Assefa, Abraham; Lapitskaya, Darya; Uusküla, Lenno

Book

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University of Tartu
Faculty of Social Sciences
School of Economics and Business Administration

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Abraham Assefa, Darya Lapitskaya, Lenno Uusküla

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Productivity and Firm Dynamics over the Business Cycle

Abraham Assefa, Darya Lapitskaya, Lenno Uusküla*

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Abstract

The paper studies the effects of technology shocks on the creation and destruction of firms. Using US data and a VAR model the paper finds Schumpeterian creative destruction for investment-specific technology shocks. A positive investment-specific technology shock increases the number of firms opening, but also leads to a higher number of firms closing. In contrast, labour-neutral technology shocks also benefit old firms. An increase in overall productivity leads to an increase in the number of new firms and a drop in the number of failures. Both margins contribute to an increase in the number of firms in the economy. A medium-scale DSGE model with endogenous entry and exit that is that is augmented with additional features is able to capture these stylised facts.

Keywords: VAR, DSGE, Firm dynamics, Productivity, Firm turnover, Technology shocks, Investment specific technology shocks

JEL Codes: E32, E23, C32, O33, D21, D22

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*Abraham Assefa (University of Tartu), Darya Lapitskaya (University of Tartu), Lenno Uusküla (University of Tartu, Luminor Group). The authors acknowledge financial support from European Union's Horizon 2020 research and innovation programme under grant agreement No. 822781 "GROWINPRO – Growth Welfare Innovation Productivity". Part of the work was done when Lenno Uusküla was working at Eesti Pank. We are grateful for seminar participants at the University of Tartu and Eesti Pank. The views expressed in this paper are personal and do not necessarily represent the official views of Eesti Pank, the Eurosystem or the Luminor Group.

1 Introduction

There is no doubt that technological shocks play a major role in explaining the business cycle next to demand factors. Technology can spread through the economy in various ways and the arrival of new technologies can be a life-or-death situation for firms. Does increase in productivity work through creative destruction where new firms are more productive and old firms exit or rather through broad-based growth where both old and new companies gain from the improvements? Why does firm entry in theoretical models react to shocks less than in the data? Some macroeconomic models predict that aggregate quantities and per firm quantities go in opposite directions. Why is that? This paper studies these questions.

On the empirical side, the paper provides new evidence on firm turnover for labour neutral and investment specific technology shocks for the US economy. Positive technology shocks always bring entry of new firms. Labour neutral technological improvements lead to a broad-based gains in the economy, where there are more new firms, but also more old firms survive. In contrast, investment specific technology shocks result in creative destruction - more new firms are created while the number of failures also increases so not all firms gain equally from the macroeconomic cycle. Our results add to the discussion in papers by Ramey (2016) and Queralto (2020) on whether creative destruction is important for specific technology shocks.

A contribution of the paper is to use the number of bankruptcy filings of firms instead of closings. Bankruptcies demonstrate the actual health of existing firms in real time as there is considerable time lag between the firm being insolvent and the company actually closing. Therefore, previous literature looking at firm closures might have underestimated the role of the exit margin in business dynamism.

In the empirical part, the paper employs a vector autoregressive (VAR) model. We estimate a benchmark six-dimensional VAR model to identify investment specific technology and labour neutral technology shocks with long-run restrictions at quarterly frequency for the period from 1992 to 2021.

In the theoretical part, we show how a medium scale new-keynesian dynamic stochastic general equilibrium (DSGE) model is able to match these stylised empirical facts for two technology shocks. The model incorporates endogenous firm entry and exit as a central feature. As a novel feature in the literature, this model incorporates the fact that new firms are much smaller than old firms and grow faster over time than old firms. In addition, the model incorporates the possibility that new firms are more likely to die after being created as is often the case in the empirical literature. These features help to improve the model on several dimensions that have been a challenge for the literature.

Investment-specific technology shocks in the model are measured as entry cost shocks. In the absence of physical capital households can invest in the creation of new firms at a sunk cost. A positive shock that makes this undertaking cheaper is making investments cheaper in relation to the general productivity of the economy, corresponding to the idea of investment-specific technology.

Aggregate quantities and per firm quantities react in opposite directions when new firms are of the same size as old firms in theoretical models. In a model where firms are small in the beginning, the per firm aggregates react in the same direction as the aggregate quantities because the production capacity of new firms is smaller. This makes the entry and failure dynamics more in line with the empirical findings, as the net present value of the firm is pro-cyclical.

Another central feature of the model is imperfect competition and steady state-markup of the intermediate goods sector. This is achieved in the model by assuming that the cost of creating a firm is less than the net present value of the firm. This is the standard assumption in the literature using monopolistic competition in the intermediate goods market. This feature, together with the small entry allows the firm entry data to react strongly. This adds to the literature that was started by Bilbiie et al. (2012a) incorporating small new firms and a higher death rate of young firms.

The model is able to increase the volatility of the entry margin and provide the internal amplification of shocks to output and hours. The paper thus adds new evidence to the discussion of whether entry or exit margin is important; see Foster et al. (2012), which shows that exit does matter. The paper finds that the higher exit of new firms has little impact on macroeconomic dynamics.

Generally, aspects of business formation are closely connected with definitions of entry and exit. According to previous research by Cavallari (2015), exits in the model are typically more volatile than firm creation; however, both are more volatile compared to output and co-move over the cycle. As a firm is essentially a product in this setup, the analysis of firm dynamics is identical to the dynamics of the survival of products. The reason is that when some products have to exit because of the entries of better products, the statistics usually include inflation from surviving products that understates the growth, if creatively destroyed products demonstrate more improvement than surviving products (Aghion et al. (2018)). In this model, firms are producing single goods, so the dynamics of products is identical to the number of firms.

Growth literature has widely accepted the fact that new firms and dying firms are part of the growth formula. Business cycle models have abstracted away from firm turnover in theoretical models and empirical evidence. Nowadays, there is a new strand of literature stressing the importance of firms in business cycle dynamics in two distinct types of models.

Recovery from the financial crisis in the US is characterised by its depth and slow recovery. Moreover, the number of productive establishments has also demonstrated a substantial decline (Wu et al. (2017)). In general, past decades are characterised by a decline in business dynamics in the US that also affects gross job creation and gross job destruction. Several factors contributed to this decline with the most crucial of them being the decline in the startup rate and the pace of entrepreneurship (Decker et al. (2016)).

There is evidence that because of changes in firm exit dynamics, firm formation in the US has become more volatile, pro-cyclical and persistent (Casares et al. (2018)). According to the study by Wu et al. (2017), a decline in new business formation is associated with a three-year-long hike in output and a slowdown in the growth rate of productivity. According to Decker et al. (2016), this is connected with a significant share of the overall decline in the pace of job reallocation. Moreover, the switch in the age composition of US business activity corresponds to 26 percent of the total decline in the pace of job reallocation. Industrial compositions and differences between sectors also plays an important role in business dynamics decline (Decker et al. (2016)).

Economic shocks have different effects on firm dynamics. Consequently, firm entry and exit can strengthen and spread the effects of aggregate shocks (Clementi and Palazzo (2016)). According to this study, entries rise following positive aggregate shocks. Interestingly, surviving young firms grow larger, producing a wider and longer expansion than in case of absence of entries or exits. Moreover, so-called investment technology shocks can lead to creative destruction that mostly benefits new firms. While labour neutral productivity shocks, on the contrary, benefit old firms as well. As a result, firm bankruptcies instead of closures should be considered for understanding business cycles.

The remainder of the paper is organized as follows. The next section provides empirical evidence on labour-neutral and investment-specific technology shocks. Section 3 presents the theoretical model and discusses the importance of various features of the economy. Section 4 concludes.

2 Empirical evidence

2.1 VAR model

In order to shed light on the dynamics of the entry and exit margins on investment-specific and labour-neutral productivity shocks, we employ a VAR model with long-term restrictions. The approach follows Fisher (2006) and identifies the two technology shocks with long-run restrictions. In general, the VAR model is a flexible model used for multivariate time series analysis.

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

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 follows: $b_i = A_0^{-1} B_i$, 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 $\Sigma_u = E(u_t' u_t)$ using the following formula $\Sigma_u = {A_0^{-1}}' \Sigma_\epsilon A_0^{-1}$.

In this paper, we are using a 6-dimensional VAR model for the benchmark results. The variables included are:

- relative price of investments to consumption;
- labour productivity;
- hours worked;
- employment gain from openings;
- employment loss from closings;
- bankruptcy filings.

The size of the VAR is a compromise between reducing the omitted variable bias and estimating a model that allows for higher degrees of freedom, as the availability of firm creation and destruction data is restricted.

In order to better understand the turnover of firms for different technology shocks, the paper studies both investment-specific and labour-neutral technology shocks. The identification of the investment-specific technology shocks follows Fisher (2006). In the idea of the identification of the shocks at the firm level is that the firms that invest more, also benefit from a shock more compared to those who do not invest or even reduce the level of capital. New firms are more likely to benefit from the investment-specific technology shocks and the incumbents gain relatively less or even lose from positive shocks.

The identification of the investment-specific technology shock is based on the assumption that only the investment-specific technology shocks can have a long-run impact on the relative price of investment goods compared to consumption goods. 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 equation for the investment-specific technology shock is as follows:

$$
\begin{aligned}
ip_t \quad = \quad & b_0^{ip} + \sum_{i=1}^{p} b_i^{ip,ip} ip_{t-i} + \sum_{i=0}^{p} b_i^{ip,lp} \Delta lp_{t-i} \\
& + \sum_{i=0}^{p} b_i^{ip,h} \Delta h_{t-i} \\
& + \sum_{i=0}^{p} b_i^{ip,g} \Delta g_{t-i} + \sum_{i=0}^{p} b_i^{ip,l} \Delta l_{t-i} + \sum_{i=0}^{p} b_b^{ip,bk} \Delta bk_{t-i},
\end{aligned}
$$

where ip is the relative price of investments to consumption, lp - labour productivity, h - hours worked; g - employment gain from openings; l - employment loss from closings; and bk - bankruptcy filings, Δ is the difference operator and b_i-s are the parameters to be estimated.

The investment-specific technology equations cannot be estimated with the ordinary least squares technique because the contemporaneous value of productivity might be correlated with the residual. Therefore, the equation is estimated using the instrumental variable (IV) technique. The instruments are the lagged values of the explanatory variables.

The equation for the labour-neutral technology shock equation is estimated next and is as follows:

$$\begin{aligned} lp_t &= b_0^{lp} + \sum_{i=1}^{p} b_i^{lp,ip} ip_{t-i} + \sum_{i=0}^{p} b_i^{lp,lp} lp_{t-i} \\ &+ \sum_{i=0}^{p} b_i^{lp,h} \Delta h_{t-i} \\ &+ \sum_{i=0}^{p} b_i^{lp,g} \Delta g_{t-i} + \sum_{i=0}^{p} b_i^{lp,l} \Delta l_{t-i} + \sum_{i=0}^{p} b_b^{lp,bk} \Delta bk_{t-i}. \end{aligned}$$

The equation for labour-neutral technology has the same problem of endogeneity; therefore, the equation is also estimated using 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, the estimation of the equations is conducted in the order of the variables. All equations are estimated using the recursive IV technique. The contemporaneous values of the previous variables were included in the regression and exploit all the estimated residuals as instruments. Therefore, for the estimation of the last equation on money velocity, we include all the other contemporaneous values of the variables in the regression and residuals in the set of instruments.

Many authors (including Kydland and Prescott (1982), Altig et al. (2005), and Ravn and Simonelli (2007)) consider technology to be a key factor in macroeconomic fluctuations. Several authors adopt the long-run restrictions approach in identifying labour-neutral technology shocks(e.g., see see Galí (1999), Altig et al. (2005), Fisher (2006), and Ravn and Simonelli (2007)). Fisher (2006) shows that the labour-neutral technology shock might be mis-specified if the investment technology shock is not identified.

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

Campbell (1998) shows that technology shocks can be important for generating a variance in plant entry and exit dynamics, which is closely related to business entry and failure variables. The theoretical literature on entry and exit has so far concentrated on the impact of technology shocks (see Campbell (1998) or Ghironi and Melitz (2005)). From the theory, it is reasonable to conclude that firm entry and exit decisions should be reflected by permanent shocks.

Some papers support the hypothesis that temporary demand type shocks could be important in determining firm creation and destruction (see Bergin and Corsetti (2005), where the authors identify monetary policy shock). Hence, the effects of a temporary monetary policy shock are also estimated.

The model is estimated assuming 3 lags. Confidence intervals are calculated with 5000 bootstrap replications. Different robustness analyses are carried out for various dimensions of the estimated model.

2.2 Data

For the main results, we use quarterly data from the US. The main VAR model covers the period from 1992 Q3 to 2021 Q1 due to data limitations on recent data on firm entry. Data on bankruptcy filings has also been used in the paper by Uusküla (2016) in the context of monetary shocks. The data includes price indexes for personal consumption expenditures, price indexes for private fixed investment hours worked, private sector establishment births and deaths, bankruptcy filings, population level from the Bureau of Labour Statistics, the US Court of Bankruptcy, the US Federal Reserve, and the US Bureau of Economic Analysis, for details see Table 2).

The chosen VAR model has six variables that are calculated in the following way:

- relative price of investments to consumption variable is a derivative of personal consumption expenditures divided by private fixed investment;
- the labour productivity variable is taken from the Utilisation for business sector dataset;
- the hours variable is taken from the Hours Worked and Employment for Total Economy and Subsectors dataset;
- employment gain from openings and employment loss from closings are taken from the Private sector establishment births and deaths; and
- the bankruptcy filing variable is taken from the Business bankruptcy filings data.

2.3 VAR results

This section presents the main results on the labour neutral technology and investment-specific technology shocks as two major sources of the business cycle and counterparts of interest for the theoretical model in the next section. Figure 1 shows impulse response functions for the labour-neutral technology shock for all the variables that are included in the VAR. A positive shock leads to a permanent change in productivity as assumed by the identifying assumption.

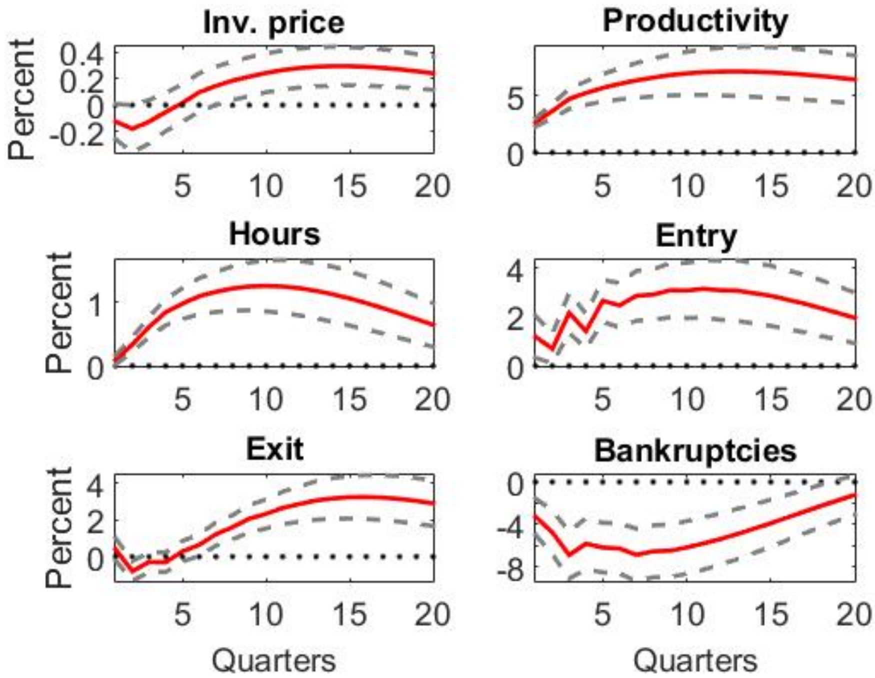

Figure 1: Macroeconomic reactions to labour neutral productivity shocks.

The results demonstrate that the standard deviation of the shock in productivity increases the level by about 3%. The hours worked increases by about 0.5% after the shock so that the output increases strongly.

We can see that the shock is also followed by an increase in the number of new firms by more than 1% and a drop in the failures by more than 4% at the peak of the reaction. Interestingly, the exit margin reacts even more strongly than the entry of firms. Moreover, the reaction of bankruptcy filings also does not lag on the macroeconomic response of entry, rather it reacts faster.

As the new firms are much smaller in size and growing slowly, macroeconomic effects are likely to work more strongly through the exit margin rather than the creation of new firms.

Hence, we can see that the empirical results demonstrate the increase in firm entries and exits, and decrease in bankruptcies. We can say that the results complement the existing literature on firm turnover and productivity shocks.

The results of the study complement and expand on previous research. For example, Cavallari (2015) also uses the endogenous exit of firms in the model and looks at the variance of the data and model-generated data with productivity shocks. She finds that entry costs have significant importance if the firm dynamics are accounted for. The author finds that entries respond positively to monetary shocks while exits demonstrate a negative reaction on impact together with estimated responses in all considered calibrations (Cavallari (2015)). In addition, the relationship between labour productivity and the relative price of investments to sector-specific technology change was also shown in the study by Watanabe (2020).

The results of the VAR models change the idea of how we understand transmission. Most models (e.g., ones used by Bilbiie et al. (2012b) and Bergin and Corsetti (2008)) assume exogenous exit rates and the dynamics work through the entry of firms.

The evolution of firm turnover measures for investment-specific technology shocks highlight the similarities and differences of the dynamics compared to labour-neutral technology shocks in Figure 1.

Similar to the labour neutral technology shocks, investment-specific technology has strong effects on entry. The creation of new firms increases by 1% in the years after the shock. The result is qualitatively similar to the reaction after labour-neutral technology shocks when entry also increased.

Bankruptcy filings increase after investment-specific technology shocks. The point estimate of failures increases by 4%, although the confidence bands are rather large compared to the estimates of labour neutral technology shocks.

The dynamics of bankruptcies are the opposite of those of the labour-neutral technology shocks when the number of bankruptcies decreased after a positive shock. This shows the role of creative destruction in the case of investment-specific technology shocks.

Figure 2 equally presents the dynamics of macroeconomic variables and firm turnover after an investment-specific technology shock. When the price of investments falls relative to consumption price. As it brings a boom to the economy, labour productivity increases, and households work more hours.

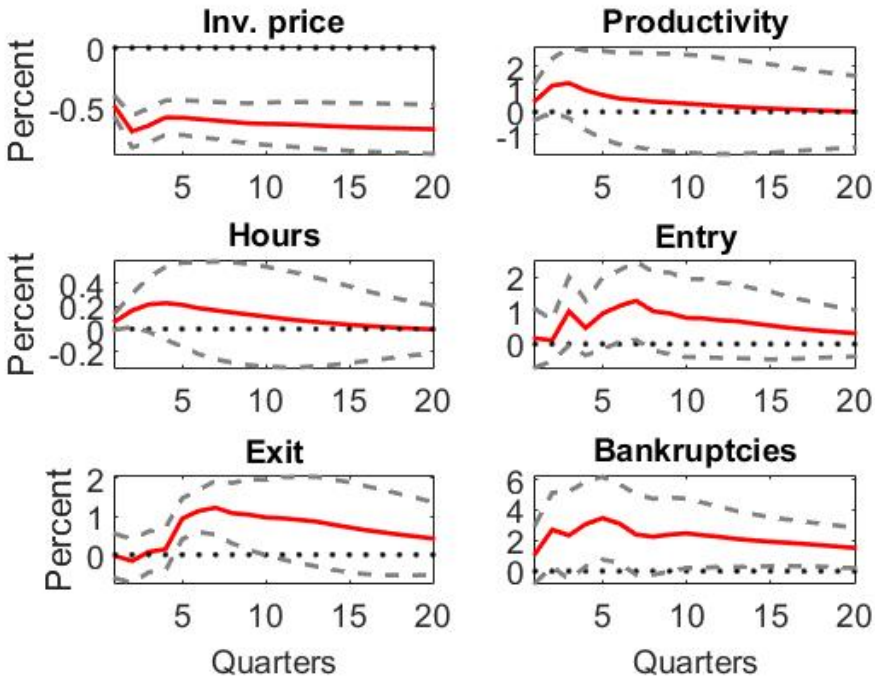

Figure 2: Macroeconomic reactions to investment-specific technology shocks.

We can see that entries react fast and strong. Firm bankruptcies decline by 2% during the second quarter after the shock, but only during the second quarter. The estimated confidence intervals are rather wide for all estimates, leaving estimates statistically insignificant for all other horizons. The estimated effects on other variables are similar to those estimated by Fisher (2006).

This can be related to the appearance of cheaper goods. For example, the number of firms producing type-writers almost disappeared with the introduction of personal computers that could be used to edit text. In these cases, the investment and production of the new good became cheaper compared to the existing technology, taking over the market of the previous product.

We can also observe an increase in firm creation and closure and a decrease in bankruptcy listings. This factor also corresponds to the research by Kim (2020), where it is indicated that a faster technological improvement in the manufacturing creates sectoral co-movements in employment in the short run but leads to sectoral shifts in the long run.

2.4 Robustness Analysis

The results are stable across various changes in the model set-up, giving confidence that the findings are central features of the data. First, we analyse the stability across various data samples as the long-run restrictions may be sensitive to the particular sample used. We begin with changing the period where the data starts and change the start of the period in two versions by removing the first 2 and 5 years from the start date. As seen in the Figure 5, after changing the start of the period to 1994, the results are similar to those presented in figures 1 and 2.

Removing the first 5 years from the data period and starting it from 1997 demonstrates that labour-neutral and investment-specific shocks (figures 6a and 6b) have stronger impacts on entries and exits compared to original results (Figures 1 and 2).

In the original model, we used 3 lags as suggested by various information criteria such as Akaike and Bayesian Information Criteria. However, in the robustness analysis the number of lags is changed to 2 and 4 (figures 7 and 8 respectively) to verify that the choice of the number of lags plays a role in the results, as too few lags might lead to biased results while too many lags leads to low efficiency of the estimates. With 2 lags the model predicts a smaller increase in price for labour neutral shocks and almost no significant increase for investment-specific shocks. The model with 4 lags demonstrates a smaller increase in exits and entries compared to the original model. However the qualitative results remain unchanged.

To check for model specification we have also constructed the model with 5 variables instead of 6 (*bankruptcy filings* variable removed). The model (Figure 9) shows similar results to the original model with a slightly bigger increase in entries for labour-neutral shocks.

3 Theoretical model

This section presents a new-keynesian dynamic stochastic general equilibrium (DSGE) model with endogenous entry and exit of firms. In this model, the economy consists of five agents: households, final good producers, intermediate goods producers, commercial banks, and a government or a central bank. The model starts from the setup used by Bilbiie et al. (2012a) that embeds firm turnover in a macroeconomic model finding inspiration from the seminal paper bu Hopenhayn (1992) on heterogeneous firms.

3.1 Household Problem

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

$$U_t = E_t \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - \chi c_{t-1})^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{A n_t^{1+\frac{1}{\kappa}}}{1+\frac{1}{\kappa}} \right) \right] \tag{3}$$

where U_t is the value of lifetime utility at period t, E_t is the expectations operator, β is the discount factor, χ describes the strength of consumption habit, σ is the intertemporal elasticity of substitution, κ describes the Frisch elasticity of labour supply and A is a scaling parameter for the disutility of labour to calibrate the share of hours worked.

A household faces a sequence of budget constraints. The available funds in period t consist of income from wages, deposits, bonds, profits, and transfers.

$$q_t B_t + D_t + C_t = W_t n_t + (1+i) D_{t-1} + B_{t-1} + V_t + G_t \tag{4}$$

where $c_t = \frac{C_t}{P_t}$, $\pi_t^C = \frac{P_t}{P_{t-1}}$ is consumer inflation defined more specifically later, D_t is deposits with banks, q_t is the discount price for the government bonds B_t, $1 + i_t$ is the gross interest rate on deposits made in the previous period, G_t are lump-sum government transfers or taxes, W_t is the wage rate and V_t are the profits received from the household's ownership of intermediate goods firms. All lower-case letters denote real and uppercase letters denote nominal variables unless clear from the context or stated otherwise.

Resources are spent on consumption, saved in bonds, or kept in deposits. In real terms, the budget constraint is:

$$q_t b_t + d_t + c_t = w_t n_t + (1+i) \frac{d_{t-1}}{\pi_t^C} + \frac{b_{t-1}}{\pi_t^C} + v_t + g_t \tag{5}$$

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

The household chooses consumption, bonds, deposits, and working hours.

The respective first-order conditions are given by:

$$\lambda_t = (c_t - \chi c_{t-1})^{-\frac{1}{\sigma}} - \beta\chi (E_t [c_{t+1}] - \chi c_t)^{-\frac{1}{\sigma}}, \tag{6}$$

$$\lambda_t q_t = \beta E_t \left[\frac{\lambda_{t+1}}{\pi^C_{t+1}}\right], \tag{7}$$

$$\lambda_t = \beta E_t \left[\lambda_{t+1} \frac{1 + i_{t+1}}{\pi^C_{t+1}}\right], \tag{8}$$

$$\lambda_t w^f_t = A n_t^{\frac{1}{\kappa}}, \tag{9}$$

Equations 6 and 7 give the Euler equation, Equation 8 describes the rule for deposits and finally the optimality condition for the labour-leisure choice gives the market clearing wage w^f_t in equation 9.

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

$$w_t = \left((1-\omega)w_{t-1} + \omega\Upsilon w^f_t\right) e^{u_{t,w}} \tag{10}$$

where w^f_t is the target market clearing wage obtained from the first-order condition of the household's optimisation problem, Υ shows the bargaining power of households, ω is the parameter for wage flexibility, $(1-\omega)$ shows backward wage indexation, and $u_{t,w}$ is a wage cost-push shock following an AR process $u_{t,w} = \rho_w u_{t-1,w} + \varepsilon_{t,w}$, where $\varepsilon_{t,w} = \rho^{ar}_w \varepsilon_{t-1,w} + \epsilon_{t,w}$ and $\epsilon_{t,w}$ is an i.i.d innovation.

The difference between the target and the actual wage introduces a labour wedge in the economy, and the household supply of labour at the given wage rate following Uhlig (2009).

3.2 Firms Producing Final Goods

Final good firms aggregate intermediate goods and produce final goods that are then consumed. The production function is standard with one notable exception. In the constant elasticity of substitution (CES), the aggregation does not go from 0 to 1 as in a standard model, but instead, it aggregates over the number of goods, which is the same as the number of firms N_t:

$$y_t = \left(\int_0^{N_t} y_{t,j}^{\frac{1}{1+\mu}} dj\right)^{1+\mu}, \tag{11}$$

where y_t is the final output, N_t is the number of intermediate inputs indexed by j,$y_{t,j}$ are an intermediate goods, $\mu = \frac{1}{\theta-1}$ and θ is the elasticity of substitution between intermediate goods.

The profit maximisation is given by:

$$P_t y_t - \int_0^{N_t} p_{t,j} y_{t,j} dj, \tag{12}$$

Finally, the firm's first order condition is given by:

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

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

In equilibrium all firms are the same, so $p_{t,j} = p_t$. Inflation $\pi_t = \frac{p_t}{p_{t-1}}$ is described in terms of intermediate goods prices, the average of prices that firms set. The consumer inflation index π_t^C adjusts for the number of firms and is given by $\frac{\pi_t}{\pi_t^C} = \frac{\rho_t}{\rho_{t-1}} = \left(\frac{N_t}{N_{t-1}}\right)^{\mu}$.

A rise in the number of firms leads to a drop in consumer inflation relative to the intermediate goods inflation rate, as the perceived price level for consumers decreases with the increasing number of varieties. When μ approaches zero, the elasticity of substitution approaches infinity, and the variety effect on consumer inflation disappears.

3.3 Intermediate Good Firms

Intermediate sector firms produce goods that are then aggregated to consumption goods by the sector producing final goods.

The market structure in this market is monopolistic competition, leaving equilibrium profits to the firms. Each firm in this sector produces only one good, as usually assumed in the literature. The number of firms is determined by a free entry condition, but differently from the rest of the literature, entry cost is equal only to a fraction of the net present value of firms, leaving some monopolistic profits to the firms as assumed by new-keynesian literature.

Intermediate firms use only labour and produce the good using linear production technology:

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

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

The intermediate firm j chooses labour $n_{t,j}$ and price $p_{t,j}$ with nominal profits described by $V_{t,j} = (p_{t,j} e^{\gamma_t} - (1+\xi i_t) MC_t) n_{t,j} - \frac{P_t \phi}{2} \left(\frac{p_{t,j}}{p_{t-1,j}\pi} - 1 \right)^2$, where π without a time index is the steady state inflation rate. Firms pay a share ξ of the cost in advance and borrow the necessary funds from commercial banks. Firms face quadratic price adjustment cost as in Rotemberg (1982), characterised by ϕ.

The profit equation in real terms is:

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

where the real profits per firm are $v_{t,j} = \frac{V_{t,j}}{P_t}$, and real marginal cost is $mc_t = \frac{MC_t}{P_t}$. The Rotemberg price adjustment simplifies the model as all firms set the same price and there is no need to keep track of the distribution of prices generated by the series of shocks and sluggish adjustment.

The cost minimisation problem gives the marginal cost net of interest rate payments:

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

Discounted profits define the net present value NPV_t of the firm. The net present value is measured at the time when production has already taken place, but firms do not yet know if they will survive until the next period.

In this way, the net present value is the same for incumbents and new firms. In nominal terms, the net present value is defined as:

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

and in the real terms after dividing by the price level:

$$npv_{t,j} = (1-\delta) E_t \left[e^{u_{t+1,surv}} \frac{\lambda_{t+1}}{\lambda_t} (v_{t+1,j} + npv_{t+1,j}) \right], \tag{18}$$

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

The survival probability is modelled as an exogenous albeit stochastic process as in Vilmi (2009). A number of papers demonstrate that firm failures are countercyclical (see Uusküla (2008) and Jacobson et al. (2013)). Similarly Elsby et al. (2009) show that the margin of job losers has to be taken into account when modeling employment dynamics.

The survival shock has several roles in the model. Most importantly the stochastic survival shock behaves very similarly to a markup shock as the relative price of goods is a linear function of the number of firms, but it also has a structural interpretation through the number of surviving firms. So the shock addresses the critique by Chari et al. (2009) as it relates the price markup shock to developments in the economy. Unlike the entry margin shock, it makes it possible to change the number of firms without having a strong impact on (labour) demand and marginal costs.

Also, contrary to what is found in the data, the number of exiting firms becomes procyclical in a model with an exogenously fixed exit rate (as shown by Rossi (2015)). By leaving the process stochastic we do not impose a particular model on the exit margin, but allow it to vary over time. Finally, in a model with a time-invariant exit rate, all changes in the number of firms are imposed on the entry margin. Imagine a period when the model would like to predict a high number of firms because of a particularly low exit. In a model with exogenous exit, the hike in the number of firms can only be achieved by an increasing number of new firms, resulting in overpredicting the entry rate and implying a high level of demand for labour. By making the exit rate stochastic the number of firms dynamic is not fully restricted by entry costs. Recently there are very promising attempts to model exit dynamics together with entry by Khan et al. (2014) and Rossi (2015).

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

$$npv_{t,j} = \frac{1}{\Psi}\xi^{ent}\frac{w_t}{e^{\gamma_t}}(1+\xi i_t)e^{u_{t,ent}}, \tag{19}$$

where ξ^{ent} is the amount of labour hired for creating a firm in the steady state, $0 < \Psi < 1$ measures the share of the net present value spent on entry costs from the net present value of the firm, and the entry cost shock $u_{t,ent}$ is described by $u_{t,ent} = \rho_{ent}u_{t-1,ent} + \varepsilon_{t,ent}$ and $\varepsilon_{t,ent} = \rho^{ar}_{ent}\varepsilon_{t-1,ent} + \epsilon_{t,ent}$, where $\epsilon_{t,ent}$ is i.i.d. The shock is a second order autoregressive process following the notation of Uhlig (2009). This allows the i.i.d shocks to generate hump-shaped responses. For the entry cost it is similar to congestion externality as in Lewis and Stevens (2015) or Bergin and Lin (2012).

When the free entry condition in a standard model also means zero profits in expected terms for new companies, then Ψ smaller than one leaves some profits for firms. This is different from other entry papers following Bilbiie et al. (2007b) and consistent with Smets and Wouters (2007) who has a fixed cost but does not use it to get the net present value of firms to zero. These equilibrium profits are necessary for monopolistic competition sticky price models.

When firms cannot change prices and profits fall, they still want to keep operating and the exit margin does not bind. The parameter also makes it possible to calibrate the share of total labour devoted to creating new firms, which in the model would be largely determined by markup.

The technology of the new firms is identical to the old firms. This is also often found in the data; for example, Foster et al. (2008) find evidence that new firms are as productive as the old companies, and Hurst and Pugsley (2011) show that most companies produce existing products for existing markets and do not innovate.

The costs of firm creation in terms of legal costs and procedures are sizeable in the US and even higher in many other countries (see Barseghyan and DiCecio (2011) and Djankov et al. (2002) for estimates of the entry costs). In this paper, the broad definition of entry costs also includes the time that is needed to come up with the idea for a new product or service, working out the business plan, making the plan work, hiring the right people, finding the right suppliers, marketing, and as a general allocation of resources to acquire the technology to produce a good or a service. The US Small Business Administration lists eleven points to consider for people who start a new company[1], described by words like choose, learn, and explore; most of the points involve taking a substantial amount of consideration and care, and not direct inputs from other firms.

The nature of the shock is stochastic technological progress that gives entrepreneurs the technology to set up a business. There is little hard evidence about changes in the cost of starting a business[2] but with the technological changes, it is widely accepted in business communities that starting a business

[1]See https://www.sba.gov/category/navigation-structure/starting-managing-business

[2]As a measure of administrative burden, the average number of days required to start a business in the US has come down from 6 to 5 and then increased to 6.2 over the last 10 years according to the World Bank survey showing considerable persistence, see (http://data.worldbank.org/indicator/IC.REG.DURS?display=default).

is different now from what it was a decade ago[3][4].

3.4 Phillips curve

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

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

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

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

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

According to the Phillips curve, the inflation rate today depends on the expected inflation and marginal cost as in the standard Phillips curve. However, the two new elements, firm turnover, and the working capital assumption make markups endogenous and separate marginal cost from the inflation rate. Shocks that increase the number of firms, push down markups and reduce consumer inflation directly. The working capital channel magnifies the effect of marginal cost on inflation as lowers interest rates lead to lower inflation.

3.5 Banks

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

$$\frac{d_{t-1}}{\pi_t^C} + \psi_t = \xi w_t n_t = l_t. \tag{22}$$

The banks operate only as intermediaries of funds from the central bank and households to firms. The loans are paid back within the period. The firms

[3] For example Stewart Butterfield, co-founder of Flickr, describes how starting a new software company has changed over the last 12 years, see (http://www.businessinsider.com/launching-startup-changed-drastically-stewart-butterfield-slack-flickr-2015-6).

[4] Business Insider wrote that Now is the best time to start a company (http://www.businessinsider.com/why-now-is-the-best-time-to-start-a-company-2014-10).

always pay back the debt. Loans to the new firms that never produce are paid back from the aggregate profits of incumbents before the remaining profits are distributed to the households. The commercial banks lend all their resources to firms, there is no credit rationing.

3.6 Firm dynamics

The number of firms N_t gives the number of firms at the end of the period when an exit has taken place. The exit is decided at the time when shocks are realised. Some of the firms close down and do not produce. So the right number for production is N_{t-1}, which is the end of period count. The number of firms N_t depends on how many of the producing firms survive from the last period and how many new firms $N_t^{E_{-2}}$, that were started two periods before survive to period t.

$$N_t = (1 - \delta^1)\epsilon_t^s N_{t-1} + N_t^{E_{-2}}, \tag{23}$$

where $N_t^{E_{-2}} = (1 - \delta^1)\epsilon_t^s N_{t-1}^{E_{-1}}$, δ^1 is the probability of exit for old firms, and ϵ_t^s is stochastic survival.

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

A partial entry gives a more general case to the law of motion before. Here the firms start working at size $0 < \eta < 1$, smaller than incumbents that were started the period before. When $\eta = 1$, the equation is identical to the standard Bilbiie et al. (2012a) equation. When $\eta = 0$ then the equation is identical to 23, where it takes two periods before a firm starts operating.

$$N_t = (1 - \delta^1)\epsilon_t^s N_{t-1} + \eta N_t^{E_{-1}} + (1 - \eta)N_t^{E_{-2}}, \tag{24}$$

where N_t is the number of firms, $N_t^{E_{-2}} = (1 - \delta^1)\epsilon_t^s N_{t-1}^{E_{-1}}$, $N_{t-1}^{E_{-1}} = (1 - \delta^1)\epsilon_{t-1}^s(1 - \delta^2)N_{t-2}^{E_0}$ and δ^2 is the additional probability of exit for new firms. It is worth noting that when firms are created, they are subject to an additional probability of exit. This makes the equation different from the law of motion for existing firms, including those that were started a period ago.

The count of the number of firms N_t^C takes into account that the new firms are counted in the number of firms at the time when they are created, not when they start operating. Therefore, the equation can be written as follows.

$$N_t^C = (1-\delta^1)\epsilon_t^s(N_{t-1}^C - N_{t-1}^E) + (1-\delta^1)\epsilon_t^s(1-\delta^2)N_{t-1}^E + N_t^E \tag{25}$$

Notice that in the count of firms, entry at period t is included in the number of firms, but it is not in the effective number of firms as there are none that start operating at the time of creating the firm.

Exit numbers come from the aggregate number of firms dynamics. So exit should be:

$$Exit_t^C = \delta^1\epsilon_t^s\left(N_{t-1}^C - N_{t-1}^E\right) + \left(\delta^1 + \delta^2 + \delta^1\delta^2\right)\epsilon_t^s N_{t-1}^E \tag{26}$$

Finally, the exit rate defined as a ratio of existing firms to total number of firms in the economy is given by:

$$ExitR_t^C = \frac{Exit_t^C}{N_t^C}.$$

This equation provides the basis for comparing model-generated data to actual data.

3.7 Net Present Value

Net present value is the central feature of the model that determines how many firms are created and how many are exiting the market. The net present values are different for new and old firms as the new firms are born small and grow over time; therefore, although the stochastic discount factor is the same, the profits that the firms provide at different horizons are not the same. This feature breaks the dynamics of entry from the dynamics of exit.

The entry cost is given by the following equation:

$$npv_{t,j} = \frac{1}{\Psi}\xi^{ent}mc_t(1+\xi i_t)\epsilon_t^e + (1-\delta^1)\epsilon_{t+1}^s(1-\eta(1-\delta^2))\frac{\lambda_{t+1}}{\lambda_t}v_{t+1,j} \tag{27}$$

Where $0 < \Psi < 1$ is the share of entry cost in the net present value. It makes the model consistent with the standard pricing rigidity papers where there is some monopoly power of the firms that firm entry does not take away.

The second term of the entry cost equation consists of forgone earnings due to increased exit rate within the first year of the newly established firms and because the new firms will not achieve the size of the incumbents instantaneously.

New net present value for entry cost alone is:

$$npv^{ec}_{t,j} = \frac{1}{\Psi}\xi^{ent} mc_t(1+\xi i_t)\epsilon^e_t \tag{28}$$

Net present value for existing firms is:

$$npv_{t,j} = (1-\delta^1)E_t\epsilon^s_{t+1}(\frac{\lambda_{t+1}}{\lambda_t})(v_{t+1,j} + npv_{t+1,j}) \tag{29}$$

Profit is a function of marginal costs and markup in the equilibrium:

$$v_j = \mu mc(1+\xi i)n_j \tag{30}$$

Total hours are fixed to a third, which means that one third of total hours is spent working. The equation for hours per firm n_j, and aggregation of hours is:

$$n_t = N_{t-1}n_{t,j} + N^E_t\xi^{ent}_t \tag{31}$$

3.8 Government sector

The central bank monetary policy is described by a Taylor rule:

$$i_t = \bar{i} + \rho_i i_{t-1} + (1-\rho_i)\left[\zeta_\pi\left(\frac{\pi_t}{\pi}-1\right) + \zeta_y\left(\frac{y^{TP}_t}{\bar{y}^{TP}}-1\right) + \epsilon_{t,i}\right], \tag{32}$$

where $\epsilon_{t,i}$ is a shock to the interest rate and ρ_i is the interest rate smoothing parameter. The interest rate reacts more than one-to-one to changes in inflation $\zeta_\pi \geq 1$ and potentially to changes in total production by $\zeta_y \geq 0$ measured by y^{TP}_t defined as the sum of consumption and total entry costs and without a time index and upper bar value at the steady state.

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

$$q_t b_t = \frac{b_{t-1}}{\pi_t} - g_t + (\nu + i_t)\psi_t g_t = (\nu + i_t)\psi_t. \tag{33}$$

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

3.9 Aggregation and market clearing

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

$$n_t = N_t n_{t,j} + N_t^E \frac{\xi^{ent} e^{u_{t,ent}}}{e^{\gamma_t}}. \tag{34}$$

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

$$v_t = N_t v_{t,j} - N_t^E w_t \xi^{ent} (1 + \xi i_t) \frac{e^{u_{t,ent}}}{e^{\gamma_t}}. \tag{35}$$

In total consumption, we take out the effect of the number of firms on consumption to keep the productivity of the economy independent of the number of firms:

$$c_t = N_t y_{t,j} = N_t^{\iota-(1+\mu)} \int_0^{N_t} y_{t,j}, \tag{36}$$

where $\iota = 1$, so in this respect, the model departs from the standard Dixit-Stiglitz aggregator. This helps to focus on the transmission of shocks through the Phillips curve (see also Bergin and Corsetti (2008)). When productivity is measured as output over hours, an increasing number of firms generates an extra source of productivity shocks without this transformation.

3.10 Calibration

The model is calibrated yearly for the US economy using parameter values consistent with the literature. Consistent with Bilbiie et al. (2007a) the exogenous death rates for incumbent firms δ^1 and new firms δ^2 are set at 0.1. This corresponds to an annual 10 % job loss in the US which averages 10.8 % as documented in Uusküla (2016) and Cavallari (2015). The discount factor for households is modelled at 0.96 following the standard in the literature for yearly data and steady state inflation is kept at an annual rate of 2%. The consumption habits of households χ is set at 0.4, which is lower than Smets and Wouters (2007) and Casares et al. (2018), where it was set at 0.7 of the annual rate.

The mark-up is set at 37 % consistent with the literature, whereas Ψ which is the share of entry cost in the net present value is set at 0.2. The intertemporal elasticity of substitution parameter σ and Frisch elasticity of labour supply are calibrated at 1.

The Rotemberg price adjustment cost ϕ is equal to 10, while the wage ad-

Table 1: Calibrated parameter values

Not.	Value	Notes
β	0.96	Discount factor
Ψ	0.2	Entry cost in NPV
δ^2	0.1	Death rate of new firms
δ^1	0.1	Death rate of firms
η	0.2	Slow entry
χ	0.4	Consumption habit
μ	0.37	Markup
σ	1	Intertemporal elasticity of substitution
κ	1	Frisch elasticity of labour supply
ϕ	10	Rotemberg price adjustment cost
ω	0.2	Wage adjustment speed
ζ_π	1.5	Taylor weight on inflation
ζ_y	0.1	Taylor weight on output gap
ρ_γ^{ar}	0.7	Autocorr. of technology shock
ρ_{ent}^{ar}	0.7	Autocorr. of firm creation shock
$\varepsilon_{t,\gamma}$	1	i.i.d shock of technology shock
$\varepsilon_{t,ent}$	1	i.i.d shock of firm creation shock

justment speed ω is set at 0.2. The autoregression coefficients ρs, for both technology shocks and firm creation shocks are kept at 0.7. Lastly, the Taylor rule parameter of the interest rate and output response to inflation are calibrated following Smets and Wouters (2007) at 1.5 and 0.1, respectively.

The extra death rate of new firms δ^2 is an additional parameter that changes the net present value of new firms. There is ample evidence that new firms are more likely to close in the first years of existence. This parameter captures this feature and allows for the high entry rates observed in the data, and the magnification of the count of firms over the business cycle.

The Rotemberg price adjustment cost follows the paper by Uusküla (2016), adjusting for the units in which the cost is measured and estimates that are consistent with the qualitative effects of a monetary shock on firm dynamics.

3.11 Results of the theoretical model

This section describes the internal amplification mechanism that the exit margin, the slow entry of firms, and the small entry cost relative to net present value bring compared to a smaller and simpler model without these features.

Figure 3 presents the impulse responses of selected macroeconomic variables resulting from a one percentage point increase in productivity. As expected, the shock leads to an immediate spike in output and hours. The exit rate of incumbents in turn drops instantly and is persistent, as their net present value exceeds the steady state due to the positive technology shock. The same dynamics govern the entry of new firms and the entry margin also spikes as net profits exceed entry costs. As the count of the number of firms peaks after two years, the entry of new firms falls below the steady state level.

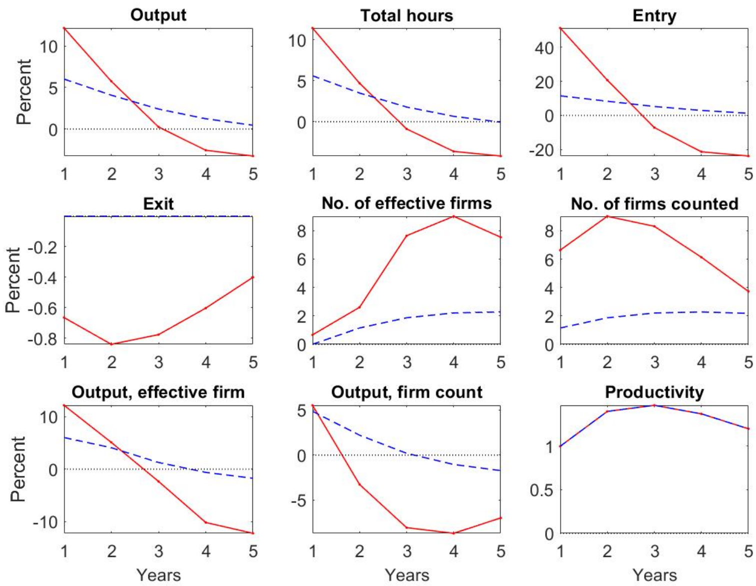

Figure 3: Effects to a 1% technology shock in the main model(solid red line) and simple model(dashed blue line)

The effective number of firms initially increases only because of the exit margin as firms survive. In later periods, however, as the new firms become operational, the effective number of firms also increases due to the entry margin. Following these dynamics, the effective number of firms reaches a peak two years later than the count of the number of firms and remains higher than the count also a year after the peak.

Recalling that new entrants start operating at full capacity two periods after being established, this explains the higher impact of the productivity shock on output per effective firm than output per firm count. The increase in the size of incumbents upon a productivity shock has also been confirmed in the literature (Cavallari (2015)).

Figure 4 presents the dynamics for a one percentage point increase in investment-specific productivity. The main model with exit margin, slow entry of firm and small entry cost is depicted with solid red lines, whereas the simple baseline model without these features is depicted with dashed blue lines. The persistent fall in the units of labour required for entry leads to a rise in the creation of new firms and a hike in the aggregate output.

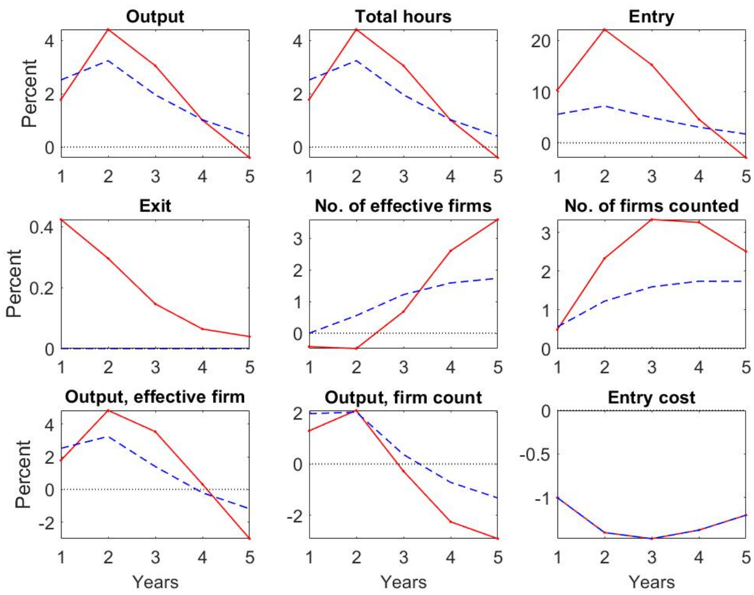

Figure 4: Effects of a 1% investment specific entry cost shock in the main model(solid red line) and simple model(dashed blue line)

The exit of firms increases after the shock as the entry of new firms pushes wage pressures upward forcing some firms to exit despite the drop in the labour units required. The effective number of firms shows a slight decrease initially due to the strong reaction of the exit margin, but then reverses course and increases sharply.

The output per effective firm increases along with the aggregate output, while the output per firm count marginally rises at first and turns negative after two years even if the aggregate output remains positive. Considering each additional feature more specifically in understanding their role in the effects of technology shocks is important in this case.

Taking away cheap entry from the model with productivity shocks results in a lower entry and exit margin without changing aggregate dynamics (Figure 10 in Appendix). However, this feature becomes more significant with an investment-specific productivity shock as the dynamics of entry are strongly affected by a cheap entry margin. Consequently, the number of new firms is reduced to almost the level of the model without additional features. Exit reacts by one-half of the size of the full model at the time of the shock and reverses to negative territory after a few years. Moreover, Output on impact reacts more strongly without cheap entry than in the full model. (Figure 10 in Appendix).

The dynamics involved when discarding slow entry alone remain the same with the full model. While discarding both these features reduces the model to the baseline model without any of the additional features indicating that the combination of small entry costs and slow entry is important in obtaining the results. (see Figures 11 and 12 in the Appendix)

The model is also good at bringing together microeconomic and macroeconomics effects of positive technology shocks. In a standard model, the output per firms increases very little or even decreases after a positive technology shock. This stands in contrast with the microeconomic evidence that technology shocks do lead to increased output per firm. In this model the dynamics of output per firm are similar to aggregate dynamics when the effective number of firms in used instead the count.

4 Conclusions

The paper studies the effects of technology shocks. It demonstrates the existence of Schumpeterian creative destruction for investment-specific technology shocks, as it leads to more new firms and also higher exit rates. The labour-neutral technology shocks are also followed by an increase in new firms, but instead the rate at which firms exit decreases, so existing firms also gain from the change. The number of bankruptcy filings, instead of firm closures should be used as the data to analyse firm death dynamics, as this is in line with the exit definition in the model. In the data, closures of firms are recorded later as closing down firms is often time-consuming.

A model with endogenous entry and exit together with features that match the small entry of firms and high death rates of existing firms, can match the stylised facts on the effects of labour neutral and investment technology shocks.

Moreover, the new features of the model provide stronger internal amplification of the business cycle and a high variability in firm entry.

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KOKKUVÕTE
Tootlikkus ja ettevõtete loomise ning sulgemise dünaamika

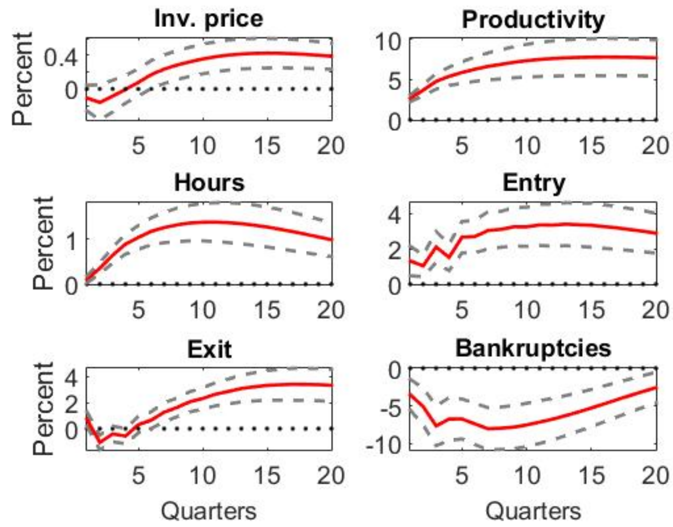
Käesolev artikkel uurib tootlikkuse ning ettevõtete loomise ja sulgemise vahelisi seoseid. Kasutades USA andmeid ja vektor-autoregressivset (VAR) mudelit, näitab artikkel, et Schumpeteri loovat hävitamist on näha peale investeerimis-spetsiifilisi šokke, sest just need viivad uute ettevõtete loomise kasvule aga samas ka rohkemate vanade ettevõtete sulgemiseni. Neutraalsed tehnoloogia šokid toovad kaasa rohkem uusi ettevõtteid kuid sellega kaasneb varem asutatud ettevõtete suurem ellujäämistõenäosus. Teoreetilises osas näitab artikkel, et kui mudelit täiendada, siis suudab keskmise suurusega dünaamiline stohhastiline üldise tasakaalu (DSGE) mudel endogeense ettevõtete loomise ja sulgemisega kirjeldada hästi neid stiliseeritud fakte. Mudel demonstreerib kui oluline on see, et uued ettevõtted on väiksemad võrreldes vanadega ja et turul valitseb piiratud konkurents ning kogu ettevõtete netoväärtust ei kulutata ettevõtete loomiseks.

5 Appendix

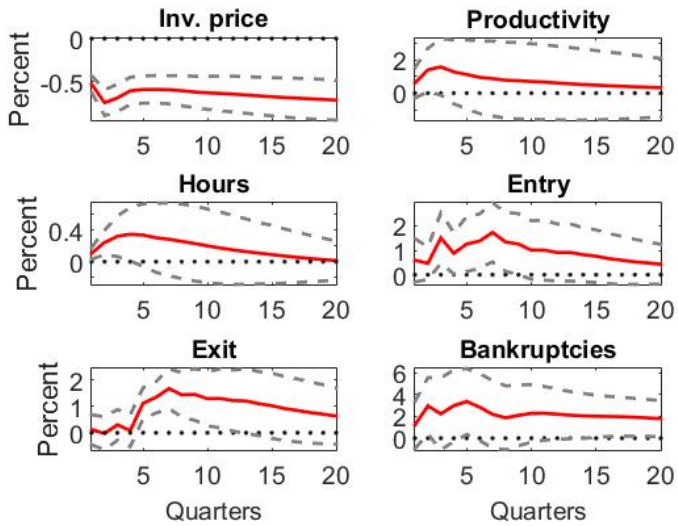
5.1 Additional Tables and Figures

Table 2: Data description and sources.

Name	Description and source
Price indexes for consumption	Price Indexes for Personal Consumption Expenditures by Major Type of Product (seasonally adjusted, from Q1 1947 to Q1 2021), Bureau of Economic Analysis
Price indexes for investment	Price Indexes for Private Fixed Investment by Type (seasonally adjusted, from Q1 1947 to Q1 2021), Bureau of Economic Analysis
Establishments births and deaths	Private sector establishment births and deaths (seasonally adjusted, from Q4 1992 to Q4 2020), Bureau of Labour Statistics
Bankruptcies	Business bankruptcy filings (from Q4 1992 to Q4 2020), US Bankruptcy court
Population	Population Level (not seasonally adjusted, from 01.01.1948 to 01.04.2021), Federal Reserve Economic Data
Utilization	Utilization for business sector (adjusted quarterly, from Q1 1947 to Q12021), Federal Reserve Bank of San Francisco
Hours	Hours Worked and Employment for Total Economy and Subsectors (seasonally adjusted, from Q1 1947 to Q1 2021, Bureau of Labour Statistics

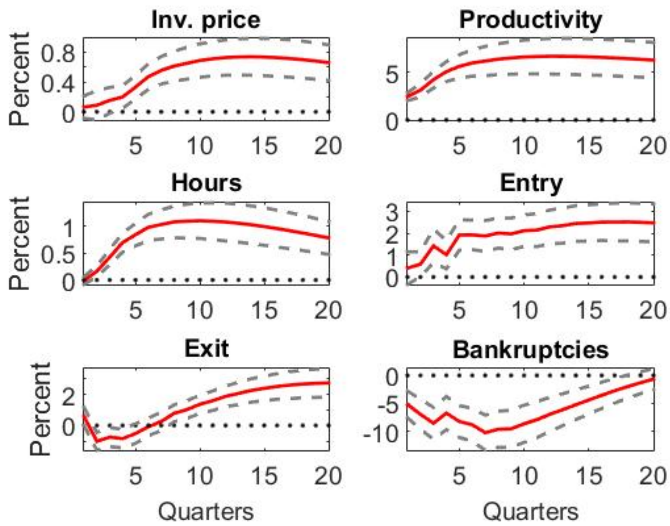


(a) Neutral shocks

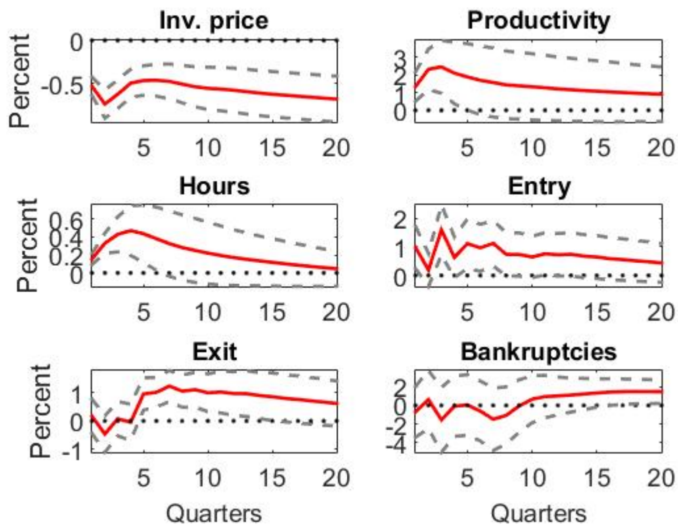


(b) Investment specific shocks

Figure 5: Robustness analysis results. First 2 years removed.

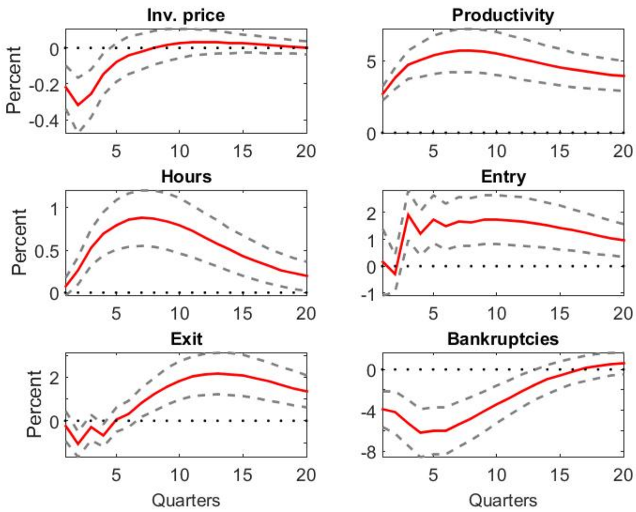


(a) Neutral shocks

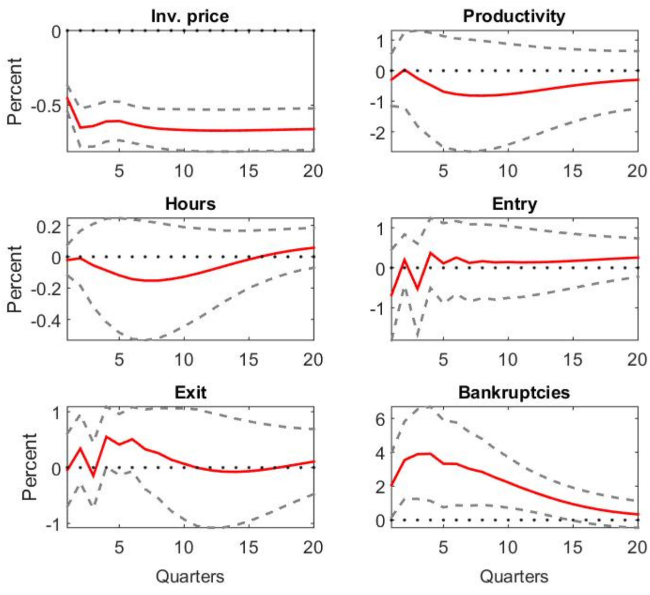


(b) Investment specific shocks

Figure 6: Robustness analysis results. First 5 years removed.

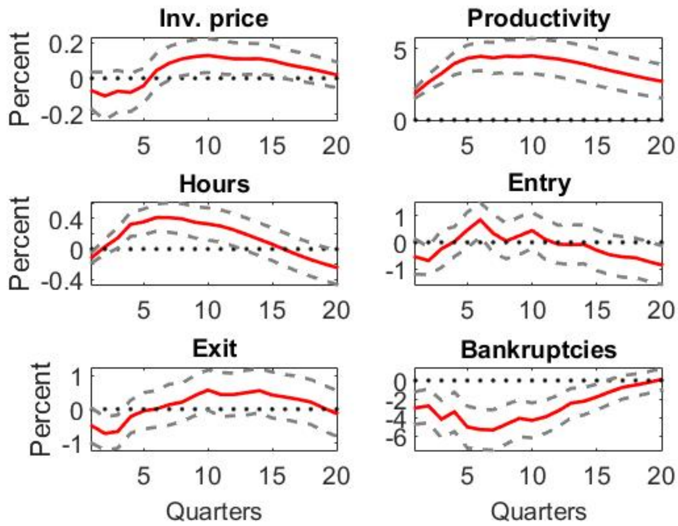


(a) Neutral shocks

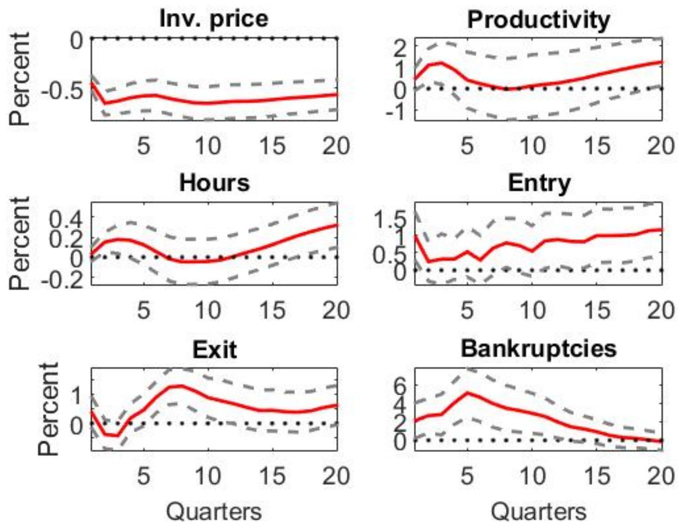


(b) Investment-specific shocks

Figure 7: Robustness analysis results. 2 lags used.

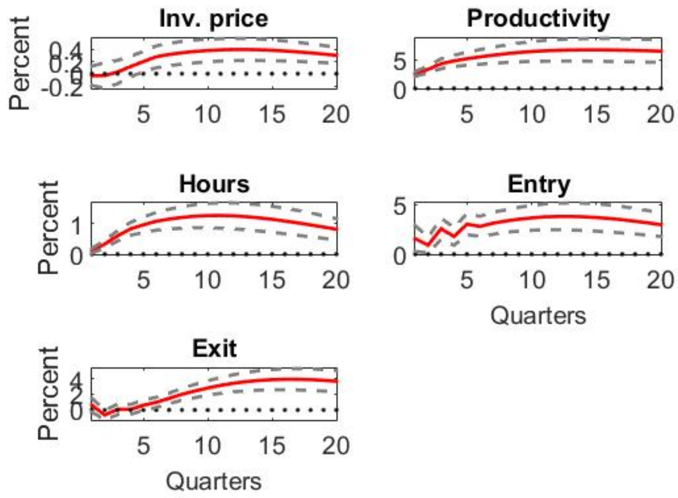


(a) Neutral shocks

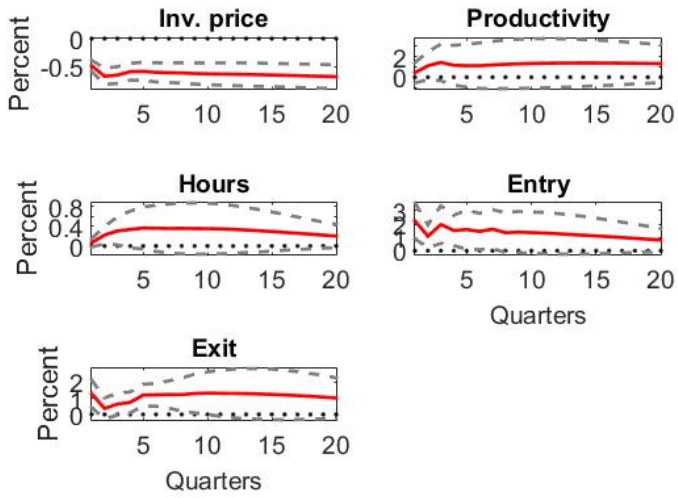


(b) Investment-specific shocks

Figure 8: Robustness analysis results. 4 lags used.

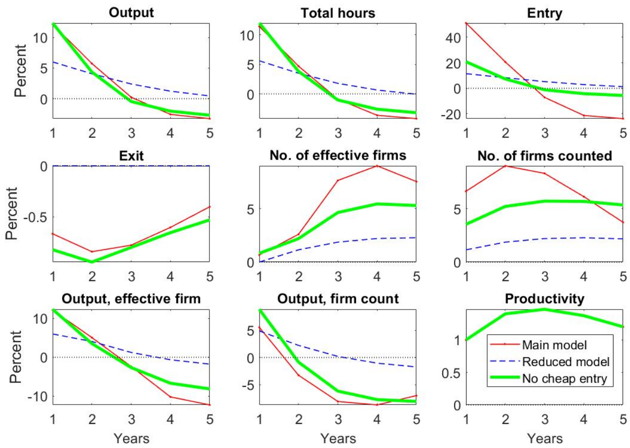


(a) Neutral shocks

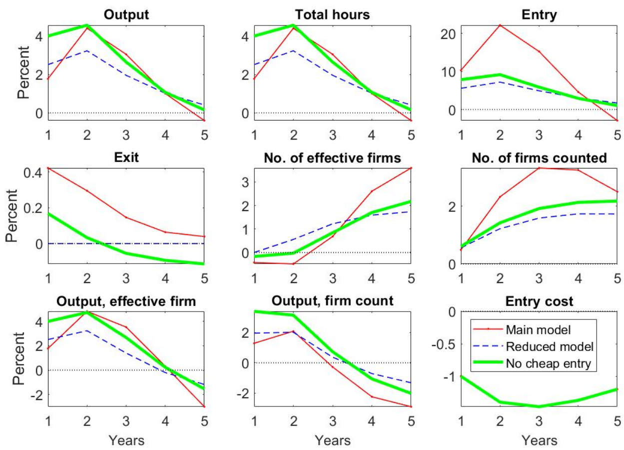


(b) Investment-specific shocks

Figure 9: Robustness analysis results. 5 variables used.

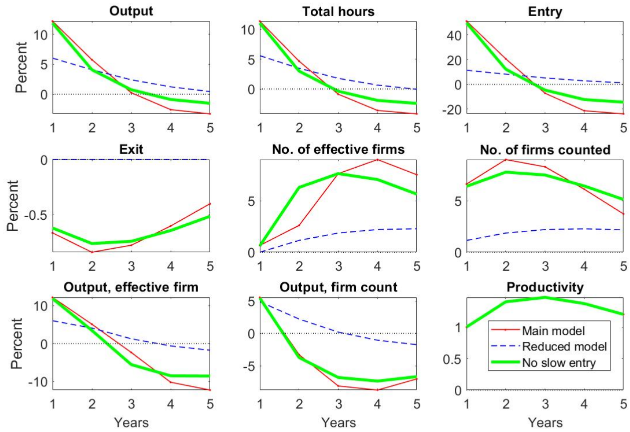


(a) Neutral technology shocks

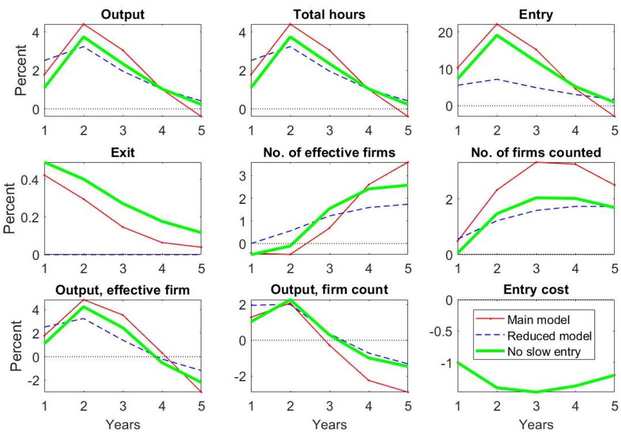


(b) Investment specific shocks

Figure 10: IRFs for the model with no cheap entry.

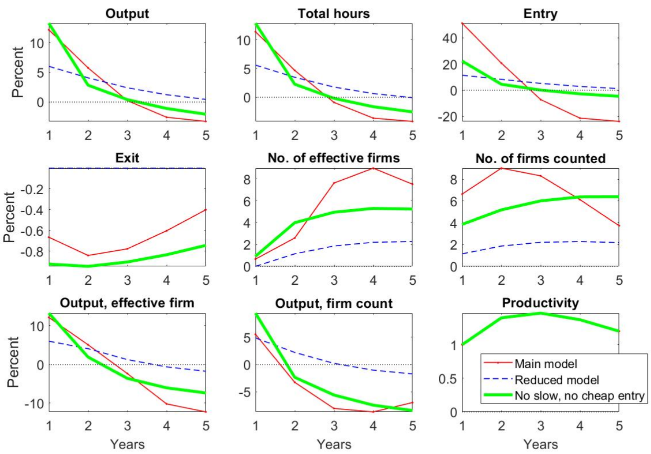


(a) Neutral technology shocks

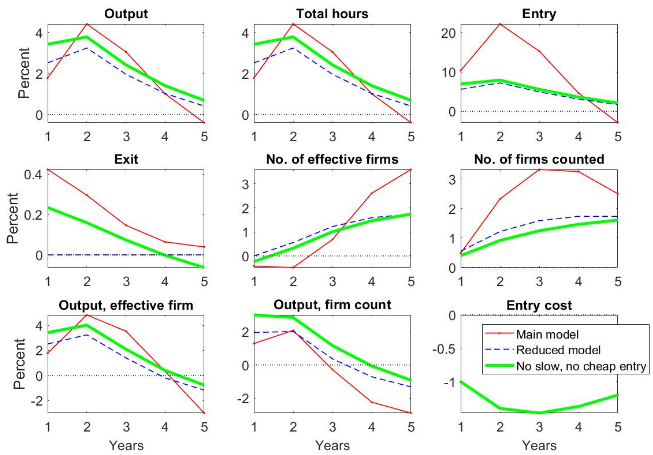


(b) Investment specific shocks

Figure 11: IRFs for the model with no slow entry.



(a) Neutral technology shocks



(b) Investment specific shocks

Figure 12: IRFs for the model with no slow and no cheap entry.