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Business cycle evidence on firm entry

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Abstract:

Business cycle models with sticky prices and endogenous firm entry make novel predictions on the transmission of shocks through the extensive margin of investment. This paper tests some of these predictions using a vector autoregression with model-based sign restrictions. We find a positive and significant response of firm entry to expansionary shocks to productivity, aggregate spending, monetary policy and entry costs. The estimated response to a monetary expansion does not support the monetary policy transmission mechanism proposed by the model. Insofar as firm startups require labour services, wage stickiness is needed to make the *signs* of the model responses consistent with the estimated ones. The *shapes* of the empirical responses suggest that congestion effects in entry make it harder for new firms to survive when the number of startups rises.

Keywords:

firm entry, business cycles, VAR

JEL-Classification:

E30, E32

Non-technical summary

Many business cycle models allow for investment at the firm level, but keep the number of firms fixed. Such models ignore the pervasive evidence of considerable firm entry and exit observed at business cycle frequencies. A growing theoretical literature advances endogenous firm entry, which we might call extensive margin investment, as an important propagation and amplification mechanism of business cycles. A significant contribution to this literature is Bilbiie et al (2007).

In that model, new firms are established as long as share prices exceed entry costs. Share prices are determined by expected profits, which in turn depend on future demand conditions. An entrant incurs a sunk entry cost by hiring labour. Increases in labour productivity or persistent rises in aggregate spending have a positive effect on future profits and thereby encourage entry, as do reductions in entry costs. However, in the model a monetary expansion leads to a fall in the number of entrants. As the interest rate (the return on bonds) falls, a no-arbitrage condition across assets ensures that today's share price rises relative to tomorrow's. At the same time, price stickiness implies an increase in the real wage, raising both production costs and entry costs. On net, entry costs rise by more than share prices and thus entry contracts.

This paper uses regression analysis to evaluate the predictions in Bilbiie et al (2007). We estimate how firm entry responds to shocks to productivity, aggregate spending, monetary policy and entry costs. The variables used in the estimation are output, inflation, interest rates, profits and net entry. While the model imposes certain priors on the responses of the first four variables, firm entry is allowed to respond freely to the shocks. First, we compare the signs and shapes of the estimated responses with the theoretical ones. Second, we discuss modifications and extensions that can reduce the discrepancies between the model and the data.

The estimation results can be summarised as follows. First, in the data, firm entry responds significantly and positively to all identified expansionary shocks. This is consistent with the model responses to productivity, spending and entry cost shocks. However, the results do not support the monetary transmission mechanism proposed above. Monetary expansions appear to *raise* profits and firm entry. Extending the model to allow for wage stickiness helps to reproduce this result by making real wages more rigid. On impact, profits and firm entry then respond positively to monetary policy shocks.

Second, the model cannot reproduce the shapes of the empirical impulse response functions. The response of firm entry to spending and monetary shocks is hump-shaped in the data, suggesting that, in addition to entry costs already accounted for in the model, other frictions prevent entrepreneurs from starting up new firms quickly in response to profit opportunities. One way to dampen the impact effect of monetary shocks on the number of entrants and to generate a hump-shaped response is to assume that the survival probability of new firms depends negatively on the increase in the number of entrants.

Nicht-technische Zusammenfassung

Viele Konjunkturzyklusmodelle berücksichtigen die Investitionen auf Unternehmensebene, gehen dabei aber von einer gleichbleibenden Zahl von Firmen aus. Diese Modelle vernachlässigen Markteintritte und Austritte von Unternehmen, die im Konjunkturzyklus zu beobachten sind. In der Fachliteratur wird zunehmend der endogene Markteintritt von Unternehmen, den man auch als Extensive-Margin-Investition bezeichnen könnte, als ein bedeutender Mechanismus zur Verbreitung und Verstärkung von Konjunkturzyklen erwähnt. Einen wesentlichen Beitrag zu diesen Untersuchungen lieferten Bilbiie et al (2007).

In diesem Modell werden neue Unternehmen gegründet, solange die Aktienkurse die Markteintrittskosten übersteigen. Die Aktienkurse werden von den erwarteten Gewinnen bestimmt, die wiederum von der künftigen Nachfragesituation abhängen. Einem neuen Marktteilnehmer entstehen durch die Einstellung von Arbeitskräften versunkene Eintrittskosten. Steigerungen der Arbeitsproduktivität oder ein anhaltender Anstieg der gesamtwirtschaftlichen Ausgaben wirken sich positiv auf die künftigen Gewinne aus und ermutigen dadurch - ebenso wie ein Rückgang der Eintrittskosten - zur Unternehmensgründung. Eine monetäre Expansion hingegen lässt in diesem Modell die Zahl der Markteintritte zurückgehen. Bei sinkenden Zinsen (Anleiherenditen) sorgt die Bedingung der Arbitragefreiheit dafür, dass der aktuelle Aktienkurs im Vergleich zum künftigen Kurs steigt. Gleichzeitig bringt die Rigidität der Preise einen Anstieg der Reallöhne mit sich, was sowohl die Produktions- als auch die Markteintrittskosten erhöht. Per saldo nehmen die Eintrittskosten stärker zu als die Aktienkurse, und dadurch sinkt die Anzahl der Markteintritte.

Im vorliegenden Diskussionspapier werden die von Bilbiie et al (2007) erstellten Voraussagen zunächst mithilfe der Regressionsanalyse evaluiert. Es wird geschätzt, wie die Markteintritte auf Schocks reagieren, die die Produktivität, die gesamtwirtschaftlichen Ausgaben, die Geldpolitik und die Markteintrittskosten verändern. Die bei der Schätzung berücksichtigten Variablen sind Produktion, Inflation, Zinssätze, Gewinne und Markteintritte. Das Modell erlegt dabei zwar bestimmte Vorzeichenrestriktionen für die Reaktionen der ersten vier Variablen auf, doch kann die Zahl der Markteintritte uneingeschränkt auf die Schocks reagieren. Zunächst werden die Vorzeichen und Formen der geschätzten Reaktionen mit den theoretischen Reaktionen verglichen. Anschließend werden Modifikationen und Erweiterungen des Bilbiie et al (2007)-Modells, die die Diskrepanzen zwischen dem Modell und den Daten verringern können, diskutiert.

Die Schätzergebnisse lassen sich wie folgt zusammenfassen: Erstens reagiert die Zahl der Markteintritte auf sämtliche identifizierten expansiven Schocks signifikant und positiv. Dies steht im Einklang mit den Modellreaktionen auf Schocks bezüglich der Produktivität, der Ausgaben und der Eintrittskosten. Die Ergebnisse stützen jedoch nicht den zuvor erwähnten geldpolitischen Transmissionsmechanismus. Monetäre Expansionen scheinen für eine *Zunahme* der Gewinne wie auch der Markteintritte zu sorgen. Erweitert man das Modell, so dass es die Lohnrigidität berücksichtigt, lässt sich dieses Ergebnis bis zu einem gewissen Grad reproduzieren, da die Reallöhne starrer werden. Letztlich reagieren dann die Gewinne wie die Markteintritte positiv auf geldpolitische Schocks.

Zweitens kann das Modell den Verlauf der empirischen Impulsantwortfunktionen nicht reproduzieren. Die Reaktion der Markteintritte auf Ausgaben- und monetäre Schocks zeigt in den Daten einen buckelförmigen Kurvenverlauf. Daraus lässt sich schließen, dass über die im Modell bereits berücksichtigten Eintrittskosten hinaus noch weitere Friktionen Unternehmer daran hindern, in Reaktion auf Gewinnchancen rasch neue Firmen zu gründen. Eine Möglichkeit, die Auswirkung monetärer Schocks auf die Zahl der neuen Marktteilnehmer zu dämpfen und eine Reaktion mit buckelförmigem Kurvenverlauf zu generieren, besteht in der Annahme, dass sich die Überlebenswahrscheinlichkeit neuer Unternehmen und der Anstieg der Zahl der Markteintritte umgekehrt proportional zueinander verhalten.

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Business Cycle Evidence on Firm Entry[1]

1 Introduction

A growing theoretical literature advances endogenous firm entry as an important propagation and amplification mechanism of business cycles.[2] Such models make novel predictions on the transmission of shocks through the extensive investment margin. This paper uses VAR analysis to evaluate the predictions in Bilbiie et al (2007), henceforth BGM. In particular, the contractionary effect of a monetary loosening on firm entry appears to be at odds with recent empirical evidence. In a VAR exercise, Bergin and Corsetti (2006) use a recursive method to identify one type of shock (a monetary policy shock). They find that entry, as measured by an index of net business formation, reacts positively to expansionary monetary policy shocks. Uusküla (2007) uses long and short run zero restrictions to identify monetary policy shocks, as well as neutral and investment-specific technology shocks. He employs data on both entry and failures. His findings are largely consistent with the results presented here and the ones in Bergin and Corsetti (2006).

In this paper, I identify a number of shocks in a model-consistent way. I use a subset of the short run impulse responses predicted by the sticky-price endogenous-entry DSGE model in BGM (2007) as sign restrictions to identify shocks in a vector autoregression. These are shocks to productivity, aggregate spending, monetary policy and entry costs. The variables in the VAR are output, inflation, interest rates, profits and firm entry. Firm profits play a crucial role in models with endogenous firm entry, but have typically been neglected in model validation exercises.[3] The responses of firm entry are left unrestricted. The model evaluation exercise consists of comparing the estimated responses with the theoretical ones along two dimensions: their sign and their shape. I then discuss modifications and extensions that can reduce the discrepancies between the model and the data. The results show that for generating model responses of profits and firm entry that are consistent with the data, wage rigidities are important, as well as congestion externalities in entry.

First, my findings indicate that firm entry responds significantly and positively to all identified expansionary shocks. This is consistent with the model responses to productivity, spending and entry cost shocks. In particular, the type of investment investigated here, i.e. investment along the extensive margin, reacts positively to spending shocks both in the model and in the data. However, my results do not support the monetary transmission mechanism proposed

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This is a substantial revision of "Macroeconomic fluctuations and firm entry: theory and evidence", National Bank of Belgium Working Paper 103. I thank Gert Peersman and Florin Bilbiie for useful comments, as well as participants at several conference and seminar presentations. All errors are my own.

[2] See Chatterjee and Cooper (1993), Devereux et al (1996), Campbell (1997), Bilbiie et al (2006, 2007), Bergin and Corsetti (2006), Jaimovich (2007), among others.

[3] Christiano et al (1997) is a notable exception.

by BGM (2007). In the model, entry costs and share prices jointly determine the number of entrants in each period. If entry costs are modelled as labour costs and prices are sticky, a monetary expansion leads to a fall in the number of entrants. As the interest rate (the return on bonds) falls, due to a no-arbitrage condition across assets, today's share price rises relative to tomorrow's. At the same time, an increase in the real wage raises both marginal production costs (which in turn dampens the rise in the share price) and entry costs. On net, entry costs rise by more than share prices and thus entry contracts. In the data, however, monetary expansions appear to lead to a *rise* in profits and firm entry. Extending the model to allow for wage stickiness helps to reproduce this result, see also Rotemberg (2007). On impact, profits and firm entry then respond positively to monetary policy shocks. Specifying entry costs as a fixed number of consumption units, rather than effective labour units, generates an expansion in entry but a drop in current profits.

Second, the model cannot reproduce the shapes of the empirical impulse response functions. The response of firm entry to spending and monetary shocks is hump-shaped in the data, suggesting that, in addition to entry costs already accounted for in the model, other frictions prevent entrepreneurs from starting up new firms quickly in response to profit opportunities. One way to dampen the impact effect of monetary shocks on the number of entrants is to assume a congestion externality in entry. The higher is the number of startups in any given period, the higher are the entry costs that each potential entrant faces. A hump-shaped response function results if we assume that the survival probability for new firms depends negatively on the increase in the number of entrants.

2 Firm Entry over the Business Cycle: Unconditional Moments

The number of firms varies over the business cycle. For the US, the cyclical properties of net entry have been documented by Chatterjee and Cooper (1993), Devereux et al (1996) and Campbell (1997). Bilbiie et al (2006) show that net entry and profits comove, and both are strongly procyclical. As shown in Figures 1 and 2, the cyclical components of US (net) entry and real GDP comove. The correlation between output and net entry measured as net business formation (NBF) is 0.71, while the correlation between output and new incorporations (NI) is 0.35. Similar to capital investment, firm entry is more volatile than GDP over the cycle, the standard deviation of NBF and NI relative to that of output is 2.19 and 3.13, respectively.

3 DSGE Model with Endogenous Firm Entry

I extend the benchmark model in BGM (2007) to allow for government spending shocks. In contrast to standard business cycle models with a variable capital stock and a fixed number of producers, this model abstracts from variations in capital and instead endogenises the number of firms. Investment is along the extensive margin. Profit opportunities over and above a sunk entry cost lead to firm entry. Goods markets are characterised by monopolistic competition

Figure 1: **Cyclical Component of Net Business Formation**

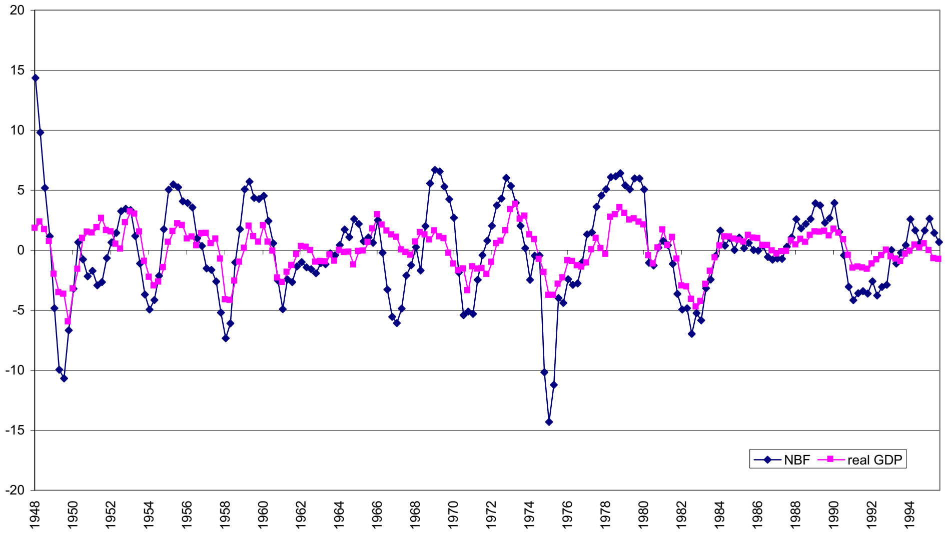
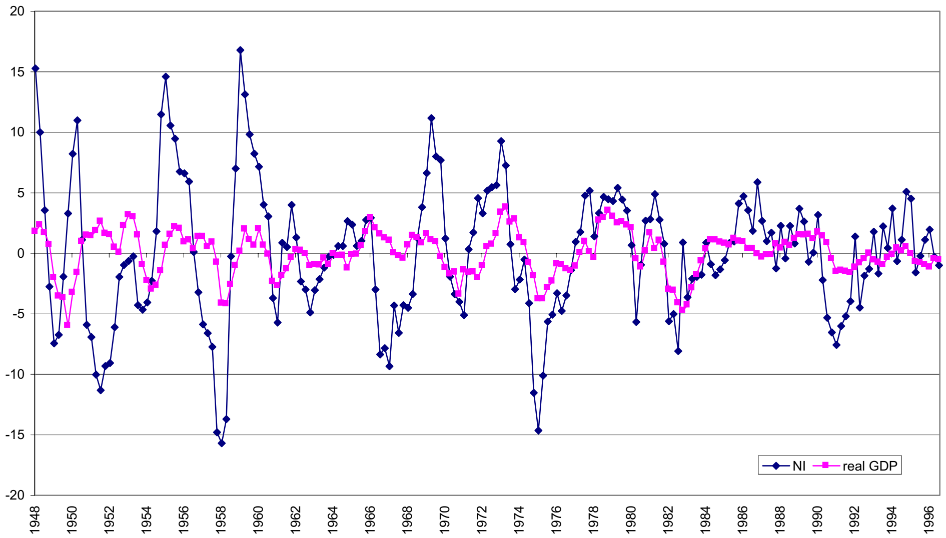


Figure 2: **Cyclical Component of New Incorporations**



These graphs show the cyclical components of firm entry and real GDP in the US over the sample period 1948q1-1995q3. Entry is measured as net business formation (top panel) and new incorporations (bottom panel). The two series have been HP-filtered with a smoothing parameter of 1600.

and nominal rigidities as in Rotemberg (1982). A competitive firm bundles the goods into an aggregate final good as in Dixit and Stiglitz (1977).

Competitive bundler

The final good is a bundle of mass N_t of differentiated goods, indexed by ω. It is produced with the technology $C_t = \left(\int_0^{N_t} c_t(\omega)^{(\theta-1)/\theta} d\omega\right)^{\theta/(\theta-1)}$, where $\theta > 1$ is the elasticity of substitution across goods. The demand for each individual good is $c_t(\omega) = (p_t(\omega)/P_t)^{-\theta} C_t$, where $p_t(\omega)$ is the price of good ω. The consumer price index (CPI), i.e. the minimum cost of producing one unit of the bundle C_t, is $P_t = \left(\int_0^{N_t} p_t(\omega)^{1-\theta} d\omega\right)^{1/(1-\theta)}$.

Government

The government consumes G_t units of the final good. Its budget constraint is $G_t = T_t$ for all t, where T_t denotes lump sum taxes. Exogenous spending shocks are modelled as changes in government consumption G_t. The arguments of this paper go through if I instead assume multiplicative shocks to household consumption C_t.

Firm Entry

Entrants must meet a sunk cost one period in advance of producing and selling each firm-specific differentiated good. Setting up a new firm requires an exogenous number $f_{E,t}$ of effective labour units, $f_{E,t}/Z_t$ units of the labour bundle l_t, or $w_t f_{E,t}/Z_t$ units of consumption. The variable Z_t is exogenous and measures labour productivity; $w_t = W_t/P_t$ is the real wage. Shocks to entry costs, given by variations in $f_{E,t}$, are similar to investment-specific technology shocks in the standard DSGE model with physical capital. Let $N_{E,t}$ be the number of entrants in period t. The number of active firms in period $t+1$ is given by $N_{t+1} = (1-\delta)(N_t + N_{E,t})$; a fraction δ of firms and entrants in any given period is hit by an exogenous exit shock. A zero-profit condition determines the number of entrants by aligning real firm value v_t with the entry cost, $v_t = w_t f_{E,t}/Z_t$.

Price Setting

Since I consider only symmetric equilibria, I can simplify the notation by dropping the firm-specific ω-subscript. The symmetry of prices implies that the consumer price index reduces to $P_t = N_t^{-1/(\theta-1)} p_t$, such that the firm price relative to the CPI can be written as $\rho_t (= p_t/P_t) = N_t^{1/(\theta-1)}$. Each firm produces a single good with the technology $y_t = Z_t l_{C,t}$, where $l_{C,t}$ is the amount of the labour bundle l_t used as an input into production. The total demand for each good y_t is found by summing the private demands over households and adding government demand to get $y_t = \rho_t^{-\theta} Y_t^C$, where $Y_t^C = C_t + G_t + PAC_t$ denotes aggregate consumption output and PAC_t are economy-wide price adjustment costs. The representative firm sets prices p_t to maximise the sum of current and expected future profits. Current profits are given by $d_t = \rho_t y_t - w_t l_{C,t} - \frac{\kappa_p}{2}\pi_t^2 \rho_t y_t$, where $\pi_t = p_t/p_{t-1} - 1$ is producer price inflation (PPI) and the term $\frac{\kappa_p}{2}\pi_t^2\rho_t y_t$ captures price adjustment costs at the firm level. The flexible-price economy is obtained in the limit by letting the parameter $\kappa_p \geq 0$ go to zero. Expected future profits are given by the share price $v_t = E_t \sum_{s=t+1}^{\infty} [\beta (1-\delta)]^{s-t} (C_s/C_t)^{-1} d_s$. The firm's relative price is set as a markup μ_t over real marginal cost, $\rho_t = \mu_t \frac{w_t}{Z_t}$, while the (linearised) markup equation is[4]

$$\widehat{\pi}_t = \beta (1-\delta) E_t \{\widehat{\pi}_{t+1}\} - \frac{\theta - 1}{\kappa_p}\widehat{\mu}_t$$

Preferences, Budget Constraint and Intertemporal Optimisation

The representative household maximises expected lifetime utility $E_t \sum_{t=0}^{\infty} \beta^t U_t$, where β is the subjective discount factor. Period utility is a positive function of consumption and a negative function of hours worked, $U_t = \ln C_t - \chi L_t^{1+1/\varphi}/(1+1/\varphi)$, $\chi > 0$ and $\varphi \geq 0$ is the elasticity of hours with respect to the real wage. The household's flow budget constraint is

$$\frac{B_{t+1}}{P_t} + v_t (N_t + N_{E,t}) x_{t+1} + C_t + T_t = \frac{R_{t-1}B_t}{P_t} + (d_t + v_t) N_t x_t + w_t L_t$$

for all t. The household purchases nominal one-period bonds B_{t+1}, shares in the total stock of incumbent firms and entrants x_{t+1}, and consumption goods C_t. Further, lump-sum taxes are added to the expenditure side. The household receives gross interest income on bond holdings, dividends and a capital gain on share holdings, and wage income. R_t denotes the gross interest rate on bond holdings between t and $t+1$. The first order optimality conditions for asset holdings are the usual consumption Euler equation and an equation expressing firm value (or the share price) as the present discounted value of future profits (or dividends).

$$\begin{aligned} C_t^{-1} &= \beta R_t E_t \left\{ \frac{P_t}{P_{t+1}} C_{t+1}^{-1} \right\} \\ v_t &= \beta (1-\delta) E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-1} (d_{t+1} + v_{t+1}) \right\} \end{aligned}$$

The first order condition for labour supply is $w_t = L_t^{1/\varphi}/C_t^{-1}$.

Aggregate Resource Constraint

Aggregating the budget constraints over households, imposing the asset market equilibrium condition $\int_0^1 B_t(h)\, dh = 0$ for all t, and using the government budget constraint $T_t = G_t$ gives the aggregate accounting identity $C_t + G_t + v_t N_{E,t} + PAC_t = d_t N_t + w_t L_t$. Total expenditure on consumption (private plus public), investment in new firms and the costs of adjusting prices must be equal to total income (dividend income plus labour income).

Labour is needed for the production activities of the existing firms ($N_t l_{C,t}$), as well as for firm startups ($\frac{N_{E,t} f_{E,t}}{Z_t}$). Using the production functions of the two sectors, total labour demand can be written as $L_t = (N_t y_t + N_{E,t} f_{E,t})/Z_t$.

[4] A hat above a variable denotes its deviations from steady state.

Monetary Policy

Monetary policy is described by a Taylor rule with interest rate smoothing. The monetary authority adjusts the interest rate in response to changes in PPI inflation[5], the output gap, and last period's interest rate

$$\widehat{R}_t = \tau_\pi \widehat{\pi}_t + \tau_Y \widehat{Y}_t^{gap} + \tau_R \widehat{R}_{t-1} + \eta_t^R$$

where $\widehat{Y}_t^{gap} = \widehat{Y}_t - \widehat{Y}_t^f$ and $\widehat{Y}_t^f$ is defined as the level of output under the assumption of perfectly flexible prices, i.e. $\kappa_p = 0$. The variable η_t^R is a white noise shock. The choice of this interest rate rule is based on empirical considerations. BGM (2007) show that in a cashless economy with an appropriate labour income subsidy that eliminates the markup distortion, it is optimal for monetary policy to stabilise firm prices p_t and let the number of firms fluctuate freely. If prices and wages are sticky, however, a tradeoff between price and wage inflation stabilisation emerges as in Erceg et al (2000). A full discussion of optimal policy in the presence of endogenous firm entry is beyond the scope of this study.[6]

4 Model Dynamics

Impulse responses are obtained by linearising the model around its deterministic steady state, which can be found in BGM (2006), calibrating it and solving for the policy functions numerically using a standard package. The linearised model equations are summarised in Table 1.

For details on the parameter values, see Table 2. I follow BGM (2007)'s benchmark calibration in most cases. However, I set the inverse labour supply elasticity φ equal to 2, which is a standard choice in the literature. BGM (2007) consider the special case where labour supply is fixed. They show that an expansionary productivity shock can lead to positive inflation if the shock is sufficiently persistent. By assuming a standard calibration, I exclude this possibility. In calibrating the persistence of the government spending shock ϕ_g and the steady state share of government spending in GDP Γ, I follow Devereux et al (1996), setting $\phi_g = 0.973$ and $\Gamma = 0.21$. For the interest rate rule, I choose a degree of interest rate smoothing $\tau_R = 0.8$ and the values on inflation and on the output gap originally proposed by Taylor (1993).

CPI data does not account adequately for changes in consumption utility arising from more or fewer available goods. To compare the model with data, I strip out this variety effect on the price index. For any variable X_t in units of consumption, the data-consistent counterpart is obtained as $\widetilde{X}_t = P_t X_t / p_t = X_t/\rho_t$. The effect on the relative price ρ_t is removed, because ρ_t is always equal to 1 when changes in the number of goods are disregarded. Since ρ_t is

[5] I suppose here that the central bank does not observe the welfare-based price index P_t, but instead measures inflation as the change in average prices p_t. The sign predictions used for my VAR identification are unaffected if instead I assume that the central bank observes P_t.

[6] For models in which firm entry does matter for monetary policy, see Berentsen and Waller (2007) and Lewis (2008).

Table 1: **Linearised Benchmark Model Equations**

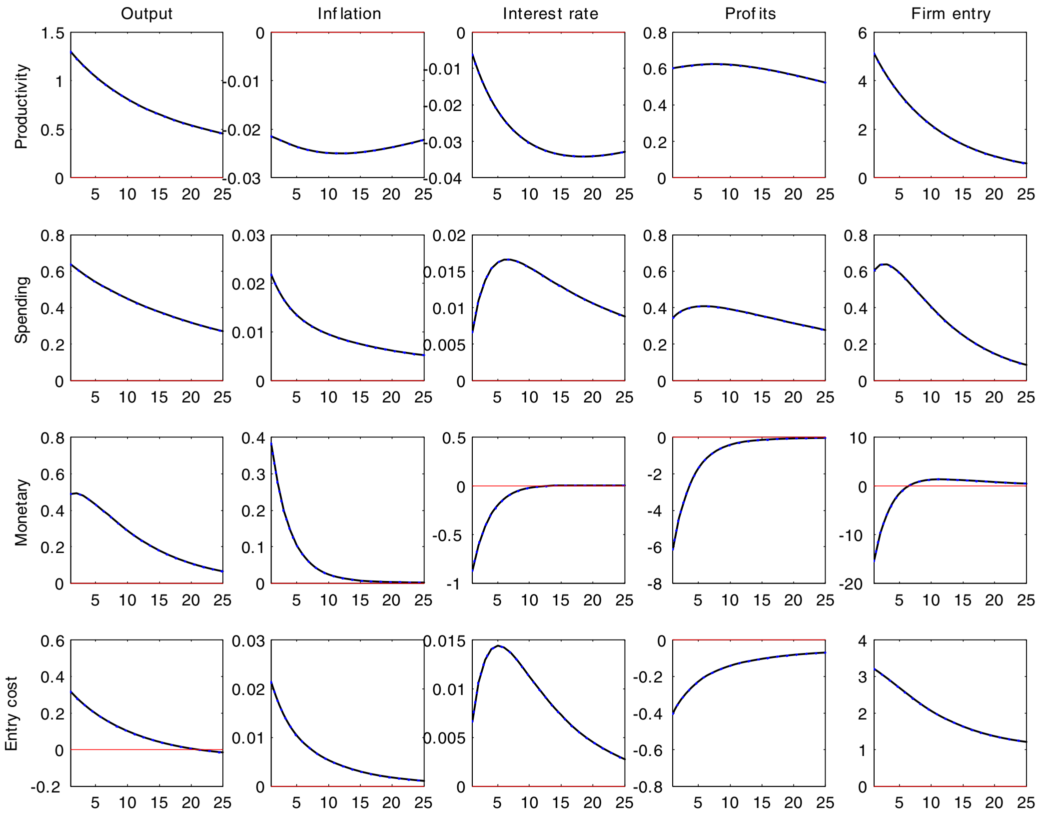
Endogenous variables	
$\widehat{\rho}_t = \frac{1}{\theta-1}\widehat{N}_t$	price index
$\widehat{d}_t = (\theta-1)\,\widehat{\mu}_t + \widehat{\rho}_t + \widehat{y}_t$	firm profits
$\widehat{\rho}_t = \widehat{\mu}_t + \widehat{w}_t - \widehat{Z}_t$	price setting
$\widehat{\pi}_t = \beta\,(1-\delta)\,E_t\,\{\widehat{\pi}_{t+1}\} - \frac{\theta-1}{\kappa_p}\widehat{\mu}_t$	markup
$\widehat{y}_t = -\theta\widehat{\rho}_t + \widehat{Y}_t^C$	firm output
$\widehat{Y}_t^C = (1-\Gamma)\left(\widehat{C}_t + \widehat{G}_t\right)$	consumption output
$\widehat{N}_t = (1-\delta)\,\widehat{N}_{t-1} + \delta\widehat{N}_{E,t-1}$	number of producers
$\widehat{v}_t = \widehat{w}_t + \widehat{f}_{E,t} - \widehat{Z}_t$	free entry
$-\widehat{C}_t = \widehat{R}_t - E_t\left\{\widehat{\pi}_{t+1}^C + \widehat{C}_{t+1}\right\}$	FOC bonds
$\widehat{v}_t = E_t\left\{\left(\widehat{C}_t - \widehat{C}_{t+1}\right) + \frac{1-\delta}{1+r}\widehat{v}_{t+1} + \frac{r+\delta}{1+r}\widehat{d}_{t+1}\right\}$	FOC shares
$\widehat{w}_t = \frac{1}{\varphi}\widehat{L}_t + \widehat{C}_t$	FOC labour
$\widehat{Y}_t = \frac{Y^C}{Y}\widehat{Y}_t^C + \frac{vN_E}{Y}\left(\widehat{v}_t + \widehat{N}_{E,t}\right)$	aggregate expenditure
$\widehat{Y}_t = \frac{dN}{Y}\left(\widehat{N}_t + \widehat{d}_t\right) + \frac{wL}{Y}\left(\widehat{w}_t + \widehat{L}_t\right)$	aggregate income
$\widehat{L}_t = \frac{L_C}{L}\left(\widehat{N}_t + \widehat{y}_t - \widehat{Z}_t\right) + \frac{L_E}{L}\left(\widehat{N}_{E,t} + \widehat{f}_{E,t} - \widehat{Z}_t\right)$	labour market clearing
$\widehat{R}_t = \tau_\pi\widehat{\pi}_t + \tau_Y\widehat{Y}_t^{gap} + \tau_R\widehat{R}_{t-1} + \eta_t^R$	interest rate rule
$\widehat{\rho}_t - \widehat{\rho}_{t-1} = \widehat{\pi}_t - \widehat{\pi}_t^C$	
Exogenous variables	
$\widehat{Z}_t = \phi_z\widehat{Z}_{t-1} + \eta_t^z$	productivity shock
$\widehat{G}_t = \phi_g\widehat{G}_{t-1} + \eta_t^g$	exogenous spending shock
$\widehat{f}_{E,t} = \phi_{fe}\widehat{f}_{E,t-1} + \eta_t^{ze}$	entry cost shock
η_t^R	monetary policy shock

Table 2: **Benchmark Calibration**

β	0.99	discount factor
φ	2	inverse labour supply elasticity
θ	3.8	elasticity of substitution (goods)
δ	0.025	firm exit rate
ϕ	3	elasticity of substitution (labour)
κ_p	77	Rotemberg price stickiness
τ_π	0.2*1.5	interest rate rule coefficient on inflation
τ_Y	0.2*0.5/4	interest rate rule coefficient on output gap
τ_R	0.8	interest rate smoothing
Γ	0.21	steady state share of government consumption
ϕ_{fe}	1	persistence entry cost shock
ϕ_z	0.979	persistence productivity shock
ϕ_g	0.973	persistence spending shock

predetermined with respect to all shocks, the impact effect on the data-consistent variables does not differ from that on the welfare-based variables. In general, the transition dynamics of the data-consistent variables are qualitatively similar to the dynamics of the welfare-based variables. Figure 3 displays the model impulse responses of the variables $\widetilde{Y}_t$, $\widetilde{\pi}_t$, R_t, $\widetilde{D}_t$ and $N_{E,t}$, which are the ones used in the empirical analysis.

Figure 3: **Theoretical Impulse Responses (DSGE Model)**



Productivity Shocks

A rise in productivity has a direct impact on the firm's pricing decision. Each firm will lower its price in response to the fall in marginal costs. As the number of producers (and also the relative price ρ_t) is predetermined, this results in an equiproportionate drop in the aggregate price level. The real wage rises as the price level falls, representing a spillover from the production sector to the investment sector. On the one hand, the increase in the real wage implies a rise in entry costs, which has a negative effect on entry. On the other hand, the demand for each existing good increases due to a rise in aggregate consumption demand. This has a positive effect on profits, which encourages entry. For my parameter values, this second effect dominates and firm entry is positive on impact. Output rises and inflation falls in response to a productivity shock. The decrease in inflation dominates the increase in the output gap in the interest rate rule, resulting in a monetary policy expansion. Because of price adjustment costs, firms lower their prices less than they would in a perfectly flexible economy, such that the markup rises.

Exogenous Spending Shocks

On impact, an exogenous spending shock reduces private consumption and raises hours worked due to the negative wealth effect of increased taxation. The expansion of aggregate demand causes output to rise. The resulting rise in inflation induces the central bank to raise the interest rate. The markup reacts countercyclically. Since the number of producers is fixed initially, the rise in aggregate demand pushes up firm output and profits. If the shock is highly persistent ($\phi_g = 0.973$), profit opportunities are expected to remain present far into the future, drawing firms into the market today. Note that this prediction is reversed, while the responses of the other variables are qualitatively unchanged, if the spending shock is less persistent, e.g. $\phi_g = 0.9$. Then the present discounted value of future profits is too low compared with today's entry cost, such that entry drops.

Monetary Policy Shocks

An expansionary monetary policy shock is modelled as an exogenous drop in the interest rate. This creates a boost to consumption and output. Given that flexible-wage output has not changed, the output gap becomes positive. However, price adjustment is imperfect and the markup contracts. In the shock period, the increased consumption demand induces firms to raise their output, which they sell at a markup over the predetermined relative price ρ_t. As firms raise prices, inflation becomes positive. On net, the reduction of the markup pulls profits down. With sticky prices and flexible wages, a monetary expansion leads to a fall in the number of entrants. As the interest rate (the return on bonds) falls, the expected return on shares also falls to eliminate arbitrage across assets. The expected return on shares is reduced by a rise in today's share price relative to tomorrow's. However, the expansion of aggregate demand also raises the real wage and thus entry costs, as nominal wages are fully flexible but prices are sticky. On balance, firm entry contracts.

Entry Cost Shocks

Similar to an investment-specific productivity shock, a drop in entry costs does not affect the productivity of existing firms, but makes investment in new ones more attractive. Consumption falls initially in order to finance the entry of new firms. Hours rise to accommodate the increased labour demand of entrants. As aggregate consumption demand falls, each incumbent sees his firm-specific demand curve shift inwards, such that firm output drops. Since relative prices (ρ_t), are unchanged initially, lower firm output also implies lower (real) profits. An entry cost shock leads to a positive output gap (driven by an expansion in firm startups), inflation, and a drop in the markup, which induces a monetary tightening by the central bank.

Table 3 summarises the signs of the short run impulse responses predicted by the model.

Table 3: **Signs of Impulse Responses predicted by Benchmark DSGE Model**

	Output	Inflation	Interest rate	Profits	Firm entry
Productivity	↑	↓	↓	↑	↑
Spending	↑	↑	↑	↑	↑
Monetary	↑	↑	↓	↓	↓
Entry cost	↑	↑	↑	↓	↑

5 Vector Autoregression with Sign Restrictions

My aim is to study the dynamic effects of exogenous shocks on firm entry in the data and compare them to those predicted by the theory. For this purpose, I estimate a vector autoregression with a subset of the model variables

$$X_t = c + \sum_{j=1}^{p} A_j X_{t-j} + B\varepsilon_t \tag{1}$$

where c is a vector of constants and linear trends, X_t is an $n \times 1$ vector of variables, A_j are coefficient matrices and ε_t are normally distributed, mutually and serially uncorrelated innovations with unit variance, i.e. $\varepsilon_t \sim N(0, I)$.

Choice of Variables and Identification

The variables in X_t chosen from the model must satisfy two conditions. First, they must be empirically observable, i.e. the variables that are expressed in real terms must be deflated by the PPI equivalent in the model, which is p_t (rather than the welfare-based price index P_t). Second, their short run responses to the exogenous shocks must be sufficiently different from each other so as to allow for the identification of each shock.

Given these considerations, I select real GDP, inflation, the interest rate and aggregate real profits. My identification scheme is presented in Table 4.

Table 4: **Signs of Impulse Responses used for VAR Identification**

	Output	Inflation	Interest rate	Profits	Firm entry
Productivity	↑	↓			
Spending	↑	↑	↑	↑	
Monetary	↑	↑	↓		
Entry cost	↑	↑	↑	↓	

Note: By construction, the identification method rules out the price puzzle. I set the sign restriction horizon to one year for all variables.

I consider shocks that increase output (temporarily) and I look at the impulse responses of the other three variables in relation to the output response. First, I identify a productivity shock by its negative effect on inflation. Second, of those shocks that lead to positive inflation, I single out monetary shocks as those that reduce the nominal interest rate. Finally, of those shocks that raise inflation and the interest rate, I distinguish entry cost shocks from exogenous spending shocks by looking at their effect on aggregate profits. An entry cost shock reduces profits, while a spending shock raises profits. I want to identify entry cost shocks separately for two reasons. First, these shocks are specific to models with endogenous firm entry, which is the focus of the paper. Second, in standard DSGE models with a variable capital stock and a fixed number of firms, investment-specific technology shocks are an important source of business cycle fluctuations (Fisher (2006)). The responses of firm entry to the various shocks are intentionally left unrestricted and are therefore fully determined by the data. In addition, the response of the nominal interest rate and profits to a productivity shock and the response of profits to a monetary shock are left unrestricted. The estimated response can then be compared with the one implied by the DSGE model.

I set $X_t = \left(\widetilde{Y}_t,\, \widetilde{\pi}_t,\, R_t,\, \widetilde{D}_t,\, N_{E,t}\right)$ in the VAR model (1), where $\widetilde{Y}_t$ is real output, inflation $\widetilde{\pi}_t$ is measured as the percentage change in the implicit GDP deflator, the interest rate R_t is the 3-month Treasury bill rate, $\widetilde{D}_t$ are corporate profits and for $N_{E,t}$ I use net entry given by the net business formation index.[7] A description of the data is given in the appendix. Output, profits and net entry are logged and multiplied by 100. These three variables have a strong upward trend. I do not carry out any stationarity-inducing transformations, nor do I impose any cointegrating relationships between the variables. Instead, I estimate the VAR in levels. Following Sims et al (1990), this is a valid and consistent estimation method even in the presence of unit roots and cointegrating vectors. It is also preferable, since more harm is done by imposing false stationarity-inducing transformation and cointegrating relationships than by imposing none at all. My sample period covers 1948q1 to 1995q3. Given that I work with quarterly data, the VAR lag length p is set to four.

Methodology

In the following, I briefly outline the estimation method in Peersman (2005); more details can be found in that paper. There are two steps to this procedure.

In the first step, I run the unrestricted VAR in (1) to obtain estimates of the reduced form coefficients $\beta = [c, A_1, A_2, \ldots, A_p]$ and the error covariance matrix Σ. Given an uninformative prior, the joint posterior distribution for β and Σ belongs to the Normal-Wishart family. From the reduced form residuals u_t with covariance matrix Σ, I construct structural innovations $\varepsilon_t = B^{-1}u_t$. An orthogonal decomposition of the residuals amounts to finding a matrix B that satisfies $\Sigma = BB'$ and computing the innovations ε_t. Many such decompositions exist, as for any orthonormal matrix Q (i.e. $QQ' = I$), $\Sigma = BQQ'B'$ is a valid decomposition of Σ. I take joint draws from the posterior distribution of the VAR coefficients and from the space of decompositions given by Q.

[7] Notice that the true measure of net entry in the theoretical model corresponds to the variable $(1-\delta)\, N_{E,t} - \delta N_t$. Given that the stock of firms N_t is predetermined, this variable reacts in proportion to $N_{E,t}$ on impact. The slow adjustment in N_t implies that the two measures of entry do not diverge too much. Simulations show that the divergence between the two series is of the order of magnitude 10^{-3}, reflecting the small value of the firm exit rate δ.

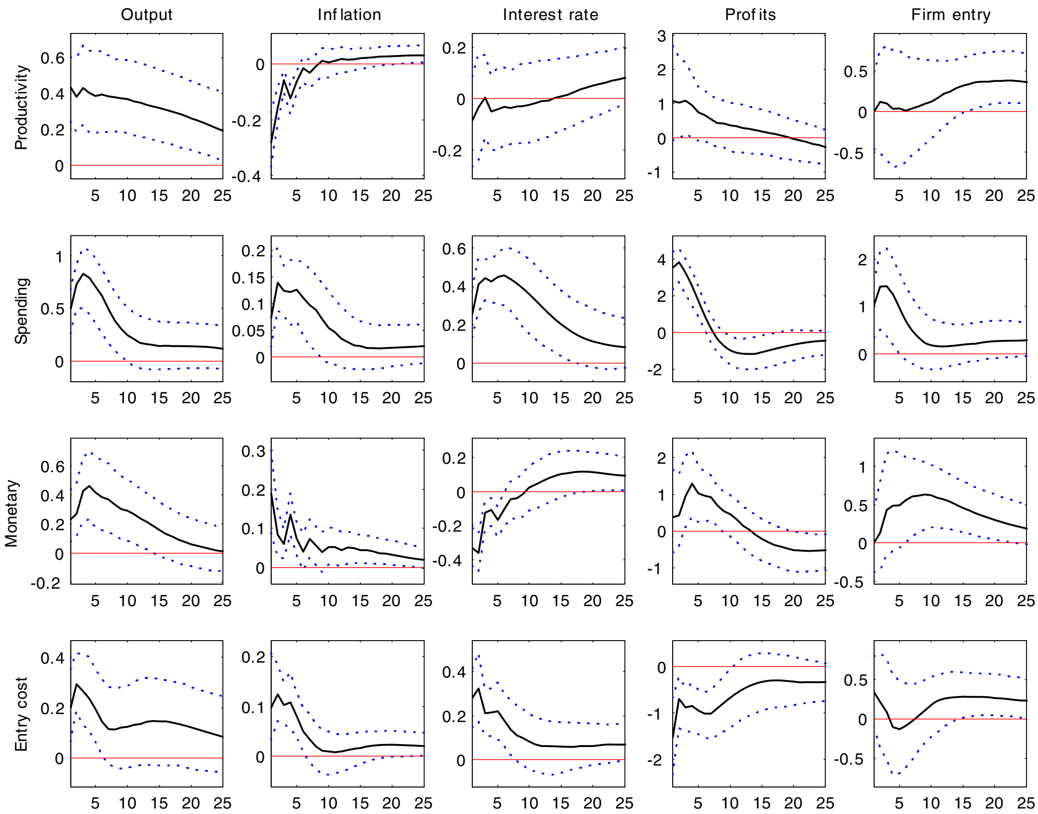
In the second step I proceed as follows. Given the orthogonal innovations ε_t, the associated impulse responses are compared with the priors given by the sign restrictions in Table 4. I accept a draw if out of the five orthogonal shocks, I identify exactly four distinct fundamental shocks; the fifth shock is interpreted as an unspecified exogenous process in the data absent from the model. Otherwise, the draw is rejected.

Steps 1 and 2 are repeated until 1000 valid decompositions have been found. Inference statements are based on the distribution given by these valid draws. I order the points on the impulse response functions and report the median, as well as the 16th and 84th percentile confidence bands.

6 VAR Results

The estimated impulse response functions are displayed in Figure 4.

Figure 4: **Estimated Impulse Responses (VAR Model)**



I find significant positive impulse responses of firm entry to all identified shocks, though at different horizons. Productivity shocks as well as reductions in entry costs have significant effects on entry in the long run, that is, 3 years after the shock. Monetary policy shocks lead to a gradual build-up in the number of firms. The response of entry is significant only at medium run horizons. Consistent with money neutrality, there is no significant long run response. Notice also that the response is hump-shaped, which is consistent with the evidence of the recursive VAR in Bergin and Corsetti (2006). Both the sign and the shape of the impulse response function are clearly at odds with the predictions of the DSGE model. Finally, exogenous spending shocks have a positive and significant impact effect on firm entry, lasting about a year. This suggests that there exists a complementarity in the data between aggregate demand and entry, consistent with the model. In comparison, the standard DSGE models with physical capital predict a decline or an insignificant response of investment to a government spending shock (see Galí et al. (2007)), while in the data, the effect is significantly positive, as shown in Peersman and Straub (2007).

As an additional check of the theoretical model, I consider the other unrestricted impulse responses. I find that the response of the interest rate to a productivity shock, while negative in the model, is insignificant in the data. Profits react positively to productivity shocks at short horizons; the long run effect is insignificant. Following a monetary policy expansion, profits increase in a hump-shaped fashion, first becoming significantly positive, followed by a significantly negative response at longer horizons. This pattern suggests that at first, the rise in aggregate consumption demand drives up the profits of existing firms. The increase in profitability induces new firm startups, but with some delay. Firm entry leads to some expenditure switching from old to new goods, thereby reducing the profits of incumbent firms. Again, the profit response in the data does not resemble the one in the model.

Turning to the variance decompositions in Table 5, it is worth noting that shocks to entry costs do not explain a large proportion of the variability of firm entry and output. Spending shocks play a much bigger role. This is consistent with the observation that overall, profits are procyclical in the data, while in the model, entry cost shocks give rise to countercyclical movements in profits. It might also reflect the fact that entry costs depend to a large extent on institutional arrangements, which are slow to change. As I show below, the negative effect of entry cost shocks on profits is not robust to the way such costs are modelled. This casts some doubt on whether the shock identified actually reflects a reduction in entry costs. In addition, Table 5 reveals that on impact, the four identified shocks explain over 90% of the variance in output but less than 60% of the variance in entry. This suggests that the entry measure is subject to a considerable amount of noise which is picked up by the unidentified shock.

7 Modifications of the Benchmark Model

In this section I consider several extensions and modifications to the theory that can reconcile the model impulse reponses with the estimated ones.

Table 5: **Estimated Variance Decomposition (VAR Model)**

		Productivity			Spending			Monetary			Entry cost		
		low	med	upp	low	med	upp	low	med	upp	low	med	upp
Output	0	9%	31%	67%	12%	43%	74%	1%	10%	33%	1%	7%	23%
	4	5%	17%	40%	21%	53%	78%	4%	14%	35%	2%	6%	15%
	8	6%	20%	44%	16%	46%	74%	4%	16%	40%	2%	5%	13%
	20	10%	27%	52%	15%	38%	64%	5%	16%	38%	3%	7%	18%
Entry	0	0%	4%	21%	6%	45%	91%	0%	3%	16%	0%	7%	31%
	4	1%	5%	22%	5%	40%	84%	1%	6%	27%	1%	5%	18%
	8	1%	7%	23%	6%	33%	76%	2%	10%	35%	2%	6%	18%
	20	3%	12%	28%	7%	28%	64%	4%	16%	40%	3%	8%	20%

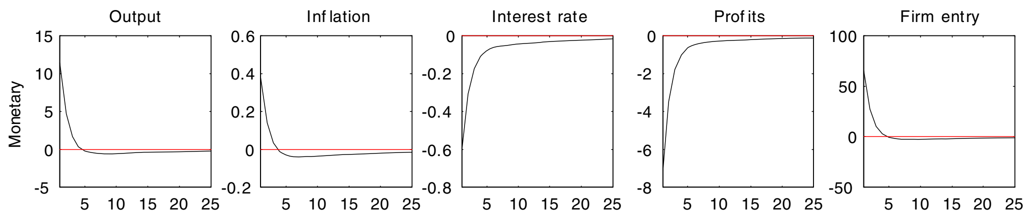
This table shows median variance decompositions ('med'), together with 16th and 84th percentile error bands ('low' and 'upp') for different time horizons expressed in quarters.

Fixed Entry Costs

Here, entry costs are modelled as labour costs and, as such, vary together with the real wage. The real wage, in turn, inherits the dynamics of the nominal wage since prices are sticky. This makes entry costs quite responsive to shocks. On impact, a monetary policy shock raises the real wage and thus the share price through the free entry condition. There is a positive effect on firm profits through the increased demand and a negative effect through a reduction in the markup. The second effect dominates and firm profits decrease, which has a negative effect on current firm value. The value of future profits must rise to bring about the necessary net increase in the current share price. This happens through a contraction in firm entry.

Replacing the sunk cost $w_t f_{E,t}/Z_t$ with an exogenous fixed entry cost in units of consumption, denoted by $f^C_{E,t}$, and adding $f^C_{E,t}$ to consumption output, overturns this last result. See Figure 5. In that case, consumption and firm output rise, while entry costs and the share price are unchanged. As a consequence, the number of entrants increases.

Figure 5: **Fixed Entry Costs**



With this specification, entry cost shocks lead to an increase in aggregate profits (not shown). The other impulse response signs are as in Table 3.

BGM (2007) also study this modification of the model. They note that fixed entry costs help to bring the model responses in line with the estimated responses. However, the negative response of profits, driven by a decline in the markup, is inconsistent with the evidence presented here and also with the main finding in Christiano et al (1997). Finally, the alternative specification makes an entry cost shock look very similar to a spending shock by boosting aggregate profits (not shown). In terms of my sign restrictions, the two shocks become indistinguishable. The other signs reported in Table 3 are unchanged.

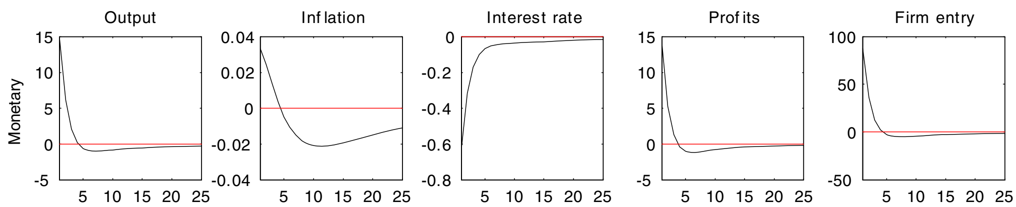
Fixed Entry Costs and Sticky Wages

Recall that the benchmark calibration assumes perfect wage flexibility. If we add the assumption of wage stickiness, we can generate an impact response of *both* firm entry and profits to monetary policy shocks with the correct sign. Suppose that the labour input into the production of goods and new firms is defined as a bundle over the differentiated labour types, indexed by h. It is produced with the technology $l_t = \left(\int_0^1 l_t\,(h)^{(\phi-1)/\phi}\,dh\right)^{\phi/(\phi-1)}$, where $\phi > 1$ is the elasticity of substitution across labour types. Symmetric firm demand for labour type h is given by $l_t(h) = (W_t(h)/W_t)^{-\phi}\,l_t$, where $W_t\,(h)$ is the wage received by worker h. The economy-wide wage index, the minimum cost of producing one unit of the labour bundle l_t, is $W_t = \left(\int_0^1 W_t\,(h)^{1-\phi}\,dh\right)^{1/(1-\phi)}$. The worker has to pay a Rotemberg-style wage adjustment cost WAC_t, which is added to the expenditure side of his budget constraint (and to the aggregate resource constraint). It is given by $WAC_t = \frac{\kappa_w}{2}\left(\frac{W_t}{W_{t-1}} - 1\right)^2 \frac{W_t}{P_t}$. Each worker has monopoly power in supplying a differentiated labour type, which allows him to set his optimal wage. The first order condition for the wage rate results in the following (linearised) wage inflation equation

$$\widehat{\omega}_t = \beta E_t\left\{\widehat{\omega}_{t+1}\right\} + \frac{\phi-1}{\kappa_w}\left(\frac{1}{\varphi}\widehat{L}_t + \widehat{C}_t - \widehat{w}_t\right)$$

where $\widehat{\omega}_t = \ln\left(W_t/W_{t-1}\right)$. Wages become perfectly flexible as the parameter $\kappa_w \geq 0$ approaches zero. Note that the wage inflation equation is not affected by the introduction of endogenous firm entry; it is analogous to the one in Erceg et al (2000). The wage rigidity dampens the response of the real wage. Therefore, marginal costs do not rise as much and aggregate profits respond positively to a monetary expansion. Figure 6 shows that entry increases sharply (by over 80 p.c.) on impact.

Figure 6: **Fixed Entry Costs and Sticky Wages**

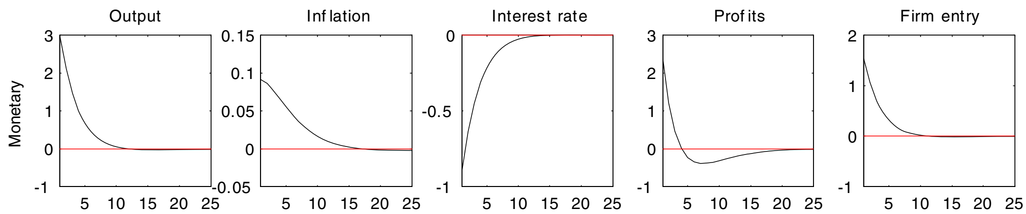


With this specification, entry cost shocks lead to an increase in aggregate profits (not shown). The other impulse response signs are as in Table 3.

Fixed Entry Costs, Sticky Wages and Congestion Externalities in Entry

An additional modification which may help here is to specify the entry cost as an increasing function of total firm entry as in Berentsen and Waller (2007). Let the entry cost for an individual firm be $f^C_{E,t}\Theta\left(N_{E,t}\right)$, where $\Theta\left(\cdot\right)=1$ if and only if $N_{E,t}=N_E$; $\Theta'\left(N_E\right)$ is constant and strictly positive. The new free entry condition becomes $\widehat{v}_t=\widehat{f}^C_{E,t}+\Theta'\left(N_E\right)\widehat{N}_{E,t}$. The idea behind this specification is that more firm startups raise entry costs by creating a congestion externality. The effect of this externality is to reduce the impact response of firm entry, which helps to bring the model closer to the data. Figure 7 displays the impulse responses of my five variables to a monetary policy shock for the parameter values $\Theta'\left(N_E\right)=2$ and $\kappa_w=77$.

Figure 7: **Fixed Entry Costs, Sticky Wages and Congestion Externality in Entry**



With this specification, entry cost shocks lead to an increase in aggregate profits (not shown). The other impulse response signs are as in Table 3.

Sticky Wages and Endogenous Survival Probability

In addition to the signs of the estimated impulse responses, we can also consider their shapes and compare them with the model. The responses of firm entry to monetary policy and spending shocks are clearly hump-shaped in the data, pointing to some sort of rigidity in entry not captured by the model. The same phenomenon is well known for investment in physical capital in the standard DSGE model. To overcome this problem, Christiano et al (2005) introduce investment adjustment costs as a function of the change in investment. A similar representation of adjustment costs, applied to firm entry, delivers the desired hump-shaped responses. Suppose the number of firms in period $t+1$ is given by the surviving producers from last period and a fraction of the new entrants, where the size of this fraction is governed by the function $F\left(\cdot\right)$

$$N_{t+1}=\left(1-\delta\right)\left[N_t+F\left(N_{E,t},N_{E,t-1}\right)\right] \tag{2}$$

$F\left(\cdot\right)$ is defined as $F\left(N_{E,t},N_{E,t-1}\right)=\left[1-S\left(N_{E,t}/N_{E,t-1}\right)\right]N_{E,t}$. This specification introduces an endogenous survival probability for new firms which depends negatively on the change in the number of startups. $S\left(\cdot\right)$ has the following steady state properties. $S\left(1\right)=S'\left(1\right)=0$, $S''\left(1\right)$ is constant and strictly positive. Then the free entry condition equates the current entry cost $w_tf_{E,t}/Z$ to the expected value of a new firm

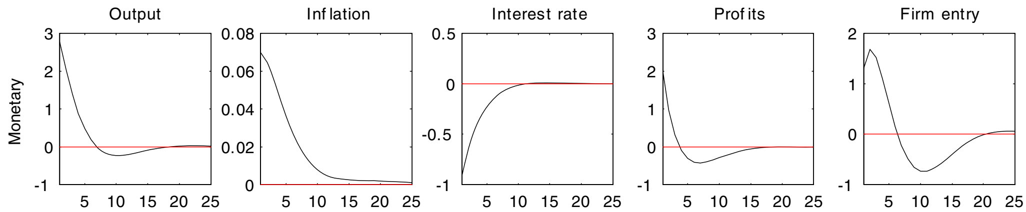
$$\frac{w_tf_{E,t}}{Z_t}=v_tF_{1,t}+\beta E_t\left\{\frac{C_t}{C_{t+1}}v_{t+1}F_{2,t+1}\right\} \tag{3}$$

In the special case of zero adjustment costs, $S(\cdot) = 0$ and $F(N_{E,t}, N_{E,t-1}) = N_{E,t}$. Then $F_{1,t} = 1$, $F_{2,t+1} = 0$ and (3) reduces to the benchmark free entry condition. In linearised form, the law of motion for the number of firms and the new free entry condition are

$$\begin{aligned} \widehat{N}_{t+1} &= (1-\delta)\widehat{N}_t + \delta \widehat{N}_{E,t} + (1-\delta)\frac{S''(1)}{N}\widehat{N}_{E,t-1} \\ \widehat{w}_t + \widehat{f}_{E,t} - \widehat{Z}_{E,t} &= \widehat{v}_t - S''(1)\left[\left(\widehat{N}_{E,t} - \widehat{N}_{E,t-1}\right) - \beta E_t\left\{\widehat{N}_{E,t+1} - \widehat{N}_{E,t}\right\}\right] \end{aligned}$$

Setting $\kappa_w = 77$ and $S''(1) = 2.5$ results in the following impulse responses to a monetary policy shock.

Figure 8: **Sticky Wages and Endogenous Survival Probability**



8 Conclusion

The aim of this paper is to improve our understanding of the driving forces of firm entry over the business cycle, with a view of testing the monetary transmission process through the extensive investment margin. Using model-based sign restrictions, I identify four shocks in a VAR. These are shocks to productivity, aggregate spending, monetary policy and entry costs. Firm entry is allowed to respond freely to these shocks. I compare the empirical and theoretical impulse responses in terms of their sign and shape. Wherever the model fares badly, I propose modifications and extensions that can bring it closer to the data. One notable finding in favour of the model is that of a positive effect of an increase in aggregate spending on entry, both in the model and in the data. This shows that aggregate spending shocks lead to adjustments in investment along the extensive margin. However, in the VAR, firm entry and profits also respond positively to monetary policy shocks. This is inconsistent with the view of the benchmark model that entry costs reflect wage costs, and that real wages respond strongly to changes in aggregate demand. Introducing wage stickiness helps to produce responses of profits and entry with the right sign. As aggregate demand increases, a dampened real wage response implies that production costs as well as entry costs rise by less than in the flexible-wage economy, allowing for profits and firm entry to expand. As for the estimated dynamics, the hump in the empirical impulse response functions of firm entry, which is typically also found for intensive-margin investment, suggests that other rigidities are present in the data that impede a speedy adjustment of firm creation. These rigidities might reflect a congestion externality whereby an increase in firm startups lowers the expected survival probability for would-be entrepreneurs. Rethinking the way that entry costs and survival rates are modelled thus remains high on the research agenda.

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Data

Data series are taken from the St. Louis Fed Economic Database, except for the data on firm entry. Net business formation (NBF) and New business incorporations (NI) are from the BEA's Survey of Current Business. These series have been discontinued; data run from January 1948 to September 1995 (for NBF) and to September 1996 (for NI). Inflation is measured as the percentage change in the implicit GDP deflator. The interest rate is the 3-month Treasury bill rate. Profits are deflated using the GDP deflator.

Table 6: **Data**

Variable	Units, Freq, Seas. adj.	Series ID
Real Gross Domestic Product, 1 Decimal	Bil. Chn. 2000 $, Q, SAAR	GDPC1
Corporate Profits with IVA and CCAdj	Bil. $, SAAR, Q	CPROFIT
3-Month Treasury Bill: Second. Mkt. Rate	%, M	TB3MS
GDP: Implicit Price Deflator	Index 2000=100, Q, SA	GDPDEF
Net business formation	Index 1967=100, M	-
New business incorporations	Thousands, M	-

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