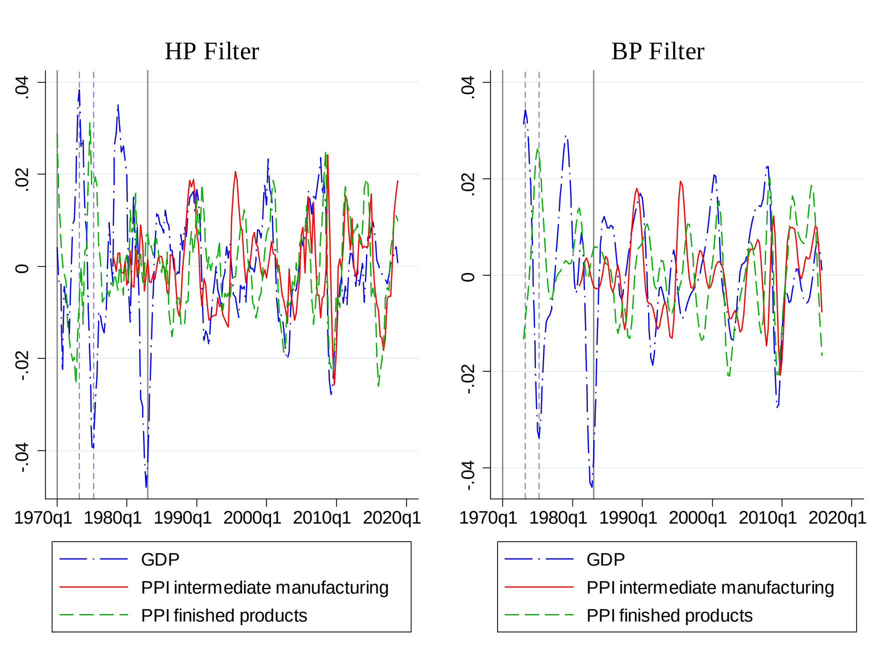

Figure 7: The cyclical behavior of the U.S. PPI in 1970Q1-2018Q4. *Notes*: The two vertical, continuous lines mark the 1970s. In the case of the HP-filtered data, we used a smoothing parameter of 1600. In the case of the BP-filtered data, we extracted cycles with periods between 1.5 and 8 years and eliminated the initial 2 years and the final 2 years from the filtered series.

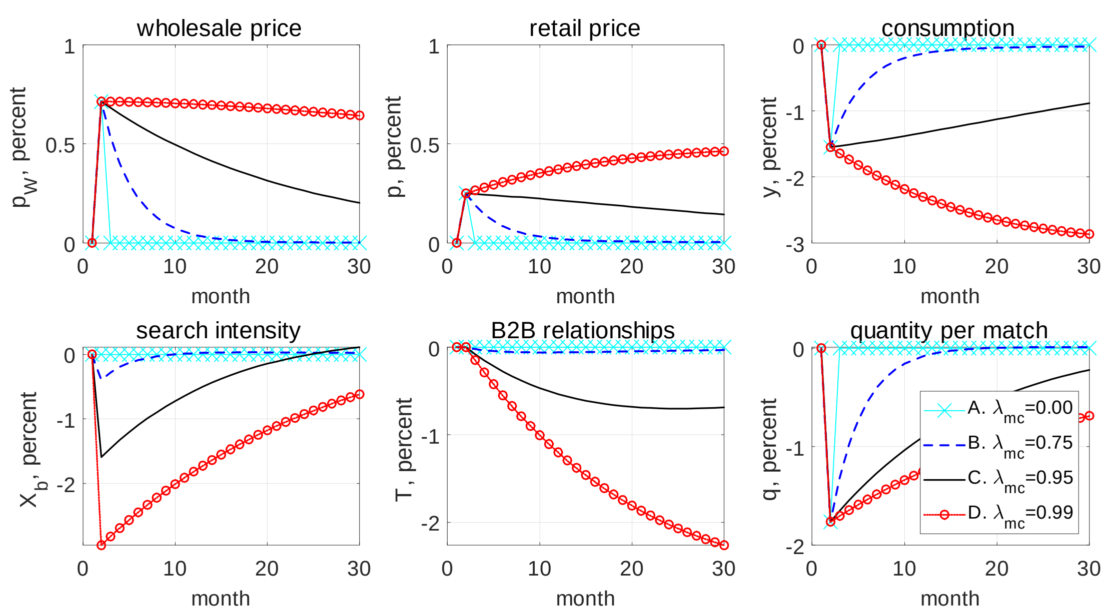

Figure 8: Responses to a 1% increase in $\widehat{mc_t}$ in partial equilibrium: robustness over λ_{mc}.

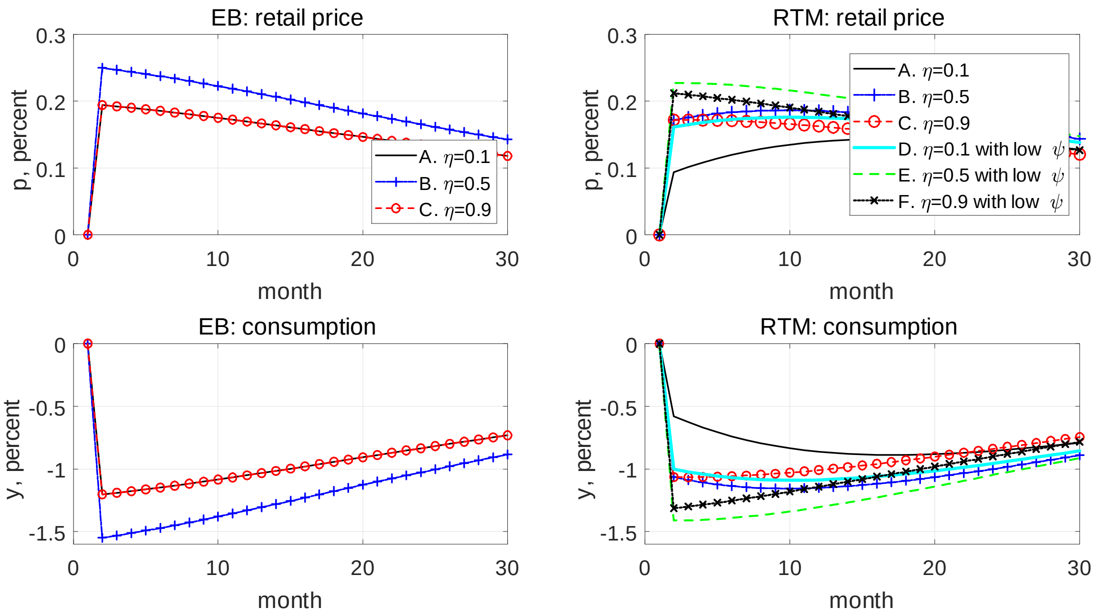

Figure 9: Selected effects of a 1% increase in $\widehat{mc_t}$ in partial equilibrium: A comparison between RTM bargaining and the EB case. *Notes:* The low value of ψ used for the sensitivity of the RTM case corresponds to the ψ of the benchmark EB case.

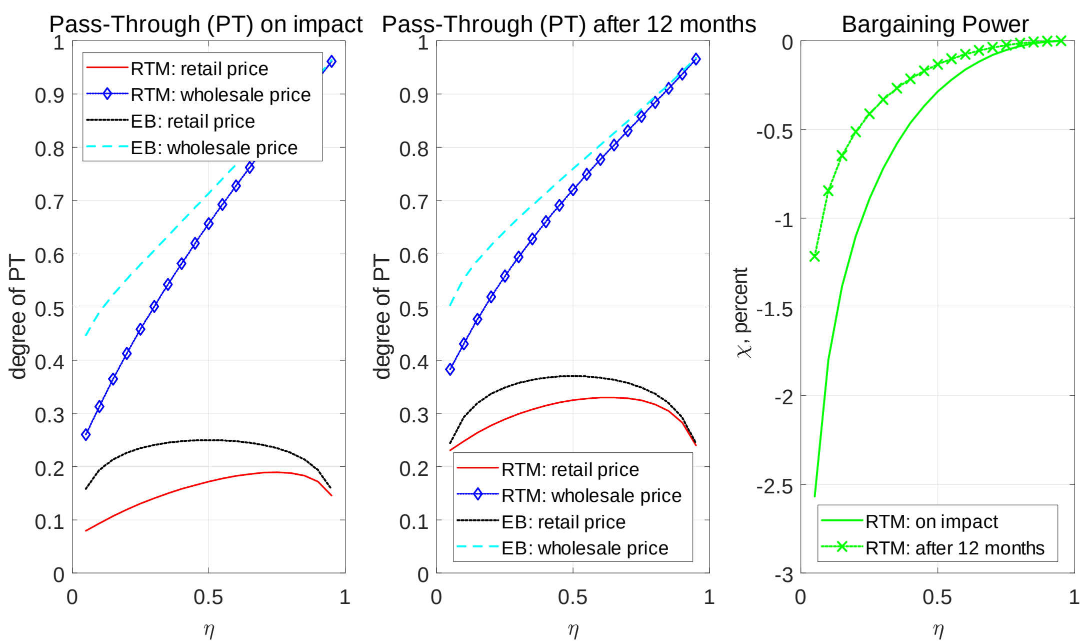

Figure 10: Pass-through of shocks to $\widehat{mc_t}$ to prices under RTM bargaining.

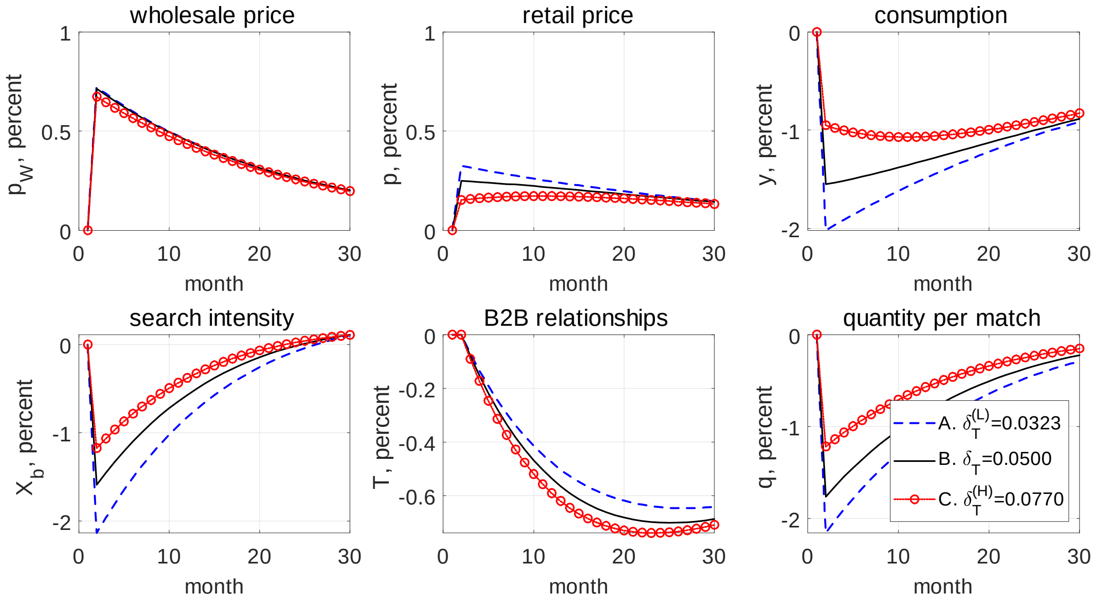

Figure 11: Responses to a 1% increase in $\widehat{mc_t}$ in partial equilibrium: robustness to the duration of the matches. *Notes*: The fourth diagram plots the search intensity of business $b = \mathcal{W}, R$ because marginal cost shocks preserve the symmetry implied by the optimal sharing rule, so firms adjust their search in the same way.

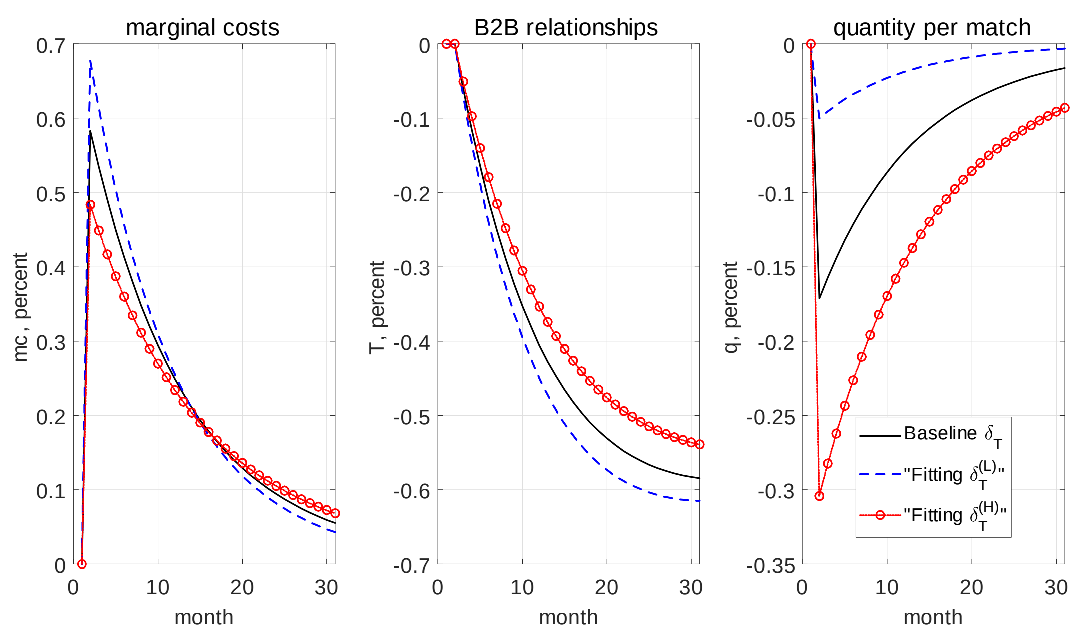

Figure 12: Responses of selected variables to a negative shock to $\widehat{Z_t}$ in general equilibrium: robustness over δ_T.