

# Propagation in a Model of Goods, Labor and Credit Market Frictions\*

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## Abstract

Building a model with three imperfect markets - goods, labor and credit - representing a product's life-cycle, we find that goods market frictions drastically change the qualitative and quantitative dynamics of labor market variables, leading to significant improvements in bridging the gap with the data both in terms of persistence and volatility, which has been central to the business cycle research agenda since its inception. Recent search models of the labor market fail in generating both the size and the persistence of their of central variables to productivity shocks, as does the RBC model in the case of output, but we show that two factors related to good market frictions change the dynamic propagation of shocks. First, the expected dynamics of congestion on the goods market, which depends consumers' search for goods which depend on the income redistributed by firms, and the entry of new products, both lagging productivity shocks. Second, the expected dynamics of prices, which may lead or lag productivity innovations depending on expectations, and alter future profit flows. In the absence of these goods market frictions, there is no persistence in the growth rates, and relatively little amplification of labor market variables, according to our calibration.

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# 1 Introduction

In this paper, we build a model with three imperfect markets - goods, labor and credit - and find that goods market frictions drastically change the qualitative and quantitative dynamics of the labor market, bridging the gap with the data both in terms of persistence and volatility. Since its inception the Real Business Cycle literature has faced the same challenge, emphasized in King and Rebelo (1999) and Cogley and Nason (1995): that of the propagation of technological shocks. In the standard RBC model, it is necessary to assume large innovations in order to obtain realistic business cycle fluctuations. Moreover, the model cannot generate the amount of autocorrelation in the growth rate of output that we see in the data. This twin failing in the lack of both amplification and persistence, which is even more severe for search models of unemployment, has generated separate literatures that either argue different values for key parameters or incorporate various frictions to specific markets.

Our modeling approach mirrors a growing literature measuring gross and net creation and destruction flows in the three markets. Following the seminal contributions in the labor markets of Davis and Haltiwanger (1990, 1992), Del'Arricia and Garibaldi (2005) have measured creation and destruction in the US loans market. Recently, Broda and Weinstein (2010) have carefully documented the magnitude of flows of entry and exits of goods, as well as the procyclical features of net product creation flows. We abstract each friction as a process matching two sides of a market. The relative supply and demand measures a degree of market tightness: the familiar vacancy to unemployment ratio for the labor market; the ratio of prospecting consumers and products on the goods market; and the ratio of investment projects to banks on the credit market.

We find that imperfect goods markets, working through the forward looking nature of job creation, change the qualitative and quantitative responses of the model to productivity shocks. In particular, the dynamics of the goods market generate persistence in the growth of the incentives to hire workers, which translates into responses of labor market tightness to productivity shocks that are hump-shaped, or highly persistent. During the first stages of an economic expansion, more firms enter the goods market relative to the change in the the effective demand from consumers. This causes an increase in congestion in the goods markets, from the point of view of firms, and a decline in the negotiated price at which the goods are eventually sold. From the perspective of a firm deciding to hire a worker, this moderates the incentive

to create a vacancy at the beginning of an expansion as it is less likely the additional production will find an outlet, and if it does, it sells at a lower price. However, as the cycle continues and productivity is returning to trend, the goods market eases in the sense of there being relatively more demand from consumers than products competing for customers. This decrease in congestion, which also leads to firms obtaining a better price, actually increases the incentive to recruit workers. We thus see a rise in labor market tightness for several periods after the initial shock, a persistence that arises from the fact that the economic value of hiring a worker is tied through interesting intertemporal linkages to congestion and prices on goods markets. These mechanisms are absent from the standard labor search model and a large class of extensions.

This paper is organized as follows. In Section 2, we briefly review the literature. In Section 3, we develop the model and discuss the evidence motivating are modeling of the goods market. In Section 4, we calibrate the model to quarterly data, using evidence on goods market flows, and investigate the sources of propagation in detail. Section 5 compares the quantitative results for alternative configurations of market frictions, emphasizing the preponderant role of goods market frictions for propagation, while Section 6 concludes.

## 2 A brief overview of the literature

Earlier research into propagation in models of the business cycle focused on the labor market, either increasing the elasticity of labor supply, e.g. models of indivisible labor in Hansen (1985) and Rogerson (1988), or introducing of a market friction in the form of wage rigidity.<sup>1</sup> The importance of the latter for amplifying the response of the demand for labor to changes in productivity has received renewed attention in search models of equilibrium unemployment as a means of addressing the lack of volatility in job vacancies and unemployment.<sup>2</sup>

The role of credit markets in amplifying exogenous shocks to economies and the existence of a *financial accelerator* has been emphasized in papers such as Bernanke and Gertler (1989), Kiyotaki and Moore (1997). We take into account the potential

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<sup>1</sup>See, for example, Taylor (1980), Christiano, Eichenbaum, and Evans (2005).

<sup>2</sup>This deficiency of the canonical model was shown in Cole and Rogerson (1999) and Shimer (2005). See also Hall (2005). Other mechanisms were suggested in the literature, such as introducing on-the-job search (Mortensen and Nagypál, 2007). Fujita and Ramey (2007) also focus on the lack of persistence in the growth rates of labor market variables in this class of models.

importance of frictional credit markets by introducing a financial accelerator of the type explored in Wasmer and Weil (2004) and Petrosky-Nadeau and Wasmer (2010).

Our main novelty here is to develop a model in which the introduction of good market imperfections generate additional insights, in a modern theoretical setup. It has of course been recognized for long that (disequilibrium-Others, such as Peter Rupert, suggest avoiding this term as even in a frictional market we can have a concept of equilibrium - what of “non-clearing” or departures from “a Walrasian equilibrium”) in goods markets can generate additional unemployment, at least since Keynes’ (1936) general theory. Several waves of research have attempted to put this intuition into models, such as the the neo-Keynesian work of Barro and Grossman (1971) and Bénassy(see Bénassy (1993) for a review). This previous literature has mostly been centered around the idea of price rigidities leading to excess supply (or demand) of goods and in turn generating inefficient outcomes in the labor market. In our paper, goods market imperfections will propagate shocks without solely relying on price rigidity. There has also been a revival of the interest in the impact of demand shocks in the good markets and their implications for the identification of technology shocks within the RBC paradigm. Bai, Rios-Rull and Storesletten (2011), in independent work, model the process of matching between consumers and firms as a matching model, with a focus on the respective role of technology shocks and shocks on the demand side of the market. Finally, a large chunk of the search literature has an explicit focus on frictions in the good market, as in Diamond (1971, 1982) for instance.

A recent paper by Broda and Weinstein (2010) has inspired our work and in particular inspired the detail of the modelization and its interpretation. The authors built up and used a unique dataset with 700 000 products with bar codes purchased by 55 thousand households. The covered sectors amount to 40 percent of all expenditures on goods in the CPI. Their findings, relevant to our approach, are as follows: they find large flows of entries and exits of “products”, actually four times more entry and exit in product markets than is found in labor markets, and a large share of product turnover happens within firms. Further, net product creation is strongly procyclical and primarily driven by creation rather than destruction. Over their 9 year sample period, 1994-2003, the entry rate of product defined as the number of new product codes divided by the stock is 0.78 quarterly, and the exit rate defined as the number of disappearing product codes over the stock is 0.72. Net product creation is strongly procyclical and driven by creation. Our model will follow closely the empirical results: throughout the paper, we will follow the birth of a “product line”, its development

and finally its death due in part to technological obsolescence, in part due to changes in consumer tastes, and will calibrate parts of the model based on the creation and destruction statistics above.

### 3 An economy with goods, labor and credit market frictions

We consider the case of a firm looking at marginal investment projects. These projects first need to obtain financing on the credit market. A financed project is then managed so as to maximize the value to the firm and the creditor, and needs to hire a worker to produce a good. However, the good cannot be sold until a consumer has been found. We review in detail the empirical case for modeling this friction in the goods market as a matching process, before determining prices and closing the model.

#### 3.1 Financing investment projects

Time is discrete. An investment project is initially in need of a financial partner (hereafter called a “banker”). This financing will cover the cost of recruiting a worker and the wage bill when the firm has not found a demand for its product. Prospecting on the credit market costs  $e$  units of effort per period of time. With probability  $p_t$  it finds a banker, and with complementary probability it remains in this stage (denoted by  $c$  like *credit*). We denote by  $J_c$  the asset value of the investment project in this stage. At the time of the meeting between banker and project, both sides agree on the terms of a financial contract whereby the resulting cost of the project are financed by the bank when its cash-flow is negative (in stages 2 and 3) and pays the banker when the cash-flow is positive (in stage 4).

Now matched with a banker, the project enters the second stage, where it prospects on the labor market in order to hire a worker. It must pay a per-period cost  $\gamma$  to maintain an active job vacancy. With probability  $q_t$  the firm is successful in hiring a worker, with complementary probability it remains in this stage (denoted by  $l$  like *labor*). We denote by  $J_l$  the asset value of a project in this stage. The firm offers a wage  $w_t$  to the worker as long as the firm is active.

In the third stage, now endowed with a worker, the firm could start producing  $y_t$  units of output from this particular project and attempt to sell it on the goods market, but it has no customers. Meeting with a consumer comes with probability

$\lambda_t$ , and production can be sold the following period. By assuming that production involves an operating cost  $\Omega$  over and above the wage, and that the good cannot be stored, the firm chooses not to produce in this stage (denote by  $g$  for *goods* market). The value of this stage is denoted  $J_g$ . Note that the bank is still financing the firm by transferring the amount of cash necessary to pay the worker. With probability  $s$ , projects are hit by an exogenous destruction shock at the end of the period in this stage, and the next.

In the fourth and final stage, now matched with a consumer, the output is sold at price  $\mathcal{P}_t$ . With revenue  $\mathcal{P}_t y_t$ , the firm pays the worker  $w_t$ , the operating cost  $\Omega$ , an amount  $\varrho_t$  to the bank, and enjoys the difference. We denote this stage by  $\pi$ , standing for profit, and by  $J_\pi$  its associated asset value. In addition, the consumer may stop consuming the particular good produced by this project with probability  $\tau$ , in which case the project returns to the previous stage  $g$  to search for another consumer.

Finally, as in Pissarides (2000), all profit opportunities are exhausted by new entrants such that the value of the entry stages are always driven to zero. In the case of the credit market, this implies that  $J_{c,t} \equiv 0$  at all times, which is also the continuation value following the destruction shock  $s$ .

Given these assumptions, the Bellman equations of the investment project, which faces a discount rate  $r$  and assuming that transitions from the credit to the labor market stages occur within a single period, are:

$$J_{c,t} = 0 = -e + p_t J_{l,t} \quad (1)$$

$$J_{l,t} = -\gamma + \gamma + \frac{1}{1+r} \mathbb{E}_t [q_t J_{g,t+1} + (1 - q_t) J_{l,t+1}] \quad (2)$$

$$J_{g,t} = -w_t + w_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [\lambda_t J_{\pi,t+1} + (1 - \lambda_t) J_{g,t+1}] \quad (3)$$

$$J_{\pi,t} = \mathcal{P}_t y_t - w_t - \varrho_t - \Omega_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [(1 - \tau) J_{\pi,t+1} + \tau J_{g,t+1}] \quad (4)$$

The bank's lifetime closely follows that of the investment project, with values denoted by  $B_j$ ,  $j = c, l, g$  or  $\pi$  for each of the stages. In stage  $c$ , it prospects on the credit market to find a viable project to finance, which occurs with probability  $\hat{p}_t$ , and pays a per period screening cost  $\kappa$ . Free entry on this side of the credit market implies that  $B_{c,t} = 0$  at all times. In stage  $l$ , the bank pays the cost of a vacancy  $\gamma$  and waits for the hiring to be realized. In stage  $g$ , the bank now pays the wage cost  $w_t$  and waits for the firm to be matched with a consumer. In stage  $\pi$ , the bank cashes

in the repayment  $\varrho_t$ .

The corresponding Bellman equations for the banker are

$$B_{c,t} = 0 = -\kappa + \hat{p}_t B_{l,t} \quad (5)$$

$$B_{l,t} = -\gamma + \frac{1}{1+r} \mathbb{E}_t [q_t B_{g,t+1} + (1-q_t) B_{l,t+1}] \quad (6)$$

$$B_{g,t} = -w_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [\lambda_t B_{\pi,t+1} + (1-\lambda_t) B_{g,t+1}] \quad (7)$$

$$B_{\pi,t} = \varrho_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [(1-\tau) B_{\pi,t+1} + \tau B_{g,t+1}] \quad (8)$$

Going forward, we will be interested in the joint values of a creditor and investment project, which we refer to as a “firm.” Let the value of a firm for each of the stages be denoted by  $S_{j,t} = J_{j,t} + B_{j,t}$ , with  $j = c, l, g, \pi$ . The Bellman equations for the value of a firm in each stage can be obtained by summing the corresponding equations for projects and banks, that is (1) to (4) and (5) to (8). We have, after rearrangement:

$$S_{c,t} = 0 \Leftrightarrow \frac{\kappa}{\hat{p}_t} + \frac{e}{p_t} = S_{l,t} \quad (9)$$

$$S_{l,t} = -\gamma + \frac{1}{1+r} \mathbb{E}_t [q_t S_{g,t+1} + (1-q_t) S_{l,t+1}] \quad (10)$$

$$S_{g,t} = -w_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [\lambda_t S_{\pi,t+1} + (1-\lambda_t) S_{g,t+1}] \quad (11)$$

$$S_{\pi,t} = \mathcal{P}_t y_t - w_t - \Omega + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [(1-\tau) S_{\pi,t+1} + \tau S_{g,t+1}] \quad (12)$$

Equation (9) states that the value of a firm in the hiring stage is equal to the sum of capitalized search costs paid by each side in the previous credit market stage. This is driven to zero in the absence of credit market frictions. The formulation the labor market stage in equation (10) describes the value of a job vacancy as a flow cost  $\gamma$  and an expected gain from hiring a worker, valued at  $S_g$ . As we will discuss in detail, the presence of a frictional goods markets fundamentally alters the dynamics of  $S_g$  compared to the standard framework through the dynamics of the goods market meeting rate,  $\lambda_t$ , and the price,  $\mathcal{P}_t$ .

## 3.2 Search and matching on the goods markets

### 3.2.1 Evidence

Broda and Weinstein (2010) document the nature, extent and cyclicity of product entry and exit in the U.S., with a focus on the implication for the measurement of aggregate consumer prices. Their data set is unique in capturing the universe of products purchased by households, and preferable to scanner data for their purposes and ours as one knows whether the product is truly new to the household. Using this data, Broda and Weinstein document three main facts.

First, the vast majority of product creation and destruction occurs within the boundary of the firm. That is, 92% of product creation and 97% of product destruction, happens within existing manufacturers. Second, they find up to four times more turnover in products than in establishment or labor market data. In a typical year, 40% of household expenditures are on goods created in the last four years, and 20% of expenditures are in goods that will disappear in the next four years. Product entry and exit rates, defined from the point of view of a household, are significant. Over their 9 year sample period, 1994-2003, the entry rate of product defined as the number of new product codes divided by the stock is 0.78 quarterly, and the exit rate defined as the number of disappearing product codes over the stock is 0.72. Third, net creation of products is strongly pro-cyclical whereas destruction is weakly counter-cyclical. This suggests that high demand leads to the introduction of new goods, reminiscent of the implementation cycles in Shleifer (1986).

There is also indirect evidence for the presence of frictional goods market that are well described by a search and matching process. New firms face lower demand than comparable older firms, a finding that Foster, Haltiwanger and Syverson (2008) explain by the presence of frictions in consumers acquiring information about a producer, or accessing a distribution network to reach consumers. Both lead to time and costs for both side of the goods market in searching before acquiring or beginning to consume a good for the first time.

### 3.2.2 Matching in the goods market

Consumers may spend their disposable income  $Y^d$  on either an essential good,  $c_0$ , or a preferred manufactured good,  $c_1$ . Consuming the later first requires searching on the goods market. When a consumer is matched with a manufacturing firm, it purchases the production,  $y_t$ , at a unit price  $\mathcal{P}_t$ . The remaining income is spent on



the essential good, which is supplied with a constant returns to scale technology and under a zero-profit condition.

At any point in time in this economy there are matched and unmatched consumers. Normalizing the mass of consumers to 1, we denote these shares by  $\mathcal{C}_{1,t}$  and  $\mathcal{C}_{0,t}$ , respectively. In equilibrium, these will be the fractions of disposable household income allocated to either categorie of goods. Unmatched consumers  $\mathcal{C}_{0,t}$ , exert an average search effort,  $\bar{e}_t$ , to find unmatched goods,  $\mathcal{N}_{g,t}$ , through a process summarized by a constant returns to scale function  $M_G(\bar{e}_t\mathcal{C}_{0,t}, \mathcal{N}_{g,t})$ .  $\bar{e}_t\mathcal{C}_{0,t}$  can be though of being the effective demand for new goods. The meeting rates between consumers and firms are given by:

$$\begin{aligned} \frac{M_G(\bar{e}_t\mathcal{C}_{0,t}, \mathcal{N}_{g,t})}{\mathcal{N}_{g,t}} &= \lambda(\xi_t) \quad \text{with} \quad \lambda'(\xi_t) > 0 \\ \frac{M_G(\bar{e}_t\mathcal{C}_{0,t}, \mathcal{N}_{g,t})}{\bar{e}_t\mathcal{C}_{0,t}} &= \tilde{\lambda}(\xi_t) \quad \text{with} \quad \tilde{\lambda}'(\xi_t) < 0 \end{aligned}$$

where  $\xi_t = \frac{\bar{e}_t\mathcal{C}_{0,t}}{\mathcal{N}_{g,t}}$  is the natural concept for tightness in the goods market (from the point of view of consumers) and  $\lambda(\xi_t) = \xi_t\tilde{\lambda}(\xi_t)$ . That is,  $\tilde{\lambda}_t$ , the probability that an unmatched consumer finds a suitable firm from which to buy goods, is decreasing in goods market tightness. Conversely, the greater  $\xi_t$ , the greater the demand from consumers relative to the goods awaiting to find consumers, and the shorter the duration of search for producers. This creates an important feedback from the goods market to the labor market as the returns to hiring a worker are greater when it is easiest to find customers.

### 3.3 Consumers and the demand for goods

Individuals want to consume manufactured goods but may not buy them before prospecting on the goods market. Let us denote by  $D_{0,t}$  and  $D_{1,t}$  the values for a consumer of being unmatched and matched, respectively. The generic utility of consuming both goods is denoted by  $v(c_1, c_0)$ , where  $c_1$  and  $c_0$  are the consumption of the manufactured and essential goods. Unmatched consumers search for a good at an effort cost  $\sigma(e)$ , with  $\sigma'(e) > 0$  and  $\sigma''(e) \geq 0$ , and perceive their search effort as influencing their effective finding rate,  $e_t\tilde{\lambda}_t$ . Consequently, we have:

$$D_{0,t} = v(0, c_{0,t}) - \sigma(e_t) + \frac{1}{1+r} \mathbb{E}_t \left[ e_t \tilde{\lambda}_t D_{1,t+1} + (1 - \tilde{\lambda}_t e_t) D_{0,t+1} \right] \quad (13)$$

$$D_{1,t} = v(c_{1,t}, c_{0,t}) + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [\tau D_{0,t+1} + (1-\tau) D_{1,t+1}] + \frac{s}{1+r} \mathbb{E}_t D_{0,t+1} \quad (14)$$

Assuming the manufactured good has great marginal utility, matched consumers will always spend up to  $\mathcal{P}_t y_t$  on  $c_{1,t}$  and then consume what is left,  $Y_t^d - \mathcal{P}_t y_t$ , on  $c_{0,t}$ . In the current version, we assume a marginal utility for  $c_1$  of  $\Phi > 0$  and that the essential good provides a basic level of utility independent of the quantity consumed (we think of food and utilities, for example).

### 3.3.1 Optimal search effort

The optimal individual search effort is simply given a condition equating the marginal cost of effort to the discounted, expected benefit yielded by the marginal unit of effort:

$$\sigma'(e_t^*) = \frac{\tilde{\lambda}_t}{1+r} \mathbb{E}_t [(D_{1,t+1} - D_{0,t+1})] \quad (15)$$

and it follows that all consumers exert the same effort :

$$e_t^* = \bar{e}_t$$

Equation (15) implies that consumer search effort is increasing in the expected capital gain from consuming the manufactured good. Both disposable income and the dynamics of the price  $\mathcal{P}$ , which we discuss next, play a determining role in this respect.

### 3.3.2 Determining the dynamics of the goods surplus and price

Consistent with the search literature, we postulate that the price  $\mathcal{P}_t$  is bargained between a consumer and a firm. The total surplus to the consumption relationship is  $G_t = (S_{\pi,t} - S_{g,t}) + (D_{1,t} - D_{0,t})$ . The price for the good is determined as  $\mathcal{P}_t = \underset{\mathcal{P}_t}{\operatorname{argmax}} (S_{\pi,t} - S_{g,t})^{1-\delta} (D_{1,t} - D_{0,t})^\delta$ , where  $\delta \in (0, 1)$  is the share of the goods surplus  $G_t$  going to the consumer. This results in the sharing rule

$$(1 - \delta) (D_{1,t} - D_{0,t}) = \delta (S_{\pi,t} - S_{g,t}) \quad (16)$$

with which we can express the goods market surplus by the Bellman equation:

$$G_t = \Phi y_t + (1 - \eta_\sigma)\sigma(\bar{e}_t) - \Omega + [(1 - \tau) - (1 - \delta)\lambda_t] \frac{1 - s}{1 + r} \mathbb{E}_t G_{t+1} \quad (17)$$

where where  $\eta_\sigma > 0$  is the elasticity of the effort cost function. The negotiated price rule,<sup>3</sup>

$$\mathcal{P}_t y_t = (1 - \delta) [\Phi y_t + (1 - \eta_\sigma)\sigma(\bar{e}_t) + (1 - s)\sigma'(\bar{e}_t)\xi_t] + \delta\Omega \quad (18)$$

first states that the price is increasing in the marginal utility  $\Phi$  and the effort cost expended by consumer searching,  $\sigma(\bar{e}_t)$ . It is also increasing in goods market tightness  $\xi_t$ : the greater the effective demand on the consumer side relative to the supply of unmatched goods  $\mathcal{N}_g$ , the greater the price and hence profits for firms.

### 3.4 Matching in the labor market and wages

We assume that matching in the labor market is governed by a function  $M_L(\mathcal{N}_{l,t}, u_t)$ , where  $u_t$  is the rate of unemployment and the total number of unemployed workers since the labor force is normalized to 1.  $\mathcal{N}_{l,t}$  is the number of firms in stage  $l$ , or the number of "vacancies." The function is assumed to be constant return to scale, hence the rate at which firms fill vacancies is a function of the ratio  $\mathcal{N}_{l,t}/u_t = \theta_t$ , a measure of the tightness of the labor market. This rate,  $q(\theta_t)$ , is given by

$$q(\theta_t) = \frac{M_L(\mathcal{N}_{l,t}, u_t)}{\mathcal{N}_{l,t}} \text{ with } q'(\theta_t) < 0.$$

Conversely, the rate at which the unemployed find a job is

$$\frac{M_L(\mathcal{N}_{l,t}, u_t)}{u_t} = \theta_t q(\theta_t) = f(\theta_t) \text{ with } f'(\theta_t) < 0.$$

Once employed, workers earn a wage  $w_t$ , which we assume, for simplicity, takes the functional form

$$w_t = \chi_w (\mathcal{P}_t y_t)^{\eta_w} \quad (19)$$

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<sup>3</sup>Expressing the price as  $\mathcal{P}_t y_t = (1 - \delta) [\Phi y_t + (1 - \eta_\sigma)\sigma(e)] + \delta\Omega + (1 - \delta)\lambda_t \frac{1 - s}{1 + r} \mathbb{E}_t [\delta G_{t+1}]$  emphasizes the forward looking aspect of price determination. Today's price is increase in the expectations of tomorrow surplus on the goods market. The details of the derivation for this and subsequent equations are provided in the appendix.

where  $\eta_w$  can be interpreted as the elasticity of wages to the marginal product of labor  $\mathcal{P}_t y_t$ . In the spirit of search models, one may want to have a wage schedule as the outcome of Nash-bargaining between the firm and the worker. We decided to avoid the complications implied by Nash-bargaining in this context in order to focus on the role played by the elasticity of wages to productivity for propagation, thus leaving aside the question of bargaining in this context for future work.<sup>4</sup>

### 3.5 Matching and bargaining in the credit market

The matching rates  $p_t$  and  $\hat{p}_t$  are made mutually consistent by the existence of a matching function  $M_C(\mathcal{B}_{c,t}, \mathcal{N}_{c,t})$ , where  $\mathcal{B}_{c,t}$  and  $\mathcal{N}_{c,t}$  are, respectively, the number of bankers and projects in stage  $c$ . This function is assumed to have constant returns to scale. Hence, denoting by  $\phi_t$  the ratio  $\mathcal{N}_{c,t}/\mathcal{B}_{c,t}$ , which is a reflection tightness of the credit market from the point of view of projects, we have

$$p_t = \frac{M_C(\mathcal{B}_{c,t}, \mathcal{N}_{c,t})}{\mathcal{N}_c} = p(\phi_t) \text{ with } p'(\phi_t) < 0. \quad (20)$$

$$\hat{p}_t = \phi_t p(\phi_t) \text{ with } \hat{p}'(\phi_t) > 0. \quad (21)$$

The division of rents from implementing a project,  $S_{l,t}$ , are determined by bargaining about  $\varrho$  upon meeting. Calling  $\beta \in (0, 1)$  the bargaining power of the bank, the Nash-bargaining condition

$$(1 - \beta)B_{l,t} = \beta J_{l,t} \quad (22)$$

states that with  $\beta = 1$  the bank receives all the surplus. Note that the rule for  $\varrho$  is determined at the time of the meeting but paid a few periods after the negotiation, when the firms becomes profitable. We assume that there is no commitment problem (as in Wasmer and Weil 2004) so that any new realization of aggregate productivity will not undo the financial contract and there is no renegotiation.

Combining (1), (5) and (22), as well as the definition of  $\hat{p}$  in (21), we can obtain

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<sup>4</sup>Some complications with bargaining are as follows. First, given that firms pays the worker in two different stages (when it does not produce and when it does), this would imply not one but two wage schedules, with analytical complications but for a small quantitative difference since the surplus value of the firm in each stage are very close and exactly equal when the discount rate is small compared to the rate at which it finds a consumer. Hence, a similar wage rule in the two stages is a quantitatively good assumption. Second, given the number of parties, several complexities arise in which we would need to make assumptions on timing and bargaining structure. We ignore these here by choosing a rather simple wage determination rule.

the equilibrium value of  $\phi_t$  denoted by  $\phi^*$  with

$$\phi^* = \frac{\kappa}{e} \frac{1 - \beta}{\beta} \forall t \quad (23)$$

Free-entry of both banks and projects on credit markets implies a credit market tightness that is constant over time, even out of the steady-state. Going forward, all the information pertaining to the credit market is contained in the total transaction costs paid by both firms and banks in stage  $c$ :

$$K(\phi^*) \equiv \frac{\kappa}{\phi^* p(\phi^*)} + \frac{e}{p(\phi^*)} \quad (24)$$

### 3.6 Stocks of consumers, employment and unemployment

Having stipulated the transition rates for all agents in the economy, we can now write the laws of motion for the stocks of consumers, firms and, consequently, employment. Potential consumers  $\mathcal{C}_0$  become consumers the period after meeting a producer, and a fraction  $0 < \tau < 1$  of current consumers separate from their product only to return to the pool of potential consumer the following period. The stocks of consumers on the goods market therefore evolve according to:

$$\mathcal{C}_{0,t+1} = (1 - \tilde{\lambda}_t) \mathcal{C}_{0,t} + [s + (1 - s)\tau] \mathcal{C}_{1,t} \quad (25)$$

$$\mathcal{C}_{1,t+1} = (1 - s)(1 - \tau) \mathcal{C}_{1,t} + \tilde{\lambda}_t \mathcal{C}_{0,t} \quad (26)$$

There is an inflow  $q(\theta_t) \mathcal{N}_{l,t}$  into the stock of firms search on the goods market,  $\mathcal{N}_g$ , in every period. To this,  $(1 - s)\tau \mathcal{N}_{\pi,t}$  firms separated from consumers lead the stocks  $\mathcal{N}_g$  and  $\mathcal{N}_{\pi}$  to evolve according to:

$$\mathcal{N}_{g,t+1} = (1 - s)(1 - \lambda_t) \mathcal{N}_{g,t} + (1 - s)\tau \mathcal{N}_{\pi,t} + q(\theta_t) \mathcal{N}_{l,t} \quad (27)$$

$$\mathcal{N}_{\pi,t+1} = (1 - s)(1 - \tau) \mathcal{N}_{\pi,t} + (1 - s)\lambda_t \mathcal{N}_{g,t} \quad (28)$$

Finally, the dynamics of aggregate unemployment and employment are then given by

$$u_{t+1} = s(1 - u_t) + (1 - f(\theta_t))u_t \quad (29)$$

$$1 - u_t = \mathcal{N}_{g,t} + \mathcal{N}_{\pi,t} \quad (30)$$

### 3.7 Disposable income

The total net profits in this economy,  $\Pi_t$ , are the sum of profit flows to projects and banks. This corresponds to:

$$\Pi_t = (\mathcal{P}_t y_t - \Omega) \mathcal{N}_{\pi,t} - w_t \mathcal{N}_t - \gamma \mathcal{N}_{l,t} - \kappa \mathcal{B}_{c,t}$$

The first term is the revenue generated by firms in stage 4, net of operating costs. The second term represents wage payments in the economy. The remaining terms represent the negative cash-flows of the bank during the first stages due to search costs in labor and credit markets.

These profits net of search costs are pooled and distributed lump sum to workers. The mass 1 of workers, the unemployed and employed, therefore receive per person and per period  $\Pi_t$  as a cash transfer. Further, resources are pooled across categories of workers, as in Merz (1995) and Andolfatto (1996), such that the average disposable income of a representative consumer,  $\Pi_t + \mathcal{N}_t w_t$ , is

$$Y_t^d = (\mathcal{P}_t y_t - \Omega) \mathcal{N}_{\pi,t} - \gamma \mathcal{N}_{l,t} - \kappa \mathcal{B}_{c,t} \quad (31)$$

This measure corresponds to the potential demand for consumption goods, not all of which will be satisfied due to frictions in the goods market.

## 4 Evaluating the sources of propagation

We begin by detailing our calibration strategy. Next, we present the quantitative results for the full model and discuss in detail the sources of propagation. This section also presents some robustness results with respect to parameters of the goods market, while we compare the role of the different frictions in Section 4.

### 4.1 Calibration strategy

We consider the basic unit of time to be a quarter and calibrate the model accordingly. The risk free rate  $r$  is set to 1%, corresponding to an annualized return close to the historical average on 3-month Treasury bills. The labor and goods market parameters are determined by matching a set of first moments, presented in Table 1 and discussed below, with the exception of the bargaining weight  $\delta$ . We estimate the values of the AR(1) parameters and the consumer bargaining weight  $\delta$  by maximizing the

likelihood of the rational expectations solution to a linear approximation of the model on quarterly data for labor market tightness over the period 1977:1 to 2004:3. This estimation procedure yields parameter estimates for technology presented in Table 2, and a bargaining weight of  $\delta = 0.34$ .

Table 1: Targeted moments: goods, labor and credit markets

Unemployment rate	$u$	10%
Wage rate	$\frac{w}{\mathcal{P}}$	0.75
Average recruiting cost over wage bill	$\frac{\gamma \mathcal{N}_t / q(\theta)}{w \mathcal{N}}$	3%
Unmatched goods	$\frac{\mathcal{N}_g}{\mathcal{N}}$	19%
Consumer matching rate	$\tilde{\lambda}$	0.75
Consumer search effort	$\mathcal{C}_0 \sigma(\bar{e}) / w \mathcal{N}$	0.1
Share of essential good in consumption	$\frac{C_0 Exp C_{0,0} + C_1 Exp C_{1,0}}{Y^d}$	15%
Mark-up over marginal cost	$\frac{\mathcal{P}}{\mathcal{N}_g w + \mathcal{N}_\pi (w + \Omega)} - 1$	15%
Share of financial sector in GDP	$\Sigma$	3%

We target an average rate of unemployment of 10%, and a wage rate of three quarters of the marginal revenue,  $\mathcal{P}$ . In addition, we require recruiting costs to represent 3% of the wage bill in steady state, consistent with the evidence reported in Silva and Toledo (2007). Based on the evidence in Davis et al. (2006), we set the exogenous job separation rate to  $s = 0.05$ . The elasticity of the labor matching function,  $M_L(\mathcal{N}_t, u) = \chi_L \mathcal{N}_t^{1-\eta_L} u^{\eta_L}$ , is set to  $\eta_L = 0.5$ , in the mid-range of values reported in the survey by Petrongolo and Pissarides (2001). The elasticity of the wage to the marginal product is set to 0.5, close to the value suggested by Gertler and Trigari (2009).

Only firms matched with a consumer sell their goods in this economy, thus workers associated with projects that are not selling their goods are, in a sense, un-utilized capacity. We thus target a capacity utilization rate of 81%, similar to the calibration in Bai, Rios-Rull and Storesletten (2011). These authors target a capacity utilization rate in the consumption sector of 81% based on the Federal Reserve's Statistical Release of Industrial Production and Capacity Utilization. Finally, the cost parameter

$\Omega$  is adjusted to match a 15% price mark-up over marginal cost.

With respect to consumer search, we target an average search duration of a little over 5 weeks before finding and deciding on a new consumption good, implying  $\tilde{\lambda} = 0.75$ . Given our other calibration targets, the steady state rate of product entry, defined as  $\frac{\tilde{\lambda}C_0}{C_1}$ , is 0.25 on an annualized basis. This is consistent with the product entry rate, weighted by expenditure shares, found by Broda and Weinstein (2010). The goods market matching function is assumed to take the form  $M_G(\bar{e}C_0, \mathcal{N}_g) = \chi_G (\bar{e}C_0)^{1-\eta_G} \mathcal{N}_g^{\eta_G}$  and we assume an elasticity of 0.5, performing a series of sensitivity tests below. To calibrate the effort placed into the search for consumption goods, we rely on the BLS' time use survey which reports that households spend on average half an hour a day purchasing goods and services (0.4 hours for men, 0.6 for women). Of course, this is not necessarily time spent searching and comparing goods before making a choice. Nor does it include travel related to these activities. Assuming an individual works on average 5 hours a day, spread over a week, the cost of time searching in the goods market corresponds to approximately 10% of wage income. That is, we target  $C_0\sigma(\bar{e})/w\mathcal{N} \simeq 0.1$ . The model product exit rate is given by  $s + (1 - s)\tau$ , which Broda and Weinstein found to be 0.24 at an annual frequency (weighted by expenditure shares). This implies quarterly goods separation rate of  $\tau = 0.011$ .

Finally, we target an expenditure share in the essential good based on the Household Consumption Expenditure survey's average annual expenditure on food consumed at home, plus utilities, over the period 1984 to 2009. This amounts to 15% of total annual expenditures. In the model, this share is defined as  $\frac{C_0 ExpC_{0,0} + C_1 ExpC_{1,0}}{Y^d}$ , where  $ExpC_{1,0} = Y^d - \mathcal{P}$  is the expenditure on the essential good of a matched consumer, and  $ExpC_{0,0} = Y^d$  the expenditure of an unmatched consumer. These expenditures are weighted by the fraction of unmatched and matched consumer.

The calibration of the credit market requires choosing parameters of the credit matching function, assumed to be of the form  $M_c(\mathcal{B}, N_c) = \chi_C \mathcal{E}^{1-\eta_C} \mathcal{B}^{\eta_C}$ , the costs of prospecting on credit markets and the bargaining weight  $\beta$ , and follows Petrosky-Nadeau and Wasmer (2011). We assume symmetry in prospecting costs  $\kappa = e$ , and the remaining parameters,  $\chi_C$ ,  $\eta_C$  and  $\beta$ , are adjusted to accommodate a targeted share of the financial sector in GDP:<sup>5</sup>

$$\Sigma = \frac{\mathcal{B}_\pi \rho - \mathcal{B}_g w - \mathcal{B}_l \gamma - \mathcal{B}_c \kappa}{Y^d}$$

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<sup>5</sup>The derivation of the steady state repayment  $\varrho$ , along with the numerical procedure, are detailed in the appendix.



Table 2: Baseline parameter values

<b>Labor market</b>			<b>Goods market</b>		
job separation rate	$s$	0.05	goods exit rate	$\tau$	0.01
matching elasticity	$\eta_L$	0.5	matching level param.	$\chi_G$	0.52
wage elasticity	$\eta_w$	0.5	matching elasticity	$\eta_G$	0.5
matching level param.	$\chi_L$	0.58	consumer barg. weight	$\delta$	0.34
wage level param.	$\chi_w$	0.57	cost function - level	$\chi_\sigma$	0.55
vacancy cost	$\gamma$	0.01	cost function - elasticity	$\eta_\sigma$	6.22
			Marginal utility of $c_1$	$\Phi$	0.64
<b>Credit market</b>			<b>Technology</b>		
bank's barg. weight	$\beta$	0.27	labor productivity	$y$	1
matching elasticity	$\epsilon$	0.5	persistence param.	$\rho_y$	0.975
matching level param.	$\chi_C$	1.9	standard deviation	$\sigma_y$	0.01
search costs	$\kappa = e$	0.05	risk free rate	$r$	0.01

## 4.2 Looking into the sources of propagation

The central equation relating labor market tightness and the expected value of hiring a worker, equation (10), lies at the heart of propagation in this class of models. In combination with (9) and calling  $o_t(r) \equiv r \left( \frac{1/q(\theta_t)-1}{1+r} \right)$  a term vanishing as the discount rate goes to zero, this is:

$$K(\phi^*)(1 + o_t(r)) + \frac{\gamma}{q(\theta_t)} = \frac{1}{1+r} \mathbb{E}_t S_{g,t+1} \quad (32)$$

which equates the average cost of creating a job - the left-hand side, equal to the financial costs properly discounted,  $K(\phi)$ , and the expected costs of search on the labor market,  $\gamma/q(\theta_t)$  - to the discounted expected value of a worker to the firm in the goods market stage (the right-hand side). A few words of comparison with the canonical search model are warranted here. First, the costs of financial intermediation enter the left hand side of the equation and place a lower bound on the value of a “vacancy” to a firm. Absent credit market frictions the average cost of creation

depends on the flow cost of a vacancy  $\gamma$  and congestion on the labor market. Second, the expected value on the right hand side corresponds to the ability to produce and sell a good once a consumer has been located. Under frictionless goods markets the right hand side is simply the value of the profit stage. Thus the current model nest the canonical search model when  $K(\phi^*)$  tends to zero and the goods market friction is removed.

A log-linear approximation around the deterministic steady state of this job creation condition yields

$$\widehat{\theta}_t = \frac{1}{\eta_L} \frac{S_g}{S_g - K(\phi)} \mathbb{E}_t \widehat{S}_{g,t+1} \quad (33)$$

where  $\eta_L$  is the elasticity of the job filling rate with respect to labor market tightness and “hatted” variables indicate proportional deviations from the steady state. Over and above the amplification of changes in  $S_g$  from frictions in the labor markets, measured as the inverse of the elasticity of the labor matching function, frictions in credit markets create an amplifying factor of  $\frac{S_g}{S_g - K(\phi)}$ . This financial accelerator is decreasing in the firm’s surplus to hiring a worker,  $S_g - K(\phi)$ , and its full potential is explored in detail in Petrosky-Nadeau and Wasmer (2011).

Goods market frictions fundamentally change the dynamics of  $S_g$  along two principal dimensions: 1) the expected likelihood of reaching the profit stage in the period after hiring the worker,  $\lambda$ ; 2) the expect profit flow, which is now dependent on the expectation of what price the goods will fetch on the market,  $\mathcal{P}$ . In order to see this more clearly, recall that the values of the goods market and profit stages derived earlier are:

$$\begin{aligned} S_{g,t} &= -w_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [\lambda_t S_{\pi,t+1} + (1-\lambda_t) S_{g,t+1}] \\ S_{\pi,t} &= \mathcal{P}_t y_t - w_t - \Omega + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t [(1-\tau) S_{\pi,t+1} + \tau S_{g,t+1}] \end{aligned}$$

along side the value of a hired worker in the Mortensen-Pissarides world:

$$S_{g,t}^{MP} = y_t - w_t + \left( \frac{1-s}{1+r} \right) \mathbb{E}_t S_{g,t+1}^{MP}$$

From the recursive nature of  $S_{g,t}^{MP}$ , all that matters for the dynamics of labor market tightness is the expected path of the net profit flow  $y_t - w_t$ . For most wage rules, this

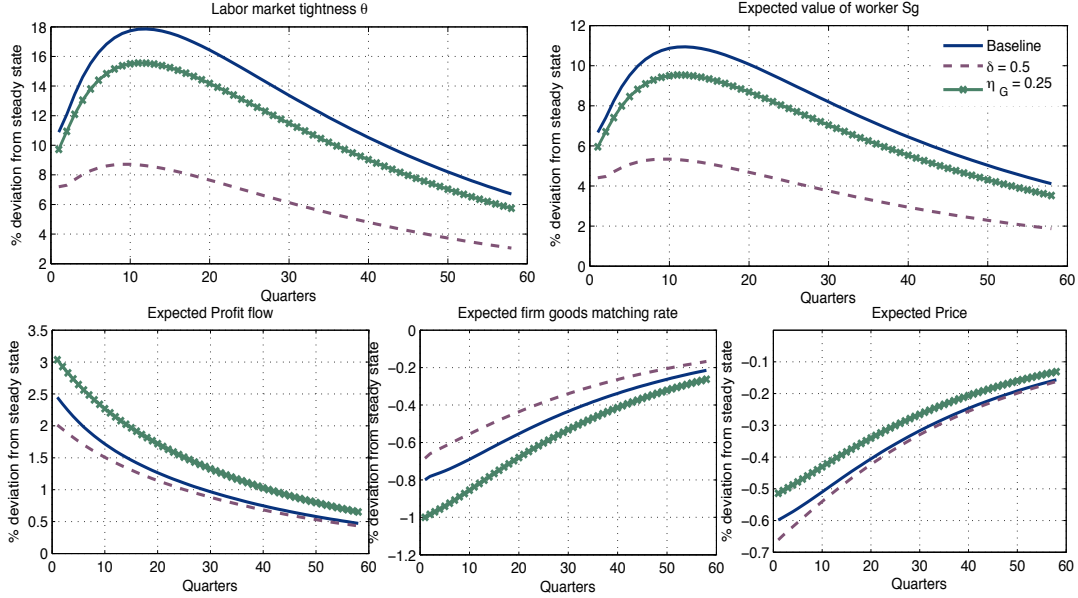


Figure 1: Impulse responses to a positive productivity shock, Baseline and Sensitivity to goods market parameters  $\eta_G$  and  $\delta$

will simply follow the path of the process for productivity and, consequently, and we have the familiar response of labor market tightness to a productivity shock (this is depicted as the crossed line in the first panel of Figure 2).<sup>6</sup>

Compare now the response of labor market tightness and  $S_g$ , with imperfect goods markets, in the first two panels of Figure 1. The same figure also plots the responses of the expectation of the key variables governing the dynamics of  $S_g$  at the moment a firm is making the vacancy decision, i.e.  $\mathbb{E}_t \lambda_{t+1}$  and  $\mathbb{E}_t \mathcal{P}_{t+2}$ . Labor market tightness and  $S_g$  reach their peak 11 periods after the realization of the shock to technology. As the bottom panels of Figure 1 indicate, firms expect a drop in the likelihood of selling their goods following recruiting a worker, but also that conditions on goods market will improve over time, both in terms of market congestion and the price at which they will sell. The evolution of the goods market thus creates increasing incentives to hire workers, even as productivity and the profit flow will be returning to trend. These first forces dominate the second in the initial phase of the expansion such that we see an increase in the value to recruiting a worker and, hence, labor market tightness.

The next table presence a series of second moments for goods market variables, in

<sup>6</sup>We can show that the autocorrelation function of the growth rate is essentially zero at all horizons.

Table 3: Unconditional second moments - goods market variables

Goods market		a	b			a	b
Tightness	$\xi$	1.37	-0.69	Consumer search effort	$e$	0.65	0.91
Firms hazard rate	$\lambda$	0.69	-0.69	Unmatched consumers	$\mathcal{C}_0$	0.53	-0.64
Consumer hazard rate	$\tilde{\lambda}$	0.69	0.69	Unmatched firms	$\mathcal{N}_g$	1.71	0.70
Price of goods $c_1$	$\mathcal{P}$	0.49	-0.79				

a: standard deviation relative to output; b: contemporaneous correlation with output. All moments are HP filtered

terms of H.-P. filtered standard deviations relative to output and contemporaneous correlations with output. Focusing first on congestion in the goods market, tightness  $\xi = \frac{\bar{e}\mathcal{C}_0}{\mathcal{N}_g}$  is countercyclical, consumers match more quickly with goods in a boom while, as we mentioned, the matching rate of firms  $\lambda$  is countercyclical. The number of unmatched firms, or goods on the market search for consumers, is greater during an expansion, capturing a notion as in Shleifer (1986) of booms being periods when more projects are implemented. Consumers search effort is pro-cyclical while the fraction of unmatched consumers is counter-cyclical.

Table 4 reports the business cycles characteristics of labor market variables, along with those for aggregate consumption and output. The baseline calibrated model comes close to replicating the amount of volatility of labor market tightness seen in the data, generating a standard deviation relative to that of output of 11.10. The same is true for the volatilities of vacancies and unemployment, and the contemporaneous correlations of each the variables with the cyclical component of aggregate output is consistent with the data. The last rows of Table 4 report the autocorrelation of output and labor market tightness growth rates at the first three lags. This measure indicates that goods market frictions generate a substantial amount of persistence in the dynamics of the labor market.

### 4.3 The role of goods market congestion and prices

The elasticity of the goods matching function,  $\eta_G$ , and the consumer's bargaining weight,  $\delta$ , will affect the responses of the variables that are key for propagation through the goods market. Figure 1 plots the impulse responses to the same technological innovation of labor market tightness,  $S_g$  and its determinants, when we increase the bargaining weight  $\delta$  from 0.34 to 0.5, and reduce the elasticity  $\eta_G$  from 0.5 to 0.25. Table 4 reports the filtered second moments for each scenario.

Table 4: Business cycle moments and sensitivity to goods market parameters

	US data		Baseline		Consumer barg. $\delta = 0.5$		Goods Match. $\eta_G = 0.25$		$\eta_L = \eta_G = 0.25,$ $\delta = 0.34$	
	a	b	a	b	a	b	a	b	a	b
	Vacancies	8.83	0.89	7.51	0.94	5.04	0.91	7.04	0.95	5.83
Unemployment	6.82	-0.88	5.00	-0.81	3.17	-0.76	4.68	-0.79	7.47	-0.90
Labor tightness	15.41	0.90	11.10	0.99	7.04	0.99	10.41	0.99	11.08	0.99
Wage	0.40	0.44	0.29	0.61	0.31	0.65	0.31	0.73	0.24	0.53
Consumption	0.59	0.80	0.68	0.89	0.65	0.81	0.71	0.92	0.81	0.97
$\sigma(GDP)$	1.40		1.13		1.03		1.08		1.47	
Persistence:	GDP	$\theta$	GDP	$\theta$	GDP	$\theta$	GDP	$\theta$	GDP	$\theta$
$corr(\Delta x_t, \Delta x_{t-1})$	0.24	0.61	0.06	0.17	0.003	0.06	0.07	0.18	0.31	0.33
$corr(\Delta x_t, \Delta x_{t-2})$	0.19	0.40	0.26	0.18	0.14	0.07	0.16	0.17	0.44	0.29
$corr(\Delta x_t, \Delta x_{t-3})$	0.05	0.30	0.12	0.15	0.04	0.06	0.09	0.14	0.32	0.24

Notes: H.-P. filtered (a) standard deviation relative to GDP; (b) contemporaneous correlation with GDP.

Data sources: B.E.A., B.L.S. and Conference Board, 1977:Q1 to 2007:Q4.

Increasing the share of the goods surplus accruing to the consumer implies a stronger downward response of the price and, although the goods matching rate for firms  $\lambda$  still drops at first, its return to steady state is very progressive. The result is much more muted response of the value of hiring a worker, with on a modest “hump.” The persistence of labor market tightness is thus only a third of what it was under the baseline parameter values, and its relative volatility decreases from 11.10 to 7.04. Reducing the elasticity of the goods matching function, on the other hand, has only a minor impact on the quantitative results: the second moments in Table 4 are mostly the same as in the baseline parameterization.

We perform a final sensitivity analysis in this Section in which we set the elasticities of the labor and goods matching function both to 0.25, retain the estimated value for the bargaining weight of 0.34. While this has little impact on the relative volatility of labor market tightness, there is a much stronger response of employment and output to the same changes in market tightness  $\theta$ . As the job finding rate varies more over the business cycle, there is a significant increase in the relative volatility of unemployment, and in terms of persistence, the model is much closer to the autocorrelation in the growth rate of  $\theta$  seen in the data.

## 5 Comparing frictions

We solve for three comparative models in which we remove and combine the different frictions to assess their relative quantitative importance. Table 5 reports the corresponding business cycle moments from these models, and summarizes the empirical shortcomings of the canonical search model of unemployment. The first concern is the well known lack of amplification of productivity shocks: labor market tightness is nearly 15 times more volatile than GDP over the business cycle whereas the model generates a relative volatility of 3. The second concern is persistence, measured by autocorrelation in growth rates. Labor market tightness is very persistent in the data, much more so than GDP, whereas the canonical model generates no persistence:  $\theta$  follows exactly the shock process. Figure 2 illustrates this lack of persistence by plotting the impulse response to a positive productivity shock. The response does not display any “hump” in the absence of frictions in the goods market. Table 5 also reveals that goods market frictions contribute most to improving the qualitative and quantitative dynamics of labor market variables.

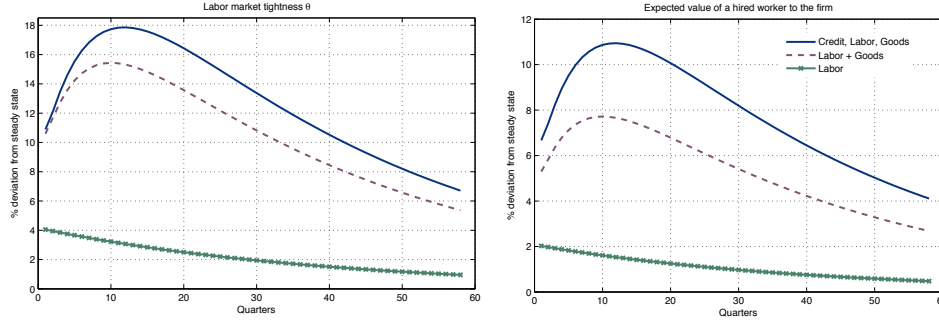


Figure 2: Good market frictions: inspecting the mechanism

Table 5: Second moments - comparing frictions

	Goods, labor and credit		Goods & labor		Labor & credit		Labor only	
	a	b	a	b	a	b	a	b
Vacancies	7.51	0.94	7.18	0.92	3.34	0.85	3.09	0.88
Unemployment	5.00	-0.81	4.72	-0.81	0.17	-0.66	0.16	-0.67
Labor tightness	11.10	0.99	10.50	0.99	3.46	0.86	3.20	0.88
Wage	0.29	0.61	0.29	0.66	0.38	0.86	0.40	0.88
Consumption	0.68	0.89	0.65	0.89	0.68	0.67	0.66	0.75
$\sigma(GDP)$	1.13		1.13		1.18		1.18	
Persistence:	GDP	$\theta$	GDP	$\theta$	GDP	$\theta$	GDP	$\theta$
$corr(\Delta x_t, \Delta x_{t-1})$	0.06	0.17	0.05	0.14	0.29	-0.01	0.26	-0.01
$corr(\Delta x_t, \Delta x_{t-2})$	0.26	0.18	0.24	0.14	0.24	-0.01	0.21	-0.01
$corr(\Delta x_t, \Delta x_{t-3})$	0.12	0.15	0.11	0.11	0.21	0	0.18	0

Notes: H-P. filtered (a) standard deviation relative to GDP; (b) contemporaneous correlation with GDP.

## 6 Conclusion

This paper investigates the significance of goods market frictions for the dynamics of the labor market in particular, and the macroeconomy in general. The qualitative and quantitative features of labor market dynamics are very much affected by intertemporal linkages with the dynamics of prices and congestion on goods markets.

We model the friction on the goods market a costly search process in which consumers prospect for goods to add to their consumption bundle and firms try to find customers for their goods. During the first stages of an economic expansion, more

firms enter the goods market relative to the change in the the effective demand from consumers. This causes an increase in congestion in the goods markets, from the point of view of firms, and a decline in the negotiated price at which the goods are eventually sold. From the perspective of a firm deciding to hire a worker, this dampens the incentive to create a vacancy at the beginning of an expansion as it is less likely the additional production will find an outlet, and if it does, it sells at a lower price. However, as the cycle continues and productivity is returning to trend, the goods market eases in the sense of there being relatively more demand from consumers than products competing for customers. This decrease in congestion, which also leads to firms obtaining a better price, actually increases the incentive to recruit workers. We thus see a rise in labor market tightness for several periods after the initial shock, a persistence that arises from the fact that the economic value of hiring a worker is tied through interesting intertemporal linkages to congestion and prices on goods markets. These mechanisms are absent from the standard labor search model and a large class of extensions.



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