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Abstract

Evidences from structural VAR show that new business formation positively co-moves with output under news shocks. The Jaimovich-Rebelo model augmented with firm dynamics can explain the empirical findings. The key assumption is endogenous survival rates for new entrants.

Keywords: Firm Dynamics, Aggregate Co-movement, Expectation-Driven Business Cycle, News Shocks

JEL Classification: E22; E32.

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1. Introduction

Recent studies find that expectations might be an important source of macroeconomic fluctuations.[1] However, the traditional real business cycle (RBC) model fails to generate the expectation-driven business cycle (EDBC). More recently, Jaimovich and Rebelo (2009) established a full-fledged but concise RBC model with several real rigidities. Their model produces a positive co-movement of aggregate variables in response to the news shocks about technology and thus explains the EDBC notably well.[2] However, their model does not look at the firm dynamics. As the literature documents,[3] the net entry in the U.S. economy is strongly procyclical and accounts for a large fraction of employment variation. This finding suggests that firm dynamics should be considered as an important aspect in the EDBC modelling as well.

In this paper, we first empirically examine how the firm entry in the U.S. economy responds to news shocks. Based on the identification strategy presented in Beaudry and Lucke (2010), we find that a positive news about the future technology leads the U.S. economy to experience a boom in stock price, output and firm entry. However, simply incorporating firm entry decision into Jaimovich-Rebelo EDBC model cannot explain our empirical findings: the economy experiences a recession, instead of a boom, under a favorable news shock. We show that this problem can be resolved through a minor modification by introducing endogenous firm survival rate.

2. Empirical Evidences from U.S. Data

We now investigate the dynamic effects of news shocks to firm entry by analyzing the U.S. macroeconomic data. The variables of interest are total factor productivity (TFP), stock price (SP), real GDP (Y) and new business formation (NF) that represents the number of firms that enter the market. All of the variables are transformed into per-capita variables using the total U.S. population count between the ages of 16 to 64. The last three series are presented in logs. Data are quarterly, running from 1948Q1 to 2009Q4. The appendix provides further details of our data.

To identify the news shock, we employ the Beaudry-Lucke identification strategy. We first arrange the order of structural shocks such that the first one is a surprise technology shock, the second is a news shock about TFP, and the last two are short-run shocks (e.g., demand shocks). Specifically, as in Beaudry and Lucke (2010) , we assume that the news shock has no impact on today's TFP but can affect today's stock price. That is, the (1,2) element in the impact matrix is zero.[4] Regarding the last two short-run shocks, we assume that they are independent of the exogenous TFP process and also have no long-run effects on TFP. This assumption means the (1,3) and (1,4) elements in both the impact matrix and the long-run matrix are set at zero. Finally, to distinguish the short-run shocks, we force the (3,4) element in the impact matrix to be zero. With

[1] See Beaudry and Portier (2006), Beaudry and Lucke (2010).

[2] Some other papers can also generate an EDBC, e.g., Den Hann and Kaltenbrunner (2009), Karnizova (2010) and among others.

[3] See Jaimovich and Floetotto (2008), Wang and Wen (2011) and among others.

[4] As the news shock has the ability to predict the TFP in the long run, the (1,2) element in the long-run matrix is not necessarily zero.

these aforementioned six restrictions,[5] all of the structural shocks are fully identified.

[Here Insert Figure 1]

To study the dynamic responses, we first estimate a Vector Error Correction Model (VECM) for the four-variable system (TFP,SP,Y,NF) with four lags and three cointegration vectors.[6] Figure 1 reports the responses of (TFP,SP,Y,NF) to one unit of positive news shock. The top left panel shows that under a positive news shock, TFP initially decreases, and after approximately 1.5 years, it reverses and gradually increases. The dynamics of TFP here share similar patterns to those found in Beaudry and Lucke (2010). This point indicates that our VAR system, despite the variables being considered, contains as much information as does the Beaudry-Lucke system to recover the news about TFP. Moreover, other panels in Figure 1 show that there are statistically significant positive effects of a news shock about future TFP on output, stock price and new business formation. Furthermore, the responses of these variables present similar hump shape. In particular, they increase in the first five quarters and gradually decrease thereafter and, finally (fifteen quarters later), tend to flatten out. Overall, the dynamics of output and stock price, as in Beaudry and Lucke (2010), highly co-move with the news shock about future TFP. The novel finding in our exercise is that the firm entry appears to have a similar pattern of co-movement, as well.

Intuitively, the phenomenon in which positive news induces more new business incorporations is mainly due to the fact that the potential firms expect their firm value to increase in the future due to the higher level of productivity. This point is well reflected by the significant co-movement relationship between firm entry and stock price. Next part, we will incorporate the firm dynamics into the Jaimovich-Rebelo model, and give the theoretical rationale for our previous empirical findings.

3. The Model

Consider a closed economy, which is characterized by a representative household, a representative firm producing final goods and a continuum of differentiated monopolistically competitive intermediate firms. The mass of intermediate firms is endogenously determined by their entry and exit decisions.

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[5] To be precise, the impact matrix is $\begin{bmatrix} * & 0 & 0 & 0 \\ * & * & * & * \\ * & * & * & 0 \\ * & * & * & * \end{bmatrix}$ and the long-run matrix is $\begin{bmatrix} * & * & 0 & 0 \\ * & * & * & * \\ * & * & * & * \\ * & * & * & * \end{bmatrix}$.

[6] Both the Akaike Information Criterion and the Final Prediction Error Criterion suggest four lags in the TFP level. Using the Johansen cointegration test, we found that the data do not reject two cointegration relationships at the 5-percent level. However, there is only one explicit exogenous trend, which is that for the TFP series in our VECM, a natural assumption on cointegration rank is three, i.e., one common trend. Taking this into account, as in Beaudry and Portier (2006), we want to be cautious of the possible misspecification bias; we conservatively choose three cointegration relationships instead of two. In fact, our results are robust with the value of the cointegration rank.

3.1. Final goods firms

The final goods firms maximize their period-by-period profit with the technology constraint, which is a CES aggregation of a continuum of intermediate goods indexed by i:

$$Y_t = \left(\int_0^{N_t} \left(y_t^i \right)^{\sigma} di \right)^{\frac{1}{\sigma}}, \tag{1}$$

where y_t^i is the production of the intermediate firm i, N_t is the mass of the intermediate firms, $\sigma \in (0,1)$ governs the elasticity of substitution across intermediate goods.

The final goods producers' profit maximization yields:

$$y_t^i = \left(p_t^i \right)^{\frac{1}{\sigma - 1}} Y_t, \tag{2}$$

and the price index function is

$$P_t = \left(\int_0^{N_t} \left(p_t^i \right)^{\frac{\sigma}{\sigma - 1}} di \right)^{\frac{\sigma - 1}{\sigma}}, \tag{3}$$

where p_t^i is the optimal price set by the intermediate firm i; P_t denotes the aggregate price index hereafter normalized to one.

3.2. Incumbent Intermediate firms

We first consider a typical incumbent firm. Each intermediate good, y_t^i, is produced by the firm i using the efficient capital, $u_t^i k_t^i$, and the labor, l_t^i, with the Cobb-Douglas production function:

$$y_t^i = A_t \left(u_t^i k_t^i \right)^{\alpha} \left(l_t^i \right)^{1-\alpha}, \tag{4}$$

where A_t denotes the aggregate technology and u_t^i is a variable rate of capital utilization. The rate of capital utilization determines the intensity of the use of capital, which affect the the rate of capital depreciation. We let $\delta \left(u_t^i \right)$ represent the rate of capital depreciation and assume that depreciation is convex to the rate of utilization: $\delta' (\cdot) > 0$, $\delta'' (\cdot) > 0$. The total cost to produce y_t^i can be obtained by:

$$\min r_t u_t^i k_t^i + w_t l_t^i$$

$$s.t. A_t \left(u_t^i k_t^i \right)^{\alpha} \left(l_t^i \right)^{1-\alpha} \geq y_t^i, \tag{5}$$

where r_t represents the rental rents per unit of efficient capital; w_t is the real wage; and let ϕ_t^i be the marginal cost. We then have the following:

$$r_t = \alpha \phi_t^i \frac{y_t^i}{u_t^i k_t^i}, \; w_t = (1-\alpha) \phi_t^i \frac{y_t^i}{l_t^i}. \tag{6}$$

Using the above two equations, we can derive that in a symmetric equilibrium the marginal cost ϕ_t^i is:

$$\phi_t^i = \frac{1}{A_t} \left(\frac{w_t}{1-\alpha} \right)^{1-\alpha} \left(\frac{r_t}{\alpha} \right)^{\alpha}. \tag{7}$$

Each intermediate firm i maximizes its static period operating profits:

$$\pi_t^i = \left(p_t^i - \phi_t^i \right) y_t^i. \tag{8}$$

The previous expression yields that optimal price and profit at each period are:

$$p_t^i = \phi_t^i / \sigma, \ \pi_t^i = (1-\sigma)\, p_t^i y_t^i. \tag{9}$$

Because the intermediate firms' technology is symmetric with respect to all inputs, we focus hereafter on the symmetric equilibrium: $u_t^i = u_t$, $k_t^i = k_t$, $l_t^i = l_t$, $y_t^i = y_t$, $r_t^i = r_t$, $\phi_t^i = \phi_t$, and $\pi_t^i = \pi_t$. The representative household provides labor, L_t, and capital, K_t, to firms for production activities. In a symmetric equilibrium, the resource constraint on the labor and capital markets imply $L_t = N_t l_t$ and $K_t = N_t k_t$. The aggregate price index from (3) implies $p_t = N_t^{\frac{1-\sigma}{\sigma}}$. Also, the technology of producing the final goods implies $Y_t = N_t^{\frac{1}{\sigma}} y_t$. Finally, the aggregate final output, the equilibrium rental rate and wage, and the intermediate firm's operating profit are given by:

$$Y_t = A_t N_t^{\frac{1}{\sigma}-1} \left(u_t K_t \right)^{\alpha} L_t^{1-\alpha}, \tag{10}$$

$$w_t = (1-\alpha)\, \sigma \frac{Y_t}{L_t}, \tag{11}$$

$$r_t = \alpha\sigma \frac{Y_t}{u_t K_t}, \tag{12}$$

$$\pi_t = (1-\sigma)\, Y_t / N_t. \tag{13}$$

3.3. Potential entrants

In order to enter the market, the potential entrants have to pay f_e units of final goods as the cost of entry. We assume that a startup becomes a functioning new firm, acting as a product monopoly with an endogenous probability q_t. The empirical literature provides fruitful evidence that the survival rate of new entries is negatively correlated with the level of industrial density.[7] Taking this correlation into account, we assume q_t is a decreasing function of the entry rate $\frac{n_t}{N_{t-1}}$:[8]

$$q_t = q \left(\frac{n_t}{N_{t-1}} \right), \tag{14}$$

[7] Mata and Portugal (1994) investigate the Portuguese manufacturing data and find the new firm failure varies positively with the extent of entry into the industry; Audretsch, et al. (2000) find a similar pattern using the Netherlands entry data; Hannan et al. (1995), using Belgium, France, Germany and Italy data, find that during the mature stage of the industry, the survival rate is negatively affected by the density of entry, due to the competition effect.

[8] Assuming q_t is a decreasing function of either $\frac{n_t}{N_{t-1}}$, $\frac{n_t}{N_t}$ or n_t does not affect our final results. This is because N_t is a stock variable that is less volatile than n_t, and thus the dynamics of q_t is mainly driven by n_t.

where n_t denotes the mass of potential entrants and the elasticity of q_t at steady state, $\frac{q' \frac{n}{N}}{q}$, is in $[-1, 0]$. This specification is a generalized version of that used in Beaudry et al. (2011). They assume that n_t startups compete to secure the $\varepsilon_t N_{t-1}$ (ε_t is an exogenous shock) new monopoly positions. This is to say, the survival rate q_t has a form of $\frac{\varepsilon_t N_t - 1}{n_t}$. In present study, we endogenize the exogenous ε_t to be an increasing concave function of the entry rate: $g\left(\frac{n_t}{N_t - 1}\right)$, with $g' \geq 0$, $g'' \leq 0$.[9]

Each incumbent firm faces a natural death rate δ_N. Thus, only a proportion $1 - \delta_N$ of existing firms will survive into the next period. We also assume that the period-t entrants produce in the current period, i.e., there is no time-to-build.[10] Therefore, the law of motion for the total mass implies:

$$N_t = (1 - \delta_N) N_{t-1} + q_t n_t. \tag{15}$$

Finally, the free-entry condition implies that the potential firms are willing to enter as long as the expected value for the startup is higher than the cost of entry. Therefore, in the equilibrium, we have

$$f_e = q_t V_t, \tag{16}$$

where V_t denotes the present discounted value of expected profits for the incumbent firm, which corresponds to the stock price in the real world.

3.4. Households

The household side is similar to what is presented in Jaimovich and Rebelo (2009). The representative household has preferences, over random stream of consumption C_t and labor L_t with the following life-time utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \psi L_t^{\theta} X_t\right)^{1-\xi} - 1}{1 - \xi}, \tag{17}$$

where

$$X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}. \tag{18}$$

We assume that $0 < \beta < 1$, $\theta > 1$, $\psi > 0$, and $\xi > 0$. The presence of X_t means that preferences is non-time-separable in consumption and labor. When $\gamma = 1$, we obtain KPR preferences, and when $\gamma = 0$, we obtain the GHH preferences. In each period, the representative household

[9] The concavity of $g(\cdot)$ is equivalent to $\frac{q' \frac{n}{N}}{q} \in [-1, 0]$. Also, the increasing feature of $g(.)$ indicates that the more startups there are, the more vacancies will be generated.

[10] The time-to-build assumption does not matter in model's dynamics, except for the response of the total mass N_t at the first period.

maximizes its utility (17) subject to the following sequence of constraints:

$$C_t + I_t + \int_0^{N_t} V_t s_t^i di \le w_t L_t + r_t u_t K_t + \int_0^{N_t} \pi_t s_t^i di + (1-\delta_N) \int_0^{N_{t-1}} V_t s_{t-1}^i di, \tag{19}$$

$$K_{t+1} = (1-\delta_t) K_t + \left(1 - \varphi\left(\frac{I_t}{I_{t-1}}\right)\right) I_t, \tag{20}$$

where s_t^i denotes the share of firm i purchased by the household in period t. As in Jaimovich and Rebelo (2009), $\varphi'\left(\frac{I_t}{I_{t-1}}\right) I_t$ is the adjustment cost in investment, such that $\varphi(1) = 0$, $\varphi'(1) = 0$, and $\varphi''(1) > 0$. The first-order conditions for $\{C, X, L, u, I, K, s\}$ are:

$$\lambda_t = \left(C_t - \psi L_t^\theta X_t\right)^{-\xi} + \mu_t \gamma C_t^{\gamma-1} X_{t-1}^{1-\gamma}, \tag{21}$$

$$\mu_t = \beta E_t \left[(1-\gamma) \mu_{t+1} C_{t+1}^{\gamma} X_t^{-\gamma}\right] - \left(C_t - \psi L_t^\theta X_t\right)^{-\xi} \left(\psi L_t^\theta\right), \tag{22}$$

$$\lambda_t w_t = \left(C_t - \psi L_t^\theta X_t\right)^{-\xi} \psi X_t \theta L_t^{\theta-1}, \tag{23}$$

$$\lambda_t r_t = \eta_t \delta_t', \tag{24}$$

$$\lambda_t = \eta_t \left[1 - \varphi\left(\frac{I_t}{I_{t-1}}\right) - \varphi'\left(\frac{I_t}{I_{t-1}}\right) \frac{I_t}{I_{t-1}}\right] + \beta E_t \left[\eta_{t+1} \varphi'\left(\frac{I_{t+1}}{I_t}\right) \left(\frac{I_{t+1}}{I_t}\right)^2\right], \tag{25}$$

$$\eta_t = \beta E_t \left[\eta_{t+1} (1-\delta_{t+1}) + \lambda_{t+1} r_{t+1} u_{t+1}\right], \tag{26}$$

$$V_t = \pi_t + \beta (1-\delta_N) E_t \left(\frac{\lambda_{t+1}}{\lambda_t} V_{t+1}\right), \tag{27}$$

where μ_t, λ_t, and η_t are the Lagrangian multipliers associated with (18), (19), and (20), respectively. Finally, the market clearing condition implies

$$C_t + I_t + n_t f_e = Y_t. \tag{28}$$

4. Exogenous v.s. Endogenous Survival Rate

We now analyze how the model economy responds to a news shock about future TFP when the survival rate is either constant or endogenous. As in Jaimovich and Rebelo (2009), the timing of the news shock that we consider is as follows. At time zero, the economy is in a steady state. At time one, the unanticipated news arrives. Agents learn that there will be a 1 percent permanent increase in A_t beginning four periods later in period five. Table 1 presents the values assigned to the calibrated parameters. For those parameters also present in Jaimovich-Rebelo model, we simply use the same values.

Table 1: Calibrated Parameters

Parameter	Value	Description
β	0.985	Subjective discount factor
ξ	1	Intertemporal elasticity of substitution
θ	1.4	Corresponds to an elasticity of labor supply of 3.3 when preferences take the GHH form
γ	0.01	The extent of non-time-separable preference in consumption and labor 0 for GHH preference, 1 for KPR preference
φ''	1.3	Second derivative of investment adjustment cost function
$\delta''(u)u/\delta'(u)$	0.15	Elasticity of $\delta'(u)$ at steady state
α	0.36	Capital share in production
σ	1/1.2	Corresponds to 20% markup.
δ_k	0.025	Steady-state depreciation rate of capital
δ_N	0.025	Corresponds to 10% annual rate of exogenous exit
f_e	0.12	Fixed entry cost
$\frac{q' \frac{n}{N}}{q}$	-0.5	Elasticity of survival rate at steady state

Figures 2 and 3 depict the responses under exogenous and endogenous survival rates respectively. The responses in Figure 2 clearly illustrate the failure of Jaimovich-Rebelo model with a constant survival rate for new entrants in generating positive co-movement. In the first period, the aggregate variables including output, consumption, total investment,[11] hours worked and entry numbers all decline. Therefore, good news leads the economy into a recession, which is contrary to the empirical findings. The failure of generating NDBC in this case is mainly due to the constant survival rate, which imposes no extra cost for a large shift in the number of firms entering the market; therefore, the potential firms have an incentive to enter the industry at the news-realized period. As shown in the Figure 2, the entry number decreases sharply in the first period, which induces less labor and capital demand and thus lowers the representative household's income. As a result, the household consumption goes down and thus traps the economy into a recession because Jaimovich-Rebelo specifications (variable capacity utilization, investment adjustment, preference with lower income effect) make the other aggregate variables positively co-move with consumption. In addition, according to the free entry condition, the asset price (V_t) in this case is constant, which is highly inconsistent with the empirical findings.

[Here Insert Figure 2 and 3]

Figure 3 shows the dynamic responses when survival rate q_t is an endogenous function of n_t/N_{t-1}. Output, consumption, total investment, hours worked and entry number all increase in response to the news about future TFP.[12] In particular, the path of entry number in this case

[11] The total investment consists of the physical capital I_t and the entry cost $n_t f_e$.

[12] As the mass of new functioning firms $q_t n_t$ is monotonic increasing in the entry number n_t, the dynamics of these two variables have similar patterns. To save the space, we only discuss the entry number.

becomes much smoother because the endogenous survival rate induces an extra cost for new entrants in the high-entry-rate period. As a result, less potential firms desire to enter the market at the news-realized period. The smaller competition effect of new entrants will enhance the future profit of production as shown in Equation (13), and thus raises the asset price of functioning firms. With this belief, more startups will be set up by entrepreneurs before the news is realized. Meanwhile, the expansion of firm entry induces higher demands for labor and capital, and, therefore, increases the representative household's income. Consequently, the aggregate economy experiences a boom in response to the news shock. The robustness check shows us that keeping other parameters unchanged, the above results hold in a wide range of $\frac{q' \frac{n}{N}}{q}$, namely, $[-1, -0.12]$.

5. Conclusion

In the literature, firm dynamics are well believed to be an important mechanism to understand business cycles, but their role in explaining EDBC is still unknown. By incorporating an endogenous firm entry problem into Jaimovich and Rebelo (2009)'s well-established model, we find it generates a recession rather than a boom in response to good news shocks. This is mainly because there is no cost for large movement of firm entry, and thus when the good news affects the economy, potential firms optimally choose to enter the industry at the news-realized period. After endogenizing the survival rate of new entry firms, we show that the endogenous survival rate for startups smooths the firm dynamics. And with this minor modification, the model can generate the positive co-movement of the main macroeconomic indicators, including output, consumption, investment, labor, entry mass and asset price.

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Appendix: Data

All of the data used in VAR analysis are quarterly frequency from 1948:Q1-2009:Q4.

1. TFP: total factor productivity, adjusted by capital utilization, downloaded from John Fernald's website: www.frbsf.org/economics/economists/staff.php?jfernald .

2. SP: real stock price, downloaded from Robert Shiller's website:

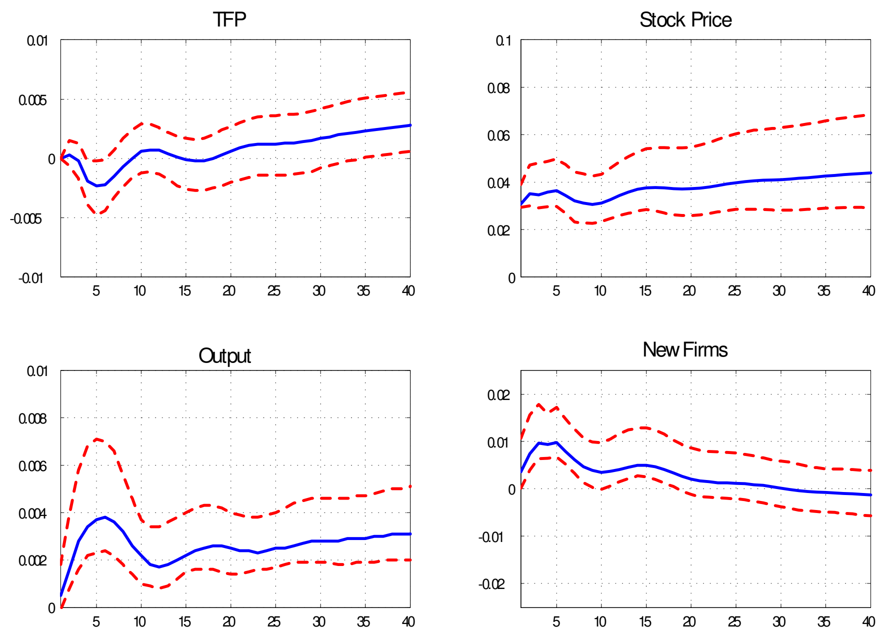
   www.econ.yale.edu/~shiller/data.htm .

3. Y: real GDP series, obtained from St. Louis FED economic database.

4. NF: the number of new business incorporations is reported by the U.S. Bureau of Economic Analysis (BEA). The data can be downloaded from the website: www.bls.gov/bdm/. Because the series is discontinued (up to 1994Q4) as a result of a reprogramming of resources at BEA, we extend it to 2009:Q4 using the U.S. Bureau of Labor Statistics (BLS)'s establishment birth and death data. To check the robustness of the series, we conduct the dynamic responses exercise by running the data up to 1994Q4; the impulse responses present similar patterns as those from the full sample.

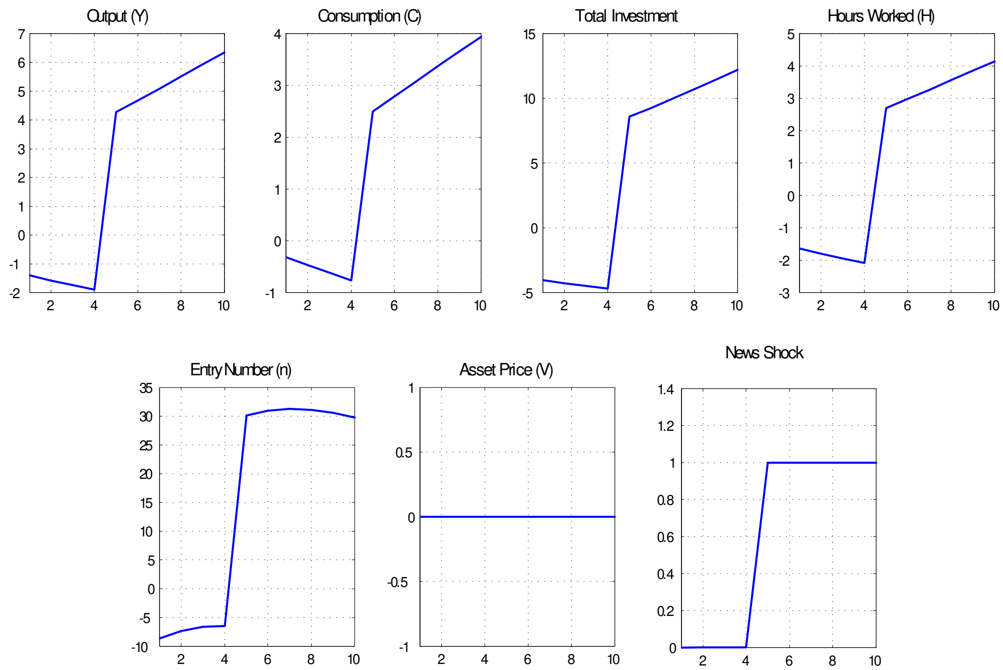
The SP, Y, NF series are transformed in per capita terms by dividing them by the population of age 15 to 64.

Figure 1: Responses to news shock in the 4-variable VECM system



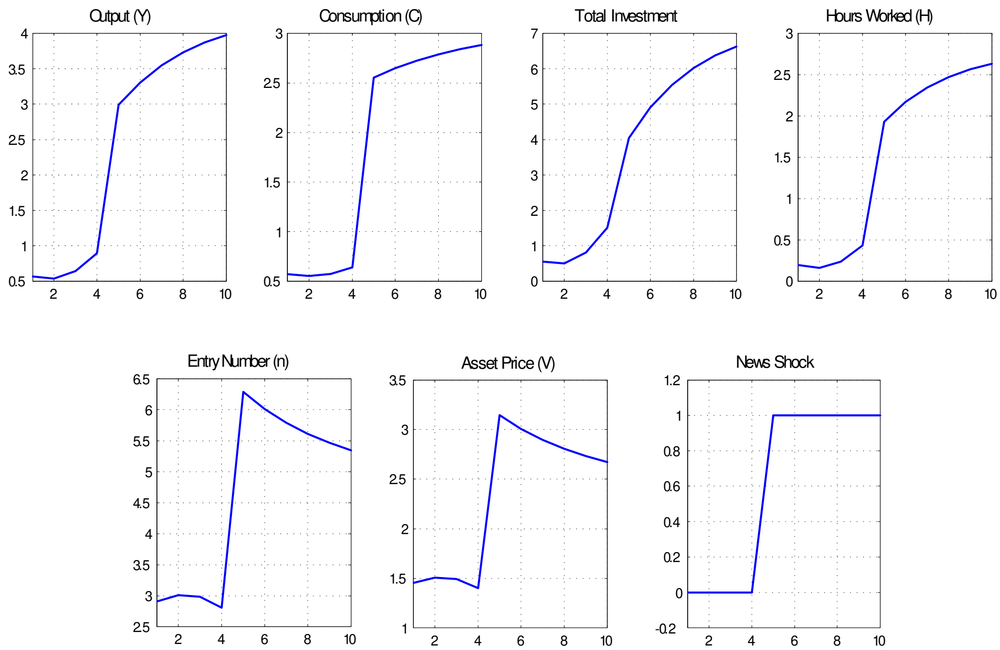
Notes: The figure shows percentage responses (0.01 corresponds to 1%). The horizontal axes indicate quarters. In each panel, the blue solid line represents the impulse response. The red dashed lines are 95% bootstrapped confidence interval computed (200 replications) by Hall's percentile interval. All the estimations are conducted in the software JMulTi.

Figure 2: Impulse responses with exogenous survival rate



Notes: The figure shows theoretical percentage responses (0.01 corresponds to 1%) to a favorable news shock about TFP (defined in the last panel). The horizontal axes indicate quarters.

Figure 3: Impulse responses with endogenous survival rate



Notes: The figure shows theoretical percentage responses (0.01 corresponds to 1%) to a favorable news shock about TFP (defined in the last panel). The horizontal axes indicate quarters.