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Firm Turnover and Inflation Dynamics

Lenno Uusküla*

Abstract

This paper examines the role of firm turnover in explaining inflation dynamics. I augment a New-Keynesian DSGE model with endogenous entry and exogenous stochastic exit and estimate with the Bayesian full information approach for the US economy. Results show that shocks to the entry cost explain more than half of the inflation variance at the business cycle frequencies. When it is cheap to create firms, the number of new firms goes up and inflation increases as labour intensive creation of firms pushes up the demand for labour. Only gradually, when the number of firms is high and the number of new firms goes down again, does inflation fall, as stressed by the standard mechanism for an increasing number of firms.

JEL Code: E32, C11, E23

Keywords: inflation, New-Keynesian Phillips curve, firm turnover

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Non-technical summary

A lot has been said since the great recession about the need for structural reform and this discussion has also touched on measures to facilitate company creation. At the same time, inflation has been relatively low and so it is important to ask whether support for company creation will raise or lower the rate of inflation.

The creation of new companies and an increase in the number of companies is usually associated with low inflation. Assessing the connection between the number of companies and inflation while controlling at the same time for all other indicators, including costs, reveals that inflation falls when there are more companies. The reason for this is that increased competition brings prices down. The same logic applies in this article, though the results show that inflation initially increases when new companies are created. Rising inflation is driven by higher demand for labour because labour resources are needed for the creation of companies, as not only are there operational tasks to do, but a business plan needs to be drawn up, products or services created, and clients found. But high demand for labour raises wages, which in turn leads to a rise in inflation. Once the effect of the shock dissipates and there are a lot of companies in existence, with new ones being added only at the usual rate, inflation starts to fall.

Although this is a technology shock, it has the features of a demand-side shock, meaning that total output and inflation move in the same direction. If it is expensive to create a company and the total output of the economy is low, then inflation is also low. In economic policy terms it is important for central banks managing inflation to moderate the GDP cycle caused by supply-side shocks, as low inflation leads to a fall in monetary policy interest rates.

Inflation is usually one of the indicators that is hard to explain empirically and the main shocks that affect inflation are exogenous mark-up and cost shocks, though these do not affect other economic indicators. However, the results of this article show the importance of the cost shock from creating companies in setting inflation. Such shocks can describe more than half of the total dynamics of inflation and a large part of the variation in hours worked and in the creation of companies.

The results come from a New Keynesian dynamic stochastic general equilibrium model, which is estimated using the Bayesian full likelihood approach on US data. The model is based on the work of Smets and Wouters (2007), Uhlig (2007) and Bilbiie, Ghironi and Melitz (2012). Households consume and do work, and companies are divided into two sectors. Companies in the end-production sector aggregate input goods to produce consumer goods and there is a set number of companies in this sector and full competition. Companies producing input goods, however, operate in a market with monopolistic competition. Creating a company takes work and the number of companies in the sector producing input goods is set by the free entry condition. Some companies cease operations during each period and the rate of this is random. The interest rate rule for the central bank is based on the Taylor rule and the interest rate reacts mainly to inflation.

Contents

1. Introduction

The New-Keynesian Phillips curve is one of the cornerstones of dynamic stochastic general equilibrium (DSGE) models. However, in Smets and Wouters (2007) exogenous price markup shocks explain more than half of the variance in inflation during the first years after a shock and later by wage cost-push shocks. This paper examines the role of firm turnover in inflation dynamics. The number of firms enters the New-Keynesian Phillips curve directly and can therefore potentially help to improve the fit of the equation.

To study the role of firm turnover in inflation I augment a medium scale sticky price and sticky wage New Keynesian DSGE model such as Uhlig (2009) or Smets and Wouters (2007) with endogenous firm entry and stochastic exogenous exit. The creation of firms is labour intensive and the number of firms is determined by free entry condition. The law of motion for the number of firms is based on Bilbiie et al. (2012). In the model the number of firms enters the Phillips curve and influences markup dynamics as in Bergin and Corsetti (2008), Bilbiie et al. (2007) and Bilbiie et al. (2012). In addition to having endogenous entry I allow the death rate of firms to be stochastic as in Vilmi (2009). Among many others, Jacobson et al. (2013) demonstrate that the exit margin is important in the business cycle. Likewise Elsby et al. (2009) results support the hypothesis that both ins and outs of unemployment are important for understanding employment and unemployment dynamics. By analogy their findings support the use of the stochastic exit margin in the current paper.

The rest of the model is relatively standard. Households consume, supply labour for intermediate firms, and face a cash-in-advance constraint and a standard budget constraint. Final sector firms produce consumption goods from the intermediate sector inputs. Intermediate good firms face nominal price rigidity and backward real wage rigidity. I allow for a working capital channel; this financial friction directly introduces the interest rate in the New-Keynesian Phillips curve and can therefore help to explain inflation. Firms borrow resources from banks to pay for a share of production and entry costs in advance. In this way a change in the interest rate has a direct impact on inflation on top of the marginal costs.[1] The model has five structural shocks:

[1]The financial friction originates from the seminal work of Christiano et al. (1997) and has more recently been employed by Ravenna and Walsh (2006) and Rabanal (2007). The financial friction has been demonstrated to be crucial for understanding entry; Uusküla (2008) shows that it allows the effects of monetary policy shocks in a model to be matched qualitatively to the empirical evidence of net entry dynamics. See also Bergin et al. (2014), Gross and Verani (2013), Macnamara (2014) and Robb and Robinson (2012) for recent evidence of financial frictions in firm turnover.

monetary policy, labour productivity and wage cost-push shocks, a shock to the sunk cost of starting a business, and a shock to the firm survival probability. I match the model with US data on consumption, hours, the inflation rate, the interest rate, and the number of new firms. I estimate the parameters of the model with the Bayesian full information approach and use the variance decomposition at the business cycle frequency and the forecast error variance decomposition to discuss the main results.

My results give a critical role to firm dynamics in understanding the inflation rate. The shocks to the cost of firm creation explain more than half of the variance in inflation at the business cycle frequency. The result is driven by matching firm turnover data in the model. When the model is estimated with wages instead of entry in the model, the importance of entry cost shocks disappears, assigning more importance to price markup and wage cost-push shocks. The benchmark results assign very little importance to the wage cost-push shocks in explaining inflation, standing in contrast with the findings of Smets and Wouters (2007). At the same time technology shocks explain a fifth of the inflation variance over the business cycle, which is in line with the DSGE and VAR literature.[2] Finally, monetary shocks and firm survival shocks explain around six percent of the variance in inflation over the business cycle.

In the estimated model an increasing number of firms due to low entry costs do not lead to an immediate drop in prices, though the literature usually stresses that the causal link is from the increasing number of firms to lower prices. The increase in the inflation rate along with the increasing number of firms happens because firm creation is labour intensive, and so a drop in the cost of entry leads to more firms being created and results in an increase in the demand for labour, pushing up marginal costs and inflation. As more firms are created and the number of firms goes up, fewer new firms are created, the markup effect becomes stronger and inflation falls again. This mechanism has an important policy conclusion, which is that inflation may not slow down when encouraging competition through entry, but instead inflation is likely to increase in the short term.

Although the firm turnover does not change the core of the model substantially, some of the parameter posteriors differ from standard estimates. The most remarkable is the very low estimate of the wage stickiness parameter. The result support the recent literature on the real wage flexibility of new hires. Pissarides (2009) in Tables II and III lists eight studies for the US and four studies for European economies that find evidence for real wage flexibility of new hires in existing companies; wages of the new employees are not sticky. Moreover, the sensitivity of wages to the economic situation is even

[2] See Smets and Wouters (2007) for the DSGE and Altig et al. (2011) for the VAR literature.

stronger in European countries. If wages are flexible for new hires in ongoing firms, it is even less likely that the wages in new firms would not depend on economic conditions. The price rigidity parameter is lower than in Ireland (2001) and Lewis and Stevens (2015). The relation of price and wage rigidity is consistent with the classic paper by Bils (1987) finding countercyclical markups.

The paper contributes to three strands of literature. First for the current policy debate on product market liberalisation the paper shows that although an increase in the number of firms may result in lower inflation, policies promoting firm creation that result in a higher number of firms might be inflationary in the short run. Second it shows that the inclusion of firm turnover can be important in the New-Keynesian Phillips curve and help to explain inflation. Third the estimation results demonstrate that DSGE models with firm turnover in many dimensions might need to be calibrated differently from models without firm turnover. The draft of the paper was the first to estimate the entry model with the Bayesian full information technique. Recently Lewis and Stevens (2015) have also estimated a somewhat different New Keynesian model concentrating on the effects of variable price markup generated by competition. Offick and Winkler (2014) estimate a real business cycle model and look at the amplification effects of firm dynamics. Neither of them consider stochastic exit or financial frictions in the model.

The rest of the paper is organised as follows. The second section introduces the model with firm turnover. The third section gives a short overview of the data and the estimation approach. The main results are presented in section four, first presenting forecast error variance decomposition results; and section five concludes.

2. The model

In this section I present a New Keynesian dynamic stochastic general equilibrium model with endogenous creation and exogenous destruction of firms. The five types of agents in the economy are households, final goods producers, intermediate goods producers, commercial banks and a government or central bank.

Households maximise their utility from consumption and leisure. Each period they face a standard budget constraint and a cash-in-advance constraint for the goods that are cash goods. They deposit funds in banks. The consumer side is very close to Uhlig (2009) and Smets and Wouters (2007).

Firms operate in two sectors. In the final goods sector, firms operate under full competition and produce consumption goods aggregating inputs from the intermediate firms. This is a slight modification from Bilbiie et al. (2012) who let the consumer consume individual goods from the intermediate sector. Moreover I take away the productivity effects that arise from varying the number of varieties in the CES aggregation in order to concentrate on the inflation dynamics of the model.

In the intermediate goods production sector firms operate under monopolistic competition structure. The creation of firms is labour intensive. The number of firms in the intermediate goods sector is determined by the free entry condition, in line with the literature on firm dynamics. In addition intermediate good firms are subject to stochastic death shocks as in Vilmi (2009).

The economy has a financial sector. Banks take deposits from households and receive monetary injections from the government. They give loans to the intermediate firms who need to borrow a share ξ of their wage bill before production from the banks. Finally, the monetary policy authority decides the monetary injections to commercial banks by targeting the interest rate.

The next subsections introduce the model in detail starting from the household problem, followed by final and intermediate goods firms, banks, the central bank and aggregation conditions. The section finishes with the definition of the equilibrium.

2.1. Household problem

The representative household maximises discounted lifetime utility from consumption c_t and they dislike time spent working n_t:

$$U_t = E_t \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - \chi c_{t-1})^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{A n_t^{1+\frac{1}{\kappa}}}{1+\frac{1}{\kappa}} \right) \right], \tag{1}$$

where U_t is lifetime utility, E_t is the conditional expectations operator, β is the discount factor, χ is the consumption habit parameter, σ is the intertemporal elasticity of substitution, κ is the Frisch elasticity of labour supply, A is a scaling parameter and t is the time index.

Households need cash at hand H_{t-1} to buy a fraction η of the consumption good. The cash-in-advance constraint is $H_{t,res} + \eta C_t = H_{t-1}$ where $H_{t,res}$ is the residual cash holding, which in equilibrium equals zero, and H_{t-1} is cash at hand in period t. The equation is divided by price level P_t to get the budget constraint in real terms:

$$h_{t,res} + \eta c_t = \frac{h_{t-1}}{\pi_t^C}, \tag{2}$$

where $c_t = \frac{C_t}{P_t}$, $h_{t,res} = \frac{H_{t,res}}{P_t}$, $h_{t-1} = \frac{H_{t-1}}{P_t}$, and π_t^C is consumer inflation defined specifically later. All lower case letters denote real and uppercase letters denote nominal variables unless clear from the context or stated otherwise.

Households face a sequence of budget constraints. The available funds in period t consist of the income from working, deposits, bonds, profits, transfers and possible residual cash.

$$H_t + D_t + q_t B_t + (1-\eta) C_t = W_t n_t + (1+i_t) D_{t-1} + B_{t-1} + H_{t,res} + V_t + G_t, \quad (3)$$

where D_t is the deposit at banks, q_t is the discount price for the government bonds B_t, $1 + i_t$ is the gross interest rate on deposits made in the previous period, G_t are lump sum government transfers or taxes, W_t is the wage rate and V_t are the profits received from the household's ownership of intermediate goods firms. Resources are spent on non-cash consumption, saved in bonds, or kept in cash or deposits.

In real terms, the equation is given by:

$$h_t + d_t + q_t b_t + (1-\eta) c_t = w_t n_t + (1+i_t) \frac{d_{t-1}}{\pi_t^C} + \frac{b_{t-1}}{\pi_t^C} + h_{t,res} + v_t + g_t, \quad (4)$$

where $d_t = \frac{D_t}{P_t}$, $b_t = \frac{B_t}{P_t}$, $w_t = \frac{W_t}{P_t}$, $g_t = \frac{G_t}{P_t}$ and $v_t = \frac{V_t}{P_t}$.

The labour market is characterised by a sluggish adjustment of real wages:

$$w_t = \left((1-\omega) w_{t-1} + \omega \Upsilon w_t^f \right) e^{u_{t,w}}, \quad (5)$$

where w_t^f is the target market clearing wage, Υ shows the bargaining power of households, ω is the parameter for wage flexibility, $(1-\omega)$ shows backward wage indexation, and $u_{t,w}$ is a wage cost-push shock following an AR process and $\epsilon_{t,w}$ is i.i.d, $u_{t,w} = \rho_w u_{t-1,w} + \varepsilon_{t,w}$ and $\varepsilon_{t,w} = \rho_w^{ar} \varepsilon_{t-1,w} + \epsilon_{t,w}$.

The difference between the target and the actual wage introduces a labour wedge in the economy, and households supply labour at the given wage rate. Uhlig (2009) discusses the inefficiency introduced in more detail.

Households choose consumption, bonds, cash at hand, deposits, and working hours. The Lagrange multiplier on the cash-in-advance equation is ϱ_t and multiplier on the budget constraint is λ_t. The respective first order conditions are given by:

$$\begin{aligned}
\eta \varrho_t &= -(1-\eta)\lambda_t + (c_t - \chi c_{t-1})^{-\frac{1}{\sigma}} - \beta\chi(c_{t+1} - \chi c_t)^{-\frac{1}{\sigma}}, && (6)\\
\lambda_t q_t &= \beta E_t \left[\frac{\lambda_{t+1}}{\pi^C_{t+1}}\right], && (7)\\
\lambda_t &= \beta E_t \left[\frac{\varrho_{t+1}}{\pi^C_{t+1}}\right], && (8)\\
\lambda_t &= \beta E_t \left[\lambda_{t+1}\frac{1+i_{t+1}}{\pi^C_{t+1}}\right], && (9)\\
\lambda_t w^f_t &= A n_t^{\frac{1}{\kappa}}. && (10)
\end{aligned}$$

Equation 7 is the Euler equation, equation 8 gives the condition for cash at hand, equation 9 describes the rule for deposits and finally the optimality condition for the labour-leisure choice gives the market clearing wage w^f_t in equation 10. Equations 7 and 9 set equal the bond and deposit interest rates.

2.2. Final good firms

Final good firms aggregate intermediate goods and produce one final good. The profit maximisation function is standard with one notable exception. In the constant elasticity of substitution (CES) the aggregation does not go from 0 to 1 as in a standard model, but instead it goes from 0 to the number of goods, which is the same as the number of firms F_t:

$$P_t y_t - \int_0^{F_t} p_{t,j} y_{t,j} dj, \tag{11}$$

where y_t is the final output, F_t is the number of intermediate inputs indexed by j with a price $p_{t,j}$ and quantity $y_{t,j}$. The production function is given by:

$$y_t = \left(\int_0^{F_t} y_{t,j}^{\frac{1}{1+\mu}} dj\right)^{1+\mu}, \tag{12}$$

where $\mu = \frac{1}{\theta-1}$ and θ is the elasticity of substitution between intermediate goods.

After some algebra, the demand for the intermediate inputs is:

$$y_{t,j} = \left(\frac{P_t}{p_{t,j}}\right)^{\frac{1+\mu}{\mu}} y_t, \tag{13}$$

where the price index is given by $P_t = \left(\int_0^{F_t} p_{t,j}^{-\frac{1}{\mu}} dj\right)^{-\mu}$. The relative price is given by $\rho_t = \frac{p_{t,j}}{P_t} = F_t^{\mu}$.

In equilibrium all firms are the same, so $p_{t,j} = p_t$. Inflation $\pi_t = \frac{p_t}{p_{t-1}}$ is described in terms of intermediate goods prices, the average of prices firms set. The consumer inflation index π_t^C adjust for the number of firms and is given by $\frac{\pi_t}{\pi_t^C} = \frac{\rho_t}{\rho_{t-1}} = \left(\frac{F_t}{F_{t-1}}\right)^\mu$. A rise in the number of firms leads to a drop in consumer inflation relative to the intermediate goods inflation rate as the perceived price level for consumer decreases with the increasing number of varieties. When μ approaches zero, the elasticity of substitution approaches infinity, and the variety effect on consumer inflation disappears.

2.3. Intermediate goods firms

Intermediate sector firms produce goods for the final goods sector. The market structure is monopolistic competition and the number of firms is determined by a free entry condition. Each firm produces only one good, as usually assumed in the literature.[3]

Intermediate firms use linear production technology in labour:

$$y_{t,j} = e^{\gamma_t} n_{t,j}, \tag{14}$$

where the common productivity shock γ_t is assumed to follow an AR process $\gamma_t = \rho_\gamma \gamma_{t-1} + \varepsilon_{t,\gamma}$ and $\varepsilon_{t,\gamma} = \rho_\gamma^{ar} \varepsilon_{t-1,\gamma} + \epsilon_{t,\gamma}$, where $\epsilon_{t,\gamma}$ is an i.i.d. shock.

Firms have to pay a share ξ of the labour input cost in advance and borrow the necessary funds from commercial banks. When changing prices they face a price adjustment cost ϕ as in Rotemberg (1982). Nominal profits are given by $V_{t,j} = (p_{t,j} e^{\gamma_t} - (1 + \xi i_t) MC_t) n_{t,j} - \frac{P_t \phi}{2} \left(\frac{p_{t,j}}{p_{t-1,j}\pi} - 1\right)^2$, and in real terms:

$$v_{t,j} = \left(\frac{p_{t,j}}{P_t} - (1 + \xi i_t) mc_t\right) y_{t,j} - \frac{\phi}{2} \left(\frac{p_{t,j}}{p_{t-1,j}\pi} - 1\right)^2, \tag{15}$$

where the real profits per firm are $v_{t,j} = \frac{V_{t,j}}{P_t}$, and real marginal cost is $mc_t = \frac{MC_t}{P_t}$. The use of the Rotemberg price adjustment cost makes the model simpler because all firms set the same price and there is no need to keep track of the distribution of prices generated by, for example, the Calvo pricing scheme.

The intermediate firm j chooses labour $n_{t,j}$ and price $p_{t,j}$. The cost minimisation problem gives the marginal cost net of interest rate payments:

$$mc_t = \frac{w_t}{e^{\gamma_t}}. \tag{16}$$

[3] Minniti and Turino (2013) present a model with multiple product producing firms where firms decide about entry in the first stage of the problem and about the number of products in the second stage.

The net present value NPV_t of the firm today is defined as the discounted profits of all future periods. The net present value is measured at the time when production has already taken place, but firms do not yet know if they will survive until the next period. In this way the net present value is the same for incumbents and new firms. In nominal terms the net present value is defined as: $NPV_{t,j} = (1-\delta)E_t\left[e^{u_{t+1,surv}}\frac{\lambda_{t+1}}{\lambda_t}(V_{t+1,j} + NPV_{t+1,j})\right]$, and in the real terms after dividing by the price level:

$$npv_{t,j} = (1-\delta)E_t e^{u_{t+1,surv}}\left[\frac{\lambda_{t+1}}{\lambda_t}(v_{t+1,j} + npv_{t+1,j})\right], \tag{17}$$

where the $\frac{\lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor of the consumer, δ is the exogenous death probability of the firm, and $u_{t,surv}$ is the exogenous survival shock of the firm. The shock process is given by $u_{t,surv} = \rho_{surv}u_{t-1,surv} + \varepsilon_{t,surv}$ and $\varepsilon_{t,surv} = \rho^{ar}_{surv}\varepsilon_{t-1,surv} + \epsilon_{t,surv}$, where $\epsilon_{t,surv}$ is i.i.d.

The survival probability is modelled as an exogenous stochastic process (as in Vilmi (2009). A number of papers demonstrate that firm failures are not time invariant (see Uusküla (2008) and Jacobson et al. (2013)). The shock has several roles in the model. First, it allows the number of firms to change from one period to another. Unlike entry it does not change labour demand or marginal costs. Second, as the number of firms is linearly interconnected with the relative price of goods, it enters the Phillips curve and acts like a markup shock. Third, it allows matching of the number of new firms in the model directly with the creation of new firms in the data. In the model where the exit rate is constant, the number of new firms also includes the exit margin, making it similar to the data definition of net entry. Measurement of exiting firms in the data is complicated and as a result net entry measures include a lot of noise. When the exit rate is constant, exit decisions are measured as the exact opposite of entry costs, as low exit frees up labour for production. When both entry and exit are high, net entry is unchanged and the labour input needed to generate new firms is underestimated. Instead when entry is high and exit is low in the data, the net entry measure overestimates input costs as non-exit is included as de nuovo entry with entry costs.

The entry mechanism is standard in the literature. In order to enter, firms have to pay a sunk entry cost in labour. The free entry condition is given in real terms:

$$npv_{t,j} = \frac{1}{\Psi}\xi^{ent}\frac{w_t}{e^{\gamma_t}}(1+\xi i_t)e^{e_{t,ent}}, \tag{18}$$

where ξ^{ent} is the amount of labour hired for creating a firm in the steady state and the entry cost shock $u_{t,ent}$ is described by $u_{t,ent} = \rho_{ent}u_{t-1,ent} + \varepsilon_{t,ent}$ and $\varepsilon_{t,ent} = \rho^{ar}_{ent}\varepsilon_{t-1,ent} + \epsilon_{t,ent}$ where $\epsilon_{t,ent}$ is i.i.d. When in a standard model free entry condition means also zero profits in expected terms for new companies, then $0 < \Psi < 1$ measures the share of the net present value spent on entry costs from the net present value. When the parameter is less than one, the net present value is higher from the entry costs, leaving some profits to the firms. These profits are necessary and often assumed for the monopolistic competition sticky price models, so that even when firms cannot change prices and profits fall they do not want to exit. The parameter also allows to calibrate the share of total labor devoted to creating new firms, which is otherwise largely determined by markup.

The costs of firm creation in terms of legal costs and procedures are sizable in the US and even higher many other countries (see Barseghyan and DiCecio (2011) and Djankov et al. (2002) for estimates of the entry costs). My broad definition of entry costs also includes the time that is needed coming up with the idea for the new product or service, working out the business plan, and making the plan work or as a general allocation of resources to acquire technology to produce a good or service.

New firms can only produce in the following period and a fraction of firms dies at the end of the period, so some of the new firms never produce. The law of motion of the firms is given by:

$$F_t = (1-\delta)e^{u_{t,surv}}(F_{t-1} + F^E_{t-1}), \tag{19}$$

where F^E_{t-1} is the number of new firms created. Wages and loan interest rates for the firms that never produce are paid from the total profits before they are distributed to households. There are no bankruptcy related costs.

Unlike Bergin and Lin (2012) and Lewis and Stevens (2015) there is no exogenous congestion externality related to entry. However, due to the labour intensity of entry, smoothing of entry takes place naturally as labour costs are high in the high entry periods and a free entry cost limits the number of entrants.

The Rotemberg price adjustment cost gives the following forward looking Phillips curve:

$$\rho_{t,j} = \frac{p_{t,j}}{P_t} = mu_{t,j}mc_t, \tag{20}$$

where $\rho_{t,j} = \frac{p_{t,j}}{P_t}$ is the relative price determined by the number of firms in the economy, and the markup $mu_{t,j}$ is given by the following equation:

$$mu_{t,j} = \frac{(1+\mu)}{\mu}\frac{1}{(1+\xi i_t)}...$$

$$\left(-\frac{1}{\mu} - \frac{\phi}{y_{t,j}}\left(\frac{\pi_t}{\pi}-1\right)\frac{\pi_t}{\rho_t\pi} + \frac{\phi}{y_{t,j}}(1-\delta)E_t\left[e^{u_{t+1,surv}}\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\pi_{t+1}}{\pi}-1\right)\frac{\pi_{t+1}}{\rho_t\pi}\right]\right)^{-1}. \tag{21}$$

As this is the key equation for understanding the results of the paper, I present for intuition the log-linearised version, which is used in the estimation:

$$\hat{\pi}_t = \frac{y_j}{\phi\mu}\left(-\hat{\rho}_t + \frac{\xi}{1+\xi i}\hat{i}_t + \hat{mc}_t\right) + \beta(1-\delta)\hat{\pi}_{t+1}, \tag{22}$$

where the variables without the time subscript denote their steady-state levels, the variables with hats denote a percentage change from the steady state with the exception of inflation and the interest rate, where it is percentage point change from the steady state, and the firm level subscript j is dropped as all firms are identical.

According to the equation 22 the inflation rate today depends on the expected inflation and marginal cost as in the standard Phillips curve. However, the two new elements, the firm turnover and the working capital assumption, uncouple marginal cost (the productivity adjusted wage rate) from the inflation rate and make markups endogenous. Any shock that results in an increase in the number of firms pushes down markups and reduces consumer inflation directly. The working capital channel magnifies the effect of marginal cost on inflation. Any shock that lowers marginal cost leads to lower inflation. By the Taylor rule, lower inflation pushes down the interest rate, making the effect of the initial shock to inflation stronger.

2.4. Banks

Banks lend money to the intermediate goods sector firms, who pay a share ξ of the wages in advance. The banks can use funds deposited by the households d_{t-1} and money injections ψ_t of the central bank. The aggregate loan condition is given by:

$$\frac{d_{t-1}}{\pi_t^C} + \psi_t = \xi w_t n_t = l_t. \tag{23}$$

The banks operate only as intermediaries of funds from the central bank and households to firms. The loans are paid back within the period. The firms always pay back the debt; the loans to the new firms that never produce are paid back from the aggregate profits before the remaining profits are distributed to the households. The commercial banks lend all there resources to firms, there is no credit rationing.

2.5. Government sector

Central bank monetary policy is described by a Taylor rule:

$$i_t = \bar{i} + \rho_i i_{t-1} + (1 - \rho_i) \left[\zeta_\pi \left(\frac{\pi_t}{\bar{\pi}} - 1 \right) + \zeta_y \left(\frac{y_t}{\bar{y}} - 1 \right) + \epsilon_{t,i} \right], \tag{24}$$

where $\epsilon_{t,i}$ is an idiosyncratic shock to the interest rate. The interest rate reacts more than one-to-one to the changes in inflation and potentially to changes in the output.

The policy interest rate is controlled through monetary operations. To determine the interest rate the central bank injects money to commercial banks who use the resources to give out loans:

$$m_t = \frac{m_{t-1}}{\pi_t^C} + \nu \psi_t, \tag{25}$$

where m_t is the aggregate money and ν determines what share of the money is taken out from the economy by the central bank at the end of the period.

The government uses lump-sum transfers or taxes g_t to balance the budget every period:

$$q_t b_t = \frac{b_{t-1}}{\pi_t} - g_t + (\nu + i_t)\psi_t g_t = (\nu + i_t)\psi_t. \tag{26}$$

The government budget constraint, and the central bank's role of giving out loans to the commercial banks closely follow the paper by Uhlig (2009).

2.6. Aggregation and market clearing

Money in this model is the sum of households' cash at hand and deposits:

$$m_t = d_t + h_t. \tag{27}$$

The hours worked by the household are divided between creating new firms and producing output:

$$n_t = F_t n_{t,j} + F_t^E \frac{\xi^{ent} e^{u_{t,ent}}}{e^{\gamma_t}}. \tag{28}$$

Aggregate profits v_t include the individual profits of the firm minus the cost of starting new businesses:

$$v_t = F_t v_{t,j} - F_t^E w_t \xi^{ent} (1 + \xi i_t) \frac{e^{u_{t,ent}}}{e^{\gamma_t}}. \tag{29}$$

In the total consumption, I take out the effect of the number of firms on consumption in order to keep the productivity of the economy independent from the number of firms:

$$c_t = F_t^{\iota-(1+\mu)} y_t, \tag{30}$$

where $\iota = 1$, so in this respect the model departs from the standard Dixit-Stiglitz aggregator. This helps to focus on the transmission of shocks through the Phillips curve. When productivity is measured as output over hours, an increasing number of firms generates an extra source of productivity shocks without this transformation.

2.7. Equilibrium

The system is described by 34 variables. Among them there are 29 endogenous variables: b_t, g_t, c_t, $n_{t,j}$, n_t, $v_{t,j}$, v_t, $y_{t,j}$, y_t, mc_t, d_t, h_t, m_t, l_t, ψ_t, i_t, q_t, w_t, w_t^f, π_t, π_t^C, NPV_t, F_t, F_t^E, $P_{t,j}$, P_t, ρ_t, ϱ_t, and λ_t.

There are five exogenous i.i.d. shocks: $\epsilon_{t,\gamma}$, $\epsilon_{t,w}$, $\epsilon_{t,ent}$, $\epsilon_{t,i}$, $\epsilon_{t,surv}$. There is an additional AR structure for the shock processes of technology γ_t, labour cost $u_{t,w}$ and entry cost $u_{t,ent}$ shocks. The equilibrium is symmetric, in that consumers maximise utility, firms and banks maximise profits, and all markets clear with the exception of the labour market.

3. Data, Estimation and Priors

I estimate the benchmark model using quarterly US data for the sample period 1983Q1–1998Q3. The sample period reflects a compromise between availability of data and institutional features of the US economy. There was a major change in the bankruptcy law in 1983 which had an impact on the entry rate. In 1998 Dun and Bradstreet Inc. stopped collecting firm turnover data. For robustness the model is also estimated using various firm turnover data from various time periods.

I use the following five series for the US economy:

- consumption – log of real non-durable consumption divided by 16 years and older civilian population, demeaned and detrended,
- hours – log of non-agricultural sector hours worked, divided by 16 years and older civilian population, demeaned and detrended,

- inflation measure, which is the consumer price index (CPI) inflation rate, demeaned,
- the Federal Funds Rate, demeaned,
- the number of new firms, log of firm creation, demeaned and detrended.

The data are presented in Figure 1. There is a strong positive correlation between hours, consumption and the creation of firms. The inflation rate and the short-term interest rate also move strongly together and the contemporaneous correlation between hours and inflation is close to zero for the full sample. Consumption and hours have similar variances, whereas the variance of firm creation strongly exceeds that of hours.

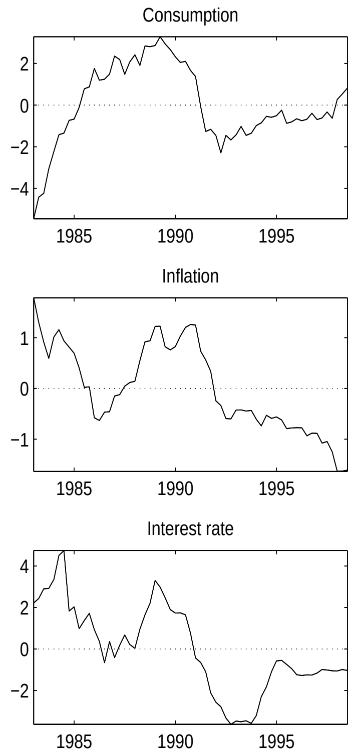

Figure 1: Data used in the estimation

The number of new firms is the right variable to be used to match the number of new firms in my model. This would not be true in a model where the exit rate is constant because then the entry margin would also include the exit margin and the similar variable in the data would be net entry. Unfortunately net entry measures include a lot of noise because it is difficult to pin down the precise timing of the closure of firms. Furthermore, in the model with the fixed exit rate the cost of closing a firm is exactly the same as the cost of opening a firm, but has a negative value. For a more detailed discussion see Uusküla (2008).

The set of variables to be matched is kept minimal to concentrate on the result on inflation. Compared to Lewis and Stevens (2015) I do not use output, investments and wages in the estimation. The paper abstracts from capital and the measurement of entry cost does not necessarily fit the data definition of investments. For the same reason the use of GDP might not be warranted. The model fit with the consumption series is less problematic and therefore I include consumption as an observable variable to capture the trade-off between consumption and leisure. The use of average wages as a measure for marginal costs in a standard model without firm dynamics is not necessarily warranted, but the problems are worse in a model with firm dynamics.

Some of the parameters are known to be difficult to estimate. The problem is aggravated because of the short sample. Therefore I calibrate some parameters using results from previous studies to concentrate the estimation of the model on the main parameters of interest relating to firm turnover, and price and wage rigidities.

The calibrated parameters are presented in Table 1. Most of the parameters do not affect the dynamics of the model very strongly or are straightforward to calibrate from the steady state values. The discount rate $\beta = .99$ is set to match the 4% annual real interest rate. The exogenous rate of firm death is set to $\delta = 0.025$ in order to match the 10.7% annual firm closing rate in the US. The number of firms in the steady state is set to 1 and I solve for the steady state entry cost. Steady state quarterly inflation is 1.005 to match the 2% annual inflation rate. People work one third of their time $\hat{n} = \frac{1}{3}$ and I solve for the value of A that satisfies this condition. The share of cash goods and the share of government money left in the economy at the end of the period are not determined by the observables and are both set equal to $\eta = \nu = 0.5$, and the wage markup is set equal to 10% (that is $\Upsilon = 1.1$).

There are a few critical parameters that play an important role in the model and are difficult to measure directly. Steady state markup is set equal to 36% ($\mu = .36$), close to Bilbiie et al. (2007) value of 35.71%. I calibrate Ψ the share of entry costs in the net present value to 0.5; firms spend half of their net present value on entry costs. The number of firms, the markup and the share of entry costs Ψ determine the entry cost to satisfy the free entry condition. The share of hours spent on creating new firms is 10.2%. When the $Phi = 1$, the model implies that 20.4% of the total hours would be spent on creating new firms. The Frisch elasticity of labour supply $\kappa = 1$, both often used in the DSGE literature. In addition I calibrate the parameters on the consump-

Table 1: Calibrated parameters

Name	Value	Notes
β	0.99	Discount factor, yearly interest rate of 4%
π	1.005	Steady state inflation, yearly 2%
δ	0.025	Share of firms closed each period, 10% per year
N	1	Number of firms, normalization
A		Matching $\bar{n} = \frac{1}{3}$
Ψ	0.5	Entry cost share in the net present value
ξ^{ent}		Implied by the model, given N=1
μ	0.36	Mark-up
χ	0.7	Consumption habit
κ	1	Frisch elast. of labor supply
Υ	1.1	Wage markup
ν	0.5	Share of money left in the economy
η	0.5	Share of cash on hand goods

tion habit $\chi = .7$. Robustness analysis is carried out for important calibrated parameters in the estimation.

I use the Bayesian full information approach to estimate the model using the Metropolis-Hastings sampler as described in Canova (2006). All calculations are done in Matlab, the model is log-linearised around the non-stochastic steady state and solved with the method of the undetermined coefficient of Uhlig (1999). The priors of the parameters are selected to represent theoretical restrictions and have very low information content (see Table 2). The autoregressive parameters are set to be between 0 and 1 with a mean of 0.5 and variance of 0.29^2. For the intertemporal elasticity of substitution and price stickiness I assume normal distributions. For the intertemporal elasticity of substitution I use a mean of 1 and relatively tight variance of 0.1. Prior for the Rotemberg price adjustment cost has a mean of 14 and a variance of 14. The prior value for the price stickiness is taken from Ireland (2001) and adjusted for the calibrated markup value and units of account in the price adjustment cost.

I take 1000000 draws in two chains. The initial values are chosen based on initial posterior maximisation and the last 80% of the draws are used in calculating the moments of the data to allow for a burn-in period. The confidence intervals for the impulse responses and variance decompositions are based on 500 independent non-parametric draws from the posterior.

Table 2: Prior distribution of the estimated parameters

Parameter	Distribution	Mean	Variance	Notes
ϕ	normal	14	14	Price stickiness
σ	normal	1	0.1	Intertemporal elast. of subst.
ξ	beta	0.5	0.029^2	Share of wages paid in advance
ω	beta	0.5	0.029^2	Weight on target wage
ζ_x	beta	0.5	0.029^2	Taylor weight on marginal cost
$\zeta_\pi - 1$	beta	0.5	0.029^2	Taylor weight on inflation
ρ_{iu}	beta	0.5	0.029^2	AR of monetary shock
ρ_{iL}	beta	0.5	0.029^2	Interest rate smoothing
ρ_w	beta	0.5	0.029^2	AR of labor supply shock
ρ_w^{ar}	beta	0.5	0.029^2	AR of labor supply shock term
ρ_{ent}	beta	0.5	0.029^2	AR of entry cost shock
ρ_{ent}^{ar}	beta	0.5	0.029^2	AR of entry cost shock term
ρ_{γ_L}	beta	0.5	0.029^2	AR of technology shock
ρ_{γ_u}	beta	0.5	0.029^2	AR of technology shock term
ρ_{surv}	beta	0.5	0.029^2	AR of survival shock
σ_i	inv. gamma	0.1	∞	Std.dev. of mon.pol shock
σ_{ent}	inv. gamma	0.1	∞	Std.dev. of entry cost shock
σ_{surv}	inv. gamma	0.1	∞	Std.dev. of survival shock
σ_w	inv. gamma	0.1	∞	Std.dev. of labor supply shock
σ_γ	inv. gamma	0.1	∞	Std.dev. of tech shock

4. Results

In this section I first present the main result for the role of the entry cost shock in explaining inflation together with alternative models without entry shocks and data to understand how the results differ from a standard model. Subsequently I discuss parameter estimates of the model. Finally I review the role of other shocks and show that the results are robust to various changes in the model.

4.1. Inflation and the role of entry cost shocks

In order to answer the question of what explains the dynamics of inflation, I look at variance decompositions and impulse response functions of the structural shock.[4] The results of the variance decomposition at the business cycle frequency are presented in Table 3.

The first column (model (1)) of Table 3 presents benchmark results for the importance of the estimated five shocks in explaining the five data series that are matched in the estimation at the business cycle frequency. It shows that the shock to the cost of entry explains 55% of the variance in inflation at the business cycle frequency.

The results of high importance of entry shocks stands in contrast with the previous decomposition of inflation dynamics. To understand better the driving force, model (2) of Table 3 shows the estimation results for a standard DSGE without firm turnover data and without entry cost and survival shocks. Instead a reduced form markup shock is added to the New Keynesian Phillips curve, the endogenous entry mechanism remains. The results are now similar to the standard estimation results where markup and wage cost-push shocks explain most of the variance of inflation at the business cycle frequency. So it is not the entry mechanism itself that changes the results, but different shocks and data matter for the results.

Model (3) presents the results for a model where real wage data is used instead of entry data in the estimation. Model (4) presents the model without the entry cost shock and no entry data used in estimation differently from the main results. Both models, (3) and (4), assign the volatility of inflation to the technology shock.

[4] The variance decomposition at the business cycle frequency is based on the counterfactual data generated by including one shock at a time. I use the Hodrick-Prescott filter with the smoothing parameter $\lambda = 1600$ to remove long run trends, and calculate variances and the share of each variance from the sum of the individual variances of the data that the five shocks produce.

Table 3: In-sample variance decompositions

	Benchmark Model 1	No entry, exit shocks Model 2	Wage data Model 3	No entry shock Model 4
Entry				
Consumption	12.49		0.92	
Hours	47.88		8.97	
Inflation	54.96		5.02	
Entry	46.06		1.18	
Interest rate	43.98		21.95	
Survival*				
Consumption	55.76	59.26	80.41	59.47
Hours	3.27	39.53	12.85	1.16
Inflation	3.24	22.32	2.37	0.18
Entry	23.12		20.64	0.00
Interest rate	2.83	24.75	1.54	0.08
Wage cost				
Consumption	11.91	13.32	1.91	24.14
Hours	46.92	3.49	24.98	94.00
Inflation	16.88	35.91	19.78	0.76
Entry	12.76		4.02	0.00
Interest rate	13.04	31.54	1.92	0.62
Technology				
Consumption	19.57	20.11	16.70	12.07
Hours	1.74	19.29	53.15	3.99
Inflation	19.27	36.59	72.41	95.27
Entry	18.02		73.74	0.00
Interest rate	14.42	27.72	53.54	70.43
Monetary				
Consumption	0.27	7.31	0.07	4.32
Hours	0.19	37.69	0.05	0.85
Inflation	5.65	5.19	0.42	3.80
Entry	0.04		0.42	0.00
Interest rate	25.72	15.99	21.05	28.86

Note: Model (2): no entry cost shock and no firm turnover data, firm survival shock is replaced by reduced form markup shock. Model (3) real wages used instead of firm turnover in estimation. Model (4): no entry shock is estimated with no entry cost shock and no firm turnover data. * For model (2) results for reduced form markup shock are presented.

The importance of the entry costs shock in explaining inflation is also confirmed by the forecast error variance decomposition analysis (see Figure 2). Variations in the cost of entry explain more than half of the variance in inflation during the first five years after a shock. I present the forecast error variance decomposition (FEVD) results and the impulse response functions for the period of 20 quarters after the shock together with the 90% confidence intervals. The line in the middle is calculated at the medians of the parameter estimates.

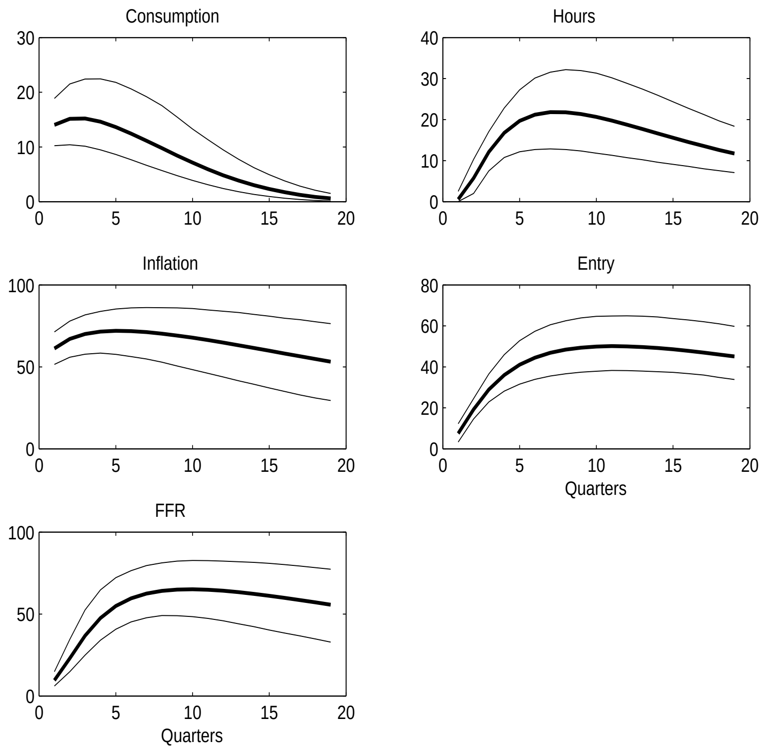

Figure 2: Forecast error variance decomposition, entry cost shock

A drop in the entry cost brings a hump-shaped increase in the creation of firms and inflation. The effect of entry cost shock on inflation works through labor market, as it is a good time to invest in the creation of new firms, demand for labour increases (see Figure 3). In order to hire more people, firms pay higher wages to workers. The increase in production costs results in immediate inflation due to forward looking Phillips curve. As the number of firms is only going up gradually, it takes time before the increase in the creation of new firms results in a higher number of firms in the economy. So markup declines with a relatively long lag. But as the number of firms stays up for a period of time, the markups are low even when the hours worked and the creation of firms have returned to their initial levels.

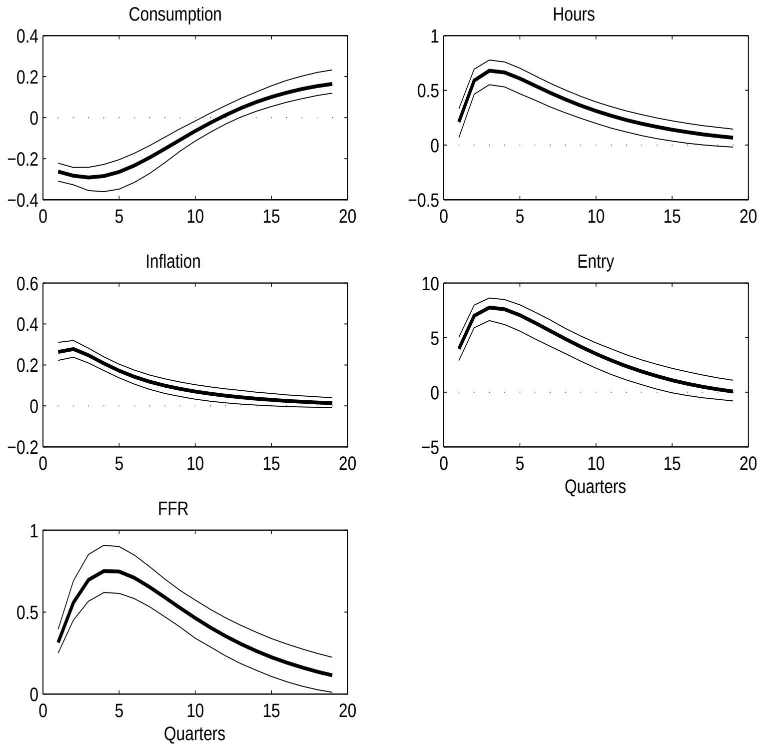

Figure 3: Impulse response functions, entry cost shock

In reaction to the shock, households initially cut consumption to create more new firms. As the number of firms goes up due to increased entry, consumption returns to its initial level after two years. However, the substitution channel moderates the reaction of hours and wages, but does not undo the effect. Aggregate output increases with the hours worked.

4.2. Parameter estimates

In order to understand the variance decomposition results, this subsection examines the parameter estimates of the model. The posteriors of the model parameters are presented in Table 4.

The results differ from the estimates of Smets and Wouters (2007) and Uhlig (2009) and are indicative of what can drive firm dynamics. First, the parameter estimate for the wage flexibility is 0.98 very close to one, leaving very little importance for wage stickiness. This stands in sharp contrast with the high wage stickiness estimates of Smets and Wouters (2007), Uhlig (2009), and Lewis and Stevens (2015). The evidence instead is consistent with the evidence that wages of new hires are not sticky. Pissarides (2009) cites several studies which demonstrate that wages of new hires in existing companies depend on market conditions. If wages of new hires are flexible in ongoing companies, it is even more likely that wages are flexible in new firms. Furthermore, search and matching models have recently indicated that as long as wages are flexible at the time a contract is signed, the wage path of existing matches does not matter for the employment decision of firms (Haefke et al. (2013)). Wage stickiness is not important either when the level of effort is not measured and changes over the cycle (Bils et al. (2014)). Kudlyak (2012) proposes a concept of "the user cost of labour" like "the user cost of capital" and shows that wages are not a good match for labour costs. The result also confirms the hypothesis that using the average wage in the estimation as a measure of marginal costs is not necessarily warranted. Average wages are known to move sluggishly. Slow movement, however, does not say anything about marginal costs and the wages new firms need to pay.

Table 4: Posterior distribution of the estimated parameters

	Prior	Posterior moments			
Parameter	Mean	Mean	Median	5%	95%
ϕ	14	9.09	8.95	2.91	15.53
σ	1	0.67	0.68	0.60	0.73
ξ	0.5	0.00	0.00	0.00	0.01
ω	0.5	0.98	0.98	0.93	1.00
ζ_x	0.5	0.00	0.00	0.00	0.00
$\zeta_\pi - 1$	0.5	0.06	0.05	0.02	0.13
ρ_{iL}	0.5	0.73	0.74	0.65	0.79
ρ_w	0.5	0.96	0.97	0.89	1.00
ρ_w^{ar}	0.5	0.25	0.23	0.12	0.42
ρ_{ent}	0.5	0.80	0.88	0.46	0.97
ρ_{ent}^{ar}	0.5	0.61	0.58	0.29	0.92
ρ_{γ_L}	0.5	0.98	0.99	0.93	1.00
ρ_{γ_u}	0.5	0.14	0.15	0.04	0.24
ρ_{surv}	0.5	0.09	0.09	0.02	0.17
σ_i	0.5	0.84	0.84	0.71	1.00
σ_{ent}	0.1	0.99	0.95	0.63	1.46
σ_{surv}	0.1	1.68	1.67	1.38	2.02
σ_w	0.1	1.07	1.03	0.74	1.53
σ_γ	0.1	0.62	0.62	0.53	0.72

Second, the price and wage stickiness parameters are lower than with the previous estimates. The parameter estimate for the Rotemberg price adjustment cost is 9. The posterior is lower from the prior value 14[5]. The price stickiness parameter value cannot be directly translated to the Calvo probability of re-setting prices since the Phillips curve contains the financial friction and the relative price.

Third, the results show no importance of the financial friction in the model. The parameter estimate for the financial friction, the share of wages paid in advance, is essentially 0. The results support the findings of Rabanal (2007) who finds that only a small share (0.15) of costs are borrowed from the banks. Likewise Uhlig (2009) calibrates the parameter to a low value of 0.1.

Fourth, broadly in line with the DSGE literature the Taylor weight on inflation is around 1.05 and the weight on output is zero, implying that the central bank is only targeting inflation. The interest rate smoothing parameter is 0.74 implying standard sluggishness in the interest rate in reacting to inflation.

The intertemporal elasticity of substitution is close to 0.7, not far from previous estimates. The autoregressive parameters are mostly different from one, with two exceptions. The autoregressive parameters of the wage cost push and technology shock processes have an upper bound very close to one, reflecting the high persistence of the hours data and difficulties in identifying the AR process of the shock. Thus in the estimated model the wages are persistent shock because of the persistent wage cost push shocks. Wages react immediately to all other shocks. The entry cost shock process is also described by a relatively presistent shock term. This might indicate some positive externalities in creating firms which are not explicitly modelled. The technology shock is approximately described by a simple AR process without additional autocorrelation in the i.i.d. Shocks and the survival shock has only some autocorrelation.

4.3. Other shocks

The firm survival shock explains around 3% of the variance of inflation at the business cycle frequency and 4% from the FEVDs during the first two years after the shock (see Figure 4).

A drop in the stochastic death rate increases the number of firms and lowers inflation. A 1% higher survival of firms brings inflation down by 0.02pp. at the time of the impact. There are two channels which lead to a drop in inflation. First, a higher number of firms cuts markup and lowers inflation. Second, an

[5]The transformed value to make the price adjustment cost comparable with the paper by Ireland (2001) as discussed in the section on priors.

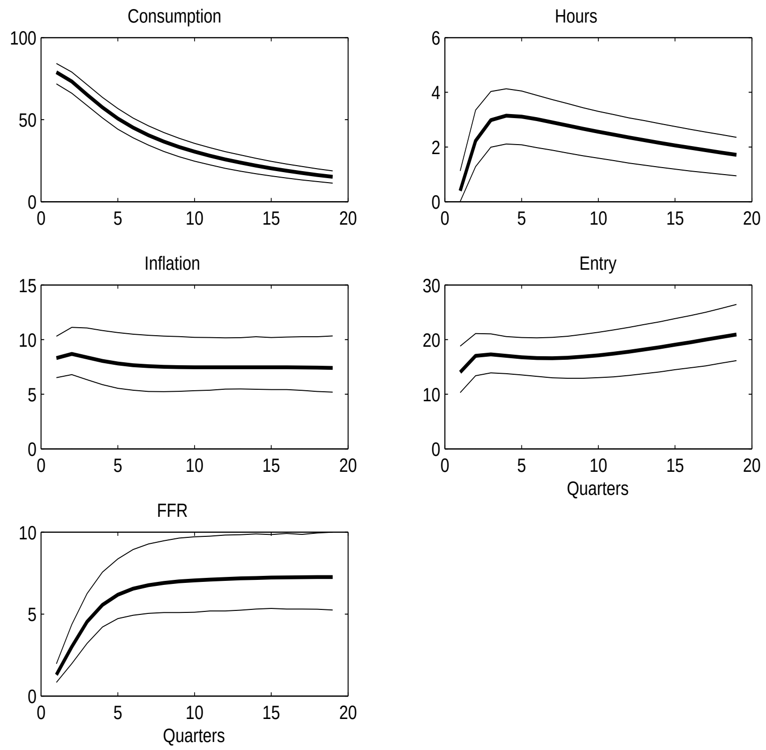

Figure 4: Forecast error variance decomposition, firm survival shock

increase in the number of firms lowers creation of new firms and subsequently reduces labour demand and wages.

The entry cost shock explains around 46% of variance in entry at the business cycle variance. However the shock generates too much variance in entry, which is captured by survival shocks. In sample data of firm creation generated by the shocks to the cost of entry and survival are negatively correlated. When the two shocks are included at the same time in the in sample variance decomposition, the share of entry explained by the two shocks is less than the sum of the two shocks explain separately, but the share of inflation explained remains qualitatively unchanged.

The effect of the number of firms on inflation can be compared to the finding of Cecioni (2010). She looks at the effect of a change in the number of firms on the inflation rate and concludes that the number of firms is an important factor determining inflation. According to her results a 10% increase in the number of firms brings inflation down by 1.4 pp. in the medium run. My results show that when the creation of firms is costly, it is important to separate how the increase in the number of firms is achieved. If a lot of new firms are created, the increase in the number of firms can even be inflationary in the short run because of the increase in the costs of production.

Variation in the exogenous technology is the second most important shock in explaining inflation. The technology shock explains around 19% of the variance in inflation at the business cycle frequency. In the FEVD it explains about 20% of the volatility in inflation in the short run, with the impact increasing in time due to the persistence of the shock. The share of the technology shock in explaining inflation is higher than the estimates of Smets and Wouters (2007), who find that productivity can explain around 5% of the variance in inflation at all horizons. The estimated importance of the technology shock is much closer to the estimate of Altig et al. (2011) VAR evidence. Their estimated technology shocks explain around 16% of the variance at the business cycle frequency.

The wage cost-push shock has also important effect on inflation. In the FEVD analysis, the median effect starts at 10% at short horizons and reaches 40% five years after the shock (see Figure 5) and stands at 17% at the business cycle frequency. This is much less from the Smets and Wouters (2007) paper where wage markup shocks explain about 50% of the inflation variance 2.5 years after the shock. Like those of Smets and Wouters (2007), my results show that a higher share of variance in inflation is explained by the cost-push shock at lower frequencies.

The monetary shock has some effects on inflation in the very short run. Inflation drops after a contractionary monetary shock and the real effects of monetary policy are small. The model even predicts a small increase in consumption and hours, similar to the findings of the agnostic identification approach results of Uhlig (2005). The number of new firms slightly decreases after an interest rate hike, but then increases after leaving the number of firms in the economy basically unchanged.

4.4. Robustness analysis

This section shows that the estimation results are stable. It first covers changes in the calibrated parameters, but also discusses results with different firm turnover data used in the estimation.

All additional models predict an increase in inflation after a drop in entry costs. The in-sample and forecast variance error decompositions confirm the importance of the entry cost shock in explaining inflation.

One of the important parameters is the markup in the intermediate goods sector. Cecioni (2010) calibrates the value at around 6%, a much lower value than in this paper. When I fix the price markup at 10%, technology and wage cost-push shocks are less important and the stochastic rate of survival is more

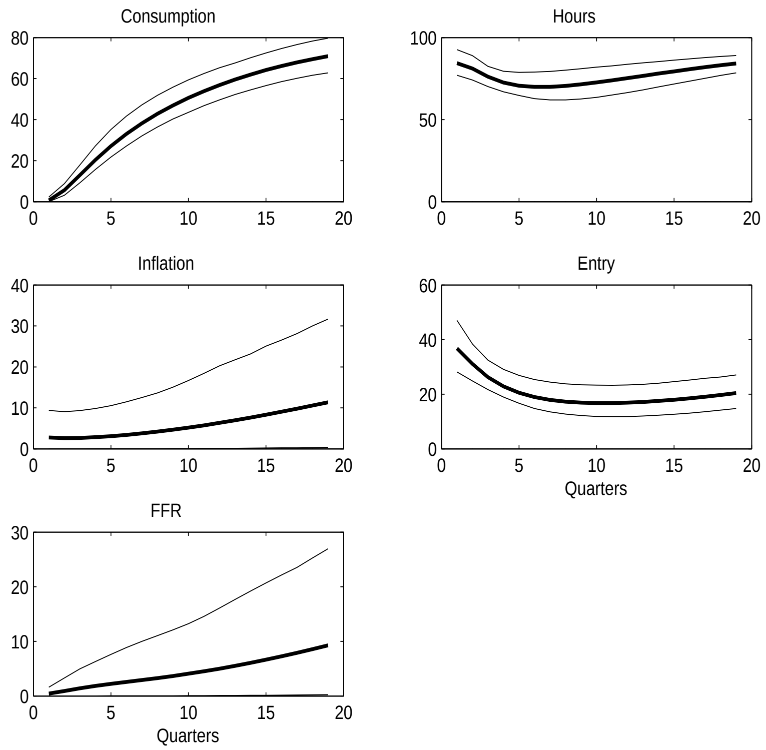

Figure 5: Forecast error variance decomposition, wage cost-push shock

important (see the first column in Table 5). When markup is 50% the results are very similar to the benchmark results (presented in the second column).

A drop in the value of the Frisch elasticity of the labour supply to a level consistent with the microeconometric evidence (0.2) increases the importance of the entry shock on inflation further, and reduces the roles of wage cost-push and technology shocks (model 3). The importance of the shock to the cost of firm creation is robust to various changes in the entry data and the time period used. As a robustness exercise I re-estimate the model with the net business creation index as a measure for new firms instead of the number of new firms. The estimation sample reduces further, and finishes in 1995Q4, but the results remain broadly unchanged (see model 4). Also when the model is estimated on the early sample from 1959Q1 to the end of 1982 (model 5) or on the full sample from 1959Q1 to 1998Q3 (model 6) the importance of the entry cost shock in explaining stays relatively similar. The posterior likelihood and variance decomposition results are not sensitive to the changes in the parameters for the share of cash goods, money left in the economy, and wage markup, implying that they are not identified.

Table 5: Robustness analysis of the in-sample variance decompositions

	markup 10% Model 1	markup 50% Model 2	Frisch 0.2 Model 3	NBF Model 4	59Q1-82Q4 Model 5	59Q1-98Q3 Model 6
Entry						
Consumption	2.24	12.42	17.86	6.93	12.40	13.45
Hours	26.71	37.15	4.34	54.16	57.36	60.31
Inflation	71.29	57.59	86.75	84.25	53.12	51.87
Entry	47.30	41.72	21.85	57.83	60.00	60.05
Interest rate	68.35	41.57	58.18	79.38	32.74	32.71
Survival						
Consumption	24.23	58.92	19.06	90.06	73.97	70.95
Hours	8.19	1.39	0.08	30.55	6.70	6.82
Inflation	15.74	1.66	1.00	1.42	5.18	4.51
Entry	34.63	18.86	5.74	40.59	28.78	29.55
Interest rate	14.25	1.40	0.51	5.10	3.33	2.92
Wage cost						
Consumption	57.99	12.08	53.42	1.25	8.24	8.91
Hours	44.24	59.76	93.33	2.80	34.58	31.48
Inflation	4.58	18.18	1.60	6.52	26.96	27.32
Entry	12.53	22.71	20.37	1.17	9.10	7.40
Interest rate	4.20	13.72	1.11	1.31	14.11	15.60
Technology						
Consumption	13.08	16.28	8.98	0.86	4.15	5.69
Hours	20.55	1.57	2.22	12.40	0.62	0.50
Inflation	6.76	16.49	5.21	4.62	2.71	2.94
Entry	5.10	16.67	51.84	0.40	2.02	2.79
Interest rate	6.09	12.00	3.81	1.63	1.08	1.24
Monetary						
Consumption	2.46	0.30	0.69	0.89	1.25	1.01
Hours	0.31	0.13	0.03	0.10	0.74	0.89
Inflation	1.63	6.07	5.44	3.19	12.03	13.35
Entry	0.44	0.05	0.19	0.00	0.09	0.21
Interest rate	7.12	31.31	36.39	12.58	48.73	47.53

5. Conclusions

In this paper I augment a medium scale DSGE model with firm turnover and financial friction, and estimate it for the US economy. My results show that the shock to the cost of entry is important in explaining the variance of inflation over the business cycle. When creating firms is labour intensive, then a drop in the cost of entry leads to an increase in the labour demand as many new firms are created. The increase in labour demand results in higher marginal costs and inflation. As the number of firms increases, markup goes down and inflation starts to diminish.

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