



News shock, firm dynamics and business cycles: Evidence and theory



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ABSTRACT

The literature of expectation-driven business cycles has overlooked the role played by endogenous entry. This paper documents empirically news shock as a major source of fluctuations in firm dynamics and comovement between firm entry and GDP using structural vector auto-regressions. We then develop a tractable dynamic stochastic general equilibrium model to study the propagation mechanism assuming fixed operating costs for incumbents and decreasing survival rates for entrants. Our quantitative prediction closely matches the positive comovement between firm entries and core macro-economic indicators upon news shock. These results remain robust at the sectoral level when the baseline model is extended to a two-sector setup.

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1. Introduction

The importance of endogenous firm entry in understanding aggregate fluctuations has been well documented in recent business-cycle literatures. For instance, Jaimovich and Floetotto (2008) show that variations in the number of operating firms lead to countercyclical markups which would amplify total factor productivity (TFP) shocks. Bergin and Corsetti (2008), Lewis (2009, 2013), Lewis and Stevens (2015), and Berentsen and Waller (2015) all find that firm dynamics affect monetary policies through the extensive investment margin. Wang and Wen (2011) augment real business cycle (RBC) model with firm entry and exit, and argue that the technology shock could be the main driving force of the business cycle. Bilbiie et al. (2012) emphasize that many sluggish producers can generate a novel endogenous shock propagation mechanism in standard RBC models. Clementi and Palazzo (2013) study the role of firm entry and exit decisions in shaping greater persistence and unconditional variations of aggregate indicators. Turning to the expectation-driven business cycles (EDBCs) literature, the empirical studies (Beaudry and Portier, 2006; Beaudry and Lucke, 2010; Barsky and Sims, 2012; Schmitt-Grohe and Uribe, 2012; and many others) have overlooked endogenous entry, and only focused on the fact of news shock accounting for a large fraction of fluctuations in variables like GDP, aggregate consumption, and total labor supply. Whether firm dynamics could play a role in linking news

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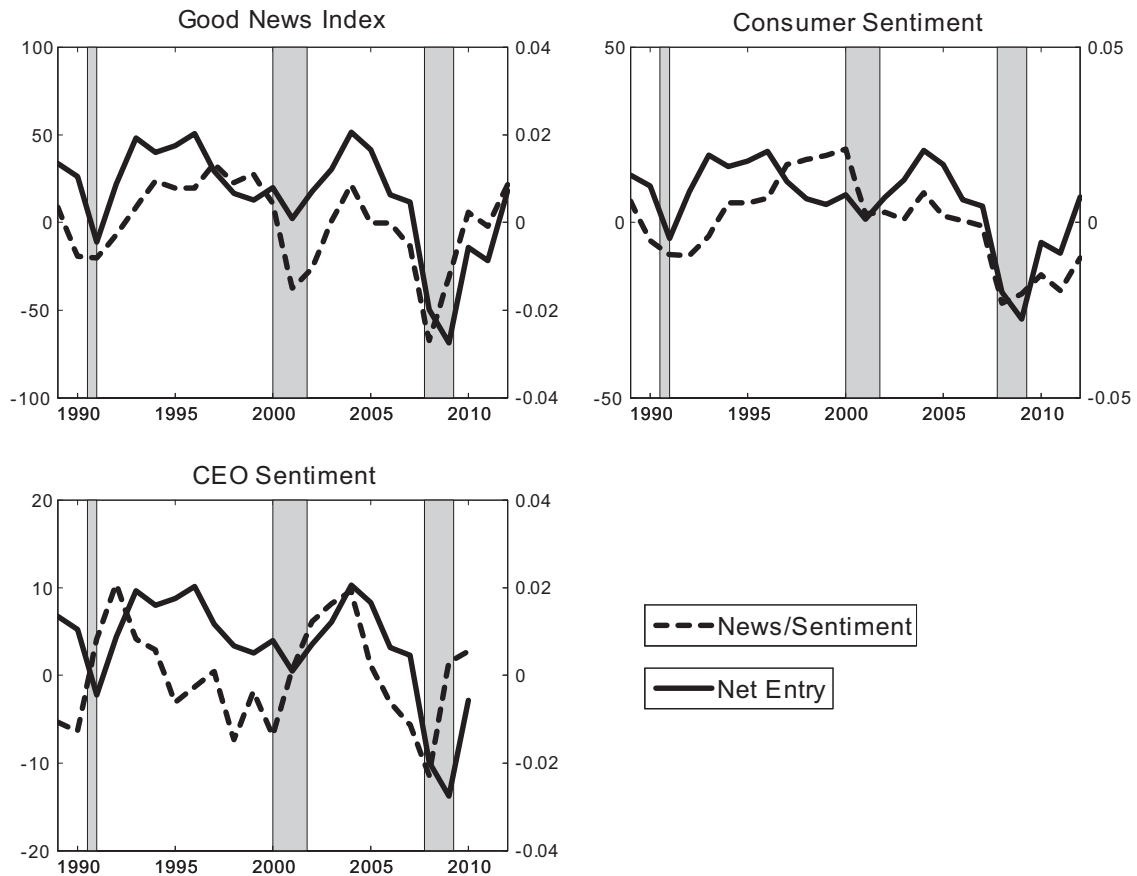


Fig. 1. Good news, sentiments and net firm entry. *Notes:* The three proxies for good news are demeaned series and are all based on annual frequency. The left vertical axis scales news/sentiments, and the right vertical axis records net firm entry (0.01 represents 1%). The shaded bars denote the NBER-defined economic recession periods. For more details on data definition, see [Appendix A](#).

shocks and business cycles remains an unanswered question. As a result, our paper aims to explain the extent to which news about future economic conditions can explain changes in firm entry, and, more importantly, to investigate whether there exists a strong correlation between firm entry and core macroeconomic outcomes in response to news shocks.

Intuitively, entrepreneurs have a tendency to start new businesses when optimistic economic outlook prevails. This strong causal relation between good news and firm entry is evident in [Fig. 1](#).¹ Good news is measured by the good-news index, which is the difference between the numbers of good news versus bad news, sourced from the Michigan Surveys of Consumers. As can be seen, the rise of amount of good news coincides with a boom in firm entry with a notably high correlation at 0.67 over business cycles. Similar patterns emerge when good news is proxied by the consumer or CEO sentiment index.²

To further establish a rigorous relation between news shocks and firm entry responses, we resort to a three-variable vector auto-regression (VAR) system that contains good-news index, net firm entry, and real GDP. The results are consistent. A positive news shock raises net firm entry and real GDP simultaneously. The response of net firm entry presents a visible hump, which peaks at the fourth quarter and gradually dampens afterwards. These dynamic patterns persist when the good-news index is replaced by either consumer sentiment or CEO sentiment measures. We utilize forecasting error variance decompositions (FEVDs) under various VAR settings and conclude that news shocks in the long run could at least account for 40% of the fluctuations in firm entries, and 60% of the fluctuations in real GDP. Moreover, augmenting the above benchmark VAR system by incorporating consumption, hours worked and stock price variables, we show that firm entries positively comove with newly added macroeconomic indicators. In robustness checks, we follow [Beaudry and Lucke \(2010\)](#) and [Barsky and Sims \(2011\)](#) to recover news on future productivity using two alternative identification schemes. The results confirm that news shocks drive fluctuations in firm entries and also generate comovements among aggregate indicators.

¹ Firm entry is a net measure defined as the percentage change of the numbers of firms from the 1988 to 2012 County Business Patterns dataset.

² [Barsky and Sims \(2012\)](#) argue that public sentiments are more informative for recovering news shocks than recovering animal spirit shocks. We thus use two sentiment indices for different types of agents: demand side and supply side. The consumer sentiment index is taken from the Michigan Surveys of Consumers, while the CEO sentiment index is obtained from the Conference Board Survey.

To explain the empirical facts, we then formulate a dynamic stochastic general equilibrium (DSGE) model, which assumes that entrant's survival rate is endogenous and the incumbent firms need to pay a per-period fixed operating cost. The increasing return to scale of production induced by the fixed operating cost implies an upward-sloping labor demand curve, which in turn leads to comovements among consumption, labor, and output conditional on news shocks.³ However, these comovements do not necessarily guarantee a news-driven economic boom provided that the survival rate of new entrants is constant. This is because potential entrants may postpone their entrance into market until the piece of good news is realized. As a result, the firm mass might fall in the current period. The slowdown in firm entries ultimately causes an economic recession.⁴

To deal with this recession trap, we introduce endogenous decreasing survival rate of entrants, i.e., new-comers' survival possibility is inversely correlated with the number of entries. Such an assumption has been employed in DSGE models such as those developed by Lewis (2009) and Beaudry et al. (2011), and also has been supported by empirical works from the industrial organization literature.⁵ Consequently, an economic boom occurs after good news, as firm mass expands in the current period according to the following chains of reactions for both entrants and incumbents: an decreasing survival rate means that the chance of failure for startups raises when there is a large number of entries. Therefore, potential producers opt to enter the market in advance to avoid this entry congestion. As a result, the number of entrants tends to smooth over time. After the realization of the good news, the number of entrants is relatively small compared to the case of a constant survival rate. This would benefit the incumbent firms by boosting up their asset prices (or firm values), since the competition pressure from new entrants is much smaller. Given the arrival of favorable news, the stock prices of existing firms will increase, attracting more entrepreneurs to enter market and ensuring an economic boom. In this regard, our model offers an alternative mechanism to understand the procyclical stock market dynamics in the EDBC.⁶

Therefore, in conjunction with fixed operating costs, an endogenous survival rate produces positive comovement in response to news shocks between firm entries and a series of macroeconomic indicators. With fairly general utility specifications (e.g., Greenwood–Hercowitz–Huffman and King–Plosser–Rebelo preferences), our quantitative model could generate comovement that replicates the empirical pattern documented in the VAR exercises.

Another important aspect towards fully understanding EDBCs is to look at cross-sector comovements. To do this, we modify our baseline DSGE model to incorporate two sectors. We show that the above-mentioned two key features, i.e., fixed operating cost and decreasing survival rate, are again essential elements to produce sectoral comovements between firm entries and a series of macroeconomic indicators. The only difference is that the desired comovement between firm entries and labor inputs at the sectoral level requires a specific form of preference—one that associates with small wealth effect on consumption and labor supply (Jaimovich and Rebelo, 2009).

Our paper contributes to a vibrant literature that attributes aggregate fluctuations to firm dynamics, including Jaimovich and Floetotto (2008), Bergin and Corsetti (2008), Lewis (2009), Lewis (2013), Wang and Wen (2011), Bilbiie et al. (2012), Clementi and Palazzo (2013), Berentsen and Waller (2015), and many others. Among these studies, our paper is most related to Lewis (2009) who also introduces endogenous survival rate into standard business cycle models in order to obtain positive response of entries under expansionary monetary policy shocks. Our paper differs from theirs in two regards. First, their emphasis is on the economy's reactions to contemporaneous monetary shocks, our focus however lies on the impact of news about future TFP. Second, we investigate comovements both empirically and theoretically, while they focus on a modeling approach.

Our paper is also closely related to a growing literature on the EDBCs. Besides aforementioned empirical works on news shocks, there exists a vast of DSGE models aiming to account for comovements among core macroeconomic indicators responding to good news. To name a few, Beaudry and Portier (2004, 2007) show that variants of neoclassical growth models fail to generate a boom in response to good news about future TFP, but adding complementarity between consumption and investment goods could solve this problem. Jaimovich and Rebelo (2009) construct a RBC model with various real frictions and a preference with low short-run labor-supply wealth effect to generate EDBCs. Wang (2012) reviews a set of models that can produce the EDBCs from a labor market perspective.⁷ Our contribution stands out unique in finding comovements between firm dynamics and macroeconomic indicators both at the aggregate and the sectoral level using two key specifications, i.e., fixed operating cost and decreasing survival rate.⁸ In specific, fixed operating cost per se guarantees the comovements among macroeconomic indicators, but it does not necessarily ensure an economic expansion (i.e., positive

³ According to Jaimovich and Floetotto (2008), fixed operating costs result in increasing returns to scale, and thus serve as an amplification factor for aggregate production.

⁴ The reduction of firm mass yields wage cuts because of a decline in labor demand. Lower income further reduces the aggregate consumption as well as the output, an economic recession thus takes place.

⁵ Among others, Mata and Portugal (1994) analyze Portuguese manufacturing data and conclude that new firm failures (the opposite to survival rate) are positively correlated with the intensity of entrance by manufacturers; Audretsch et al. (2000) draw a similar conclusion with entry data from the Netherlands; Hannan et al. (1995) use data from Belgium, France, Germany and Italy. They find that during the mature stage of an industry, the survival rate is negatively affected by the density of entries due to intensified competition effect.

⁶ Christiano et al. (2006) show that a standard real business cycle model with capital (or investment) adjustment cost cannot produce procyclical stock price in response to news shocks; however, a New Keynesian model with wage rigidity and inflation targeting monetary policy can solve the problem.

⁷ Other studies on this topic include Christiano et al. (2006), Den Haan and Kaltenbrunner (2009), Karnizova (2010), Gunn and Johri (2011), Auray et al. (2013), and many others. See Beaudry and Portier (2014) for a more comprehensive survey about the literature.

⁸ Fan and Xu (2014) and Li and Mehkari (2009) also discuss the similar issue regarding the news shock and firm dynamics. The former relies on the mechanism in Jaimovich and Rebelo (2009) to generate comovements between firm dynamics and macroeconomic indicators in the one-sector model. In our paper, the comovement among economic indicators is guaranteed by the fixed operating cost. The latter reveals that time-variant sunk entry cost and variable capital utilization together will create the EDBCs in a quantitative framework.



Fig. 2. Net entries of establishments and firms: annual series.

comovements) in response to good news. Our decreasing survival rate imposes a penalty on a sudden and sharp rise in firm entries, inducing potential entrants to act in advance upon favorable news. Hence, positive comovements are guaranteed. Last but not the least, this paper provides a systematic empirical analysis on news-driven firm dynamics.

The remainder of the paper is organized as follows. Section 2 conducts various structural VAR analyses to investigate firm entry dynamics in response to a news shock. Section 3 presents a baseline one-sector RBC model with endogenous firm entry to show how fixed operating costs and decreasing survival rate can reproduce the EDBCs. Section 4 extends the baseline model to a two-sector setup and tests the model's capability to account for sectoral comovements. Section 5 concludes, followed by an Appendix that contains data sources, equilibrium characterizations, all proofs and robustness analysis.

2. Empirical evidences

In this section, we first describe databases that provide information on quarterly net firm entry series. We then present our empirical findings in a baseline structural VAR setting, where firm dynamics and macroeconomic indicators rise simultaneously conditional on good news. We finally establish the robustness of our results by extending the baseline VAR system, exploring historical entry measures, and focusing on only TFP news shocks.

2.1. Data description

The U.S. Bureau of Economic Analysis (BEA) reports series of net business formations which corresponds ideally to the net firm entry concept we purport to measure. But this series on a quarterly frequency stops updating after the last quarter of 1994 due to reprogramming data resources. A complementary source is the U.S. Bureau of Labor Statistics (BLS) who reports the net birth of establishments starting from 1993Q2 to recent years. One might suspect that the definition of “establishment” is conceptually different from that of “firm”. We argue that the difference in terms of dynamics is small and the net birth of establishments is indeed a valid proxy for net firm entry. To back up our argument, fortunately, annual sequences of both numbers of establishments and firms are available from the U.S. census website (from 1988 to 2012). We compute their percentage changes separately. Fig. 2 shows that the net entry of establishments moves in strict accordance with the net entry of firms. The correlation between them is as high as 0.92, also indicating that the dynamics of establishments tracks the firm dynamics notably well. Therefore, we are confident to take the quarterly series of the net birth of establishments as a proxy of net firm entry in our baseline VAR analysis. Nevertheless, in robustness analysis we use the historical net firm formation series (1960Q1–1994Q4) and the results are unchanged.

2.2. Findings of the baseline structural VAR system

To identify news shocks, we first follow Barsky and Sims's (2012) identification approach to build a three-variable VAR system with the sequential order of good-news index, log real GDP and net firm entry.⁹ Note that all series are on the basis of quarterly frequency during the time span 1993Q2–2014Q4. To be specific, the good-news index is calculated as the difference of favorable versus unfavorable news heard on recent changes in business conditions; the net firm entry is proxied by the net birth of establishments (as percentage of total number of existing establishments).¹⁰ Appendix A provides

⁹ An alternative strategy (see Barsky and Sims, 2012) is to put the good-news index at the end of the sequence, and identify innovation in firm entries as news shocks. However, the pattern of impulse responses changes little with this alternative strategy. We thus do not report the results to save space.

¹⁰ Since for some periods the good-news index values are negative, we do not take logarithm for this index when running the VAR estimation.

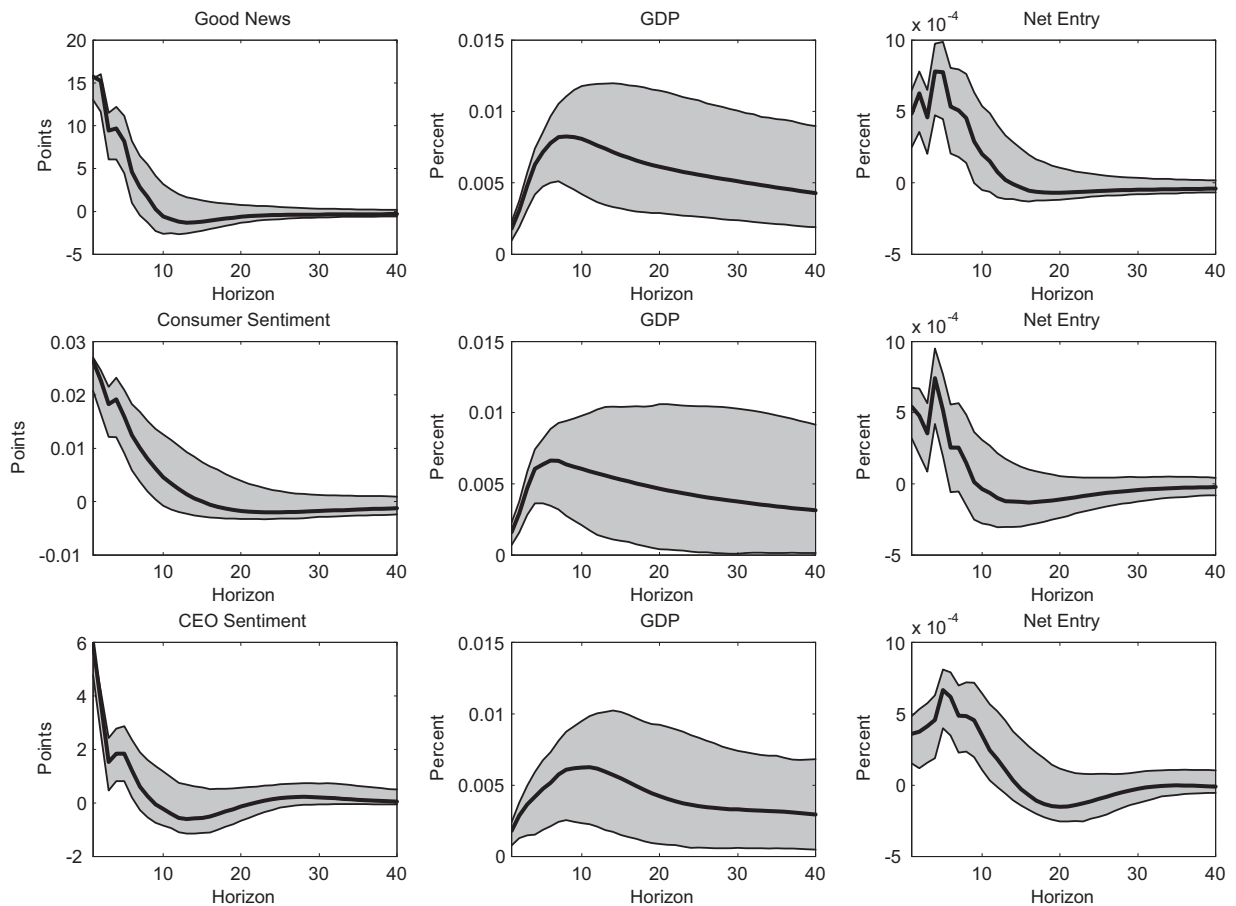


Fig. 3. Impulse responses to a positive news shock in the baseline VARs. *Notes:* Responses are from three-variable VARs. Each VAR system includes four-period lags. The shaded areas are one-standard-error confidence bands computed from bias-corrected bootstrap method with 2000 replications. Each period represents one quarter in a year, and $0.01 = 1\%$. For the VAR systems using good-news index and consumer sentiment, the time span is from 1993Q2 to 2014Q2; for the VAR system using CEO sentiment, the time span is from 1993Q2 to 2011Q4 due to the availability of CEO sentiment index.

more details about the construction procedure for these data series. The system includes four-period lags for each variable, and the results are fairly robust to different numbers of lag periods.¹¹ A Cholesky decomposition is conducted on the covariance matrix of innovations. We identify the first orthogonal innovation as the news shock, which is the only source of fluctuations in good-news index in the impact period. The first row in Fig. 3 presents the impulse responses to an increase of one-standard-error change in the good-news index: a positive news shock raises both output and net firm entry. In terms of the magnitude, if the favorable news shock is reflected by a 15 points increment in the good-news index, GDP and net firm entry would increase by around 0.25% and 0.05%, respectively. The immediate consequences of these effects are relatively low, but the follow-up consequences become significant over time. One interesting observation is that the response of net firm entry has a visible hump, peaking in the fourth quarter and dampening gradually afterwards.

Barsky and Sims (2012) find that the consumer sentiment is informative for recovering news shocks instead of animal spirit shocks. Following their argument, we consider two modified VAR models: one replaces the good-news index with the consumer sentiment taken from the Michigan Survey of Consumers, and another uses CEO sentiment from the Conference Board Survey as a proxy for the good-news index. The second and third rows in Fig. 3 report the corresponding responses to a positive news shock in the two modified models. As can be seen, the responses of GDP and net firm entry resemble the responses in the original VAR model with good-news index as the measure for news shocks.

It turns out that news shocks are the major source of fluctuations in both aggregate output and firm entry. Fig. 4 reports the forecasting-error variance-decompositions (FEVDs) for VAR estimations using different measures for news shocks. When news shocks are measured by the good-news index (solid lines), news shocks in the long run can explain over 70% of the fluctuations in GDP and approximately 45% of the fluctuations in net firm entry. Alternatively if news shocks are

¹¹ Additionally, we consider the potential cointegration between GDP and net firm entry. More specifically, we repeat the estimation using a vector error correction model with two cointegration vectors (i.e., one common trend). We then conduct the same Cholesky decomposition described in the text. The responses of output and net entry to news shocks exhibit very similar patterns to those in the baseline VAR exercises.

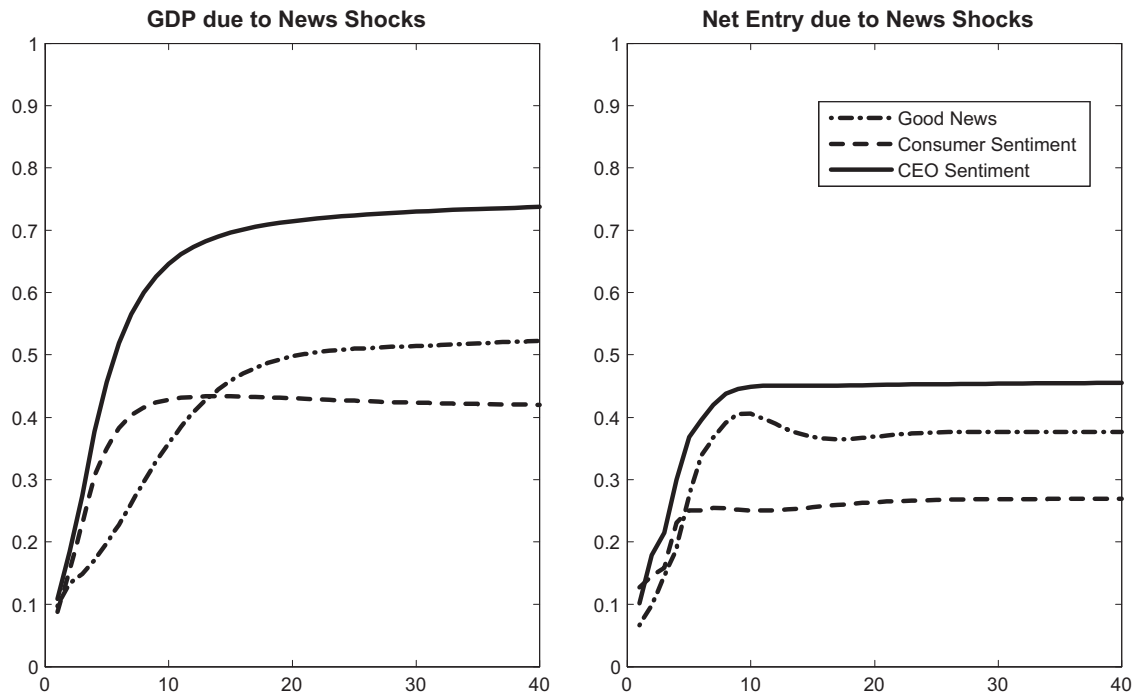


Fig. 4. Forecasting error variance decomposition in different VARs.

measured by sentiment indices (dashed lines and dash-dot lines), the importance of news shocks in explaining aggregate fluctuations is moderately reduced, but they still account for a major part of output and entry fluctuations, especially in the long run. Our finding that new shocks are important for understanding aggregate fluctuations is generally consistent with that documented by Barsky and Sims (2012).

2.3. Robustness checks

We undertake three different exercises in this subsection. FEVDs analyses from all these exercises confirm that news shocks are indeed the driving force behind fluctuations in aggregate output as well as net firm entry.

An extended structural VAR system: The baseline VAR exercises focus only on the positive comovement between net firm entry and aggregate output. To see how firm dynamics interact with other core macroeconomic indicators responding to a positive news shock, we extend the baseline model by incorporating consumption, hours worked, and stock price. The responses reported in the Supplementary Appendix A (Fig. S1) suggests that GDP and net firm entry present similar patterns of dynamics compared to those in the baseline exercise. Consumption, hours worked, and stock price all respond positively to favorable news, of which stock price displays a visible hump-shape response after good news' impact, analogous to the response of net firm entry. The patterns of impulse responses stay almost unchanged when the good-news index is replaced by consumer or CEO sentiments. In the modeling part, we will show that procyclical stock price upon news shocks is the crucial feature where our model differs from a RBC model with capital (or investment) adjustment cost.

Historical net business formation: As discussed earlier, due to data availability, we employ the net birth of establishment as a proxy for endogenous entry. To check if our main results are robust to different measures of firm dynamics, we re-run the baseline VAR exercise using BEA's historical series of the net business formation index. This series describes the net change of firm numbers from 1960Q1 to 1994Q4. The responses reported in the Supplementary Appendix A (Fig. S2) display similar pattern to those observed in Fig. 3.

News on future productivity: It is natural to directly identify news shocks from indicators such as good-news index or sentiments. However, the news shocks recovered from the baseline VAR analysis are general in the sense that it is not clear whether the identified news shocks are related to the fundamental of supply side or demand side. To document the response of firm entry to news about future productivity, we conduct two types of structural VAR exercises that are widely used in the literature.¹² First, we follow Beaudry and Lucke (2010) by constructing a four-period lagged-variable system with

¹² Supplementary Appendix B provides more discussions regarding the identification and the subsequent econometric issues.

the sequential order of TFP, good-news index (or consumer/CEO sentiment), real GDP and net firm entry.¹³ The identification strategy is to recover news shocks that do not have an effect on current TFP during the impact period, but may affect the contemporaneous good-news index and possibly future TFP. Second, we follow Barsky and Sims (2011). Similar to the Beaudry–Lucke identification scheme, a four-period lagged-variable system with the sequential ordering of TFP, good-news index (or consumer/CEO sentiment), real GDP and net firm entry is estimated. This time, news shocks are identified as ones that do not impact the level of TFP, but maximize the share of the variance of TFP in a range of periods. Figs. S3 and S4 in Supplementary Appendix A report the impulse responses to Beaudry–Lucke and Barsky–Sims type of positive news shocks, respectively. In both identification schemes, favorable news about future TFP raises the aggregate output and induces more firms to enter the market.

3. The one-sector model

The empirics provide strong and robust evidences that news shocks account for the major part of firm entry variations and drive the positive comovement between firm entry and core macroeconomic indicators. These stylized facts imply two theoretical considerations. First, firm dynamics are significantly affected by public expectations of future economic conditions. Second, net firm entry, namely an extensive margin, may provide a crucial propagated channel through which news shocks are transmitted. In this section, we develop a tractable DSGE model to explore in this regard.

The economy is characterized by a continuum of firms and households. In a perfectly competitive market, two types of firms exist: incumbents and entrants. The incumbent firms produce homogenous consumption goods, and the potential entrants must pay a fixed entry cost in order to enter the market. There is a success probability that new entrants would become an incumbent, and this endogenous probability will be defined in detail later. Thus, the mass of incumbent firms is endogenously determined by entries and exits of firms. The households are representative and fit in standard profiles: they consume final goods, supply homogenous labor hours to producers, and purchase firm equities as savings instruments.

3.1. Incumbent firms

Here we describe the profit maximization problem faced by incumbents. Each incumbent firm produces y_t units of goods using labor input l_t according to a production function $y_t = A_t l_t^{1-\alpha}$, where A_t denotes the aggregate technology.¹⁴ During the production process, firms not only pay workers' wages but also spend ξ units of final goods to cover a per-period fixed operating cost. In real life, this operating cost may correspond to the cost of updating or maintaining equipment and the inevitable operating waste during manufacture. Therefore, the total profit in each period can be obtained by solving the following optimization problem:

$$\begin{aligned} \max \quad & y_t - w_t l_t - \xi, \\ \text{s.t.} \quad & y_t = A_t l_t^{1-\alpha}, \end{aligned}$$

where w_t represents the market wage rate. The optimal condition for labor input implies a labor demand of $w_t = (1-\alpha)\frac{Y_t}{L_t}$. Each producing firm earns a operating profit of $\pi_t = \alpha y_t - \xi$.

The representative household provides labor L_t to firms for their production activities. Therefore, the resource constraint in the labor market implies $L_t = N_t l_t$, where N_t is the total mass of operating firms. The aggregate amount of final goods Y_t equals $N_t y_t$. To sum up, the aggregate final output, the labor demand curve, and the representative firm's operating profit are given by the following equations, respectively:

$$Y_t = A_t N_t^\alpha L_t^{1-\alpha}, \quad (1)$$

$$w_t = (1-\alpha)\frac{Y_t}{L_t}, \quad (2)$$

$$\pi_t = \alpha \frac{Y_t}{N_t} - \xi. \quad (3)$$

3.2. Potential entrants

To enter the market, potential entrants have to pay a fixed cost, f_e , denominated in final goods. We assume that after entry a startup will become a producing firm with an endogenous probability q_t . In other words, $1 - q_t$ denotes the failure

¹³ Fan and Xu (2014) closely follow Beaudry and Lucke (2010) to conduct a simple exercise of their VAR system. Unlike our paper, Fan and Xu (2014) use stock price instead of the good-news index and use new business formation instead of net firm entry.

¹⁴ Incorporating physical capital into the production function complicates the dynamics in equilibrium. So we follow Bilbiie et al. (2012) and assume labor as the sole inputs for production. When capital is included, the model can still generate comovements among aggregate variables as long as investment adjustment cost is considered.

rate, which is referred as hazard rate in the industrial organization (IO) literature. The empirical evidences in IO literature show that higher failure rate is associated with tougher market competition (Mata and Portugal, 1994; Hannan et al., 1995; Audretsch et al., 2000). Therefore, we follow this literature and assume that startups' success probability or survival rate, q_t , is a decreasing function of the entry density $\frac{n_t}{N_{t-1}}$, where n_t is the number of entrants at time t ¹⁵:

$$q_t = q\left(\frac{n_t}{N_{t-1}}\right), \quad (4)$$

where the elasticity $\frac{q_t}{q} \frac{n_t}{N_{t-1}}$ in the steady state ranges over $[-1, 0]$. The above specification is to some extent equivalent to the one given in Beaudry et al. (2011), which assume that a larger number of newborn firms will create more vacancies for new entrants. In their paper, the survival rate q_t takes the form of $\frac{\eta_t N_{t-1}}{n_t}$, where η_t is concave in $\frac{n_t}{N_{t-1}}$,¹⁶ and $\eta_t N_{t-1}$ indicates the number of vacancies available to new entrant firms.¹⁷

Each incumbent firm suffers from a natural death rate δ . Thus only a $1 - \delta$ proportion of existing firms would stay in market for the next period. We also assume that the period- t entrants can produce promptly once entered, i.e., we allow no time to build.¹⁸ Therefore, the number of operating firms evolves according to the following rule:

$$N_t = (1 - \delta)N_{t-1} + q_t n_t. \quad (5)$$

Note that the decreasing survival rate imposes a penalty on the entrants when there is a sharp increase in the number of startups. As a result, to seize a good business opportunity and to avoid competing with others, a rational firm has an incentive to enter the market in advance, not after the realization of a news shock.

Finally, the free entry condition implies that potential entrants will enter the market as long as the expected value of production is greater than the cost of entry. Thus, in equilibrium we must have the free entry condition

$$f_e = q_t V_t, \quad (6)$$

where V_t denotes the discounted cash flows for incumbents, i.e., the present value of all expected profits or the stock price of an incumbent firm. The above equation tells us that as $1/q_t$ is increasing in the number of entrants n_t , n_t is positively correlated with the firm value V_t . Consequently, more firms will enter this competitive market when the expected firm value is higher. This idea is consistent with the impulse responses reported in our six-variable VAR exercises in Section 2.3.

From the aggregate production function (1), the number of firms, N_t , seems to be analogous to the capital stock in a traditional Cobb–Douglas specification, while the number of entrants, n_t , looks similar to capital investment. This makes our specification for success probability, q_t , analogous to capital adjustment cost.¹⁹ That being said, there are two differences between the endogenous survival rate, q_t , and capital adjustment cost. First, they generate different implications on stock price dynamics. In our model the free entry condition (6) implies procyclical stock price; while in standard RBC models with capital adjustment cost (e.g., Hayashi (1982), the investment and the stock price actually decline in response to a positive news shock. The reason is that the adjustment cost for the level of capital cannot strongly smooth investment dynamics. As a result, a notable consumption growth caused by a positive news shock in effect crowds out investments. Since the optimal investment rate monotonically increases with the price of capital, this crowd-out effect implies a fall in stock price. Therefore, the RBC model with capital adjustment cost cannot produce EDBC in the capital market and the stock market.²⁰ Since our six-variable VAR analysis documents procyclical stock price, the prediction from the model with capital adjustment cost turns out to be at odds with the U.S. data. Second, the determination and evolution of n_t and physical capital investment are different. In our model, n_t is determined by market-clearing conditions in equilibrium, and q_t affects each firm's entry decision through the externality of congestion. In the model with capital adjustment cost, the investment (or capital) is chosen optimally by firms, and capital adjustment cost influences each firm's decision through dynamic complementarity—the investment made today becomes firm's capital stock tomorrow.

¹⁵ Alternatively, assuming q_t to be decreasing with the number of entries n_t or the growth rate $\frac{n_t}{N_{t-1}}$ instead of the entry rate $\frac{n_t}{N_{t-1}}$ does not change our main results.

¹⁶ To be specific, η_t is a concave function of the entry rate: $g\left(\frac{n_t}{N_{t-1}}\right)$, where both $g' > 0$ and $\frac{g''}{g} \in [0, 1]$. The fact that $g(\cdot)$ is an increasing function indicates that a larger number of newborn firms will create more vacancies for new entrants. This assumption is equivalent to our previous condition $\frac{q_t}{q} \frac{n_t}{N_{t-1}} \in [-1, 0]$. The specification in Beaudry et al. (2011) implies that this elasticity equals -1 if the shock η_t is constant.

¹⁷ Beaudry et al. (2011) assume that the probability for a startup to become a functioning firm is given by $\min\{1, \frac{n_t N_{t-1}}{n_t}\}$. And they only discuss the case when $n_t \geq \eta_t N_{t-1}$.

¹⁸ The time-to-build assumption does not affect our model's dynamics except for its effect on the dynamics of the total mass N_t in the impact period.

¹⁹ Our specification of $q\left(\frac{n_t}{N_{t-1}}\right)$ implies that the number of survived new entrants $q\left(\frac{n_t}{N_{t-1}}\right)n_t$ is a concave function of n_t and N_{t-1} . This makes the accumulation equation of the number of operating firms (5) analogous to the capital accumulation equation in a standard RBC model with capital adjustment cost.

²⁰ Indeed, even for the RBC model with investment adjustment cost (e.g., Jaimovich and Rebelo, 2009), a positive news shock would lead to a rise in investment but a decline in stock price. The reason is that higher investment reduces the marginal cost of producing capitals. In a competitive market, this reduction effectually causes a fall in the price of capital, see Christiano et al. (2006) for more discussions.

3.3. Households and the general equilibrium

The economy is inhabited by a continuum of identical households with the mass normalized to one. The representative household has preferences over labor L_t and a random sequence of consumption C_t . In each period, the household maximizes the following lifetime utility function:

$$\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t), \quad (7)$$

where $U(C, L)$ is a twice continuously differentiable and quasi-concave function with $U_C > 0$, $U_L < 0$, $-\frac{U_{CC}}{U_C} > -\frac{U_{LL}}{U_L}$, and $\frac{U_{CL}}{U_C} > \frac{U_{LC}}{U_L}$. The representative household chooses the optimal bundle of consumption, labor supply, and incumbent firms' stock share (s_t) by maximizing (7) subject to the following sequence of budget constraints:

$$C_t + N_t V_t s_t \leq w_t L_t + N_t \pi_t s_t + (1 - \delta) N_{t-1} V_t s_{t-1}, \quad (8)$$

where V_t , s_t , and π_t are stock price, quantity of shares held by the household at time t , and firm profit, respectively. In the equilibrium, the budget constraint implies that

$$C_t + I_t = Y_t, \quad (9)$$

where the aggregate investment I_t equals to $n_t f_e + N_t \xi$. The first-order conditions in a symmetric equilibrium with respect to consumption, labor and asset price are given by

$$\Lambda_t = U_C(C_t, L_t), \quad (10)$$

$$\Lambda_t w_t = U_L(C_t, L_t), \quad (11)$$

$$V_t = \pi_t + \beta(1 - \delta) \mathbf{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} V_{t+1}, \quad (12)$$

where Λ_t is the Lagrangian multiplier associated with Eq. (8).

The general equilibrium is defined as follows. Given the process of the exogenous shock A_t , the equilibrium is characterized by a collection of nine equations listed in [Appendix B](#) such that: (i) households choose their optimal consumptions, labor supplies, and equity shares; (ii) firms maximize their operating profits; and (iii) goods, labor and equity markets clear.

4. Dynamics in the one-sector model

In this section, we first analyze the crucial role played by fixed operating costs and decreasing survival rates in generating EDBC or positive comovements among aggregate variables. We then report quantitatively responses of aggregate indicators to a news shock under *calibrated parameters*.

4.1. Fixed operating costs and decreasing survival rates

To examine the capability of our one-sector model to produce EDBC, the following proposition states that the fixed operating cost ξ ensures the economy exhibiting comovements among output, consumption, investment, labor input, wage, firm entry, and number of operating firms. Let $\hat{x}$ be the percentage deviation in x from its steady state. We follow the strategy in [Beaudry and Portier \(2007\)](#) to prove: $\frac{\partial \hat{C}_t}{\partial N_t} > 0$, $\frac{\partial \hat{L}_t}{\partial N_t} > 0$, $\frac{\partial \hat{Y}_t}{\partial N_t} > 0$, $\frac{\partial \hat{I}_t}{\partial N_t} > 0$, $\frac{\partial \hat{w}_t}{\partial N_t} > 0$, and $\frac{\partial \hat{n}_t}{\partial N_t} > 0$.

Proposition 1. A sufficiently large fixed operating cost ξ guarantees comovements among output, consumption, investment, labor input, wage, firm entry and number of operating firms in response to good news about future TFP.

Proof. See [Appendix C](#).

As shown in [Wang \(2012\)](#), the reason that standard RBC models fail to obtain news-driven comovements can be explained from a labor market perspective. In RBC models, a positive future TFP shock increases prospective income, and therefore, induces forward-looking households to raise their current consumptions.²¹ This income effect may increase households' leisure time or, equivalently, reduce their labor supply. As a result, the equilibrium labor decreases, causing the output to fall as well. Positive news about the future TFP thus implies that output and consumption will move in opposite directions.

Our strategy to resolve this issue is to change the labor demand curve from downward-sloping to upward-sloping. This is why we assume a positive per-period fixed operating cost—it generates increasing return to scale for aggregate variables. More specifically, a one-unit increase in factor inputs can cause net output to increase by more than one. Hence, a

²¹ Since future shocks would not materialize at present, consumers' reactions to news are all reflected in autonomous changes in current consumption demand. For this reason, a model that can generate EDBC upon demand shocks would be able to produce TFP based EDBC as well.

Table 1
Calibrated parameters in benchmark model.

Parameter	Value	Description
β	0.985	Subjective discount factor
α	0.36	Capital share in production
η	1	Parameter in utility function
γ	0.30	Inverse of the Frisch elasticity of labor supply
δ	0.025	Exogenous firm exit rate
f_e	1	Entry cost
q	0.975	Steady-state survival rate of startups

sufficiently large operating cost would derive an upward-sloping labor demand curve, implying a parallel comovement between consumption and labor.²² In addition, a large fixed operating cost also ensures a positive comovement between the number of firms and labor because a favorable news shock increases the aggregate consumption and attracts more entrants to enter market, which creates extra demands for labor in production. Given the definition $l_t = n_t f_e + N_t \xi$, the investment comoves with the number of firms as well. Results in Proposition 1 therefore apply.²³

Although it can help to generate comovement, the fixed cost per se cannot ensure positive comovements among the aggregate variables in response to news shocks. Good news about future technology might cause a recession instead of a boom because more advanced technology in the future implies that producing today is relatively less profitable. In particular, when there is a constant survival rate for entrants, potential firms have strong incentives to postpone the current entry until the good news is realized. If this happens, the total number of incumbents in the current period decreases, market wage then falls due to a decline in labor demand, followed by a reduction in total household consumption, and eventually an economic recession occurs.²⁴

Our strategy to producing positive comovements is to introduce decreasing survival rate q_t . Once introduced, the number of entrants smooths over time because q_t imposes a penalty on sharp movement. As a result, compared to the model with constant survival rate, the number of entrants n_t in the model with endogenous survival rate increases relatively less when the good news is realized. Fewer entrants further benefits the incumbents as the competition pressure from potential entrants is reduced. Thus, potential entrants would value the production opportunity more due to higher expected value. Anticipating this, more firms enter when good news arrive at the current period and an economic expansion is attained.²⁵

4.2. Impulse responses

We now discuss quantitatively the dynamics of the main aggregate variables in EDBC. In our baseline exercise, we consider the Greenwood–Hercowitz–Huffman (GHH) preferences: $U(C_t, L_t) = \frac{1}{1-\eta} \left(C_t - a_l \frac{L_t^{1+\gamma}}{1+\gamma} \right)^{1-\eta}$. In the Appendix E, we conduct robustness analysis based on separable King–Plosser–Rebelo (KPR) preferences. In the GHH type of utility function, η is set to 1, implying a natural logarithm functional form; γ , the inverse of the Frisch elasticity of the labor supply to the wage, is set to 0.3; and $a_l > 0$ is set such that the steady-state labor input is at 0.33. The other common deep parameters are calibrated as in Table 1.

The time unit corresponds to one quarter. The discount factor β is calibrated at 0.985, which implies a steady-state annual real interest rate of 6%. The share of capital α is set to 0.36, as commonly used in the literature. The natural death rate of firms, δ , is set to be 0.025, leading to a 10% annual rate of exogenous exits in our model. This specification is consistent with the empirical finding that the annual job destruction rate in the U.S. is approximately at the level of 10%. The steady-state survival rate $q(\frac{\eta}{N})$ is set to equal $1 - \delta$, so new entrants have a $1 - \delta$ probability to survive in the steady state. Since the value of the entry cost f_e does not affect aggregate dynamics, we set it to 1 to simplify calculation. Regarding the process of news shocks, we conform with Jaimovich and Rebelo (2009) and assume that the economy is at the steady state initially and there is an announcement that the technology will increase 1% permanently in the fifth period.

The fixed operating cost, ξ , and the elasticity of survival probability with respect to entry rate, $\frac{q_t \eta}{q}$, are crucial for the dynamics. We set ξ to equal to 1.5, which implies that total consumption accounts for roughly 65% of the final output in the

²² An increase in $\hat{C}_t$ shifts the labor supply curve up and the labor demand curve down simultaneously, see Fig. C1 in Appendix C. So the new equilibrium level of labor input $\hat{L}_t$ will increase.

²³ To confirm the above analysis, we simulate the impulse responses with or without the fixed cost, with the survival rate set to be constant. The results show that in the scenario with fixed cost, aggregate variables such as output, consumption, hours worked, net firm entry and investment do not positively comove with each other under a news shock. In contrast, in the latter case, the positive comovements can be generated as long as the fixed cost is sufficiently large. The simulation results are available upon request.

²⁴ The above analysis is verified by the impulse responses in a model with non-zero fixed cost and constant survival rate. The simulation results are available upon request.

²⁵ We prove these analyses quantitatively by comparing impulse responses in the model with decreasing survival rates and those in the model with constant survival rate. All the simulation results are available upon request. In addition, the argument in Proposition 1 also applies if news are about future demand shocks. The impulse responses show that the aggregate comovements can be achieved after the demand news hits the economy.

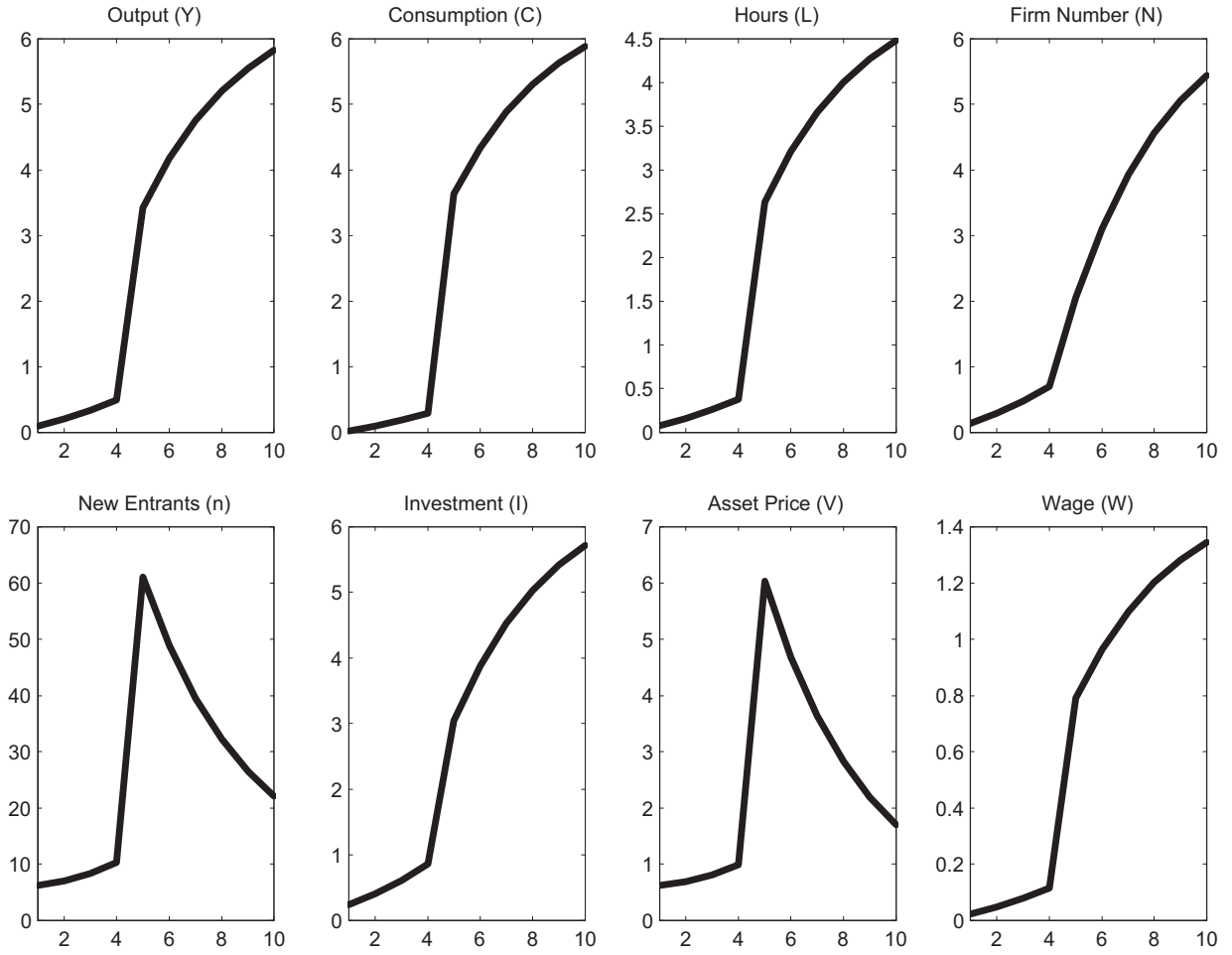


Fig. 5. Responses to the news about future technology. *Notes:* The figure shows percentage responses to news shocks about future TFP. The horizontal axes indicate quarters. The economy is assumed to stay in steady state at period 0 and a positive news shock arrives at period 1. Each news shock is defined as a permanent one-percent increase at period 5.

steady state. This value of ξ also satisfies the inequality condition presented in the proof of [Proposition 1](#). The elasticity parameter $\frac{q'_N}{q}$ is set to -0.1 . This negative number is useful to generate an immediate increase in firm entries upon good news. The impulse responses in [Fig. 5](#) summarize the consequences with the above calibrations for GHH preferences. The economy exhibits the EDBC as expected after the arrival of good news about the future TFP. Moreover, the number of entrants peaks at the fifth period (i.e., when this piece of news is realized) and then gradually declines, replicating the visible hump observed in our VAR analysis. These results remain robust when the preferences take the KPR form, as shown in [Appendix E](#) for details. By now, we have shown that our model is able to explain the empirics found in the VAR exercises.²⁶

Next, we continue to validate the results by robustness checks. What we did is to employ a two dimensional diagram to outline the feasible set for a range of values of $\frac{q'_N}{q}$ and ξ , under which our model can produce positive comovements among the aggregate variables after a news shock. The shaded area in [Fig. 6](#) indicates the set of desirable values.²⁷ If we take a closer look at [Fig. 6](#), the feasible set covers a large area of the plane, i.e., $\frac{q'_N}{q} < -0.03$ and $\xi > 1$.²⁸

²⁶ Notice that the new entrants n_t reported in [Fig. 5](#) slightly differs from the net firm entry documented in the empirical analysis. Indeed, the impulse response of net firm entry $q_t n_t - \delta N_{t-1}$ is smoother than that of new entrants, but the pattern is of no significant difference.

²⁷ We hold other parameters unchanged while assigning different values for elasticity $\frac{q'_N}{q}$ and fixed cost ξ . These two parameters of interest are adjusted simultaneously to determine the extent to which impulse responses exhibit a pattern of positive comovement after a news shock.

²⁸ Different values of ξ barely change steady-state ratios. The consumption–output ratios when $\xi \in (1, 10)$ are centered around 65%, close to the average level observed in U.S. data.

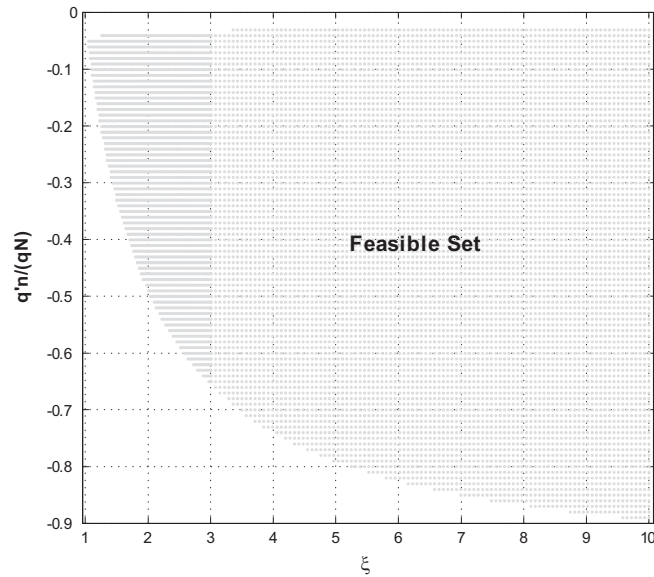


Fig. 6. Feasible values of parameters $\frac{q'n}{qn}$ and ξ . Notes: This figure plots the feasible combinations of parameter values of $\{q'/qn/N, \xi\}$: The preferences are of the GHH form. The shadow area indicates values of $\{q'/qn/N, \xi\}$ such that the responses of aggregate economic variables in the initial period are all positive.

5. The two-sector model

The sectoral comovements among output, labor input, and investment are as critical as aggregate-level results for understanding business cycles (Basu et al., 2013). Christiano and Fitzgerald (1998) find that a two-sector version of the neoclassical TFP driven model cannot generate sectoral comovement between the investment and the labor input. Huffman and Wynne (1999) provide empirical evidences for sectoral comovements in response to contemporaneous shocks and propose a corresponding model that explains their findings. However, their model is incapable of producing comovements in response to a news shock, as their model allows no compensation for the negative wealth effect on labor supply. Jaimovich and Rebelo (2009) unify contemporaneous and news shocks and develop a model whose predictions on sectoral comovements are consistent with data. However, their model predicts countercyclical stock price.

In this section, we extend our benchmark model to incorporate both the consumption goods sector and the investment goods sector. This extended model could generate aggregate and sectoral comovements. Like Jaimovich and Rebelo (2009), our model is unified in terms of its power to generate aggregate and sectoral comovements in response to both contemporaneous and news technology shocks.²⁹ In contrast to their papers, our model can generate procyclical asset price as well.

In respect to the demand side, households' preferences remain unmodified and satisfy (7). Turning to the production side, potential entrants in both sectors need to pay f_e units of fixed entry cost in term of investment goods. Production in both sectors now incurs a fixed operating cost denominated in investment goods. The production function in either sector is thus given by

$$X_t = A_t z_{X,t} N_{X,t}^\alpha L_{X,t}^{1-\alpha}, \quad X \in \{C, I\}, \quad (13)$$

where A_t is a neutral aggregate TFP and $z_{X,t}$ is a sector-specific technology for sector X . The labor demand equation in either sector is of the form

$$w_t = (1-\alpha) \frac{P_{X,t} X_t}{L_{X,t}}, \quad X \in \{C, I\}, \quad (14)$$

where $P_{C,t} = 1$ and $P_{I,t}$ is the relative price of investment goods to consumption goods. For each sector, $N_{X,t}$ evolves according to

$$N_{X,t} = (1-\delta)N_{X,t-1} + q \left(\frac{n_{X,t}}{N_{X,t-1}} \right) n_{X,t}, \quad X \in \{C, I\}, \quad (15)$$

The total number of operating firms (N_t) and new entrants (n_t) are defined as follows:

$$N_t = N_{C,t} + N_{I,t}, \quad (16)$$

²⁹ The impulse responses to contemporaneous technology shocks are available upon request.

$$n_t = n_{C,t} + n_{I,t}. \quad (17)$$

In addition, the two sectors' respective operating profits and expected firm value are given by

$$\pi_{X,t} = \alpha \frac{P_{X,t} X_t}{N_{X,t}} - P_{I,t} \xi, \quad (18)$$

$$V_{X,t} = \pi_{X,t} + \beta(1-\delta) \mathbf{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} V_{X,t+1}, \quad X \in \{C, I\}, \quad (19)$$

The free entry conditions for each sector are given by

$$P_{I,t} f_e = q \left(\frac{n_{X,t}}{N_{X,t}-1} \right) V_{X,t}, \quad X \in \{C, I\}. \quad (20)$$

Finally, the market clearing conditions imply the following equalities:

$$I_t = (N_{I,t} + N_{C,t}) \xi + (n_{I,t} + n_{C,t}) f_e, \quad (21)$$

$$L_t = L_{C,t} + L_{I,t}, \quad (22)$$

$$Y_t = C_t + P_{I,t} I_t. \quad (23)$$

Given the processes of a neutral TFP shock A_t and two sector-specific shocks $z_{C,t}$ and $z_{I,t}$, the equilibrium is jointly characterized by all production-related equations in this section, as well as the three households' Eqs. (10)–(12).

5.1. Dynamics in the two-sector model

The proposition below justifies the presence of operating costs and decreasing survival rate $q(\cdot)$ as vital factors to generate aggregate and sectoral comovements upon a news shock in our two-sector economy. The figure below plots impulse responses due to news concerning three technological shocks: a neutral TFP shock, a consumption-specific technology shock, and an investment-specific technology shock.

Proposition 2. *The existence of a sufficiently large operating cost ξ provides a channel to generate both aggregate and sectoral comovements among output, consumption, investment, labor input, firm entry and number of operating firms in response to a news shock. To guarantee sectoral comovements between sectoral labor inputs, one needs to impose an extra set of restrictions on parameter values for the purpose of restraining wealth's effects on consumption and labor supply.*

Proof. See [Appendix D](#).

Essentially, [Proposition 2](#) emphasizes the key role of a sufficiently large ξ in generating aggregate and sectoral comovements. However, with general forms of utility, a sufficiently large operating cost cannot guarantee labor input comovements at the sectoral level. To figure out the constraint needed to overcome this undesirable outcome, we express the labor input in the consumption goods sector as (see proof in [Appendix D](#))

$$\hat{L}_{C,t} = \hat{N}_{C,t} - \frac{1}{\alpha} [(\gamma_{lc} - \gamma_{cc}) \hat{C}_t + (\gamma_{ll} - \gamma_{cl}) \hat{L}_t], \quad (24)$$

where the last two terms $(\gamma_{lc} - \gamma_{cc}) \hat{C}_t + (\gamma_{ll} - \gamma_{cl}) \hat{L}_t$ reflect the wealth effects on consumption and labor supply. To attain our goal that $L_{C,t}$ positively comoves with $N_{C,t}$ and other sectoral variables, a small wealth effect is required; that is, the coefficients $\gamma_{lc} - \gamma_{cc}$ and $\gamma_{ll} - \gamma_{cl}$ cannot be too large. Considering the case of GHH preferences, the above equation is reduced to

$$\hat{L}_{C,t} = \hat{N}_{C,t} - \frac{\gamma}{\alpha} \hat{L}_t. \quad (25)$$

Good news about future TFP lead to an increase in $\hat{L}_{C,t}$ as long as the inverse substitute elasticity γ is small enough.³⁰

[Fig. 7](#) presents impulse responses to three different types of technological news shocks under GHH preferences. For utility function parameters, we employ the same calibration values as in the one-sector model. From the figure, we can see that our model is capable of generating both aggregate and sectoral comovements responding to various types of news. Numerical investigation indicates that, leaving other parameters unchanged, the range of γ that can guarantee aggregate and sectoral comovements lies within $[0, 0.35]$. The above results remain robust when the preferences take the KPR form, as shown in [Appendix E](#) for details. Lastly, we need to mention that numbers of entrants in both sectors display visible humps, resembling patterns shown in VAR exercises and one-sector model.

³⁰ Alternatively, consider the KPR case, we have $\hat{L}_{C,t} = \hat{N}_{C,t} - \frac{\eta}{\alpha} \hat{C}_t - \frac{\gamma}{\alpha} \hat{L}_t$. Compared to the GHH case, there is an additional term, $\frac{\eta}{\alpha} \hat{C}_t$, which means that KPR preferences render stronger wealth effects. Hence, $\hat{L}_{C,t}$ will increase only if η and γ are sufficiently small.

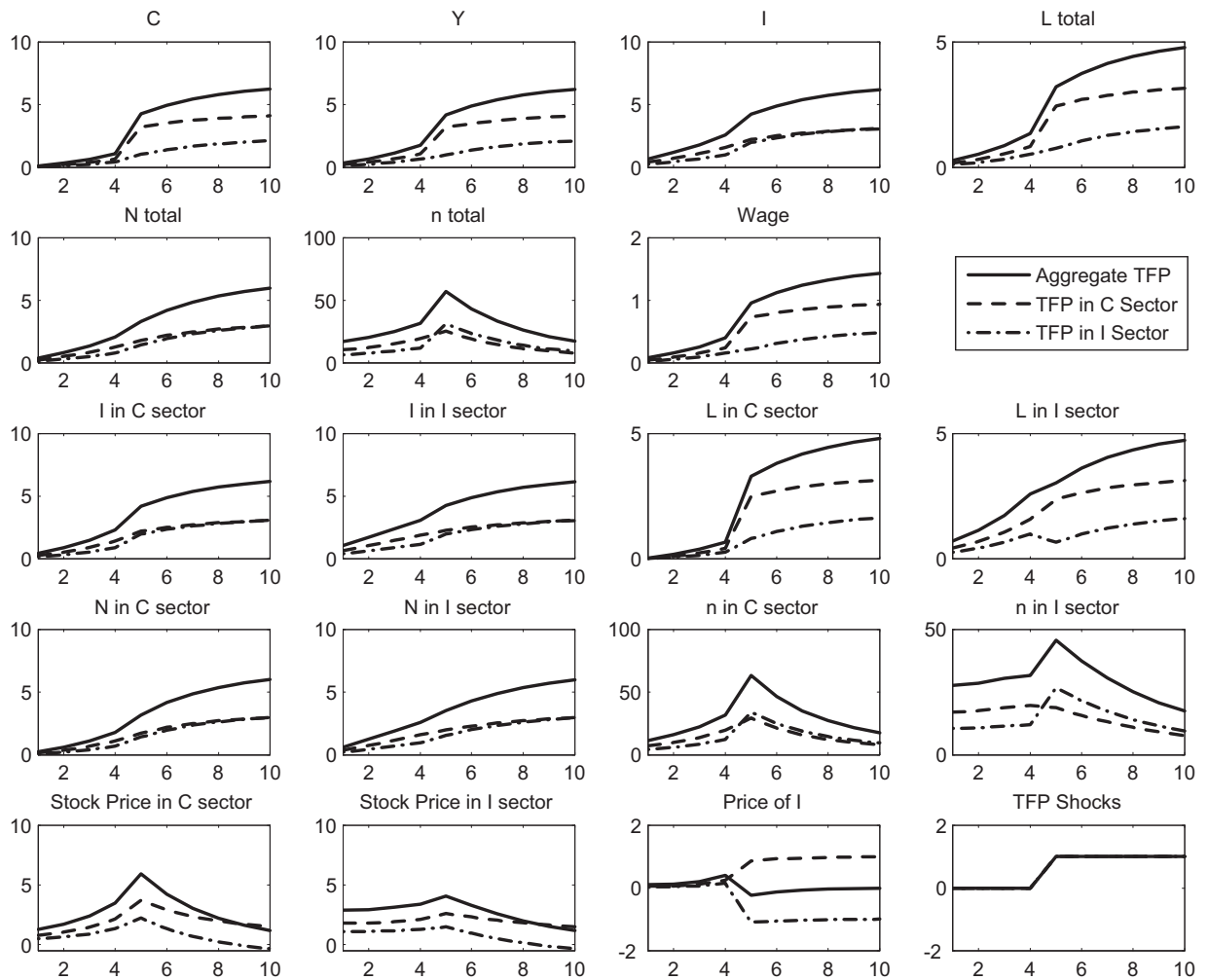


Fig. 7. Responses to news shocks in two-sector model. *Notes:* This figure shows percentage responses to news shocks about different technology shocks. The horizontal axes indicate quarters. The economy is assumed to stay in steady state at period 0 and a positive news shock arrives at period 1. Each news shock is defined as a permanent one-percent increase at period 5.

6. Conclusion

This paper explores both empirically and theoretically linkages between firm dynamics and aggregate fluctuations in EDBC. By means of VAR analysis, we find that news shocks are of great significance for understanding interactions among core macroeconomic indicators and firm entry. In order to explain the empirics, we build a DSGE model, in which we show that non-zero operating costs of incumbents and decreasing survival rates of entrants are two key ingredients in producing positive comovements in aggregate variables. On the one hand, the fixed operating costs introduce a degree of increasing returns to scale that derives an upward-sloping labor demand curve, guaranteeing comovements among output, consumption, labor input, investment, wage, firm entry and incumbent firm mass as well as asset price in EDBC. However, these comovements do not necessarily ensure a boom in response to good news. On the other hand, the decreasing survival rates impose a penalty on sharp increase in firm entries, inducing potential entrants to enter the market immediately when favorable news arrive. Consequently, the aggregate economy, including asset price and firm entries, experiences a boom in response to favorable news about future TFP. Finally, we extend the baseline model economy to a two-sector version, and show that the above two specifications are also crucial to produce sectoral comovements.

Acknowledgment

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Appendix A. Data descriptions

This appendix presents detailed sources and treatments of data series employed in the paper.

Annual data series:

1. *Numbers of firms*: This series records the annual total number of firms from 1988 to 2012. Data source: 1988–2012 County Business Patterns, downloadable from www.census.org.
2. *Numbers of establishments*: This series records the annual total number of establishments from 1988 to 2012. Data source: 1988–2012 County Business Patterns, downloadable from www.census.org.

Quarterly data series in baseline VARs:

Since different data sources have different length of coverage, to be consistent, for most series we choose the period from 1993Q2 to 2014Q2.

1. *Net birth of establishments*: This series records the growth rate of numbers of establishment in quarterly frequency. As for construction method, we first compute the level of net birth of establishments, which is the difference between the birth and the death of establishments. All the series are downloadable from the website of U.S. Bureau of Labor Statistics. We then take the total number of establishment in 1992 as an initial value and compute the quarterly numbers of establishments by accumulating the net birth in each quarter. The net birth of establishments is the growth rate of total numbers of establishments.
2. *Good-news index*: This series is calculated as the difference of the index of favorable news and the index of unfavorable news. The indices of favorable and unfavorable news are published by Michigan Surveys of Consumers.
3. *Consumer sentiment index*: This series is sourced from Michigan Surveys of Consumers.
4. *CEO sentiment index*: This series records the business executive confidence index from the Conference Board. It describes executives' expectations for the U.S. economy six months ahead. Units are in percentage. The time span is from 1993Q2 to 2011Q4.
5. *Real GDP*: This series is the U.S. real Gross Domestic Product in chained 2009 dollars. Data source: St. Louis FED economic database.

Quarterly data series in robustness analysis:

1. *Real consumption*: This series is the U.S. real personal expenditures in nondurable goods and services. Data source: U.S. Bureau of Economic Analysis.
2. *Hours worked*: This series is the U.S. hours of all persons in non-farm business sector. The value in 2009 normalized to 100. Data source: St. Louis FED economic database.
3. *Real stock price*: S&P 500 index deflated by consumer price index. Data source: Robert Shiller's website: <http://www.econ.yale.edu/~shiller/data.htm>.
4. *Net business formation*: This series records the net business incorporations. It is reported by the U.S. Bureau of Economic Analysis. The series is discontinued and ends at 1994Q4 due to reprogramming of resources at BEA. The time span is from 1960Q1 to 1994Q4.
5. *Total factor productivity*: The TFP series is adjusted by the capital utilization from Fernald (2012). Data source: <http://www.frbfsf.org/economic-research/indicators-data/total-factor-productivity-tfp/>.

Appendix B. Summary of full system in the one-sector model

The full dynamic system in the one-sector model, except the exogenous shock process of A_t , is summarized as follows.

1. Consumption:

$$U_C(C_t, L_t) = \Lambda_t. \quad (\text{B.1})$$

2. Intratemporal optimally:

$$U_L(C_t, L_t) = \Lambda_t w_t. \quad (\text{B.2})$$

3. Resource constraint:

$$C_t + n_t f_e + N_t \xi = Y_t. \quad (\text{B.3})$$

4. Number of operating firms:

$$N_t = (1 - \delta)N_{t-1} + q \left(\frac{n_t}{N_{t-1}} \right) n_t. \quad (\text{B.4})$$

5. Aggregate output:

$$Y_t = A_t N_t^\alpha L_t^{1-\alpha}. \quad (\text{B.5})$$

6. Profit:

$$\pi_t = \alpha \frac{Y_t}{N_t} - \xi. \quad (\text{B.6})$$

7. Real wage:

$$w_t = (1 - \alpha) \frac{Y_t}{L_t}. \quad (\text{B.7})$$

8. Free entry condition:

$$f_e = q \left(\frac{n_t}{N_{t-1}} \right) V_t. \quad (\text{B.8})$$

9. Value for incumbent firm:

$$V_t = \pi_t + \beta(1 - \delta) E_t \frac{\Lambda_{t+1}}{\Lambda_t} V_{t+1}. \quad (\text{B.9})$$

Appendix C. Proof of Proposition 1

To demonstrate the role of fixed operating cost, we set the elasticity of $q(\cdot)$ to zero, i.e., the survival rate of entrants is fixed. For simplicity, we assume that news about technology will be realized in the next period, which implies that the percentage change in predetermined variables at the current period t and jump variables at the previous period $t - 1$ is zero. Log-linearizing marginal utilities of labor and consumption yield

$$\hat{U}_L = \gamma_{lc} \hat{C}_t + \gamma_{ll} \hat{L}_t, \quad \hat{U}_C = \gamma_{cc} \hat{C}_t + \gamma_{cl} \hat{L}_t, \quad (\text{C.1})$$

where $\gamma_{lc} = C_{U_L}^{U_C}$, $\gamma_{ll} = L_{U_L}^{U_C}$, $\gamma_{cc} = C_{U_C}^{U_C}$, $\gamma_{cl} = L_{U_C}^{U_C}$. The assumption that consumption and leisure are normal goods implies $\gamma_{lc} - \gamma_{cc} \geq 0$ and $\gamma_{ll} - \gamma_{cl} \geq 0$. The formal proof includes three steps.

Step 1: Prove that the existence of fixed operating cost ξ implies $\frac{\partial \hat{C}_t}{\partial \hat{N}_t} > 0$. According to the optimal labor and consumption equations, we have the labor supply

$$\hat{w}_t = (\gamma_{lc} - \gamma_{cc}) \hat{C}_t + (\gamma_{ll} - \gamma_{cl}) \hat{L}_t. \quad (\text{C.2})$$

Labor demand (2), together with the production function (1), imply

$$\hat{w}_t = \alpha \hat{N}_t - \alpha \hat{L}_t. \quad (\text{C.3})$$

Substituting (C.3) into (C.2) yields

$$\hat{L}_t = \frac{\alpha}{\gamma_{ll} - \gamma_{cl} + \alpha} \hat{N}_t - \frac{\gamma_{lc} - \gamma_{cc}}{\gamma_{ll} - \gamma_{cl} + \alpha} \hat{C}_t. \quad (\text{C.4})$$

The resource constraint implies

$$\frac{C}{Y} \hat{C}_t + \frac{N}{Y} \frac{\delta}{1 - \delta} \hat{n}_t + \frac{N}{Y} \xi \hat{N}_t = \alpha \hat{N}_t + (1 - \alpha) \hat{L}_t. \quad (\text{C.5})$$

The law of motion of the number of incumbents, N_t , implies

$$\hat{n}_t = \frac{\hat{N}_t - (1 - \delta) \hat{N}_{t-1}}{\delta}. \quad (\text{C.6})$$

Combining (C.4)–(C.6) yields

$$\frac{C}{Y}\hat{C}_t + \left[\frac{N}{Y} \left(\frac{1}{1-\delta} f_e + \xi \right) - \alpha \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha} \right] \hat{N}_t - \frac{N}{Y} f_e \hat{N}_{t-1} = -(1-\alpha) \frac{\gamma_{lc} - \gamma_{cc}}{\gamma_{ll} - \gamma_{cl} + \alpha} \hat{C}_t. \quad (C.7)$$

Plugging the steady-state ratio $\frac{N}{Y} = \frac{\alpha}{[1-\beta(1-\delta)] \frac{f_e}{1-\delta} + \xi}$ into the last equation and set $\hat{N}_{t-1} = 0$, we obtain

$$\left[\frac{\alpha \frac{f_e/\xi}{1-\delta} + \alpha}{[1-\beta(1-\delta)] \frac{f_e/\xi}{1-\delta} + 1} - \alpha \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha} \right] \hat{N}_t = - \left(\frac{C}{Y} + (1-\alpha) \frac{\gamma_{lc} - \gamma_{cc}}{\gamma_{ll} - \gamma_{cl} + \alpha} \right) \hat{C}_t, \quad (C.8)$$

Note that the coefficient of $\hat{C}_t$ is negative, thus $\frac{\partial \hat{C}_t}{\partial \hat{N}_t} > 0$ if and only if the coefficient of $\hat{N}_t$ is less than zero. In the case where $\xi = 0$ or $f_e/\xi = \infty$, the coefficient of N_t equals $\frac{\alpha}{[1-\beta(1-\delta)]} - \alpha \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha}$, which is larger than zero in our calibration because $\alpha \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha}$ belongs to the range of $(\alpha, 1)$. In the case where $\xi = \infty$ or $f_e/\xi = 0$, the coefficient of N_t equals $\alpha - \alpha \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha}$, which is less than zero. As $\frac{\alpha}{[1-\beta(1-\delta)] \frac{f_e/\xi}{1-\delta} + 1} \left(\frac{f_e/\xi}{1-\delta} + 1 \right)$ is increasing in f_e/ξ , the coefficient of N_t is less than zero if and only if the fixed operating cost ξ satisfies the following condition:

$$\xi > \frac{1 - \frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha} [1 - \beta(1 - \delta)]}{\frac{\gamma_{ll} - \gamma_{cl} + 1}{\gamma_{ll} - \gamma_{cl} + \alpha} - 1} \frac{f_e}{1 - \delta}. \quad (C.9)$$

Hence, Eq. (C.8) implies that $\frac{\partial \hat{C}_t}{\partial \hat{N}_t} > 0$ if the fixed operating cost ξ is large enough.

Step 2: Prove $\frac{\partial \hat{L}_t}{\partial \hat{N}_t} > 0$. The labor demand (C.3) and the resource constraint (C.5) when combined together imply the following labor demand equation:

$$\hat{w}_t = \alpha \frac{1 - \frac{\alpha \frac{f_e/\xi}{1-\delta} + \alpha}{[1-\beta(1-\delta)] \frac{f_e/\xi}{1-\delta} + 1}}{\frac{\alpha \frac{f_e/\xi}{1-\delta} + \alpha}{[1-\beta(1-\delta)] \frac{f_e/\xi}{1-\delta} + 1} - \alpha} \hat{L}_t - \frac{\alpha}{\frac{\alpha \frac{f_e/\xi}{1-\delta} + \alpha}{[1-\beta(1-\delta)] \frac{f_e/\xi}{1-\delta} + 1} - \alpha} \frac{C}{Y} \hat{C}_t. \quad (C.10)$$

Under condition (C.9), the coefficient before $\hat{L}_t$ is larger than the coefficient before $\hat{L}_t$ in (C.2), indicating that the labor demand curve is steeper than the labor supply. Fig. C1 provides a graphical illustration. In particular, the solid lines represent the labor demand and supply curves before C_t is changed; the dashed lines represent these two curves after C_t is changed. It can be seen from the graph that, as C_t increases, the labor demand curve shifts downward and the labor supply curve shifts upward. As a result, L_t increases, i.e., $\frac{\partial \hat{L}_t}{\partial \hat{C}_t} > 0$. Therefore, given the proof in step 1, we have $\frac{\partial \hat{L}_t}{\partial \hat{N}_t} > 0$.

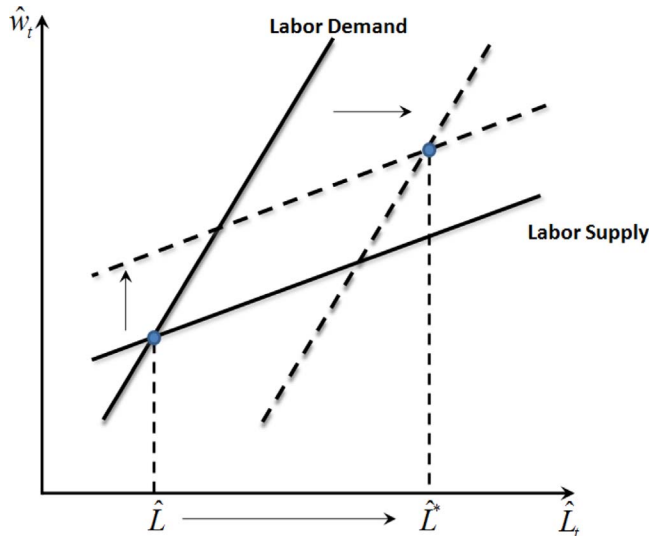


Fig. C1. Illustration for labor market dynamics.

Step 3: Prove all other variables comove with the number of operating firms N_t . The definition of investment straightly implies $\frac{\partial \hat{I}_t}{\partial \hat{N}_t} > 0$. The evolution of N_t implies $\frac{\partial \hat{N}_t}{\partial \hat{N}_t} > 0$. From the labor supply equation (C.2), $\frac{\partial \hat{C}_t}{\partial \hat{N}_t} > 0$ and $\frac{\partial \hat{L}_t}{\partial \hat{N}_t} > 0$ jointly imply that $\frac{\partial \hat{W}_t}{\partial \hat{N}_t} > 0$. Finally, the production function (1) associated with $\frac{\partial \hat{L}_t}{\partial \hat{N}_t} > 0$ imply $\frac{\partial \hat{Y}_t}{\partial \hat{N}_t} > 0$.

From Steps 1 to 3, we have shown that output, consumption, investment, labor input, wage, firm entry, and number of operating firms comove if and only if condition (C.9) is satisfied. By now we have finished proving Proposition 1.

Appendix D. Proof of Proposition 2

Similar to the proof of Proposition 1, we again assume that news shocks concerning technology will be realized in the next period and set the elasticity of $q(\cdot)$ at zero. The proof procedure contains four steps.

Step 1: Prove that, under a news shock, the price of the investment goods $\hat{P}_{I,t} = 0$. According to the free entry conditions, firm values deflated by $P_{I,t}$, namely $\frac{V_{C,t}}{P_{I,t}}$ and $\frac{V_{I,t}}{P_{I,t}}$ are constant. Furthermore, the asset-pricing formulas in (19) associated with the definition of profits in both sectors (18) imply the following relationship:

$$\frac{C_t}{N_{C,t}} = \frac{P_{I,t} I_t}{N_{I,t}}. \quad (D.1)$$

In addition, the labor demand functions (14) gives us the following equality:

$$\frac{C_t}{L_{C,t}} = \frac{P_{I,t} I_t}{L_{I,t}}. \quad (D.2)$$

The above two equations directly yield

$$N_{C,t}/L_{C,t} = N_{I,t}/L_{I,t}. \quad (D.3)$$

Combining two sectoral production functions (13), we further have

$$P_{I,t} = \frac{C_t}{I_t} \frac{L_{I,t}}{L_{C,t}} = \frac{z_{C,t}}{z_{I,t}} \left(\frac{N_{C,t}/L_{C,t}}{N_{I,t}/L_{I,t}} \right)^\alpha = \frac{z_{C,t}}{z_{I,t}}, \quad (D.4)$$

which implies that $\hat{P}_{I,t} = 0$ since the consumption sector specific technology $z_{C,t}$ and the investment sector specific technology $z_{I,t}$ will not change at time t .

Step 2: Show that the aggregate variables comove with the number of operating firms N_t , i.e., $\frac{\partial \hat{C}_t}{\partial \hat{N}_t}, \frac{\partial \hat{I}_t}{\partial \hat{N}_t}, \frac{\partial \hat{L}_t}{\partial \hat{N}_t}, \frac{\partial \hat{Y}_t}{\partial \hat{N}_t}, \frac{\partial \hat{N}_t}{\partial \hat{N}_t} > 0$. To simplify notation, we assume that sector-specific parameters share the same values as in the one-sector case. This assumption implies that the steady-state values of the aggregate variables in the two-sector model are the same as in the one-sector case. In addition, as we have already shown that the percentage change of the investment good price is zero ($\hat{P}_{I,t} = 0$) in response to a news shock, we can obtain the same log-linearized equations for aggregate variables as those in the one-sector case. More specifically, we have

1. Law of motion of N_t :

$$\hat{N}_t = (1 - \delta)\hat{N}_{t-1} + \delta\hat{n}_t. \quad (D.5)$$

2. Definition of investment:

$$\hat{I}_t = \frac{N_t^\xi}{I} \hat{N}_t + \frac{nf_e}{I} \hat{n}_t. \quad (D.6)$$

3. Aggregate output:

$$\hat{Y}_t = \frac{C}{Y} \hat{C}_t + \frac{P_I I}{Y} \hat{I}_t. \quad (D.7)$$

4. Labor demand:

$$\hat{W}_t = \alpha \hat{N}_t - \alpha \hat{L}_t. \quad (D.8)$$

The households' problem remains unchanged. Thus, according to the proof of Propositions 1, we can easily show that with non-zero operating cost $\xi_C = \xi_I = \xi$ that satisfies condition (C.9), the partial derivatives $\frac{\partial \hat{C}_t}{\partial \hat{N}_t}, \frac{\partial \hat{I}_t}{\partial \hat{N}_t}, \frac{\partial \hat{L}_t}{\partial \hat{N}_t}, \frac{\partial \hat{Y}_t}{\partial \hat{N}_t}, \frac{\partial \hat{N}_t}{\partial \hat{N}_t}$ are all greater than zero.

Step 3: Prove $\frac{\partial \hat{N}_{C,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{N}_{I,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{n}_{C,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{n}_{I,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{l}_{C,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{l}_{I,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{L}_{I,t}}{\partial \hat{N}_t} > 0$. Eq. (D.3) implies

$$\hat{N}_{C,t} - \hat{L}_{C,t} = \hat{N}_{I,t} - \hat{L}_{I,t}.$$

The market clearing condition for the investment goods (21), together with the investment goods production Eq. (13), yields

$$\alpha \hat{N}_{I,t} + (1-\alpha) \hat{L}_{I,t} = \frac{1 + \frac{1}{1-\delta} \frac{f_e}{\xi}}{1 + \frac{\delta}{1-\delta} \frac{f_e}{\xi}} \hat{N}_t. \quad (D.9)$$

The definitions for total labor and the total mass of firm yield

$$\hat{L}_t = \frac{L_C}{L} \hat{L}_{C,t} + \frac{L_I}{L} \hat{L}_{I,t}, \quad (D.10)$$

$$\hat{N}_t = \frac{N_C}{N} \hat{N}_{C,t} + \frac{N_I}{N} \hat{N}_{I,t}. \quad (D.11)$$

According to the above four equations, we can solve for the sectoral variables

$$\hat{N}_{C,t} = \left[1 - \frac{N_I}{N_C} \left(\frac{\frac{f_e/\xi}{1-\delta} + 1}{\frac{\partial f_e/\xi}{1-\delta} + 1} - \alpha \right) \right] \hat{N}_t + \frac{N_I}{N_C} (1-\alpha) \hat{L}_t, \quad (D.12)$$

$$\hat{L}_{I,t} = \left(\frac{\frac{f_e/\xi}{1-\delta} + 1}{\frac{\partial f_e/\xi}{1-\delta} + 1} - \alpha \right) \hat{N}_t + \alpha \hat{L}_t, \quad (D.13)$$

$$\hat{N}_{I,t} = \hat{L}_{I,t} + \hat{N}_t - \hat{L}_t, \quad (D.14)$$

$$\hat{L}_{C,t} = \hat{N}_{C,t} - \hat{N}_t + \hat{L}_t. \quad (D.15)$$

Under condition (C.9), the coefficient before $\hat{N}_t$, $1 - \frac{N_I}{N_C} \left(\frac{\frac{f_e/\xi}{1-\delta} + 1}{\frac{\partial f_e/\xi}{1-\delta} + 1} - \alpha \right)$, in Eq. (D.12), is strictly positive if $\beta \rightarrow 1$. Given that the coefficient of $\hat{L}_t$ is larger than zero and $\frac{\partial \hat{L}_t}{\partial \hat{N}_t} > 0$, $\hat{N}_{C,t}$ comoves with $\hat{N}_t$. Condition (C.9) also ensures that the coefficient before $\hat{N}_t$, $\left(\frac{\frac{f_e/\xi}{1-\delta} + 1}{\frac{\partial f_e/\xi}{1-\delta} + 1} - \alpha \right)$, in Eq. (D.13) is larger than zero. Hence, we have $\frac{\partial \hat{L}_{I,t}}{\partial \hat{N}_t} > 0$. Eq. (D.15) and the labor supply (C.2) jointly imply $\frac{\partial \hat{N}_{I,t}}{\partial \hat{N}_t} = \frac{\partial \hat{L}_{I,t}}{\partial \hat{N}_t} + \frac{1}{\alpha} \frac{\partial \hat{N}_t}{\partial \hat{N}_t} > 0$, which derives $\frac{\partial \hat{N}_{I,t}}{\partial \hat{N}_t} > 0$. Furthermore, the laws of motion for the number of incumbent firms imply $\frac{\partial \hat{n}_{C,t}}{\partial \hat{N}_t} > 0$ and $\frac{\partial \hat{n}_{I,t}}{\partial \hat{N}_t} > 0$. According to the definitions of $I_{C,t}$ and $I_{I,t}$, we have $\frac{\partial \hat{l}_{C,t}}{\partial \hat{N}_t} > 0$ and $\frac{\partial \hat{l}_{I,t}}{\partial \hat{N}_t} > 0$ since $\frac{\partial \hat{N}_{C,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{N}_{I,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{n}_{C,t}}{\partial \hat{N}_t} > 0$, $\frac{\partial \hat{n}_{I,t}}{\partial \hat{N}_t} > 0$.

Step 4: Prove $\frac{\partial \hat{L}_{C,t}}{\partial \hat{N}_t} > 0$. The labor supply equation (C.2) and equation (C.3), together with equation (D.15), imply

$$\hat{L}_{C,t} = \hat{N}_{C,t} - \left(\frac{\gamma_{lc} - \gamma_{cc}}{\alpha} \right) \hat{C}_t - \left(\frac{\gamma_{ll} - \gamma_{cl}}{\alpha} \right) \hat{L}_t. \quad (D.16)$$

The coefficients of $\hat{C}_t$ and $\hat{L}_t$ measure the wealth effect of labor supply and consumption, respectively. Therefore, in order to make $\hat{L}_{C,t}$ comove with $\hat{N}_{C,t}$ and $\hat{N}_t$, we need $\gamma_{lc} - \gamma_{cc}$ and $\gamma_{ll} - \gamma_{cl}$ to be sufficiently small. That is, the utility function must have the characteristic that can derive a weak wealth effect.

Appendix E. Dynamics under KPR preferences

The separable King–Plosser–Rebelo (KPR) utility function specified as $U(C_t, L_t) = \frac{C_t^{1-\eta}}{1-\eta} - a_l \frac{L_t^{1+\gamma}}{1+\gamma}$. For the one-sector model, the utility parameters are set in line with the baseline case. In particular, $\eta = 1$, $\gamma = 0.3$, and $a_l > 0$ is set such that the steady-state labor input is at 0.33. Fig. E1 reports the impulse responses of aggregate variables to a favorable news shock. Obviously, the model generates positive comovements like the baseline model with GHH preferences.

Next consider the extended two-sector model. As discussed in the main text, generating desirable comovements requires small η and γ for the KPR preferences, so we set γ to 0.3 and η to 0.1. Fig. E2 is constructed in the same way as Fig. 7 except that the utility function is of KPR form. Additional numerical simulations show that the feasible range for η is $[0, 0.15]$ when γ is fixed at 0.3.

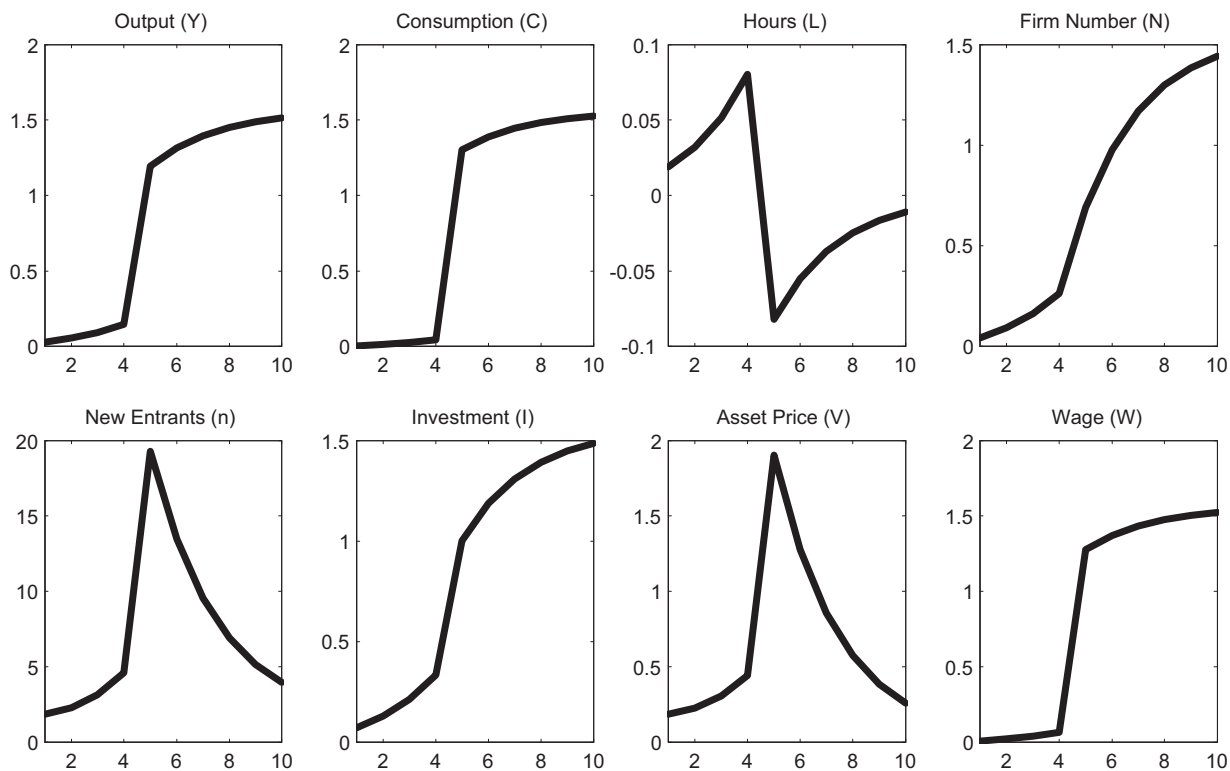


Fig. E1. Responses to the news about future technology in the one-sector model: KPR preferences. *Notes:* The figure shows percentage responses to news shocks about future TFP. The horizontal axes indicate quarters. The economy is assumed to stay in steady state at period 0 and a positive news shock arrives at period 1. Each news shock is defined as a permanent one-percent increase at period 5.

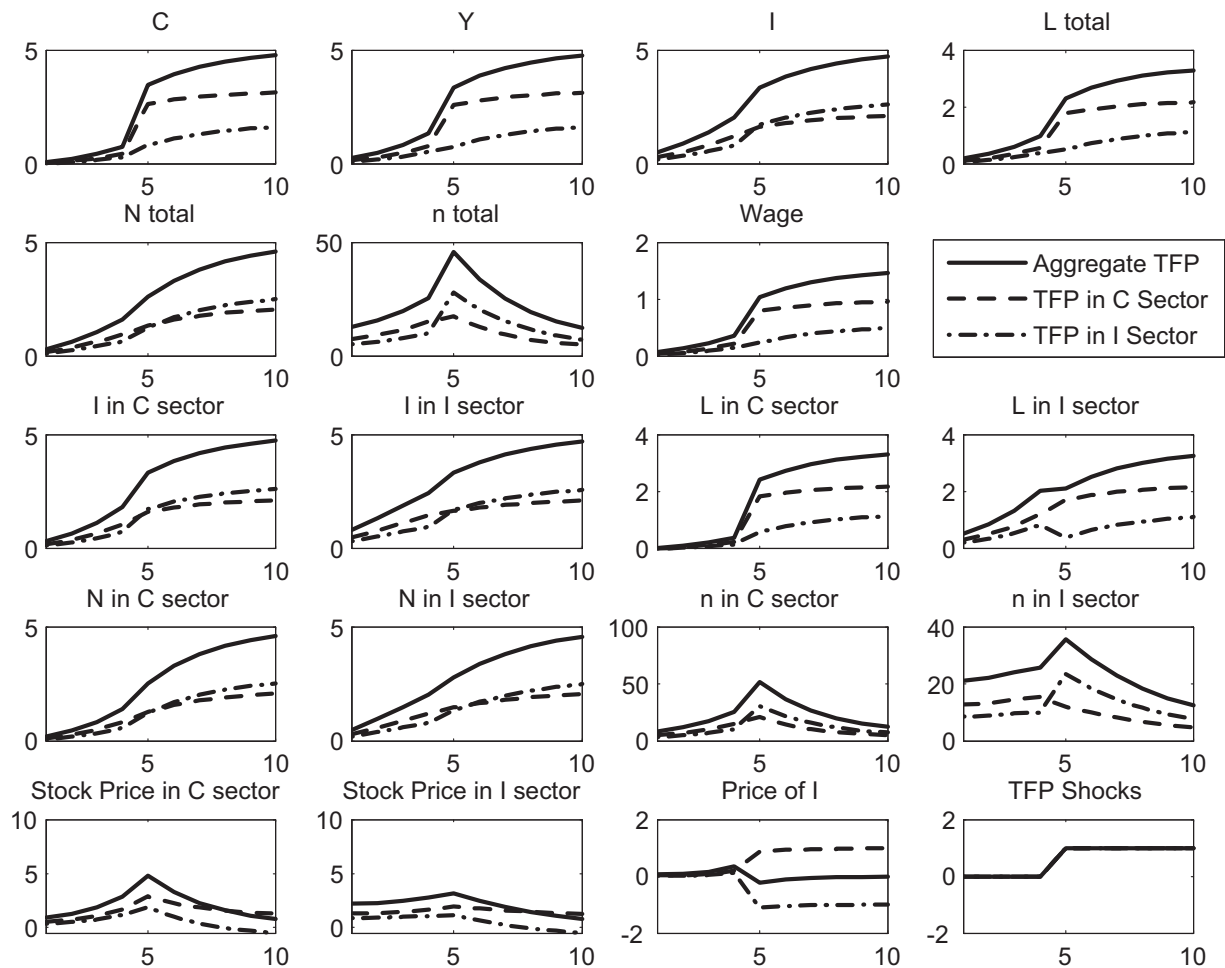


Fig. E2. Responses to news shocks in two-sector model: KPR preferences. *Notes:* This figure shows percentage responses to news shocks about different technology shocks. The horizontal axes indicate quarters. The economy is assumed to stay in steady state at period 0 and a positive news shock arrives at period 1. Each news shock is defined as a permanent one-percent increase at period 5.

Appendix F. Supplementary data

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.jedc.2016.09.010>.

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