Limited Participation or Sticky Prices? New Evidence from Firm Entry and Failures

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April 29, 2008

First draft

Abstract

Traditional models of monetary transmission such as sticky prices and limited participation abstract from firm creation and destruction. Only a few papers look at the empirical effects of the monetary shock on the firm turnover measures. But what can we learn about monetary transmission by including measures for firm turnover into the theoretical and empirical models? Based on a large scale vector autoregressive (VAR) model for the U.S. economy I show that a contractionary monetary policy shock increases the number of business bankruptcy filings and failures, and decreases the creation of firms and net entry. According to the limited participation model, a contractionary monetary shock leads to a drop in the number of firms. On the contrary the same shock in the sticky price model increases the number of firms. Therefore the empirical findings support more the limited participation type of the monetary transmission.

Keywords: monetary transmission, limited participation, sticky prices, firm entry, firm bankruptcy, structural VAR

JEL code: E52, C32, C61, E12, D21

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1 Introduction

Two popular approaches for understanding monetary transmission are limited participation and sticky price models. These models rarely include firm turnover: entry and exit of firms. What can we learn about monetary transmission by including the number of firm dynamics into these models? What are the empirical effects of monetary shocks on the firm turnover variables?

The empirical results of the paper show that a contractionary monetary shock leads to an increase in the number of business failures and to a decrease in the creation of firms. The sticky price and limited participation models give contradicting predictions about the firm turnover dynamics. According the sticky price model a contractionary monetary policy shock leads to an increase in the number of firms, whereas in the limited participation model the same shock leads to a decrease in the number of firms. Therefore the empirical evidence supports limited participation hypothesis of monetary transmission in comparison to the sticky prices.

I estimate an 11-variable vector autoregressive (VAR) model for the U.S. economy including labor productivity, total hours, GDP deflator, capacity utilization, real wage, consumption, investment, Federal Funds Rate, money velocity, and one-by-one alternative firm turnover measures: firm entry, net entry, business bankruptcy filings, and failures. I adopt the recursive approach in identifying monetary shocks which is based on contemporaneous restrictions. In addition I identify investment specific and neutral technology shocks with long run restrictions in order to minimize problems of mis-specification. The monetary policy results are robust to the use of non-borrowed reserves and the Federal Funds Rate (FFR) in order to identify the shock, inclusion and exclusion of the firm turnover measures from the central bank information set, difference and level stationarity of hours, reduction of the estimation period, etc.

My empirical findings are in line with the previous literature measuring the effects of the monetary policy on the creation of firms. Bergin and Corsetti (2005) use a relatively small scale VAR of monthly data and impose short run restrictions in order to identify the monetary shock. They find that net entry decreases after a contractionary monetary shock when either the FFR or non-borrowed reserves are used in order to identify monetary policy shocks. The firm creation decreases only if non-borrowed reserves are used to identify the monetary shock. Lewis (2006) adopts a sign restriction approach to estimate the effect of the monetary shock to net entry. She finds that net entry decreases only with a significant lag after a contractionary monetary policy shock.

In the theoretical part of the paper I augment two simple models of monetary transmission, a limited participation and a pre-set price model as a simple case of sticky prices, with the endogenous firm creation and exogenous firm destruction dynamics. I assume that creation and operating firms is labor intensive. According to the limited participation model, firms pay wages before production and have to borrow the wage bill from the financial intermediary. A contractionary monetary policy shock decreases the liquidity of the financial intermediaries: bank lending falls and the interest rate increases. The real wage and hours worked decrease because firms can borrow less money to pay for their workers. The marginal cost of production for the firm remains constant because the real wage declines and interest rate increases. Fall in the total production leads to a drop in the creation of firms.

In a standard sticky price model, a contractionary monetary shock leads to a drop in demand for the consumer good and consequently to a drop in demand for labor. Therefore labor costs fall equally for production of goods, and for operating and creating firms. Increasing profits per firm lead to higher creation of firms up to the level where the free entry condition is satisfied. These results are the opposite of the predictions of the limited participation model and the empirical results.

Some recent models of monetary transmission include the firm turnover dynamics. In the Bilbiie et al. (2007) model with quadratic adjustment cost of prices, a contractionary monetary policy shock leads to an increase in the number of firms (in their interpretation varieties) when creating firms is labor intensive. Instead, in order to get a decrease in the number of firms, Bilbiie et al. (2007) and Bergin and Corsetti (2005) assume that for the entry cost, new firms buy goods from the existing firms, who sell at pre-set prices. Then monetary contractions decrease entry of firms because of the increase in the real entry cost. However, a decrease in the demand for the output leads to a drop in wages and to an increase in profits for the existing firms. Increasing profits should still lead to an increase in entry in the production sector.

Carried by a similar idea Mancini-Griffoli and Elkhoury (2006) assume that in order to create a firm, entrepreneurs have to buy goods from a specific sector in the economy - lawyers - who have to set their prices in advance, whereas the rest of the entrepreneurs set the prices of their goods freely. In such a set-up, a contractionary monetary shock raises the real cost of entry and consequently the creation of firms decreases. A contractionary monetary shock in the sticky wage model leads to a drop in the entry of firms (see Lewis (2006)). The sticky wage model also predicts that a monetary contraction increases the real wage. The empirical evidence in this paper shows instead that the real wage decreases.

2 The Empirical Methodology

I set up the VAR model in order to estimate the effects of the monetary policy shock to the firm turnover measures. I adopt the recursive approach in identifying the monetary shock. In order to reduce the problem of mis-specification, I identify in addition two technology shocks: investment specific and neutral technology shocks with the long-run restrictions.

The reduced form VAR is given as:

$$y_t = b_0 + \sum_{i=1}^{p} b_i y_{t-i} + u_t, \tag{1}$$

where, b_0 represents all the deterministic terms which are used in the estimation including constants, seasonal and impulse dummies, b_i-s are matrices of coefficients, p is the number of lags used in the model, u_t is the error term, and y_t is the set of endogenous variables.

The VAR contains 11 endogenous variables. They are listed in Table 1 in the order as they appear in the model. I use the Federal Funds Rate (FFR) to measure monetary conditions. The change of the log of the GDP (Gross Domestic Product) deflator is used as a proxy for the inflation. I include the relative price of investment in order to identify an investment specific technology shock and a labor productivity variable in order to identify a neutral technology shock. I add a list of macroeconomic variables in order to reduce possible omitted variable bias. The additional macroeconomic variables are capacity utilization, hours worked, real unit labor cost (real wage), consumption and investment shares in GDP and money velocity. For a detailed description of the data see Table 2 in the Appendix.

Table 1: Variables used in the benchmark VAR

Notation	Name of the variable
ip	change in logarithm of investment price
lp	change in logarithm of labor productivity
$GDPdef$	change in logarithm of GDP deflator
$capu$	level of capacity utilization
h	logarithm of per capita hours worked (level)
w	logarithm of real labor cost
c	logarithm of consumption share in GDP
i	logarithm of investment share in GDP
ee	change in logarithm of firm demographics measure
FFR	federal funds rate (level)
vel	logarithm of money velocity

Several other authors have estimated similar systems of VARs. Altig et al. (2005) estimate a 10-variable VAR including relative price of investment, productivity, GDP deflator, hours, consumption, investment, and several other variables, but do not include a measure of firm dynamics in their system. Ravn and Simonelli (2007) estimate a 12-dimensional VAR adding to the system government expenditures and, specific to their paper, several labor market variables.

The structural VAR is given as:

$$A_0 y_t = B_0 + \sum_{i=1}^{p} B_i y_{t-i} + \epsilon_t \tag{2}$$

where, B_i-s are matrices of the structural coefficients, related to b_i-s as the following: $b_i = A_0^{-1} B_i$, ϵ_t are the structural shocks, the variance-covariance matrix ($\Sigma_\epsilon = E(\epsilon_t' \epsilon_t)$ is assumed to be diagonal and related to the reduced form shock variance-covariance matrix ($\Sigma_u = E(u_t' u_t)$) by the following formula $\Sigma_u = A_0^{-1\prime} \Sigma_\epsilon A_0^{-1}$.

The recursive approach of identifying the monetary policy shocks builds on a Taylor rule type of argument. A central banker who takes into account contemporaneous values of the variables in his information set Ω decides then about the shock (ζ_t) by setting the interest rate (R_t),

$$R_t = F(\Omega) + \zeta_t. \tag{3}$$

In order to obtain identification, I impose short-run restrictions. The variables in the information set can have contemporaneous effect on the interest rate, but not vice versa. All the variables placed before the interest rate can have contemporaneous effects on the interest rate, but are assumed not to be affected contemporaneously by the interest rate. For example, money velocity, which is the only variable after the interest rate, is contemporaneously influenced by the interest rate, but does not affect the FFR in the same period. I assume that the firm turnover variables enter into the central bank's information set Ω. Therefore I estimate the following equation:

$$\begin{aligned} FFR_t \;=\; & b_0^{FFR} + \sum_{i=0}^{p} b_i^{FFR,ip} ip_{t-i} + \sum_{i=0}^{p} b_i^{FFR,lp} lp_{t-i} \\ & + \sum_{i=0}^{p} b_i^{FFR,GDPdef} GDPdef_{t-i} + \sum_{i=0}^{p} b_i^{FFR,capu} capu_{t-i} + \sum_{i=0}^{p} b_i^{FFR,h} h_{t-i} \\ & + \sum_{i=0}^{p} b_i^{FFR,w} w_{t-i} + \sum_{i=0}^{p} b_i^{FFR,c} c_{t-i} + \sum_{i=0}^{p} b_i^{FFR,i} i_{t-i} + \sum_{i=0}^{p} b_i^{FFR,ee} ee_{t-i} \\ & + \sum_{i=1}^{p} b_i^{FFR,FFR} FFR_{t-i} + \sum_{i=1}^{p} b_i^{FFR,vel} vel_{t-i} + u_t^{FFR}. \end{aligned} \tag{4}$$

The explanatory variables for the interest rate are all the contemporaneous values and lags of the variables placed before it, plus the lags of the interest rate and the money velocity.

The recursive identification scheme for the monetary policy is widely used in empirical literature, including Altig et al. (2005), Ravn and Simonelli (2007), and Boivin et al. (2007). The main alternative is a non-recursive approach proposed by Sims and Zha (2006), but has been shown to result in very similar impulse responses to the recursive identification scheme. Uhlig (2005) proposes an identification scheme based on sign restrictions on the impulse response functions. The sign restrictions approach challenges some of the empirical results obtained by the short-run restrictions. See Christiano et al. (1998) for an overview of the main results of the monetary shock and the comparison of various identification approaches.

Differently from my VAR, Bergin and Corsetti (2005) exclude the firm turnover variable from the information set of the central bank. The reason might be the use of monthly data in their estimation. As shown in the robustness analysis section of this paper, the results are not sensitive to different timing.

I base the identification of the investment specific technology shock on the assumption that only the investment specific technology shocks can have long-run impact on the relative price of investment good. Therefore the explanatory variables for the estimated equation on the relative price of investment are the lags of the investment price itself and the lagged values of all other variables differenced once. The use of differenced data implements the zero long-run restrictions, see Shapiro and Watson (1988). The contemporaneous values of the FFR and velocity are excluded because of the identification of the monetary shock.

For the permanent neutral technology shock, I assume that only the neutral and investment embodied technology shocks can lead to permanent changes in the labor productivity. Therefore all the other variables are differenced once. Again, contemporaneous values of the FFR and money velocity are excluded in the set of explanatory variables in order to identify the monetary policy shock.

The embodied technology equation cannot be estimated with the ordinary least squares technique because contemporaneous value of productivity might be correlated with the residual. Therefore I estimate the equation by IV. The instruments are the lagged values of the explanatory variables. Also the equation on neutral technology is estimated with the IV technique using the same instruments as for the equation on the investment price adding the residual from the investment price equation.

After estimating the two technology shocks, I proceed the estimation of the equations in the order of the variables in Table 1. I estimate all the equations by the recursive IV technique. I include the contemporaneous values of the previous variables in the regression and exploit all the estimated residuals as instruments. Therefore for the estimation of the last equation on money velocity, I include all other contemporaneous values of the variables in the regression and residuals in the set of instruments.

Many authors consider technology shocks as the key shocks for macroeconomic dynamics, including Kydland and Prescott (1982), Altig et al. (2005), Ravn and Simonelli (2007), etc. Several authors adopt the long run restrictions in identifying neutral technology shocks, for example see Gali (1999), Altig et al. (2005), Fisher (2006), and Ravn and Simonelli (2007). Fisher (2006) shows that the neutral technology shock might be mis-specified if the investment technology shock is not identified. Campbell (1998) shows that technology shocks can be important for generating variance in the plant entry and exit dynamics, closely related to the business entry and failure variables.

3 Data

The creation of firms (number of new incorporations) and the number of business failures (number of firms failed) are available for the period 1959Q1-1998Q3, and the net entry index (net business formation) can be obtained for the period 1959Q1-1995Q4. This data are collected and calculated by the Dun&Bradstreet Inc. available through various sources (see Table 2 in the Appendix). The number of business bankruptcy filings is from the U.S. Court of Bankruptcy. It is used in the estimations for the period 1960Q3-2005Q4. The firm turnover data are presented in log-levels in Figure 1 in the Appendix.

The Dun&Bradstreet database covers around 90% of the enterprizes with at least one employee and some without employees. The registration of the company at the Dun&Bradstreet database is voluntary and the registration of the firm takes place some time after the actual start of the business. Therefore the entry data contain noise. The index of net entry of firms is not available in the aggregate numbers because of difficulties in counting for the number of closing firms. In addition to the above mentioned problems, Armington (2004) discusses several other weaknesses of the firm creation and net entry variables.

Up to the year 1984 the number of business failures included only commercial and industrial sectors, and excluded banks, railroads, real estate, insurance, holding, financial companies etc. In 1984 The Dun&Bradstreet extended the coverage, which made the data directly not comparable. Naples and Arifau (1997) propose an adjustment which makes the post 1984 time-series comparable to the pre 1984 period. According to their results, the number of business failures increased on average about 31% because of the increase in the coverage. For the period 1984-1996, I use the adjusted data. There are no adjusted failure numbers available for the years 1997 and 1998. For these two years I use the average increase of 31%.

In 1978 a new bankruptcy law eased the bankruptcy procedure. The number of failures increased steadily and stabilized at a higher level around 1983. In order to capture the change in the law, I add a dummy variable to the equation of the business failures. The number of bankruptcy filings is increasing in the beginning and decreasing in the end of the period, inclusion of dummies for different periods however does not change the results given the confidence intervals of the estimated results.

Table 3 in the Appendix presents the (augmented) Dickey-Fuller stationarity test results for the firm turnover measures. The variables are stationary in first differences but not in levels. The results are robust to the number of lags, and the inclusion and exclusion of the trend. The number of business failures has a statistically significant seasonal pattern. Hence for the equation on failures, I include seasonal dummies in the set of explanatory variables. Ravn and Simonelli (2007) show that statistical tests are not robust in determining whether the level of hours is stationary or not. Based on their results, in the robustness analysis I allow also for difference stationarity of hours. For all other series I assume stationarity.

4 Empirical results

This section presents the main empirical results. The benchmark SVAR model has 3 lags. The 68% confidence intervals are centered around the point estimates and based on 1000 bootstrap replications.

Figure 2 in the Appendix illustrates the dynamics of the firm turnover variables in response to a contractionary monetary policy shock - an increase in the interest rate by one standard deviation. The number of business bankruptcy filings and failures increase by 2% starting from the second quarter (see the two upper panels). The effect lasts for more than four years for both of the failure measures. The net entry index decreases by 0.5% after one quarter (see the third panel). The effect is statistically significant up to quarter ten. The entry of firms, presented in the lower panel, decreases by 0.6% and the impact is statistically significant for 11 quarters.

The failure rate increases after the contractionary monetary shock, but the results are uninformative about the changes in the entry rate. The failure rate increases because a higher number of firms fail from a smaller number of total firms in the economy (net entry is negative, the entry of firms is lower and the number of failures is higher). Depending on the relative size of firm entry to net entry, the entry rate can either increase or decrease.

All the reactions of the firm turnover measures remain statistically significant also at the 95% confidence level, at least for some quarters. The estimated impulse response functions for the entry of firms and net entry are with relatively lower confidence level compared to other economic data and to the number of failures. This can be explained by a high level of noise in these the entry variables as explained before.

The result about decrease in the net entry after the contractionary monetary shock is similar to the finding of Bergin and Corsetti (2005). In contrast to my findings, the creation of firms in their model does not react to a contractionary monetary shock when FFR is used to identify monetary shock. In comparison to the results in Lewis (2006), I find that after a contractionary monetary shock, net entry becomes statistically significantly different from zero after one quarter, not after 2 years.

In addition the contractionary monetary shock leads to a hump-shapes decrease in hours, output, consumption, investments, capacity utilization, and velocity of money. The results can be found in Figure 3 in the Appendix for the results of the VAR that includes bankruptcy filings as the firm turnover measure. The investment price, productivity, and inflation react very little. Inflation decreases after a lag of one year. The real wage declines after the contractionary shock. The results on the macroeconomic variables are similar to several previously estimated VAR models, such as Altig et al. (2005), Christiano et al. (1998), and others.

5 Robustness Analysis

In this section I show that the results are robust to various changes in the set-up. As in Bergin and Corsetti (2005), I replace the FFR with the ratio of non-borrowed reserves to total reserves (NBR/TR) in the VAR. A contractionary monetary policy shock is now described by a drop in the NBR/TR ratio. The impact of the shock is smaller for the business bankruptcy filings and higher for the other three measures.

For a standard deviation sized contractionary monetary shock in the NBR/TR ratio leads to an increase in the bankruptcy filings by 2% and the business failures by more than 3%. The entry of firms and net entry decrease both by more than 0.6%. The impulse response functions of the firm turnover measures are presented in Figure 4 and all other economic variables in Figure 5, both figures are in the Appendix.

Positioning the firm turnover measure after the interest rate, therefore excluding it from the central bank's information set as done in Bergin and Corsetti (2005), does not change results much. The contemporaneous effect of the monetary shock is insignificant for the new firms, net entry, and bankruptcy filings, but significant for the failures: contractionary shock is associated with a small contemporaneous increase in the number of failures. Therefore for the variables Bergin and Corsetti (2005) were concerned (the entry of firms and net entry), the results are similar.

When two firm turnover measures: the entry of firms and failures are added to the VAR simultaneously, the results again change very little. The entry of firms still decreases by 0.6% and is statistically significant for 12 quarters. The number of failures increases by 2% and lasts for 18 quarters. Differencing hours instead of using it on levels leads to stronger effects to all variables, the entry of firms does not converge in 20 quarters.

Dropping first 2 or 5 years from the sample does not change the reaction of the firm turnover measures much compared to the baseline, only the failure measure converges quicker than in the benchmark case. However, exclusion of the last 2 or 5 years leads to a stronger and more persistent effect on the business bankruptcy filings and the entry of firms, but does not change the results on the business failures and net entry.

Using 8 variables instead of 11, that is, dropping consumption, investment and the real wage from the initial set-up, makes the effects of the monetary contraction to all firm turnover variables stronger and longer lasting. Using 4 lags instead of 3 leads to a weaker effect on the entry of firms and a stronger effect on the bankruptcy filings, leaving the reaction of the other two variables unchanged.

It is impossible to carry out a structural break test related to the change in the bankruptcy law in 1983 because there are two additional important changes that took place around the same time. According to Bernanke and Mihov (1998) the period 1979-1982 is described as a change in the monetary policy regime in the U.S. In addition, around the year 1980, several banking regulations were changed, including the interest rate ceilings for the deposits, which might have changed the transmission of shocks in the U.S. economy (see Mertens (2006)). For the robustness analysis I drop 20 years of data from the beginning and from the end in order to make the degrees of freedom comparable. The variables are stationary in differences as it was the case for the full period (see Tables 4 and 5 in the Appendix).

Dropping 20 years from the beginning of the sample makes the impulse responses stronger and longer lasting for the case of new firms. Dropping last 20 years makes the reactions of the business failures, net entry and the entry of firms short - the effect lasts up to 3 quarters. The impact of the shock on the bankruptcy filings remains unchanged. As bankruptcy filings data includes the latest period, years from 1999 to 2005, the effects of monetary shocks to firm turnover measures have remained strong. The inclusion of the last 6 years of the data leads to much smoother and stronger impulse responses also for other economic variables.

The use of unadjusted measure for failures, and the regression without dummy for the period of high increase for failures, do not change results significantly. There is one more measure available for the business failures. The Dun&Bradstreet published the failure rate based on 10000 listed enterprizes for the period 1959Q1-1983Q4. The exit rate is stationary only if they are differenced once (see Table 6 in the Appendix). A contractionary monetary shock leads to an increase in the failure rate by 1.5% with the effect lasting for 15 quarters.

6 Limited participation model

In this section I present a simple limited participation model for analyzing the effects of a monetary shock to the number of firms dynamics. I adopt the model of Christiano et al. (1997) and add the endogenous creation and exogenous destruction of firms in the intermediate goods producing sector. The economy consists of a representative consumer, final and intermediate good firms, financial sector, and a monetary authority.

6.1 Consumer problem

The representative consumer maximizes her lifetime utility derived from consumption and leisure:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma} - 1}{1-\sigma} - \psi_0 ln(n_t) \right), \tag{5}$$

where c_t is real consumption at period t, n_t denotes the hours spent working, E_t is the expectations operator, $0 < \beta < 1$ is the discount factor, and the weight on the disutility of labor is given by $\psi_0 > 0$. The inverse of elasticity of substitution is denoted by $\sigma > 1$ and together with the logarithmic disutility of labor, it means that the Frisch elasticity of labor supply is positive. Upper case letters denote nominal and lower case letters real variables unless clear from the context.

The consumer faces the following intertemporal budget constraint:

$$M_t - H_t \leq W_t n_t + M_{t-1} - H_{t-1} - P_t c_t + R_t H_{t-1} + R_t X_t + D_t + J_t, \tag{6}$$

where M_t is the nominal money decided at period t to be used for the purchases at $t+1$, H_t is the deposit decided at period t to be given to the financial intermediary the next following, W_t is the nominal wage, P_t is the price level, R_t is the gross interest rate, $R_t X_t$ are the nominal profits received from the financial intermediary, and the nominal profits from the intermediate and final good production firms are denoted respectively by D_t and J_t.

In addition the consumer faces a cash-in-advance constraint. For the consumption purchases, she can only use the cash left one period before $(M_{t-1} - H_{t-1})$ and labor income, so the condition is:

$$P_t c_t \leq W_t n_t + M_{t-1} - H_{t-1}. \tag{7}$$

The consumer decides about consumption c_t, labor input n_t, money M_t, and deposits H_t. The predetermined variables are cash M_{t-1}, the deposits H_{t-1}, profits from the financial intermediaries $R_t X_t$, and profits from final and intermediate good firms, respectively J_t and D_t.

The optimality conditions are the following:

$$E_t \left(\frac{c_{t+2}}{c_{t+1}} \right)^{\sigma} = \beta E_t \frac{R_{t+1}}{\pi_{t+2}} \tag{8}$$

$$\psi_0 c_t^{\sigma} = w_t n_t \tag{9}$$

where $\pi_t = P_t / P_{t-1}$ is one plus the inflation rate and the real wage $w_t = \frac{W_t}{P_t}$. The equation (8) is the Euler condition and the equation (9) is the optimality condition for labor-leisure choice.

6.2 Final good firm

The final good sector produces the consumption good. It uses a constant elasticity of substitution (CES) aggregator to combine the goods from the intermediate sector:

$$y_t = \left(\int_0^{F_t} y_{i,t}^{1-1/\varepsilon} di \right)^{1/(1-1/\varepsilon)}. \tag{10}$$

where y_t is the output made from intermediate goods, F_t is the number of firms, $y_{i,t}$ is the input good from the intermediate good producer i at period t and $\varepsilon > 1$ is the elasticity of substitution between the intermediate goods. The production function implies positive productivity from an enlarged number of varieties.

The final good firm maximizes profits:

$$O_t = P_t y_t - \int_0^{F_t} P_{i,t} y_{i,t} di \tag{11}$$

where O_t is the profit of the final good firm from aggregating the intermediate goods, as there is perfect competition and no entry or exit, it is always equal to zero.

After some rearrangements the first order condition with respect to y_{it} gives the following demand for each of the intermediate good:

$$y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} y_t, \tag{12}$$

where the $P_t = \left(\int_0^{F_t} P_{i,t}^{1-\varepsilon} \right)^{1/(1-\varepsilon)}$ is the price index, with the empirical counterpart of $P_t = F_t^{-\varepsilon/(\varepsilon-1)} \left(\int_0^{F_t} P_{i,t}^{1-\varepsilon} \right)^{1/(1-\varepsilon)}$, where $F_t^{-\varepsilon/(\varepsilon-1)}$ removes variety effect from the price index.

In addition, the final output (y_t^{TOT}) includes the output of the work done for creating and operating firms. The final goods sector sells it at the price of the final good and distributes profits (J_t) to the consumer:

$$
\begin{aligned}
y_t^{TOT} &= F_t^{-1/(\varepsilon-1)} y_t + \int_0^{F_t} \xi^{op} di + \int_0^{F_t^N} \xi^{ent} di, & (13) \\
J_t &= P_t \left(\int_0^{F_t} \xi^{op} di + \int_0^{F_t^N} \xi^{ent} di \right), & (14)
\end{aligned}
$$

where F_t^N is the number of new firms at period t, $\xi^{op} \geq 0$ is the fixed operation cost in labor units for the existing firms, and $\xi^{ent} > 0$ is the fixed entry cost in labor units for the new firms. Again, the term $F_t^{-1/(\varepsilon-1)}$ removes the positive productivity effect of the increasing number of varieties in order to make the total output comparable to the empirical counterpart.

6.3 Intermediate good firms

The present value ($V_{i,t}$) of an existing intermediate good producing firm is defined by discounted flow of profits. Writing it in the value form for an existing firm gives the expression:

$$
V_{i,t} = D_{i,t} + \beta(1-\delta) E_t \left(\frac{c_{t+1}}{c_{t+2}} \right)^{-\sigma} V_{i,t+1} \tag{15}
$$

where $0 < \delta < 1$ is the probability of a death shock to a firm and the future profits are discounted with the stochastic discount factor of the consumer.

In each period, a share of the existing firms is hit by the death shock. The death shock is realized before the entry decisions are made, so all new firms produce and there is no time to build lag. The aggregate number of firms is described by the law of motion equation:

$$
F_t = (1-\delta) F_{t-1} + F_t^N. \tag{16}
$$

The production function of the intermediate good firms is linear:

$$
y_{i,t} = l_{i,t}. \tag{17}
$$

The market structure is monopolistic competition. The firm takes the demand from the final good sector as given. They pay wages in advance borrowing the wage bill from the financial intermediary. The marginal cost of production is equal to the nominal wage times the gross interest rate ($MC_t = R_t W_t$). The intermediate good firms use a fixed quantity of labor (ξ^{op}) for operating. The profits are sales minus the costs:

$$
D_{i,t} = (P_{i,t} - R_t W_t) y_{i,t} - \xi^{op} R_t W_t. \tag{18}
$$

In order to maximize profits, take the derivative with respect to the price $P_{i,t}$ and get the pricing rule $P_{i,t} = \frac{\varepsilon}{\varepsilon-1} R_t W_t$. Firms set the price as a constant mark-up over marginal cost.

The entry to the market of the intermediate goods is free, but every entrant has to pay a one-time fixed cost ξ^{ent} in labor. Hence the free entry condition is written as follows:

$$V_{i,t} = \xi^{ent} R_t W_t. \tag{19}$$

6.4 Financial intermediary

In the limited participation model the intermediate good firms borrow their wage bill from the financial intermediaries: $W_t N_t = H_{t-1} + X_t$. For giving out loans financial intermediaries use deposits H_{t-1} and the money injection of the monetary authority X_t. At the end of each period, financial intermediary pays out its' profits to the consumer $R_t X_t = R_t(H_{t-1} + X_t) - R_t H_{t-1}$. Bank gets income from giving out loans, and cost deposits returned to the consumers with gross interest rate R_t.

6.5 Monetary authority

In the limited participation model monetary authority decides about the money injection to the financial intermediary X_t. It is a one time shock with zero autocorrelation.

6.6 Market clearing conditions and the equilibrium

All the aggregate output (equation 20) is consumed: total labor equals total output. The total profits by firms consist of the aggregate operating profits minus the entry costs paid by the newly created firms (equation 22).

$$c_t = y_t^{TOT} \tag{20}$$

$$n_t = c_t \tag{21}$$

$$D_t = \int_0^{F_t} D_{i,t} di - \int_0^{F_t^N} W_t R_t \xi^{ent} di \tag{22}$$

Definition of the equilibrium: Equilibrium of the model is the sequence of quantities $\{c_t, n_t, m_{t+1}, h_{t+1}, d_t, d_{i,t}, j_t, F_t, F_t^N\}_{t=0}^{\infty}$, and prices $\{P_t, R_t\}_{t=0}^{\infty}$, given the initial conditions $\{m_0, h_0, F_{-1}\}$, and the sequence of government money injections $\{X_t\}_{t=0}^{\infty}$, such that consumer maximizes her lifetime utility, final and intermediate good firms are maximizing their profits, financial intermediaries maximize their profit, the free entry condition is satisfied, and the markets clear.

7 Model with pre-set prices

In this section I present a simple pre-set prices model as an example of sticky prices. Again I augment the simple model with endogenous entry and exogenous exit of firms in the intermediate goods firms. Creation and destruction of firms in this sector takes place after the shock and the prices are fixed before the monetary shock is realized. The entry is determined by the free entry condition. Fully competitive final goods sector aggregates the goods from intermediate goods sector, there is no entry and exit. Differently from the limited participation model, there is no financial sector.

7.1 Consumer problem

For the pre-set prices model I adopt a money-in-utility approach. The representative consumer maximizes lifetime utility derived from consumption, leisure, and money balances:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma} - 1}{1-\sigma} - \psi_0 ln(n_t) + \frac{1}{1-\varphi} \left(\frac{M_{t+1}}{P_t} \right)^{1-\varphi} \right). \tag{23}$$

where M_{t+1} is the nominal money transferred to the next period and $0 < \varphi < 1$ is the inverse of elasticity of substitution for money demand. The consumer decides about consumption and work today, and money left for tomorrow. The utility function implies neutrality of money, so the real effects are caused by the imposed sticky prices.

The consumer faces the following budget constraint:

$$P_t c_t + B_{t+1} + M_{t+1} = W_t n_t + (1 + i_{t-1}) B_t + M_t + D_t + J_t, \tag{24}$$

where B_t are the bonds at period t. In order to buy the consumption good, the consumer can use all the profits received from the firms, money, and bonds. There is no cash-in-advance condition.

In order to maximize consumer utility, take first order conditions with respect to the bonds B_{t+1}, money M_{t+1}, consumption c_t, and labor n_t. There are three optimality conditions for the consumer:

$$E_t \left(\frac{c_{t+1}}{c_t} \right)^{\sigma} = \beta E_t \frac{1 + i_t}{\pi_{t+1}} \tag{25}$$

$$\psi_0 c_t^{\sigma} = w_t n_t \tag{26}$$

$$\left(\frac{M_{t+1}}{P_t} \right)^{-\varphi} = \frac{i_t}{1 + i_t} c_t^{-\sigma}. \tag{27}$$

The Euler equation (no. 25) determines consumption tradeoff between the present and the following period. It is different from the tradeoff in the limited participation model, where the trade-off was between tomorrow and the day after. The money demand is given by the equation 27. Its is different from the limited participation approach, where the money demand was determined by the cash-in-advance constraint. The labor-leisure choice equation 26 is identical to the one in the limited participation model.

7.2 Final good firm

The final good sector is identical to the limited participation model. The demand for each of the intermediate good is given by:

$$y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon} y_t, \tag{28}$$

where the price index P_t is the same as in the sticky wage model.

The final good sector output, as in the limited participation model, includes the factor inputs in creating and operating firms, and the final good sector sells the factor inputs at the price of the final good.

$$\begin{aligned} y_t^{TOT} &= F_t^{-1/(\varepsilon-1)} y_t + \int_0^{F_t} \xi^{op} di + \int_0^{F_t^N} \xi^{ent} di, & (29) \\ J_t &= P_t \left(\int_0^{F_t} \xi^{op} di + \int_0^{F_t^N} \xi^{ent} di \right). & (30) \end{aligned}$$

7.3 Intermediate good firms

In the intermediate good sector there are three differences compared to the limited participation model. First, the wages are not payed out before production: labor cost does not include the interest rate. Second, the prices must be set one period in advance and the new firms set the same price as all the other firms. Third, according to the consumer problem, stochastic part of the discount factor for the firms includes today and tomorrow.

The value of the firm in the intermediate good sector is given by:

$$V_{i,t} = D_{i,t} + \beta(1-\delta) E_t \left(\frac{c_t}{c_{t+1}}\right)^{-\sigma} V_{i,t+1}, \tag{31}$$

where the stochastic discount factor is taken from the consumer problem.

The number of firms dynamics is described as before by:

$$F_t = (1-\delta) F_{t-1} + F_t^N. \tag{32}$$

The production technology in the intermediate good sector is again linear:

$$y_{i,t} = l_{i,t}. \tag{33}$$

The nominal marginal cost of production is given by the shadow price of producing an additional unit of output ($MC_t = W_t$). Wages are paid out at the time when the final output is sold.

The firms decide about their prices one period in advance, maximizing the following profit function:

$$\max_{P_{i,t}} E_{i,t-1} \left(\frac{c_t}{c_{t+1}}\right)^{-\sigma} D_{i,t} = E_{i,t-1} \left(\frac{c_t}{c_{t+1}}\right)^{-\sigma} \left[(P_{i,t} - W_t) \left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon} y_t - \xi^{op} W_t \right], \tag{34}$$

The firms take the derivative with respect to $P_{i,t}$ and solve for $P_{i,t}$ to get condition for optimal pricing, mark-up over the expected marginal cost:

$$P_{i,t} = \frac{\varepsilon}{\varepsilon - 1} E_{t-1} W_t. \tag{35}$$

The entry to the market of intermediate goods is free, but every entrant has to pay a one-time fixed cost $\xi^{ent} W_t$. The free entry condition is written as follows:

$$V_{i,t} = \xi^{ent} W_t. \tag{36}$$

The crucial assumption in this model in order to have the effects of the monetary policy on the creation of firms is that the firm creation decisions are made during the period in which the nominal rigidities are still binding. Therefore the results also hold when I would assume longer price rigidities and let the firms to enter with a lag.

In the present version of the model, the new firms are not allowed to set different prices from the existing firms. Such a change would complicate the aggregation of the demand without affecting the results much, so the extension is left for the future.

7.4 Monetary authority

The monetary authority decides about the money injection to the economy. There is one time shock to the money growth g_t^m with zero autocorrelation.

7.5 Market clearing conditions

Again, all the production (equation 37) is consumed and the total labor equals to the total output. The aggregate profits by the firms are the sum of total operating profits from each firm minus the entry costs (equation 39).

$$c_t = y_t^{TOT} \tag{37}$$

$$n_t = c_t \tag{38}$$

$$D_t = \int_0^{F_t} D_{i,t} di - \int_0^{F_t^N} W_t \xi^{ent} di \tag{39}$$

Definition of the equilibrium: Equilibrium is defined by the sequence of quantities $\{c_t, n_t, b_{t+1}, M_{t+1}, j_t, d_t, d_{i,t}, F_t, F_t^N\}_{t=0}^{\infty}$, and prices $\{P_t\}_{t=1}^{\infty}$, given the initial conditions $\{m_0, F_{-1}, P_0\}$, and government money injections, such that the consumer maximizes her lifetime utility, final and intermediate good firms maximize their profit, free entry conditions for firms is satisfied, and markets clear.

8 Calibration and results from the two models

I log-linearize the model around the steady state and solve it computationally by using the method of undetermined coefficients proposed by Uhlig (1999). The steady states and the log-linearized equations for both models are presented in the Appendix.

I follow traditional parameter values in the calibration of the two models for the quarterly frequency (see Table 7 in the Appendix). I set the inverse of the intertemporal elasticity substitution $\sigma = 2$. The probability of death of a firm is calibrated to 2.5%, which is 10.7% per annum, very close to the actual number of exit rate per year in the U.S., which is around 11%. I assume that shocks to the economy are small so that there is always positive entry. The discount factor reflects real interest rate of 4% per year. The elasticity of substitution ($\varepsilon = 17$) gives a mark-up of 6%, which is standard in the literature, but the only role of it is, together with death probability, operation and entry costs, to determine the number of firms in the economy. The cost of entry is calibrated to be higher than the operation cost. Steady state yearly inflation in the limited participation model is 2%. Inverse of the elasticity of substitution of money in the middle of the allowed rage between zero and one, and constant in front of the disutility of labor do not change the qualitative results on the number of firms.

Figure 6 in the Appendix presents the impulse response functions to a monetary shock in a limited participation framework. The monetary contraction leads to a drop in the funds which the financial intermediary can lend to the intermediate good producers. This results in lower wages and hours. However, an accompanied increase in the gross interest rate leaves marginal costs for the intermediate good firms unchanged. As output drops, profits per firm decrease. The lower value of a firm reduces the entry of firms to satisfy the free entry condition. In the simple limited participation model, a monetary contraction brings an economic expansion from the second period onwards. Nonetheless the number of new firms is decreasing in the first period. By making the limited participation model empirically more plausible for the period two onwards (see Christiano and Eichenbaum (1992)), the decrease in the number of created firms would become stronger. The prediction of the limited participation model is in line with the empirical results on the reaction of the number of firms.

In the pre-set price framework, a contractionary monetary policy shock leads to an increase in the number of firms. Results are presented in Figure 7 in the Appendix. Lower wages lead to an increase in profits and a decrease in the entry cost. The entry of firms increases to the level in which the free entry condition is satisfied. This stands in sharp contrast with the empirical findings about the creation and destruction of firms in the previous section.

The theoretical results depend on the assumption that inverse of the intertemporal elasticity of substitution (σ) is greater than one. The value below one means negative Frisch elasticity of labor supply; decrease in wages leads to an increase in the hours worked. In this version of the model, the results are reversed. In the sticky price model, after a contractionary monetary shock wages decrease, hours increase, and number of firms increases. Under the limited participation hypothesis, the number of firms decreases. The empirical evidence in this paper does not find support for this assumption as a contractionary shock leads to a statistically and economically important decrease in the hours worked.

9 Concluding remarks

Many authors add firm creation and destruction to the traditional dynamic stochastic general equilibrium models. Intuitively the extensive margin plays an important role in propagating shocks, but it is unclear if it constitutes a different propagation mechanism? What does firm turnover influence? These are the questions most of the firm turnover literature tries to answer. This paper takes a different route. Here the question is instead, What can we learn about modelling monetary transmission by introducing firm creation in the models? The answer is that the empirical results about firm creation and destruction reaction after a monetary shock are more in line with the predictions of the limited participation model than those of the sticky prices.

The paper offers extensive evidence that a contractionary monetary policy shock increases failures and decreases entry of firms. This is a robust finding of a VAR model where the monetary shock is identified by using recursiveness assumption based on the Taylor rule type of argument. When the number of firms that file a bankruptcy after an unexpected monetary contraction increases, it is a sign that their expected future profit decreased and restructuring of activity costs more than bankruptcy. This evidence does not necessarily say anything about amplification of shocks in the economy because existing firms could expand their production and possibly increase profits. But the evidence shows that some existing firms do suffer from the shock. The same is true for some of the new firms. Monetary contraction means that fewer firms are created: some of the business ideas are not realized because they are not profitable.

Although standard models of monetary transmission assume away firm creation and destruction, it is straightforward to augment them with firm turnover. I take two alternative approaches, limited participation and sticky price models and augment with endogenous creation and exogenous destruction of firms. The predictions of the two main models of monetary transmission are at odds with each other. According to the sticky price model the number of firms increases after a contractionary monetary policy shock. After the same shock, the limited participation model predicts a decrease in the number of firms in the economy. Therefore the empirical findings about firm turnover support more the limited participation type of monetary transmission compared to the sticky prices.

The models are very simple and stylized with the purpose of being clear about the mechanism that drives the results. Because of the simplicity, it also allows to discuss intuitively certain extensions. The results also hold for sticky information type of transmission. The sticky price model where only the firms with low markups change their prices can help to reduce the counterintuitive results of the sticky price approach and lead to no effect of monetary shocks to firm turnover, but cannot deliver reversal of the impact. When one assumes very high menu costs for changing prices, firms could file a bankruptcy instead of lowering prices after a contractionary monetary shock, but then menu costs should also lead to more bankruptcies for expansionary monetary shocks. Therefore the mechanism that causes the firm turnover dynamics must be different from price stickiness.

My empirical results also show that prices do react very little to the shock within a one-year period, whereas output, and firm entry and failures react after two quarters. So if prices do not react, then in order to have increase in the profits at least for some firms, the cost of production has to decrease. When prices are exogenously assumed to be sticky, there is even more need for the costs to decrease.

The simple limited participation model predictions fit well the qualitative empirical results. Monetary contraction leads to an increase in the interest rate, drop in wages, no movement in prices, and increase in firm bankruptcies. The economic contraction that brings drop in the expected profits can explain an increase in failures and a decrease in the creation of firms.

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10 Appendix: Tables and Figures

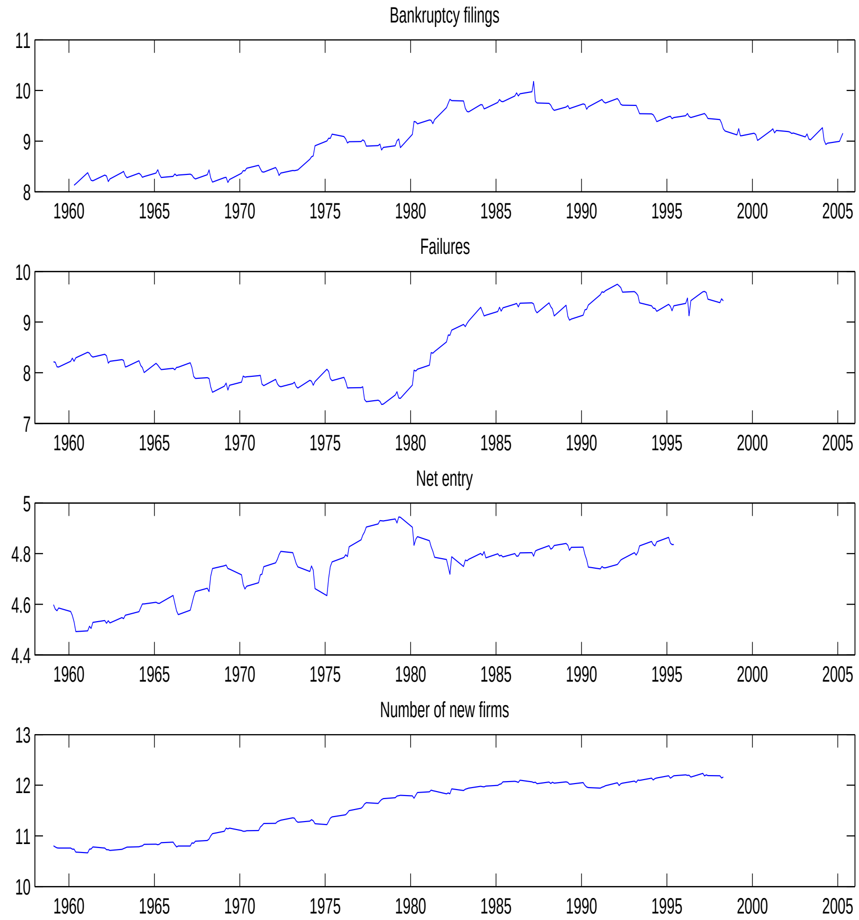

Figure 1: Business Bankruptcy Filings, Failures, Net Entry and New Firms Data in Log Levels

Table 2: Data Description and Sources

Name	Explanation	Source
Consumption	Consumption of non-durables, services and government expenditures	BEA (Bureau of Economic Analysis)
Investment	Nominal investment in household consumption of durables and gross private domestic investment	BEA
Investment price	Price of investment relative to consumer prices	For period 1959-1990 from Ravn and Simonelli (2007)
Price of investment	Nominal divided with real investments	BEA
Price of consumption	Nominal divided with real consumption	BEA
Nominal output	Nominal Gross Domestic Product (GDP)	BEA
Real output	Real Gross Domestic Product (GDP)	BEA
GDP deflator	GDP deflator, nominal GDP/ real GDP	BEA
Hours	Gross non-farm business hours (HOANBS)	BEA from Fed. St. Louis
Population	Total population over the age of 16	CPS
Capacity utilization	Index of capacity utilisation in manufacturing	Board of Governors
Nominal wages	Nominal hourly non-farm business compensation	BLS
New incorporations	Number of new enterprises created, mostly employee firms	Dun&Bradstreet, Economagic
Net entry	Index composed by Dun&Bradstreet	Dun&Bradstreet, BEA
Firm failures	Number of firms failed in a quarter	Dun&Bradstreet, Economic Report of the President
Failure rate	Firm failures / listed companies	Dun&Bradstreet, Economic Report of the President
No. of bankruptcies	Number of bankruptcy failings by companies	U.S. Courts of Bankruptcy
FFR	MZM	Fed. St. Louis
NBR/TR	Non- borrowed reserves / Total reserves	Fed. St. Louis
Money stock	Monetary aggregate MZM	Fed. St. Louis

Table 3: Stationarity Analysis of Business Bankruptcy Filings, Failures, Entry of New Firms and Net Entry

	Bankruptcy Filings		Failures		Net entry		New firms	
Level/Diff	Level	Diff	Level	Diff	Level	Diff	Level	Diff
Trend	y	n	y	n	n	n	n	n
Seas dum	y	n	y	y	n	n	n	n
0	-1.48	-12.00	-1.48	-12.04	-1.33	-9.91	-0.75	-12.65
1	-1.45	-7.98	-1.49	-6.76	-1.65	-7.71	-0.86	-7.41
2	-1.25	-5.70	-1.71	-5.68	-1.66	-6.41	-1.01	-7.17
3	-1.42	-5.22	-1.76	-4.62	-1.62	-5.11	-1.00	-5.72
4	-1.43	-5.01	-1.92	-3.57	-1.86	-4.48	-1.05	-4.99

Note: Constant is included in every regression. The asymptotic critical values for rejecting the hypothesis of unit root on the level of the lagged dependent variable in an (augmented) Dickey-Fuller regressions case without trend are -3.43, -2.86 and -2.58 and with trend -3.96, -3.41 and -3.12 respectively for 1(*), 5(**) and 10(***)% critical levels.

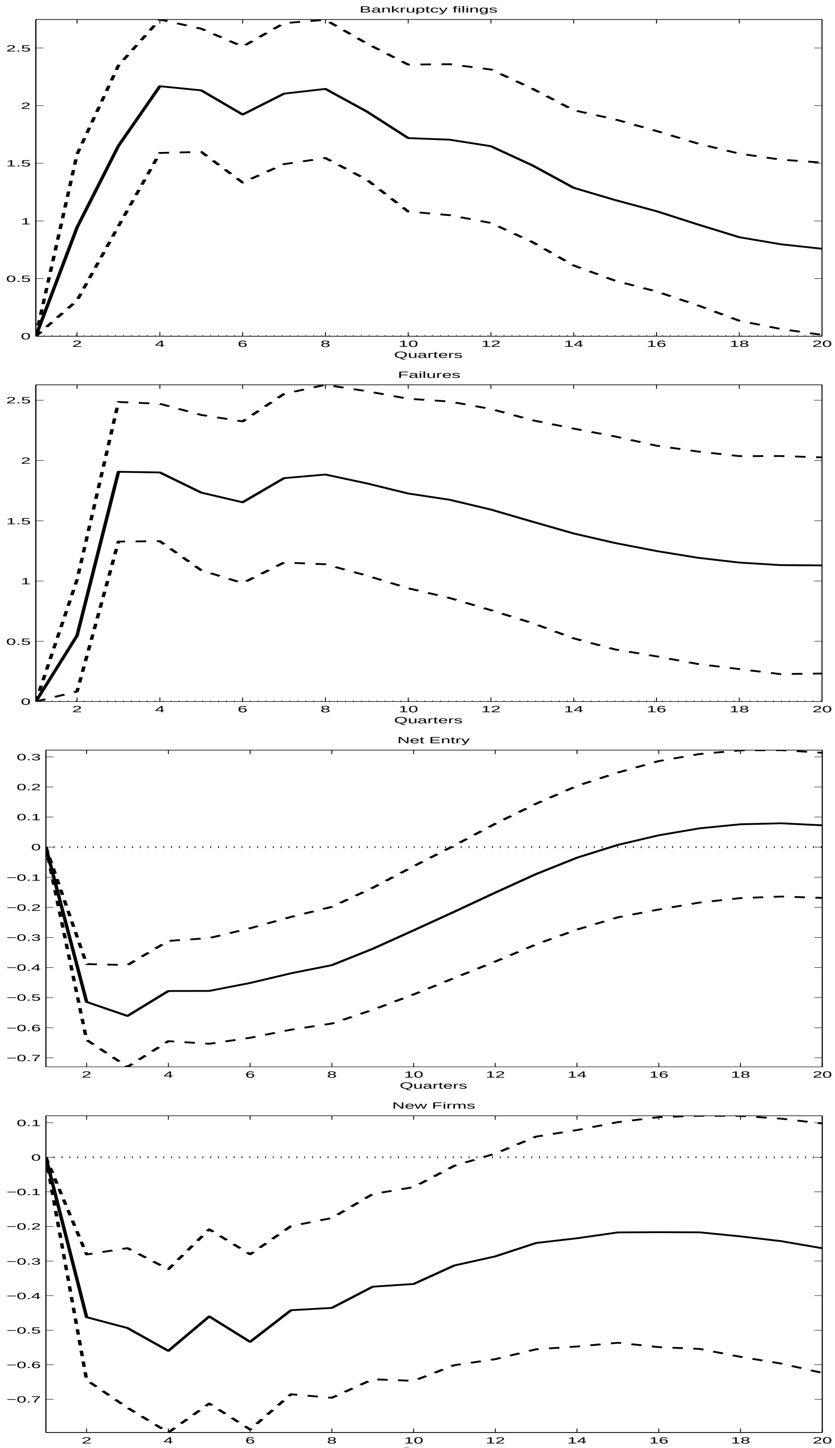

Figure 2: Impulse Response Functions of **Business Bankruptcy Filings, Failures, Net Entry and New Firms** to a Contractionary Monetary Shock, 68% Confidence Intervals around the Point Estimates

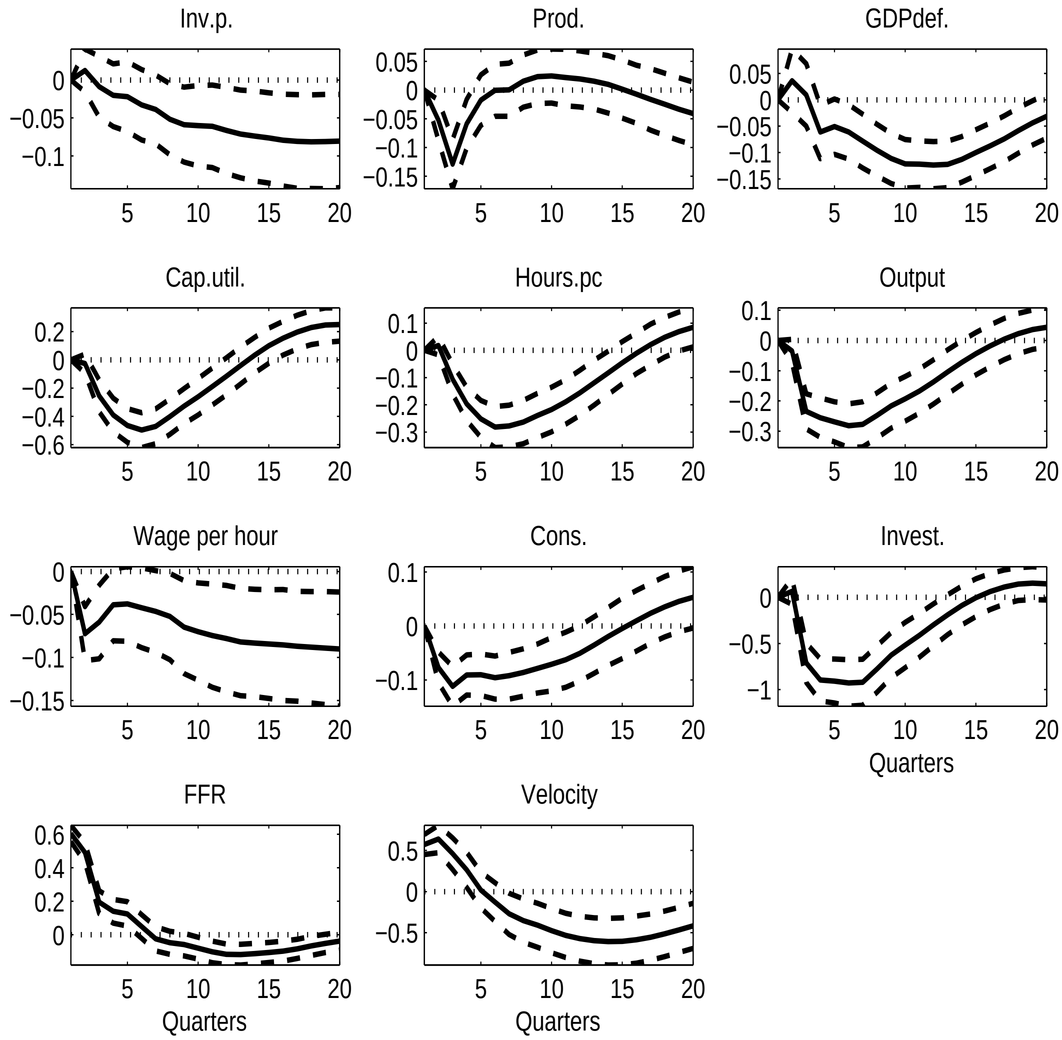

Figure 3: Impulse Response Functions of Macroeconomic Variables to a Contractionary Monetary Shock, SVAR with **Business Bankruptcy Filings** Included, 68% Confidence Intervals around the Point Estimates

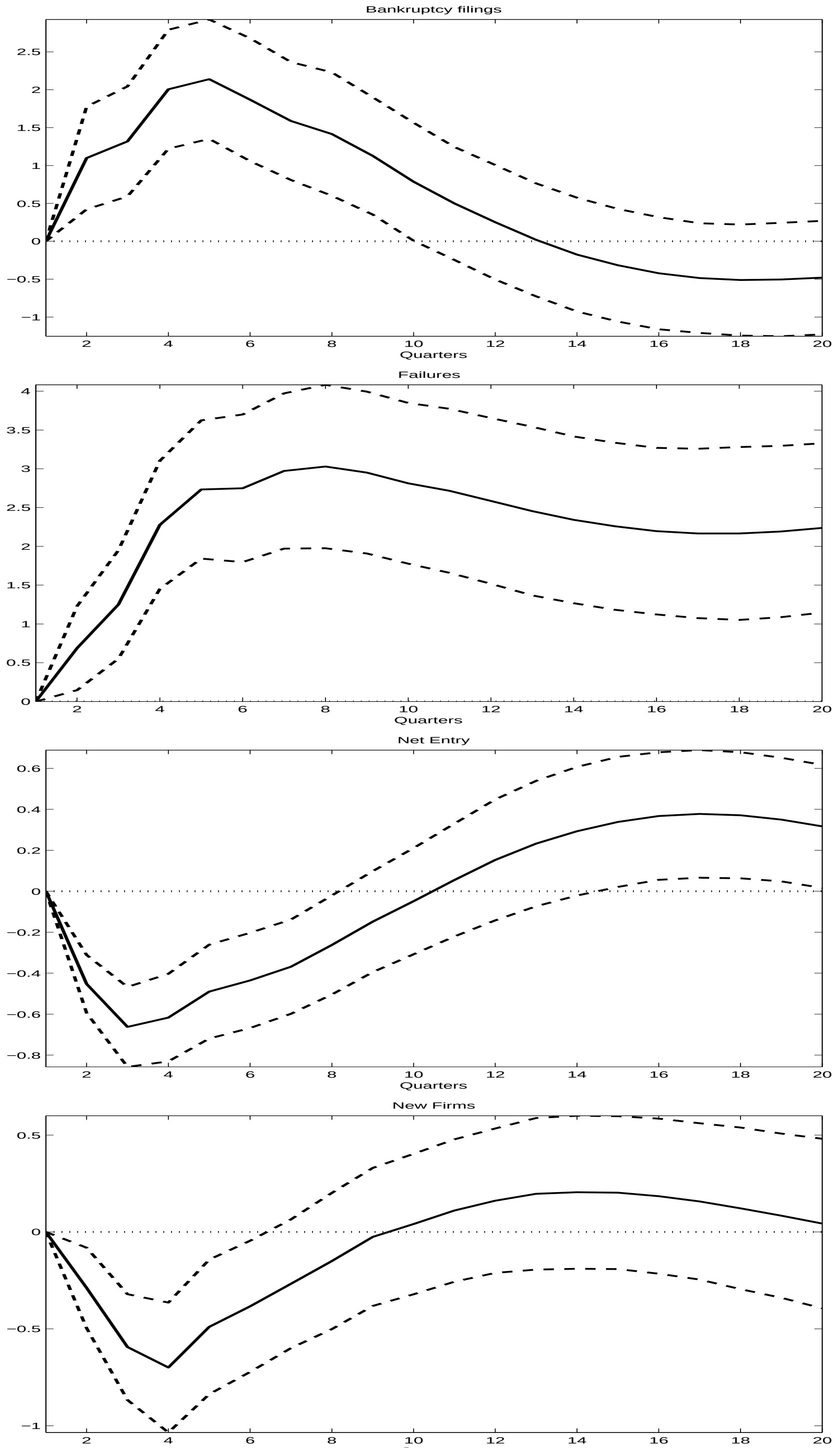

Figure 4: Impulse Response Functions of Business Bankruptcy Filings, Firm Failures, Net Entry and New Firms to a Contractionary Monetary Shock Defined by Change in the NBR/TR ratio, 68% Confidence Intervals around the Point Estimates

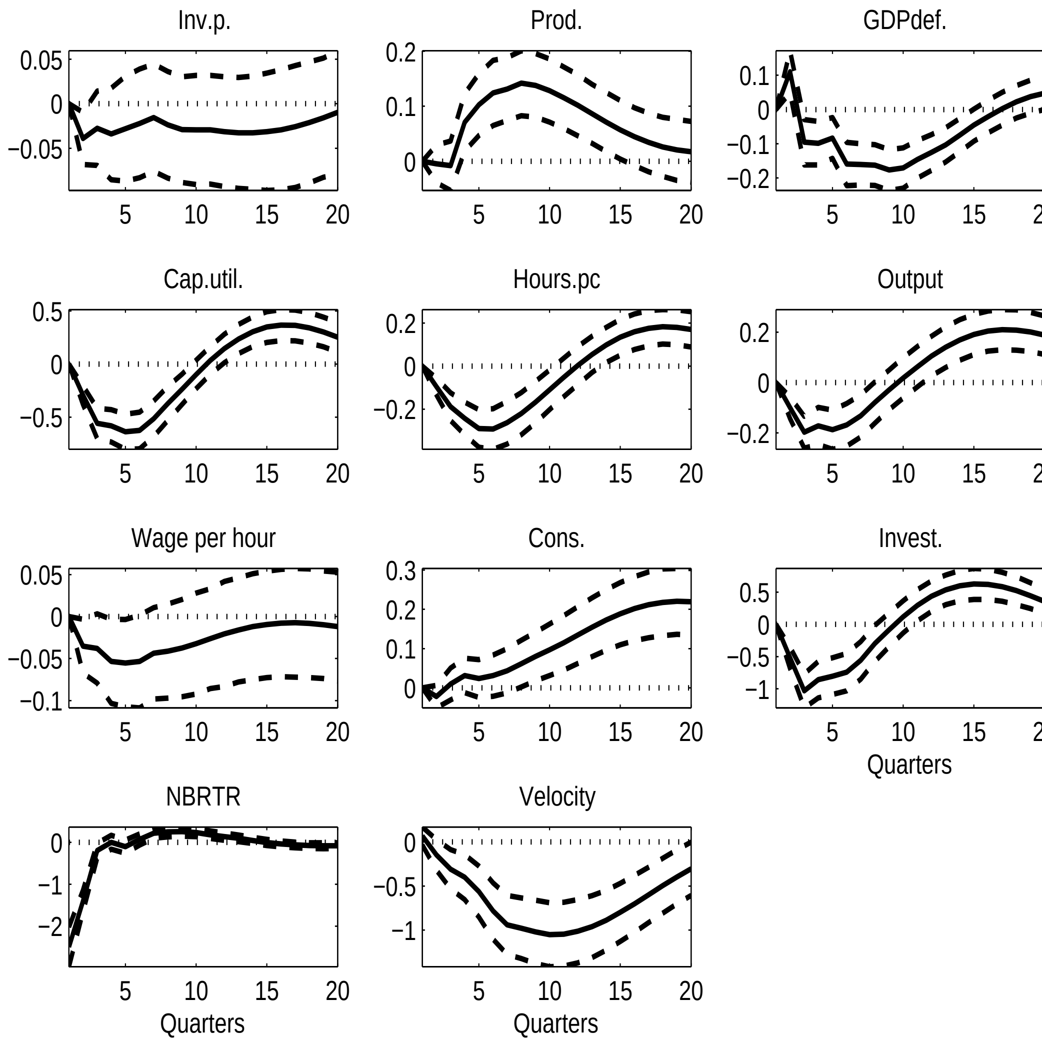

Figure 5: Impulse Response Functions of the Macroeconomic Variables to a Contractionary Monetary Shock Defined by a Drop in the NBR/TR ratio, When Business Bankruptcy Filings is Included, 68% Confidence Intervals around the Point Estimates

Table 4: Stationarity Analysis for Period of First 20 Years Omitted

	Bankr. filings	Failures	Net entry	New firms
Level/Diff	Diff	Diff	Diff	Diff
trend	n	n	n	n
seas dum	y	y	n	y
0	-8.95	-8.49	-5.48	-6.06
1	-4.88	-4.62	-5.44	-4.97
2	-3.78	-3.99	-4.24	-4.57
3	-3.94	-3.82	-3.63	-3.97
4	-3.82	-3.36	-3.25	-2.88

Note: A constant is included in every regression. The asymptotic critical values for the level of the lagged dependent variable in an (augmented) Dickey-Fuller regressions case without trend are -3.43, -2.86 and -2.58 and with trend -3.96, -3.41 and -3.12 respectively for 1(*), 5(**) and 10(***)% critical levels.

Table 5: Stationarity Analysis for Period of Last 20 Years Omitted

	Bank filings	Failures	Net entry	New firms
Level/Diff	Diff	Diff	Diff	Diff
trend	n	n	n	n
seas dum	y	y	y	n
0	-8.22	-8.77	-8.44	-12.62
1	-6.96	-4.97	-5.13	-6.23
2	-4.94	-4.15	-3.94	-5.65
3	-4.53	-3.23	-3.18	-4.18
4	-4.48	-2.66	-3.03	-3.86

Note: A constant is included in every regression. The asymptotic critical values for the level of the lagged dependent variable in an (augmented) Dickey-Fuller regressions case without trend are -3.43, -2.86 and -2.58 and with trend -3.96, -3.41 and -3.12 respectively for 1(*), 5(**) and 10(***)% critical levels.

Table 6: Stationarity Analysis for Failure Rate

	Failure rate	
Level/Diff	Level	Diff
trend	y	y
seas dum	y	y
0	-0.14	-12.70
1	0.76	-7.53
2	0.79	-5.63
3	0.70	-4.00
4	0.06	-2.92

Note: A constant is included in every regression. The asymptotic critical values for the level of the lagged dependent variable in an (augmented) Dickey-Fuller regressions case without trend are -3.43, -2.86 and -2.58 and with trend -3.96, -3.41 and -3.12 respectively for 1(*), 5(**) and 10(***)% critical levels.

Table 7: Parameter values

Notation	Value	Name
σ	2	Inverse of intertemporal elasticity of substitution
β	0.99	Discount factor
ψ_0	2	Disutility of labor
ε	17	Elasticity of substitution
δ	0.025	Share of firms hit with death shock
ξ^{ent}	10^{-5}	Units of labor for entry
ξ^{op}	10^{-10}	Units of labor for operation
Specific to the SP model		
g_m	1	Size of a shock
φ	.5	Inverse of elasticity of substitution of money
π	1	Inflation in the steady state
Specific to the LP model		
π	1.005	Inflation in the steady state

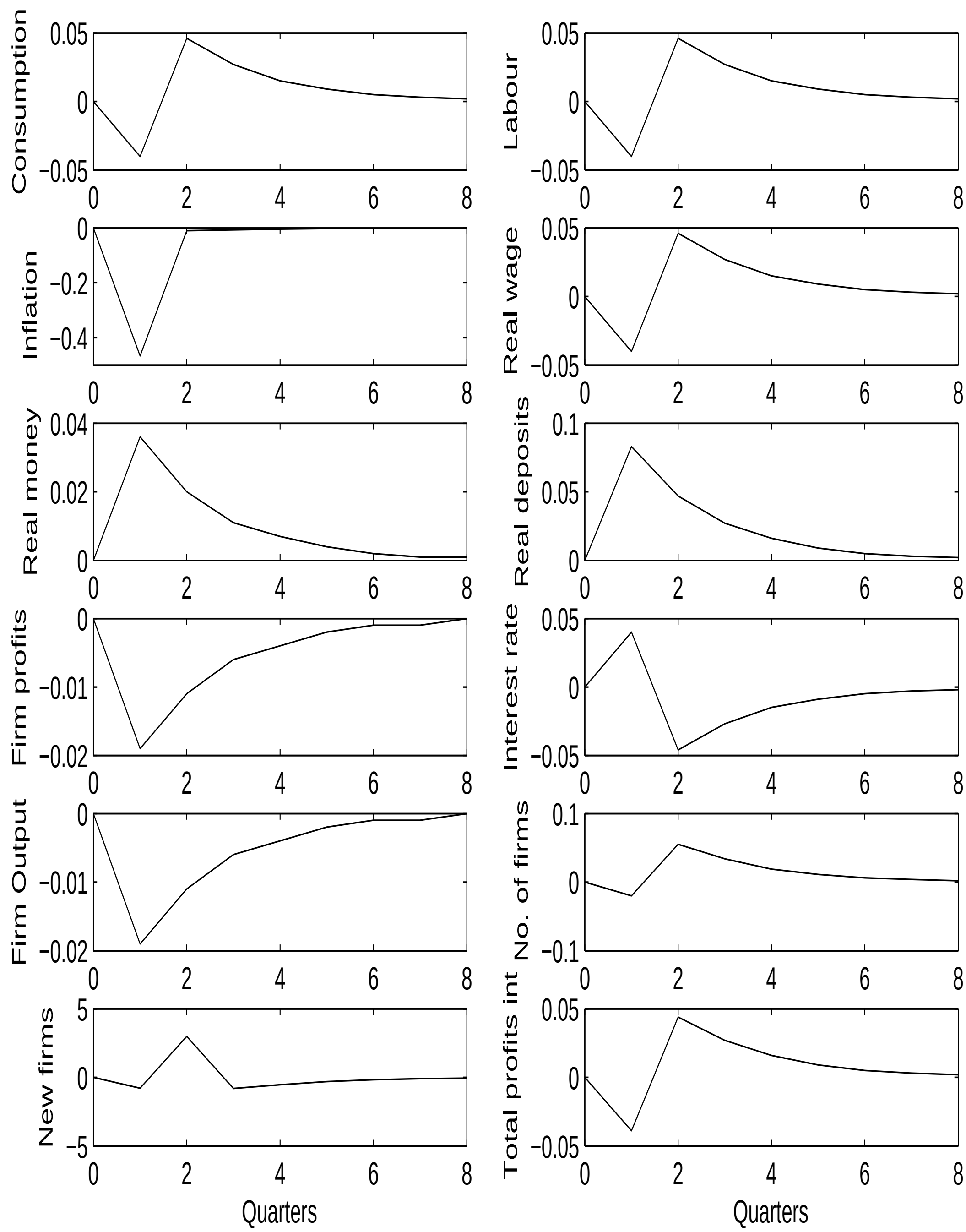

Figure 6: Impulse Response Functions of Economic Variables to a Contractionary Monetary Shock in a Limited Participation Model

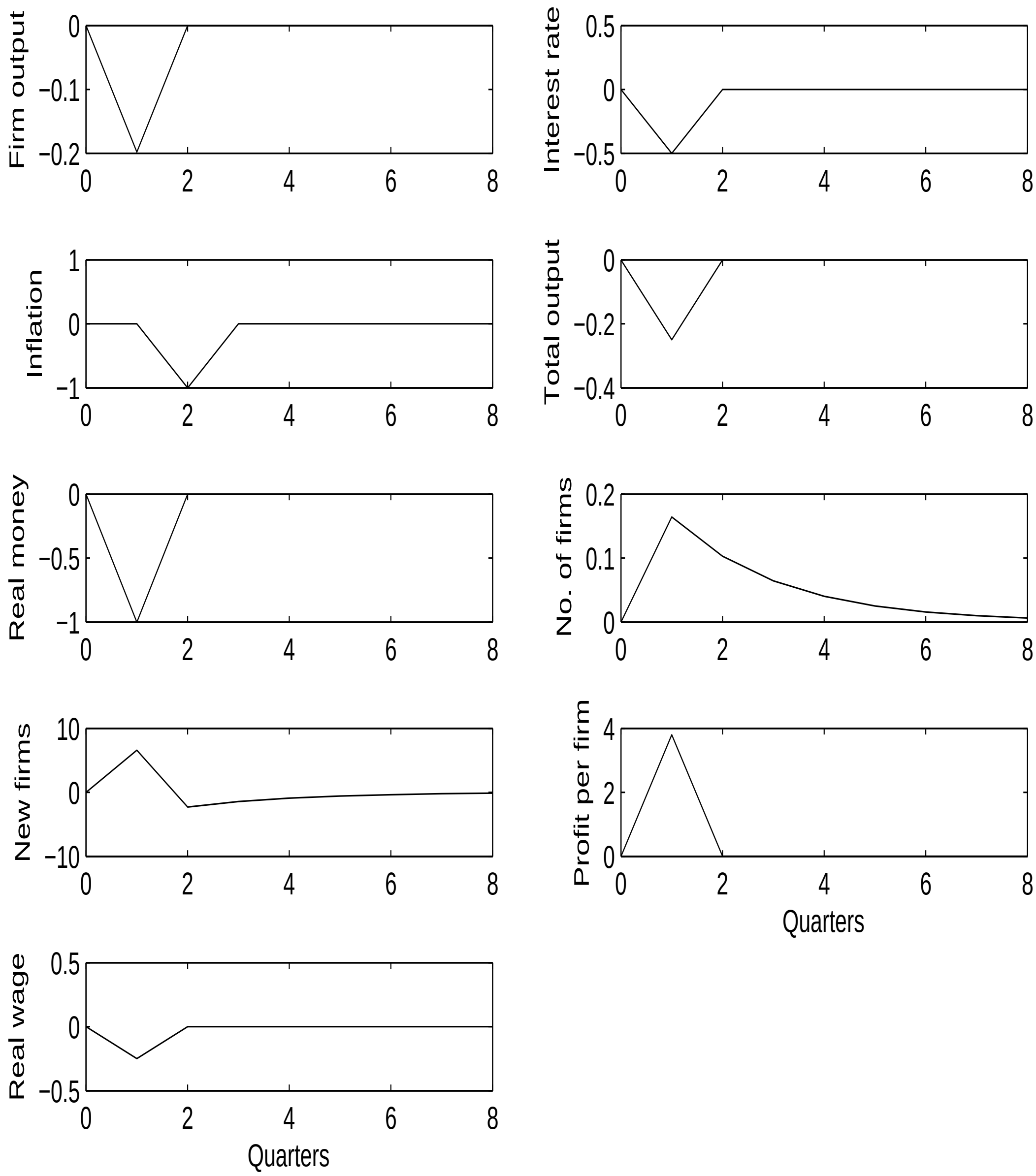

Figure 7: Impulse Response Functions of Economic Variables to a Contractionary Monetary Shock in a Preset Prices Model

11 Appendix: Full models

Steady state of the limited participation model

By exploiting the definition of the equilibrium, the model is characterized by the following steady state conditions. Letters without time subscript denote steady state values and lower case letters denote real variables, e.g. $w = W/P$, $m = M/P$ etc.

$$\pi = \beta R \tag{40}$$

$$w = \frac{1}{\mu R} \tag{41}$$

$$c = \left(\frac{w}{\psi_0}\right)^{1/(\sigma-1)} \tag{42}$$

$$c = n \tag{43}$$

$$h = c\left[(1-w)(\pi-1)-w\right]\left(\frac{R}{\pi}-R-1\right)^{-1} \tag{44}$$

$$x = wc - h \tag{45}$$

$$m = (wc-h)\left(\frac{\pi-1}{\pi}\right)^{-1} \tag{46}$$

$$d_i = RW\xi^{ent}(1+\beta(1-\delta)) \tag{47}$$

$$v_i = \frac{d_i}{1-\beta(1-\delta)} \tag{48}$$

$$y_i = \frac{d_i + w\xi^{op}R_t}{1-wR} \tag{49}$$

$$F = n\left[(1-\delta)(y_i+\xi^{op})+\delta(y_i+\xi^{op}+\xi^{ent})\right]^{-1} \tag{50}$$

$$F^N = \delta F \tag{51}$$

$$d = Fd_i - F^N wR\xi^{ent} \tag{52}$$

$$j = F\xi^{ent} + F^N\xi^{ent} \tag{53}$$

Log-linearization around the steady state - limited participation model

The log-linearized system is given by the following equations, where $\tilde{x}$ denotes percentage change from the steady state.

$$
\begin{aligned}
\sigma\tilde{c}_t &= \tilde{w}_t + \tilde{n}_t && (54)\\
\sigma(\tilde{c}_{t+2} - \tilde{c}_{t+1}) &= \tilde{R}_{t+1} - \tilde{\pi}_{t+2} && (55)\\
m\tilde{m}_t &= wn\tilde{w}_t + wn\tilde{n}_t + \frac{m}{\pi}\tilde{m}_{t-1} + (R-1)\frac{h}{\pi}\tilde{h}_{t-1} \\
&\quad + \frac{1}{\pi}((R-1)h - m)\tilde{\pi}_t + R\left(x + \frac{h}{\pi}\right)\tilde{R}_t \\
&\quad + Rx\tilde{x}_t - c\tilde{c}_t + d\tilde{d}_t && (56)\\
c\tilde{c}_t &= wn\tilde{w}_t + wn\tilde{n}_t - \frac{m}{\pi}\tilde{m}_{t-1} \\
&\quad - \frac{h}{\pi}\tilde{h}_{t-1} + \frac{1}{\pi}(h-m)\tilde{\pi}_t && (57)\\
-\tilde{R}_t &= \tilde{w}_t && (58)\\
d\tilde{d}_{i,t} &= y_i(1 - wR)\tilde{y}_{i,t} - wR(y_i - w)\tilde{w}_{i,t} - wr(y_i + \xi^{op})\tilde{R}_{i,t} && (59)\\
wn\tilde{w}_t &= -wn\tilde{n}_t + \frac{h}{\Pi}\left(\tilde{h}_{t-1} - \tilde{\pi}_t\right) + x\tilde{x}_t && (60)\\
\tilde{c}_t &= \tilde{n}_t && (61)\\
v\tilde{v}_{i,t} &= d\tilde{d}_{i,t} + \beta(1-\delta)v\tilde{v}_{i,t+1} && (62)\\
\tilde{v}_{i,t} &= \tilde{R}_{i,t} + \tilde{w}_{i,t} && (63)\\
\tilde{F}_t &= (1-\delta)\tilde{F}_{t-1} + \delta\tilde{F}_t^N && (64)\\
d_i\tilde{d}_t &= Fd_i(\tilde{F}_t + \tilde{d}_{i,t}) \\
&\quad - F^N wR\xi^{ent}(\tilde{F}_t^N + \tilde{w}_t + \tilde{R}_t) && (65)\\
j\tilde{j}_t &= F\xi^{op}\tilde{F}_t + F^N\xi^{ent}\tilde{F}_t^N && (66)
\end{aligned}
$$

Steady state - sticky prices model

According the definition of the equilibrium the steady state is characterized by the following equations.

$$
\begin{aligned}
w &= \frac{\varepsilon-1}{\varepsilon} && (67)\\
c &= \frac{w}{\psi}^{1/(\sigma-1)} && (68)\\
\frac{M_{t+1}}{P_t} &= (\frac{i}{1+i})^{-1/\varphi}c^{\sigma/\varphi} && (69)\\
(1+i) &= (1+r)\pi && (70)\\
y_i &= \frac{\xi^{op}w+d_i}{1-w} && (71)\\
l_i &= y_i && (72)\\
V &= \frac{d_i}{1-\beta(1-\delta)} && (73)\\
V &= \xi^{ent}w && (74)\\
F &= c(y_i+\xi^{op}+\delta\xi^{ent})^{-1} && (75)\\
F &= \frac{1}{\delta}F^N && (76)
\end{aligned}
$$

Log-linearization around the steady state - sticky prices mode

The log-linearized system is the following.

$$
\begin{aligned}
\sigma(\tilde{c}_{t+1}-\tilde{c}_t) &= \tilde{i}_t-\tilde{\pi}_{t+1} && (77)\\
\tilde{w} &= (\sigma-1)\tilde{c}_t && (78)\\
\frac{\tilde{M_{t+1}}}{P_t} &= \frac{\sigma}{\varphi}\tilde{c}_t-\frac{1}{\varphi}\tilde{i}_t && (79)\\
\tilde{F}_t &= (1-\delta)\tilde{F}_{t-1}+\delta\tilde{F^N}_t && (80)\\
v\tilde{v}_{i,t} &= d_i\tilde{d}_{i,t}+\beta(1-\delta)v\tilde{v}_{i,t+1} && (81)\\
\tilde{v}_t &= \tilde{w}_t && (82)\\
d_{i,t} &= y_i(1-w)\tilde{y}_{i,t}-w(y_i+\xi^{op})\tilde{w}_t && (83)\\
\tilde{\pi}_{t+1} &= \tilde{g}_t^m && (84)\\
\frac{n}{F}\tilde{n}_t &= \delta(y_i+\xi^{ent}+\xi^{op})\tilde{F}_t^N+y_i\tilde{y}_{i,t}+(1-\delta)(\xi^{op}+y_i)\tilde{F}_{t-1} && (85)\\
\frac{\tilde{M_{t+1}}}{P_t}-\frac{\tilde{M}_t}{P_{t-1}} &= \tilde{g}_t^m-\tilde{\pi} && (86)\\
\tilde{c}_t &= \tilde{n}_t && (87)
\end{aligned}
$$