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Collateral Constraint and News-driven Cycles

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Keywords: The news-driven cycles; collateral constraints; Tobin's q; bankruptcies.
JEL Classifications:E22, E32, E37, G12.

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(Incomplete and preliminary)

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Abstract

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1 Introduction

The boom-bust cycles such as the episode of the "Internet bubble" in the late 1990s may be described as the business cycle driven by changes in expectations or news about the future. Recently there has been a growing interest in examining the role of such "news shocks" as a driving force of business cycles. The literature includes, among others, Beaudry and Portier (2004a, b), Christiano, Motto, and Rostagno (2006), Christiano and Fujiwara (2005), Jaimovich and Rebelo (2006), Den Haan and Kaltenbrunner (2004) and Lorenzoni (2005). As is well known, in the standard real business cycle model, changes in expectations (or news shocks) move consumption and labor in opposite directions due to the wealth effect. For instance, if an increase in the expected level of future productivity raises the present discounted value of income, the consumer increases both consumption and leisure today, and hence reduces labor supply. It follows that output and investment decline as well.

In order for news shocks to generate business cycles (i.e, comovement between consumption, investment, labor, and output), the papers listed above modify preferences and/or technology from the standard model. For instance, Beaudry and Portier (2004a, b) introduce a certain type of complementarity between production technologies in a two-sector model; Christiano, Motto, and Rostagno (2006) introduce habit persistence in consumers' preference and a specific form of the adjustment costs in investment; Jaimovich and Rebelo (2006) assumes preferences without income effect on labor supply, the same adjustment cost as Christiano, Motto and Rostagno, and variable capital utilization.

In this paper, we propose a different mechanism to generate news-driven cycles. Our story is based on collateral constraint and fluctuations in asset prices play a key role in generating news-driven cycles. We consider an economy with a productive asset with fixed supply ("land"). Producers must pay the costs for inputs, such as labor, in advance of production, and they need external funds to finance them. The amount that they can borrow is limited by the value of the collateral (land and/or capital). Its important consequence is that the collateral constraint makes the allocation of labor inefficient by introducing a wedge between the marginal product of labor and the marginal rate of substitution between leisure and consumption. Furthermore, the wedge becomes greater as the collateral constraint binds more tightly. Thus, the labor market inefficiency and the financial market inefficiency are closely linked with each other.

We consider two models of collateral constraint. For the sake of exposition, we start with a very simple model of collateral constraint, which has a representative household. In this model, news of a future productivity increase generates a boom today as follows. The news raises the price of land today, which relaxes the collateral constraint. Since the input finance is collateral constrained, the relaxation of the collateral constraint reduces the inefficiency in the labor market (the gap between the wage rate and the marginal product of labor becomes lower). It shifts the labor demand curve outward. If this force is sufficiently strong, it offsets the wealth effect on the labor supply schedule, and the equilibrium labor supply increases. So do output and investment. Consumption increases because the wealth effect of the good news. With augmented by adjustment cost of investment, the model also generates procyclical movement in Tobin's Q.

We then consider a version of Carlstrom and Fuerst's (1998) model, which has two types of agents: households (lender) and entrepreneurs (borrowers). Having two types of agents brings about a new feature. In the representative-household model, when the news actually turns out to be false, the economy essentially jumps back to the initial steady state, although there are some transitional dynamics. In particular, false information does not cause a recession: the level of output does not get lower than the steady state level. In our second model with two types of agents, however, if the information turns out to be wrong, the economy falls into a recession. This is because, when the good news arrives, the price of the collateral asset increases, and hence entrepreneurs need a less share of land to achieve the desired value of collateral. Hence, in response to the good news about future, entrepreneurs sell their land. When the news turns out to be wrong, the land price essentially goes back to its steady state level. However, since the share of land held by entrepreneurs is lower than the steady state level, the value of their collateral is lower than the steady state level. It follows that the financial constraint becomes tighter, which increases the labor market inefficiency, and reduces labor, output, and consumption.

The organization of the paper is as follows. In the next section, we describe our first model. The collateral constraint is formalized in the manner of Kiyotaki and Moore (1997). In Section 3, we describe the second model in which the collateral constraint is formalized in the manner of Carlstrom and Fuerst (1998). Section 4 provides concluding remarks.

2 Model 1: Lack of commitment

In this section we describe our first model of collateral constraint. The collateral constraint arises because borrowers cannot credibly commit to repay their debt. For simplicity, the first model is set up so that we can use a representative household framework. Thanks to this, the dynamics of the model would be easily and clearly understood. We shall see that what is crucial in our model is the interaction between the financial market inefficiency and the labor market inefficiency. We also see that, with adjustment costs of investment, our model naturally generates procyclical movement in Tobin's Q.

2.1 Basic model

Our model economy is a closed economy that consists of continua of identical households and banks, whose measures are both normalized to one. A representative household consists of a worker-manager pair. At the beginning of each period, the worker and the manager split, and act separately until the end of the period. The worker supplies labor n_t to a firm owned by another household at the wage rate w_t. The manager hires labor

$\tilde{n}_t$ and purchases intermediate input m_t from other households to produce output, y_t, using the following production technology:

$$y_t = A_t^{(1-\eta)(1-\alpha)} m_t^{\eta} a_t^{(1-\eta)\nu} k_t^{(1-\eta)\alpha} \tilde{n}_t^{(1-\eta)(1-\alpha-\nu)}, \tag{1}$$

where k_t is capital and a_t is land, both of which the manager owns at the beginning of period t. Parameter A_t represents the level of productivity. The productivity growth rate, $\zeta_t \equiv \ln A_t - \ln A_{t-1}$, evolves stochastically following an AR(1) process:

$$\zeta_t = (1-\rho)\overline{\zeta} + \rho\zeta_{t-1} + \epsilon_t, \tag{2}$$

where $\rho > 0$, and ϵ_t is an i.i.d. noise with mean zero.

We assume that a bank can issue bank notes that can be circulated in the economy as payment instruments. The manager needs to borrow bank notes because we assume that he must pay for the inputs in advance of production. Let b_t be the amount that the manager borrows. Then, given b_t, the manager's choice of $\tilde{n}_t$ and m_t is constrained by

$$w_t\tilde{n}_t + m_t \leq b_t. \tag{3}$$

Borrowing and lending are intra-period; if R_t is the gross rate of bank loans, the manager is supposed to repay $R_t b_t$ after production. (As discussed below, since borrowing and lending are intra period, $R_t = 1$ in equilibrium.) As in Kiyotaki and Moore (1997), however, the manager cannot fully commit himself to repay the debt. He can abscond without repayment at the end of period t, and the bank cannot keep track of the absconder's identity from the next period on. Instead, an imperfect commitment technology is available for the manager and the bank: The manager can put up a part of capital and land that he owns as collateral, and the bank can seize the collateral when the borrower absconds. Therefore, the value of collateral gives the upper limit of bank loan:

$$b_t \leq \phi k_t + \psi q_t a_t, \tag{4}$$

where ϕ and ψ $(0 \leq \phi, \psi \leq 1)$ are the ratios of respective assets that can be put up as collateral, and q_t is the price of land in period t. The bank's problem is to maximize the return on the loan, $(R_t - 1)b_t$. Since the bank faces no risk of default if the intra-period loan b_t satisfies (4), competition among banks implies that the return on the loan should be zero ($R_t - 1 = 0$) in equilibrium. Therfore, in equilibrium, the banks become indifferent to the amount of b_t, and work as passive liquidity suppliers to the households. So we can neglect the banks' decision-making, since it has no effect on the equilibrium dynamics of this economy. Conditions (3) and (4) together imply the following collateral constraint on the manager's purchase:

$$w_t \tilde{n}_t + m_t \leq \phi k_t + \psi q_t a_t. \tag{5}$$

At the end of period t, after production, the household sells y_t, repays $R_t b_t$, and determines consumption, c_t, investment, i_t, and land, a_{t+1}, subject to the flow budget constraint:

$$c_t + i_t + q_t a_{t+1} + R_t b_t = q_t a_t + w_t n_t + b_t + \pi_t,$$

where π_t is the profit from the firm owned by this household: $\pi_t = y_t - m_t - w_t \tilde{n}_t$, and $R_t = 1$ in the equilibrium. The reduced form of the budget constraint is

$$c_t + i_t + q_t a_{t+1} = q_t a_t + w_t n_t + y_t - m_t - w_t \tilde{n}_t. \tag{6}$$

A representative household maximize its lifetime utility, U, defined over sequences of consumption and leisure, $1 - n_t$. To ensure the existence of a balanced growth path, we assume the following class of utility functions:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} [c_t (1 - n_t)^{\gamma}]^{1-\sigma}, \tag{7}$$

where E_0 denotes the expectation conditional on the information available at time 0. The law of motion for capital accumulation is

$$k_{t+1} = i_t + (1 - \delta) k_t, \tag{8}$$

where δ is the rate of capital depreciation.

The dynamics of this economy are determined as the solution to the representative household's problem, in which the household maximize (7) subject to (1), (2), (5), (6), and (8). The market clearing conditions are

$$y_t = c_t + i_t + m_t, \tag{9}$$

$$n_t = \tilde{n}_t, \tag{10}$$

$$a_t = 1. \tag{11}$$

Note that the final output is also used as the intermediate input in this model, as usually assumed in the literature (see, for example, Rotemberg and Woodford [1995], Chari, Kehoe, and McGrattan [2004], and Commin and Gertler [2006]).

The role of the collateral constraint: Our model departs from the standard real business cycle model in a minimal way. The only difference is the collateral constraint on input finance.[1] For instance, if ϕ and ψ in (5) are so large that the collateral constraint does not bind at all, our model would reduce simply to the standard model. How does our collateral constraint affect the economy? The key is the interaction between inefficiencies in the labor market and in the financial market.

To see this, let λ_t and μ_t be the Lagrange multipliers associated with (6) and (5), respectively, and form the Lagrangian as (for the sake of exposition ignore the other constraints for now):

$$\sum_{t=0}^{\infty} \beta^t \Big\{ \frac{1}{1-\sigma} \Big[c_t (1-n_t)^\gamma \Big]^{1-\sigma} + \mu_t \Big[\phi k_t + \psi q_t a_t - w_t \tilde{n}_t - m_t \Big]$$
$$+ \lambda_t \Big[q_t a_t + w_t n_t + y_t - m_t - w_t \tilde{n}_t - c_t - i_t - q_t a_{t+1} \Big] \Big\}$$

The labor supply decision implies that the marginal rate of subsitution equals the wage rate:

$$\gamma \frac{c_t}{1-n_t} = w_t,$$

[1]Our model is close in spirit to Mendoza (2006). He assumes that payment for inputs is collateral constrained, while capital is used as collateral.

which is standard. The labor demand decision, however, is different from the standard model and it does not imply that the marginal product of labor equals the wage rate. Using the equilibrium condition $n_t = \tilde{n}_t$, the labor demand condition is expressed as

$$(1-\eta)(1-\alpha-\nu)\frac{y_t}{n_t} = (1+x_t)w_t, \tag{12}$$

where $x_t \equiv \frac{\mu_t}{\lambda_t}$ measures how tightly the collateral constraint (5) binds. Since the left-hand side of (12) is the marginal product of labor, x_t is the wedge between the marginal product of labor and the wage rate. We have $x_t > 0$ if the collateral constraint binds, and x_t can be viewed as a measure of the financial market inefficiency. At the same time, it is the wedge between the marginal product of labor and the wage rate, and hence it is a measure of the labor market inefficiency.

Notice that the effect of a reduction in x_t on the labor demand function is similar to the effect of a positive productivity shock. As long as a higher price of a collateral asset today relaxes the collateral constraint, it affects the labor demand curve in the same way as a positive productivity shock today, by reducing the inefficiency in the labor market. It is then clear how our collateral constraint help generate news-driven cycles. Suppose that a piece of news arrives that there is a positive productivity shock in the future. Such news raises the land price today, and tends to relax the collateral constraint.[2] Other things being equal, it reduces the labor/financial market inefficiency, x_t, and shifts the labor demand curve outward. If this force is strong enough to overcome the wealth effect on the labor supply curve, the equilibrium labor supply rises, and so do consumption, ivnestment, and output.

Our result implies that the collateral constraint on input payment may be a powerful tool to reproduce business cycles, in contrast to the formulation by Kiyotaki and Moore (1997). In their model, consumption smoothing and capital accumulation are distorted, because the agents cannot issue optimal amounts of intertemporal debt, since debt issuance is constrained by collateral. These intertemporal distortions in consumption and capital accumulation are said to have quantitatively insignificant effects in business fluctuations (See Cordoba and Ripoll [2004]). Our result show, however, that when working

[2]For this to be the case, the elasticity of intertemporal substitution, $1/\sigma$, must be sufficiently high.

capital expenditure (or input payment) is constrained, the collateral constraint may have a significant effect on business fluctuations.

The role of intermediate inputs: The requirement of intermediate inputs, m_t, in the production technology (1) is not necessary to generate news-driven cycles in our model. The collateral constraint (5) is enough for that purpose. However, it reinforces the effect of the collateral constraint and does increase the set of parameter values which are consistent with news-driven cycles.

To see this, note that the first-order condition for m_t is

$$\eta \frac{y_t}{m_t} = \frac{\lambda_t + \mu_t}{\lambda_t} = 1 + x_t \tag{13}$$

As the demand for labor, the demand for the intermediate good, m_t, is also distorted when the collateral constraint (5) binds (i.e., when $x_t > 0$). Equation (13) shows that in response to a fall in the financial market inefficiency, x_t, the intermediate input, m_t, increases more than proportionally to the increase in gross output, y_t. This is an additional force shifting the labor demand curve (12) outward, and hence reinforces the mechanism described above. Indeed, using (13) to eliminate m_t, the marginal product of labor can be expressed as

$$(1-\eta)(1-\alpha-\nu)\frac{y_t}{n_t} = (1-\eta)(1-\alpha-\nu)\left(\frac{\eta}{1+x_t}\right)^{\frac{\eta}{1-\eta}} A_t^{1-\alpha} a_t^{\nu} k_t^{\alpha} n_t^{-\alpha-\nu}.$$

As long as $\eta > 0$ and $x_t > 0$, a fall in the financial market inefficiency, x_t, expands the marginal product of labor.

The above mechanism can also be seen by looking at the total factor productivity (TFP) in the production of value added, $y_t - m_t$. By eliminating m_t from (1), the gross output production function can be written as

$$y_t = \left(\frac{\eta}{1+x_t}\right)^{\frac{\eta}{1-\eta}} A_t^{1-\alpha} a_t^{\nu} k_t^{\alpha} n_t^{1-\alpha-\nu}.$$

It follows that the production function for value added is

$$y_t - m_t = \left(1 - \frac{\eta}{1+x_t}\right)\left(\frac{\eta}{1+x_t}\right)^{\frac{\eta}{1-\eta}} A_t^{1-\alpha} a_t^{\nu} k_t^{\alpha} n_t^{1-\alpha-\nu}. \tag{14}$$

Then, TFP for the production of value added, $\tilde{A}(A_t, x_t)$, is defined as

$$\tilde{A}(A_t, x_t) \equiv \left(1 - \frac{\eta}{1+x_t}\right)\left(\frac{\eta}{1+x_t}\right)^{\frac{\eta}{1-\eta}} A_t^{1-\alpha}, \tag{15}$$

where $\partial\tilde{A}/\partial x < 0$ if $\eta, x_t > 0$. Thus, a fall in the financial market inefficiency increases TFP in the production of value added.[3]

Numerical experiments: Our numerical experiments follow Christiano, Motto, and Rostagno (2006). For $t \leq 0$, the economy is at the deterministic steady state, where the representative agent believes that there shall be no productivity shock at all in the future: $\epsilon_t = 0$ for all t. In period $t = 1$, however, the agent receives news that there will be a positive productivity shock at $t = T$: $\epsilon_T = \bar{\epsilon} > 0$. The agent is totally confident about the news, so that, for $t = 1, \ldots, T-1$, she believes that $\epsilon_T = \bar{\epsilon}$ with probability one. At $t = T$, however, the news may or may not turn out to be true, and both cases are considered. There is no productivity shock except possibly at $t = T$: $\epsilon_t = 0$ for $t \neq T$.

The unit of time is a quarter, and we set $T = 5$ so that the news received in period 1 says that the productivity shock occurs in a year later. The parameter values are set as follows: $\beta = .99$; $\gamma = 1.3$; $\sigma = .5$; $\delta = .025$; $\eta = .5$; $\alpha = .3$; $\nu = .03$; $\phi = 0$; $\psi = .1$; $\bar{\zeta} = 0$; $\rho = .95$; $\bar{\epsilon} = .0025$. Most of these values seem standard. As a benchmark, we consider the case where only land is used as collateral ($\phi = 0$), but including capital in the collateral ($\phi > 0$) does not change the main result. The value of ψ is chosen so that the collateral constraint binds tightly enough. With this value, the steady-state value of $x_t = \mu_t/\lambda_t$ is 0.085. For our story of news-driven cycles to work, the elasticity of intertemporal substitution (EIS), σ^{-1}, must be greater than one. This is because, if the EIS is less than one, a higher rate of productivity growth tends to reduce the value of land relative to output. Thus, in order for a future productivity shock to relax the collateral constraint, we need EIS to be greater than one. In our simulation, we set the EIS equal to two ($\sigma = 0.5$). Here, we'd like to stress that what matters in our model is a

[3]It is pointed out by Chari, Kehoe, and McGrattan (2004) that frictions in financing intermediate inputs are observed as changes in the TFP in a standard growth model. The same mechanism works in our model.

high EIS rather than a low risk aversion (there is nothing stochastic in our simulation), although our utility function does not distinguish them. Setting the EIS greater than one appears consistent with the empirical evidence: see, for instance, Mulligan (2002), Gruber (2006), and Vissing-Jorgensen and Attanasio (2003).

The model is first detrended by A_t, and then solved numerically by log-linearization using the method of Uhlig (1999). Figures 1-2 plot the dynamic responses of the economy to the news shock. They corresponds to the case where the news turns out to be wrong, and the case where it turns out to be correst, respectively.[4] Both figures show that the positive news shock raises output, consumption, investment, and labor for $t = 1, \dots, 4$. This comovement of the main macro variables can be understood by looking at the behavior of the Lagrange multipliers, λ_t and μ_t. When the news of a future increase in productivity arrives in period 1, the value of land held by the representative agent rises, and also her expected future wage rates go up. As a result, her marginal utility of wealth, λ_1, falls, and consumption increases. Other things being equal, it tends to reduce labor supply. Thanks to the collateral constraint, however, in our model, the higher land price relaxes the collateral constraint, and hence lowers μ_1 and $x_1 = \mu_1/\lambda_1$. As discussed above, a lower x_1 reduces the inefficiency in the factor markets, which increases both the wage rate, w_1, and the TFP. With this effect sufficiently strong, labor supply increases and so do output and investment.

Note that, as Figure 1 shows, if the news turns out to be false in period 5, the economy goes back to the initial steady state almost immediately. In particular, the level of output does not fall below the steady-state level. In this sense, we may say that false information does not create a recession in this model of collateral constraint. We shall see in Section 3 that in our second model, which is based on the costly state verification, the economy falls into a recession when the news turns out to be false.

[4]The plotted values are detrended ones. This is why variables such as value added, consumption, etc. decline for $t \geq 5$ in Figure 2, that is, in the case where the productivity shock does hit the economy in period five as the news has suggested.

2.2 Adjustment costs and Tobin's Q

In the previous work such as Jaimovich and Rebelo (2006) and Christiano, Motto and Rostagno (2006), a specific form of adjustment cost of investment is necessary to generate news-driven cycles. Following the terminology of Christiano, Motto and Rostagno (2006), the *level* specification of adjustment cost is

$$k_{t+1} = (1-\delta)k_t + i_t - H\left(\frac{i_t}{k_t}\right)k_t, \tag{16}$$

where

$$H(x) = \frac{\sigma_H}{2\delta}(x-\overline{x})^2.$$

Here $\overline{x}$ is the steady state level of i_t/k_t. The *flow* specification of adjustment cost is

$$k_{t+1} = (1-\delta)k_t + i_t - G\left(\frac{i_t}{i_{t-1}}\right)i_t, \tag{17}$$

where

$$G(x) = \frac{\sigma_G}{2}(x-\overline{x})^2.$$

Here $\overline{x}$ is the steady state level of i_t/i_{t-1}.

The models of Jaimovich and Rebelo (2006) and Christiano, Motto and Rostagno (2006) generate news-driven cycles with the flow specification (17), but not with the level specification (16) of adjustment cost. Furthermore, as discussed in detail by Christiano, Motto and Rostagno (2006), their model does not yield procyclical movement in Tobin's Q, which may not be consistent with the observation that stock prices fluctuate procyclically.[5] The model of Jaimovich and Rebelo (2006) has the same problem. In this section, we show that our model can generate news-driven cycles with both specifications of adjustment cost, and that Tobin's Q fluctuates procyclically in response to the news shock.

For the sake of simplicity, we continue to focus on the case where $\phi = 0$ in the collateral constraint (5).[6] Let $\lambda_{c,t}$, μ_t, and $\lambda_{k,t}$ be the Lagrange multipliers associated

[5]To make Tobin's Q procyclical, they augment their model with sticky prices and wages, and a certian form of monetary policy rule.

[6]If $\phi \neq 0$, the collateral constriant must be modified as $w_t\tilde{n}_t + m_t \leq \phi p_{k',t}k_t + \psi q_t a_t$.

with the flow budget constraint (6), the collateral constraint (5), and the law of motions of capital (16) or (17), respectively. Then Tobin's Q is defined as the (shadow) price of installed capital, $p_{k',t}$:

$$p_{k',t} = \frac{\lambda_{k,t}}{\lambda_{c,t}}.$$

Let us start with the level specification (16). The first-order condition for i_t implies the familiar relationship between the level of investment and Tobin's Q:

$$\frac{i_t}{k_t} = \delta + \frac{\delta}{\sigma_H}\frac{p_{k',t} - 1}{p_{k',t}}.$$

Thus, the investment-capital ratio is higher than the steady state value δ if and only if Tobin's Q is greater than unity. Letting $\hat{i}_t \equiv \ln(i_t/A_t)$, $\hat{k}_t \equiv \ln(k_t/A_{t-1})$, $\hat{p}_{k',t} \equiv \ln p_{k',t}$, its log-linear approximation is written as

$$\hat{i}_t = \frac{1}{\sigma_H}\hat{p}_{k',t} + \hat{k}_t - \zeta_t,$$

where $\zeta_t = \ln A_t - \ln A_{t-1}$. Hence, with this specification, procyclical investment implies procyclical Tobin's Q.

As a benchmark, we set $\sigma_H = 1$, that is, the elasticity of investment with respect to Tobin's Q is unity, which is consistent with the empirical evidence. The other parameter values are the same as those used for Figure 1. Figure 3 shows the impulse responses to the same news shock as in Figure 1, where the news turns out to be false. The news shock increases Tobin's Q, as well as other macroeconomic variables. It is worth noting that introducing the adjustment cost of investment enlarges the set of parameter values that are consistent with news-driven cycles. For instance, the EIS, σ^{-1}, can be made very close to unity. Figure 4 plots the result when $\sigma = 0.9$. The effects of the news shock are smaller compared to the benchmark case of $\sigma = 0.5$, but we still obtain comovements of the variables of interest.

With the flow specification (17), the relationship between the level of investment and Tobin's Q becomes less clear. The first-order condition for i_t is written as

$$p_{k',t}\left[1 - G\left(\frac{i_t}{i_{t-1}}\right) - G'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + \beta p_{k',t+1} G'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2 = 1$$

We set $\sigma_G = 15.1$ folloging Christiano, Motto, and Rostagno (2006). The other parameter values are the same as before. Figure 5 plots the impulse responses to the news shock. Again, the model is successful in generating comovements, including Tobin's Q.

Our success in reproducing procyclical Tobin's Q may be explained as follows: Loosening of the collateral constraint increases labor and intermediate inputs, leading to an increase in the marginal product of capital. Therefore, capital becomes more valuable, implying higher Tobin's Q. On the other hand, in Christiano, Motto, and Rostagno's (2006) model and in Jaimovich and Rebelo's (2006) model, when the good news arrives, agents anticipate that they need to pay a large amount of adjustment costs during transition to the new steady state; thus, agents increase investment today to reduce the adjustment cost that they must pay in the future; and the increase in investment makes capital more abundant and cheeper today. Christiano et al. needs to introduce sticky prices and a Taylor-type monetary policy rule in order to generate the procyclicality in the price of capital. We do not need such a complication in the model to explain capital prices. Policy implications are quite different: On one hand, Christiano et al. conclude that the news-driven cycle, if it exists at all, should be caused by a mechanical conduct of monetary policy and therefore the central bank is to be blamed; and on the other hand, our model implies that the news-driven cycle may be an inevitable feature of the economy in which agents are subject to collateral constraints.

3 Model 2: Costly state verification

In this section we consider a version of the costly-state-verification model due to Carlstrom and Fuerst (1997, 1998). Specifically, we augment Carlstrom and Fuerst's (1998) model with land, and assume that only land can be used as collateral in the debt contract. The key difference from the first model is that the second model has two types of agents: households (lenders) and entrepreneurs (borrowers). We first show that this two-agent model can also reproduce news-driven cycles, and that with the level specification of the adjustment cost, it can reproduce procyclicality of Tobin's Q. The basic mechanism that generates this result is the same as in the first model. In our second model, however, when the news of a future increase in productivity turns out to be wrong, the economy falls into a recession (the level of output falls below the steady state level). This feature is absent in our first model, as well as in the models of Christiano, Motto and Rostagno (2006) and Jaimovich and Rebelo (2006).[7]

The economy consists of a representative household and a continuum of entrepreneurs with unit mass. The household consumes, supplies labor, accumulates capital, holds land, and lends to entrepreneurs. An entrepreneur produces output under idiosyncratic risk, holds land, and borrows from the household.

Household: The household maximizes (7) subject to the flow budget constraint:

$$c_t + i_t + q_t a_t = w_t n_t + r_{k,t} k_t + (q_t + r_{a,t}) a_t + (R_t - 1) b_t, \tag{18}$$

and the law of motion for capital accumulation, either (17) or (16), where $r_{k,t}$ and $r_{a,t}$ are the rental rates of capital and land, respectively, and $(R_t - 1)b_t$ is the return on intra-period loans, b_t, to entrepreneurs. Although entrepreneurs are subject to idiosyncratic risk, the loans to them are intermediated through a mutual fund so that the household faces no risk. Since the loans are made within period, $R_t = 1$ must hold in equilibrium. Thus, the household becomes indifferent to b_t in the equilibrium.

Let $\lambda_{c,t}$ and $\lambda_{k,t}$ be the Lagrange multipliers associated with the flow budget constraint (18) and the law of motion of capitla accumulation (17) or (16), respectively. Then Tobin's Q, $p_{k',t}$, is defined as

$$p_{k',t} \equiv \frac{\lambda_{k,t}}{\lambda_{c,t}}.$$

Entrepreneurs: Entrepreneurs are indexed by $i \in [0, 1]$. We assume that only land can be used as collateral in the debt contract. As a result, entrepreneurs do not hold physical capital. Entrepreneur i holds land, $a'_t(i)$, at the beginning of period t, produces output, $y_t(i)$, and then determines consumption, $c'_t(i)$, and land holdings, $a'_{t+1}(i)$. Entrepreneurs

[7]Note that the original model of Carlstrom and Fuerst (1998) does not generate news-driven cycles. The success of our model in this respect is due to the introduction of an asset in fixed supply (land) in the debt contract.

faces an idiosyncratic productivity shock in producing output. Specifically, entrepreneur i produces $y_t(i)$, employing intermediate input, $m_t(i)$, land services, $\tilde{a}_t(i)$, capital services, $k_t(i)$, and labor input, $n_t(i)$, under an idiosyncratic shock, $\omega_t(i)$, using the following production technology:

$$y_t(i) = \omega_t(i)F[A_t, m_t(i), \tilde{a}_t(i), k_t(i), n_t(i)], \tag{19}$$

where

$$F(A, m, a, k, n) = A^{(1-\eta)(1-\alpha)}m^{\eta}a^{(1-\eta)\nu}k^{(1-\eta)\alpha}n^{(1-\eta)(1-\alpha-\nu)}.$$

The idiosyncratic shock $\omega_t(i)$ is private information; it is i.i.d. across agents and across time; its probability distribution and density function are denoted by $\Phi(\omega)$ and $\phi(\omega)$, respectively; its mean is unity, and its standard deviation is denoted by σ_ω. Note that $\tilde{a}_t(i) \neq a'_t(i)$, in general. If $\tilde{a}_t(i) > a'_t(i)$, entrepreneur i rents $\tilde{a}_t(i) - a'_t(i)$ from another entrepreneur or the household; and if $\tilde{a}_t(i) < a'_t(i)$, he rent $a'_t(i) - \tilde{a}_t(i)$ to another entrepreneur.

The quantities of inputs, $m_t(i)$, $\tilde{a}_t(i)$, $k_t(i)$, $n_t(i)$, are determined prior to the realization of $\omega_t(i)$. Therefore, the input costs, $s_t(i) \equiv m_t(i) + w_t n_t(i) + r_{k,t}k_t(i) + r_{a,t}\tilde{a}_t(i)$, must be paid in advance. Cost minimization and the Cobb-Douglas technology leads to the following first-order conditions:

$$\begin{aligned} w_t n_t(i) &= (1-\eta)(1-\alpha-\nu)s_t(i), \\ r_{k,t}k_t(i) &= (1-\eta)\alpha s_t(i), \\ r_{a,t}\tilde{a}_t(i) &= (1-\eta)\nu s_t(i), \\ m_t(i) &= \eta s_t(i). \end{aligned}$$

Let $e_t(i)$ be the net worth of entrepreneur i. Since the only asset that entrepreneur i holds at the beginning of period t is $a'_t(i)$, her net worth is given by

$$e_t(i) = (q_t + r_{a,t})a'_t(i).$$

Since $s_t(i)$ must be paid in advance, entrepreneur i needs to borrow $s_t(i) - e_t(i)$ from the household. Let p_t be the markup rate, that is, a project of size $s_t(i)$ yields gross return

$p_t s_t(i)\omega_t(i)$. Let $\mu p_t s_t(i)$ be the cost of monitoring a project of size $s_t(i)$. As discussed by Carlstrom and Fuerst (1997, 1998), given $\{p_t, e_t(i)\}$, the optimal debt contract is described by $\{s_t(i), \overline{\omega}_t\}$. Here, the borrower with net worth $e_t(i)$ conducts a project of size $s_t(i)$, and pays back to the lender $p_t s_t(i)\overline{\omega}_t$ as long as $\omega_t(i) \geq \overline{\omega}_t$. If $\omega_t(i) < \overline{\omega}_t$, then the borrower goes default, and pays back only $p_t s_t(i)\omega_t(i) < p_t s_t(i)\overline{\omega}_t$. Thus $\Phi(\overline{\omega}_t)$ equals the fraction of entrepreneurs who go default. As shown in Appendix, the optimal debt contract $\{s_t(i), \overline{\omega}_t\}$ is determined as

$$s_t(i) = \frac{e_t(i)}{1 - p_t g(\overline{\omega}_t)},$$
$$\frac{1}{p_t} = 1 - \Phi(\overline{\omega}_t)\mu + \phi(\overline{\omega}_t)\mu \frac{f(\overline{\omega}_t)}{f'(\overline{\omega}_t)},$$

where $f(\omega)$ and $g(\omega)$ are the functions defined in Appendix.

Given $\{p_t, \overline{\omega}_t\}$, entrepreneur i chooses $\{c'_t(i)\}$ and $\{a'_{t+1}(i)\}$ to maximize his utility:

$$E_0 \sum_{t=0}^{\infty} (\beta')^t c'_t(i),$$

subject to the flow budget constraint:

$$c'_t(i) + q_t a'_{t+1}(i) = p_t s_t(i) \max\{\omega_t(i) - \overline{\omega}_t, 0\},$$

where $s_t(i) = \frac{(q_t + r_{a,t})a'_t(i)}{1 - p_t g(\overline{\omega}_t)}$. We assume that $\beta' < \beta$ to ensure that entrepreneurs are borrowing constrained in equilibrium.[8]

Because of the linearity in the entrepreneurs' utility and the debt contract, the entrepreneur sector is easily aggregated by integration over i. Let z_t denotes the aggregate variable of $z_t(i)$ for $z_t(i) = s_t(i), c'_t(i), a'_t(i)$, etc. The aggregate variables solve

$$\max E_0 \sum_{t=0}^{\infty} (\beta')^t c'_t, \tag{20}$$

[8]Strictly speaking, we need to prevent the possibility that the net worth of each entrepreneur becomes zero. For that sake, Carlstrom and Fuerst (1997) assume that entrepreneurs supply labor. Here, however, for simplicity, we follow Carlstrom and Fuerst (1998) and consider the limiting case where entrepreneurs' labor income is approximately zero. Explicit consideration of entrepreneurs' labor does not change our result.

subject to

$$c'_t + q_t a'_{t+1} = p_t s_t f(\overline{\omega}_t), \tag{21}$$

where

$$s_t = \frac{(q_t + r_{a,t})a'_t}{1 - p_t g(\overline{\omega}_t)}, \tag{22}$$

$$\frac{1}{p_t} = 1 - \Phi(\overline{\omega}_t)\mu + \phi(\overline{\omega}_t)\mu \frac{f(\overline{\omega}_t)}{f'(\overline{\omega}_t)}. \tag{23}$$

The total output produced is

$$y_t = A_t^{(1-\eta)(1-\alpha)} m_t^{\eta} \tilde{a}_t^{(1-\eta)\nu} k_t^{(1-\eta)\alpha} n_t^{(1-\eta)(1-\alpha-\nu)}. \tag{24}$$

Since the price of output is unity (numeraire), p_t is the mark-up rate:

$$y_t = p_t s_t. \tag{25}$$

The market clearing conditions are

$$c_t + c'_t + i_t + m_t = [1 - \Phi(\overline{\omega}_t)\mu] y_t, \tag{26}$$

$$\tilde{a}_t = 1. \tag{27}$$

The factor market equilibrium conditions are given by:

$$w_t n_t = (1-\eta)(1-\alpha-\nu)s_t, \tag{28}$$

$$r_{k,t} k_t = (1-\eta)\alpha s_t, \tag{29}$$

$$r_{a,t} \tilde{a}_t = (1-\eta)\nu s_t, \tag{30}$$

$$m_t = \eta s_t. \tag{31}$$

Equilibrium: The equilibirum dynamics of this economy are determined by the solution to the household's problem, i.e., maximization of (7) subject to (18) and either (17) or (16); the aggregate entrepreneurs' problem, (20)–(23); and the conditions (24)–(31).[9]

[9]The total amount of loans from the household to entrepreneurs is given by $b_t = s_t - (q_t + r_{a,t})a'_t$, though it is irrelevant to the dynamics.

The financial-market inefficiency and the factor-market inefficiency: As in the first model, a crucial feature of this model is the interaction between the inefficiencies in the financial market and in the factor market. The inefficiency in the factor market is measured by the mark up rate, p_t, which is the wedge between the marginal products and the input prices. For instance, it follows from (25) and (28) that the marginal product of labor equals p_t times the wage rate:

$$(1-\eta)(1-\alpha-\nu)\frac{y_t}{n_t} = p_t w_t;$$

and similar conditions hold for the other inputs.

The financial-market inefficiency may be measured by $\overline{\omega}_t$, which is the threshold value for default. Equation (23) implies that $p_t = p(\overline{\omega}_t)$ is an increasing function of $\overline{\omega}_t$, that is, an increase in the financial market inefficiency will raise the factor market inefficiency. In addition, the definition of $g(\overline{\omega}_t)$ in Appendix implies that $p(\overline{\omega}_t)g(\overline{\omega}_t)$ is an increasing function of $\overline{\omega}_t$. It follows from (22) that, other things being equal, a higher land price, q_t, lowers the financial market inefficiency $\overline{\omega}_t$. Therefore, this model has the same mechanism as the first one: a higher land price q_t tends to reduce the financial market inefficiency $\overline{\omega}_t$, which, in turn, decreases the factor-market inefficiency p_t. This is the basic mechanism that generates news-driven cycles.

Similarly, as in the first model, the requirement of intermediate inputs, m_t, implies that the (observed) TFP depends negatively on the inefficiency of the financial market. The value added in this economy is given by $[1-\Phi(\overline{\omega}_t)\mu]y_t - m_t$. Then, define the TFP in this economy, $\tilde{A}(A_t, p_t, \overline{\omega}_t)$, as

$$[1-\Phi(\overline{\omega}_t)\mu]y_t - m_t = \tilde{A}(A_t, p_t, \overline{\omega}_t)\tilde{a}_t^{\nu} k_t^{\alpha} n_t^{1-\alpha-\nu}. \tag{32}$$

Equations (24), (25), (31), and (32) imply that

$$\tilde{A}(A_t, p_t, \overline{\omega}_t) \equiv \left[1-\Phi(\overline{\omega}_t)\mu - \frac{\eta}{p_t}\right]\left(\frac{\eta}{p_t}\right)^{\frac{\eta}{1-\eta}} A_t^{1-\alpha}. \tag{33}$$

Because of the monitoring cost, the financial market inefficiency $\overline{\omega}_t$ directly affects the TFP through the term $\Phi(\overline{\omega}_t)\mu$. But the negative dependence of $\tilde{A}_t$ on p_t is based on the same mechanism as we have seen in (15). Hence, the TFP is, again, a decreasing function of the financial-market inefficiency, $\overline{\omega}_t$. As a result, other things being equal, a higher land price, q_t, tends to increase the TFP. Although $\eta > 0$ is not necessary to generate news-driven cycles, it reinforces the mechanism that drives news-driven cycles.

Numerical experiments: We conduct the same experiments as those in Section 2: At $t = 1$, the agents receive a signal that $\epsilon_T = \overline{\epsilon} > 0$, which turns out to be true or false at $t = T$. The parameter values are set as follows: $\beta = .99$; $\beta' = \beta * .973$; $\sigma = .5$; $\gamma = 1.3$; $\eta = .5$; $\nu = .03$; $\alpha = .3$; $\delta = .025$; $\sigma_H = 1$; $\sigma_G = 15.1$; $\sigma_\omega = .37$; $\mu = .15$; $\rho = .95$; $\overline{\epsilon} = .0025$; and $T = 5$. Here, the values for β', σ_ω and μ are taken from Carlstrom and Fuerst (1998). The rest are the same as in Section 2.2.

Here we report the case where the news turns out to be wrong at $t = T$. The results for the level specification model (16) and for the flow specification model (17) are shown in Figures 6 and 7, respectively. Just as in the representative-agent model of Section 2.2, the news of a future productivity increase brings about a boom in periods $t = 1, \dots, T - 1$. Aggregate consumption, value added, investment, and labor all rise during these periods.[10] The measured TFP also rises for $t = 1, \dots, T-1$. The mechanism that the news shock produces the boom is the same as in the previous model. Tobin's Q rises with the level specification of adjustment cost, while it does not with the flow specification.

What is notable in the second model is what happens when the news turns out to be wrong in period $t = T$. In the previous model with a representative household, when the news turns out to be wrong in period $t = T$, the economy essentially jumps back to the initial steady state, although there are some transitional dynamics (see Figures 1, 3, 5). In particular, the wrong news does not cause the economy to fall into a recession (the economic activity does not fall below the steady state level). That is not true in

[10]The aggregate consumption is the sum of the household's consumption and the entrepreneurs' consumption. As can be inferred from the dynamics of $\lambda_{c,t}$, the household's consumption slightly declines for $t = 1, \dots, T - 1$. The aggregate consumption rises because the entrepreneurs' consumption increases by amounts that are more than offsetting the declines in the household's consumption.

our second model. In period $t = T$, when the news turns out to be false, value added, consumption, and labor supply get lower than their steady state levels.

What causes this remarkable difference is the fact that there are two types of agents in the second model: borrowers and lenders. Look at the dynamics of the share of land held by entrepreneurs, $\{a'_{t+1}\}$ (note that in the figures, the plotted value of a' at t is a'_{t+1}, rather than a'_t). When the good news hits the economy in period $t = 1$, entreprenrus sell their land to households so that a'_2 is lower than the steady state level, $\overline{a}'$, which is reflected in the sharp decline in a' occuring at $t = 1$ in Figures 6 and 7. Enrepreneurs sell their land in period 1, because, given the increase in the land price caused by the good news, entrepreneurs need less land to achieve their desired level of net worth (or collateral). So the share of land held by entrepreneurs becomes lower than the steady state level as long as the price of land is higher than its steady state level. It follows that, when the news turns out to be wrong in period T, the share of land held by entrepreneurs at the beginning of period T is lower than the steady state value: $a'_T < \overline{a}'$. The enrepreneurs' borrowing constraint (22) and the markup equation (25) imply that, at $t = T$, gross output equals:

$$y_T = \frac{p(\overline{\omega}_T)}{1 - p(\overline{\omega}_T)g(\overline{\omega}_T)}(q_T + r_{a,T})a'_T$$

Here, $p(\overline{\omega})/(1 - p(\overline{\omega})g(\overline{\omega}))$ is increasing in $\overline{\omega}$. Since at this point our agents realize that the productivity increase does not happen, the land price goes back to the steady state value: $q_T \approx \bar{q}$. Then, the fact that entreprenerus hold a share of land which is less than the steady state level, $a'_T < \overline{a}'$, implies that the financial market inefficiency gets higher, $\overline{\omega}_T > \overline{\omega}$, which, in turn, raises the factor market inefficiency, p_T. As a result, the economy falls into a recession in period $t = T$, as the figures show. Note also that the countercyclicality in $\overline{\omega}_t$ in the figures can be interpreted as the countercyclicality in bankruptcies, which seems realistic but is not reproduced in the original models of Carlstrom and Fuerst (1997, 1998).

4 Conclusion

The boom-bust cycles such as the episode of the "Internet bubble" in the late 1990s may be described as the business cycle driven by changes in expectations or news about the future. We have seen that such news-driven cycles can be reproduced by models with collateral constraint. Key assumptions are that an asset with fixed supply ("land") is used as collateral, and that firms are collateral constrained to finance the input costs. The first assumption is to ensure that the price of a collateralized asset fluctuates enough in response to news about future productivity growth. The second assumption is to introduce an interaction between the financial market inefficiency and the labor market inefficiency.

We start with a simple model of collateral constraint with a representative household. In this model, news of a future productivity increase generates a boom today as follows. The news raises the price of land today, which relaxes the collateral constraint. Since the input finance is collateral constrained, the relaxation of the collateral constraint reduces the inefficiency in the labor market (the gap between the wage rate and the marginal product of labor becomes lower). It shifts the labor demand curve outward. If this force is sufficiently strong, it offsets the wealth effect on the labor supply schedule, and the equilibrium labor supply increases. So do output and investment. Consumption increases because the wealth effect of the good news. With augmented by adjustment cost of investment, the model also generates procyclical movement in Tobin's Q.

We then consider a version of Carlstrom and Fuerst's (1998) model, which has two types of agents: households (lender) and entrepreneurs (borrowers). Having two types of agents brings about a new feature. In the representative-household model, when the news actually turns out to be false, the economy essentially jumps back to the initial steady state, although there are some transitional dynamics. In particular, false information does not cause a recession: the level of output does not get lower than the steady state level. In our second model with two types of agents, however, if the information turns out to be wrong, the economy falls into a recession. This is because, when the good news arrives, the price of the collateral asset increases, and hence entrepreneurs need a less share of land to achieve the desired value of collateral. Hence, in response to the good news about future, entrepreneurs sell their land. When the news turns out to be wrong, the land price essentially goes back to its steady state level. However, since the share of land held by entrepreneurs is lower than the steady state level, the value of their collateral is lower than the steady state level. It follows that the financial constraint becomes tighter, which increases the labor market inefficiency, and reduces labor, output, and consumption.

In comparison with the existing models of the news-driven cycles, our collateral constraint models are simpler and exhibit more realistic performance. Collateral constraint on input finance by a fixed-supply asset may be a good ingredient to develop a comprehensive theory of the business cycles from a point of the "News" view (Beaudry and Portier [2005]).

5 Appendix

Following Carlstrom and Fuerst (1998), we derive the optimal contract for intra-period debt for an entrepreneur that faces an idiosyncratic risk.

We consider an entrepreneur with his own fund x. If he undertakes a project of size s, it generates stochastic return $p\omega s$ units of output, where p is a constant that represents the market rate of mark-up, and ω is a unit-mean iid random variable. The probability distribution of ω is $\Phi(\omega)$ and the probability density is $\phi(\omega)$. The entrepreneur must borrow $s - x$ from the household, while ω is private information for the entrepreneur. The lender must pay μps to monitor the outcome of the project, where μ is a constant.

As Carlstrom and Fuerst (1998) argue briefly, it is well known that in this costly-state-verification setting, the optimal financial contract is a risky debt. Given (p, x), the optimal contract is characterized by $(s, \overline{\omega})$, where s is the size of the project, i.e., the size of the borrowing is $s - x$; and the amount that the borrower repay is

$$ps \times \min\{\omega, \overline{\omega}\}. \tag{34}$$

$\overline{\omega}$ can be viewed as the threshold value for default: The lender will monitor the project outcome if and only if the entrepreneur reports that ω is less than $\overline{\omega}$; and in such a case the lender will confiscate all the returns from the project, $ps\omega$.

Define $f(\overline{\omega})$ and $g(\overline{\omega})$ as the expected shares of output for the entrepreneur and the lender, respectively:

$$f(\overline{\omega}) \equiv \int_0^\infty (\omega - \min\{\omega, \overline{\omega}\})\, \Phi(d\omega), \tag{35}$$

$$g(\overline{\omega}) \equiv \int_0^\infty \min\{\omega, \overline{\omega}\} \Phi(d\omega) - \Phi(\overline{\omega})\mu. \tag{36}$$

We assume that lending is fully diversified across projects, so that the lender only cares about the expected rate of return, and that borrowing and lending are intra-period, so that the equilibrium rate of return is unity. Under these assumptions, the optimal contract $(s, \overline{\omega})$ is determined as the solution to the following problem, given (p, x):

$$\max_{s,\overline{\omega}} psf(\overline{\omega}) \ \text{ s.t. } psg(\overline{\omega}) \geq (s - x). \tag{37}$$

The solution is (implicitly) given as

$$\frac{1}{p} = 1 - \Phi(\overline{\omega})\mu + \phi(\overline{\omega})\mu \frac{f(\overline{\omega})}{f'(\overline{\omega})}, \tag{38}$$

$$s = \frac{1}{1 - pg(\overline{\omega})} x. \tag{39}$$

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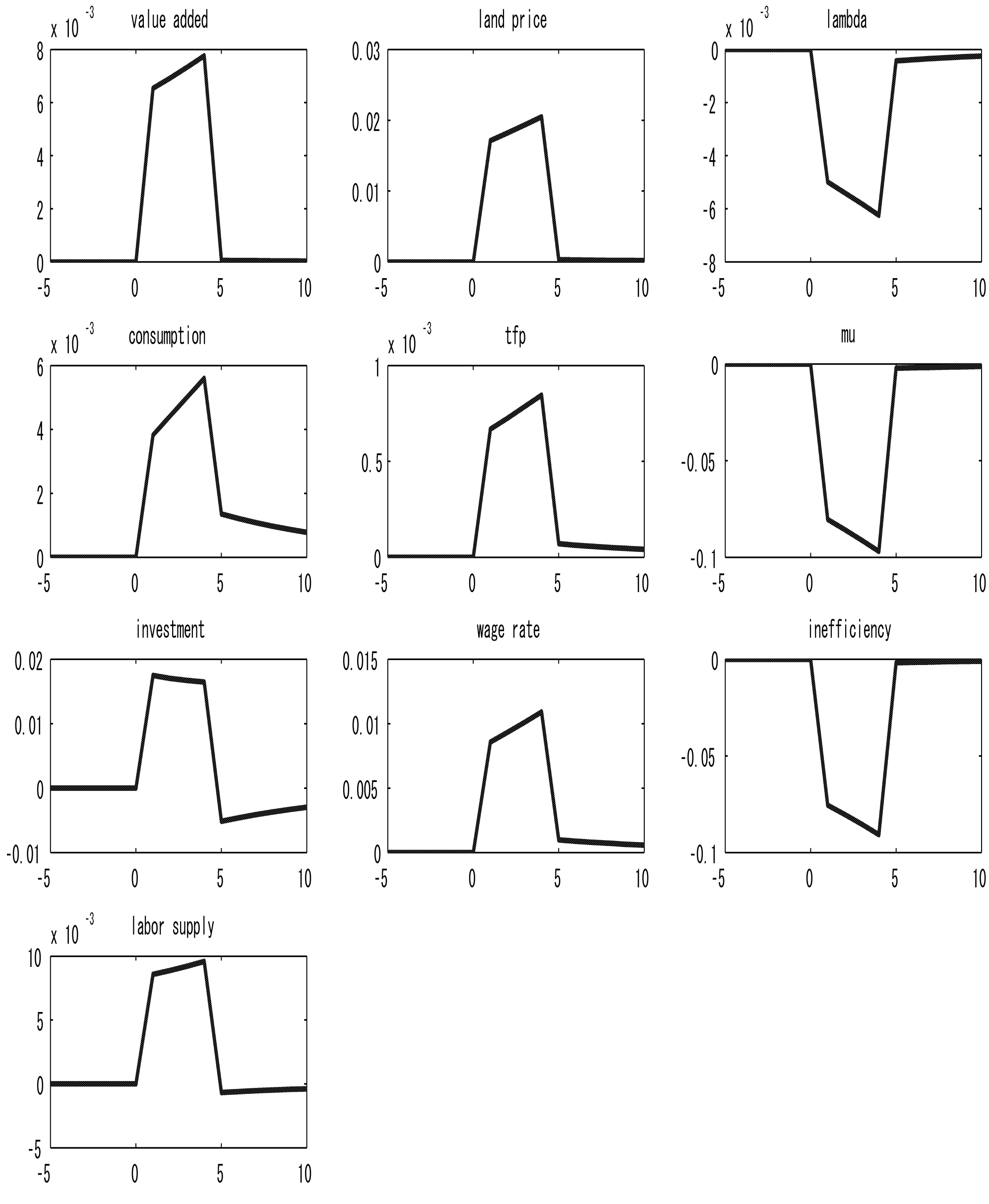

Figure 1: Model 1: The case where the news turns out to be false.

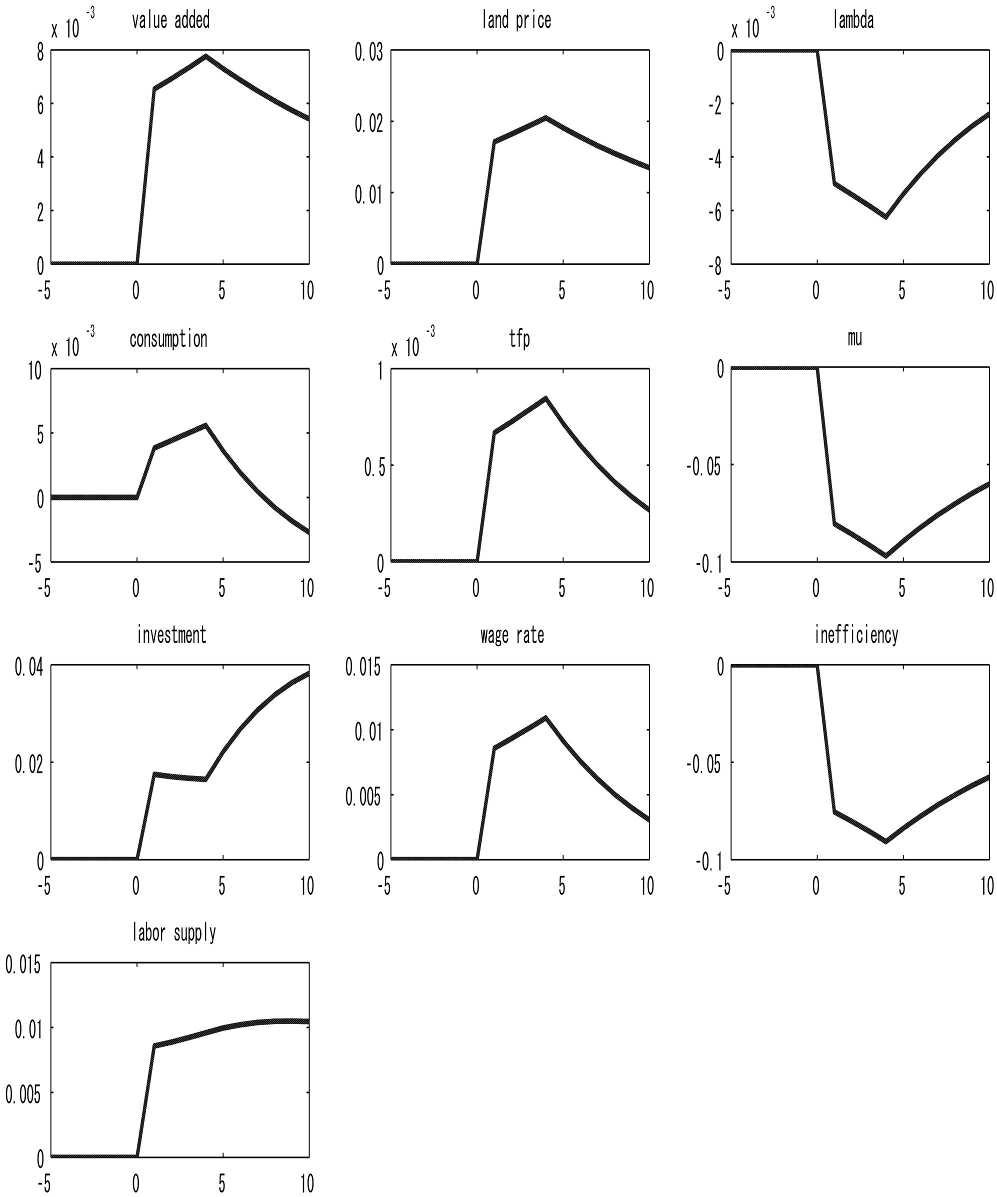

Figure 2: Model 1: The case where the news turns out to be correct.

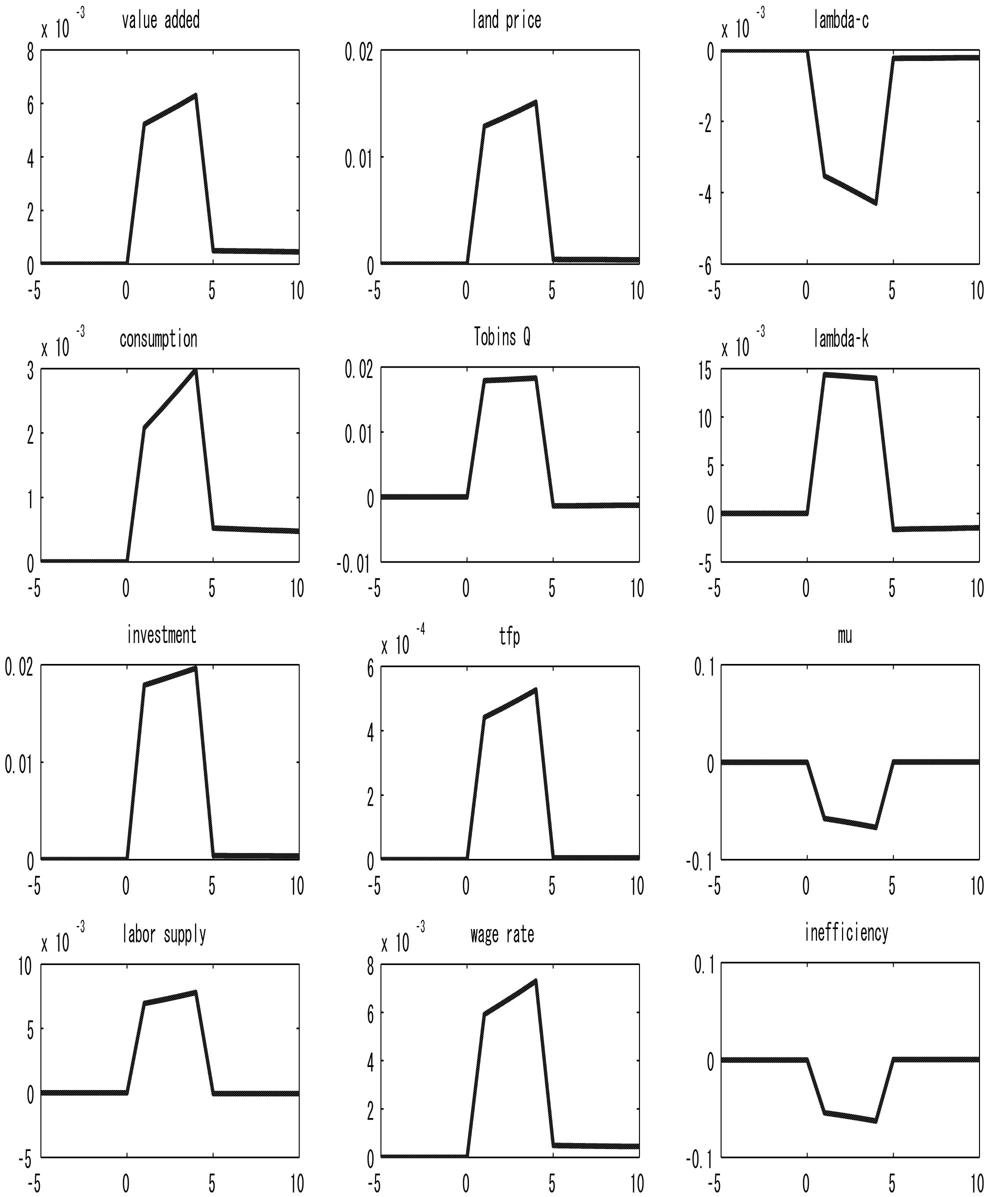

Figure 3: Model 1 with the level specification of adjustment cost: The case where the news turns out to be false.

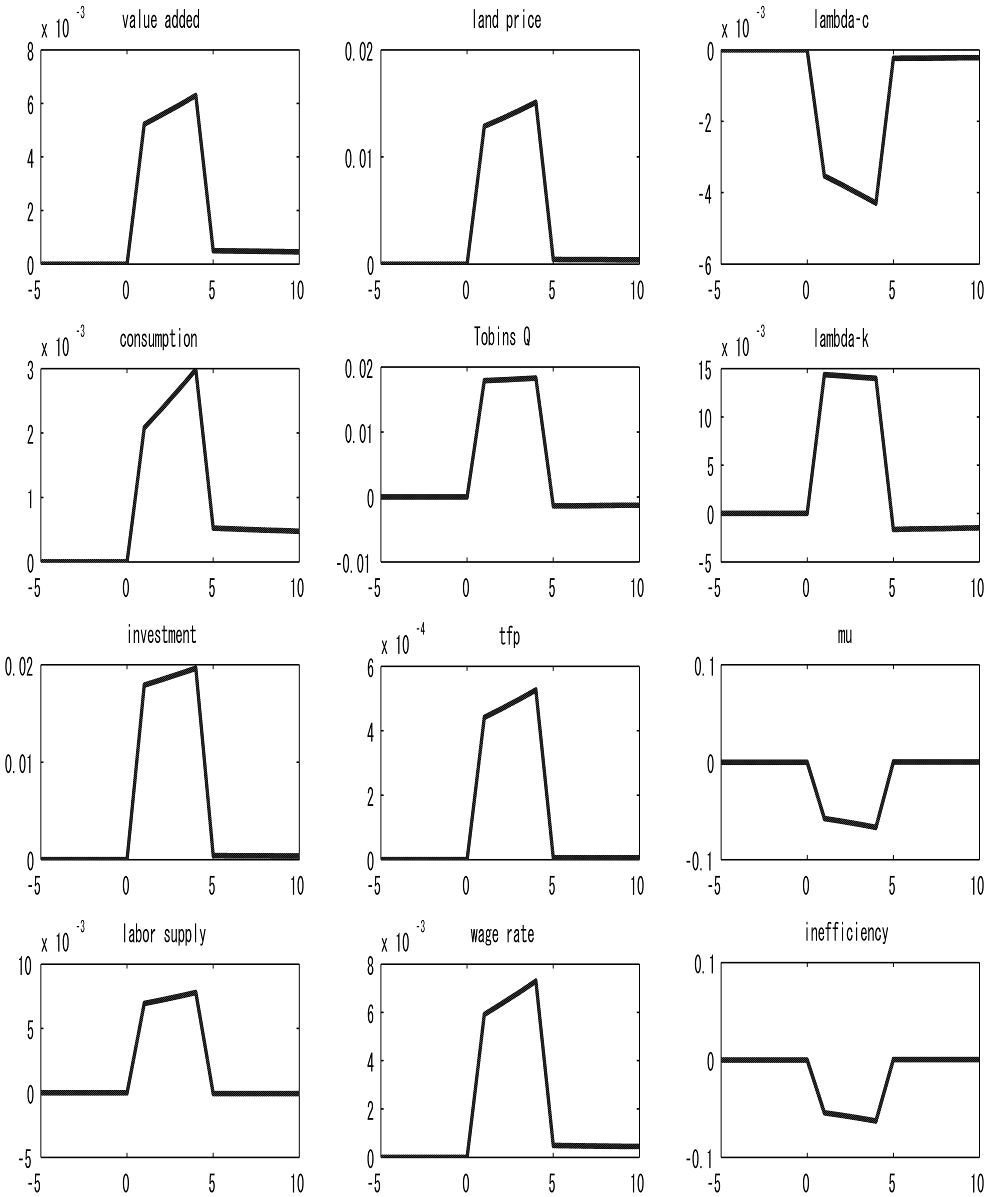

Figure 4: Model 1 with the level specification of adjustment cost and $\sigma = 0.9$: The case where the news turns out to be false.

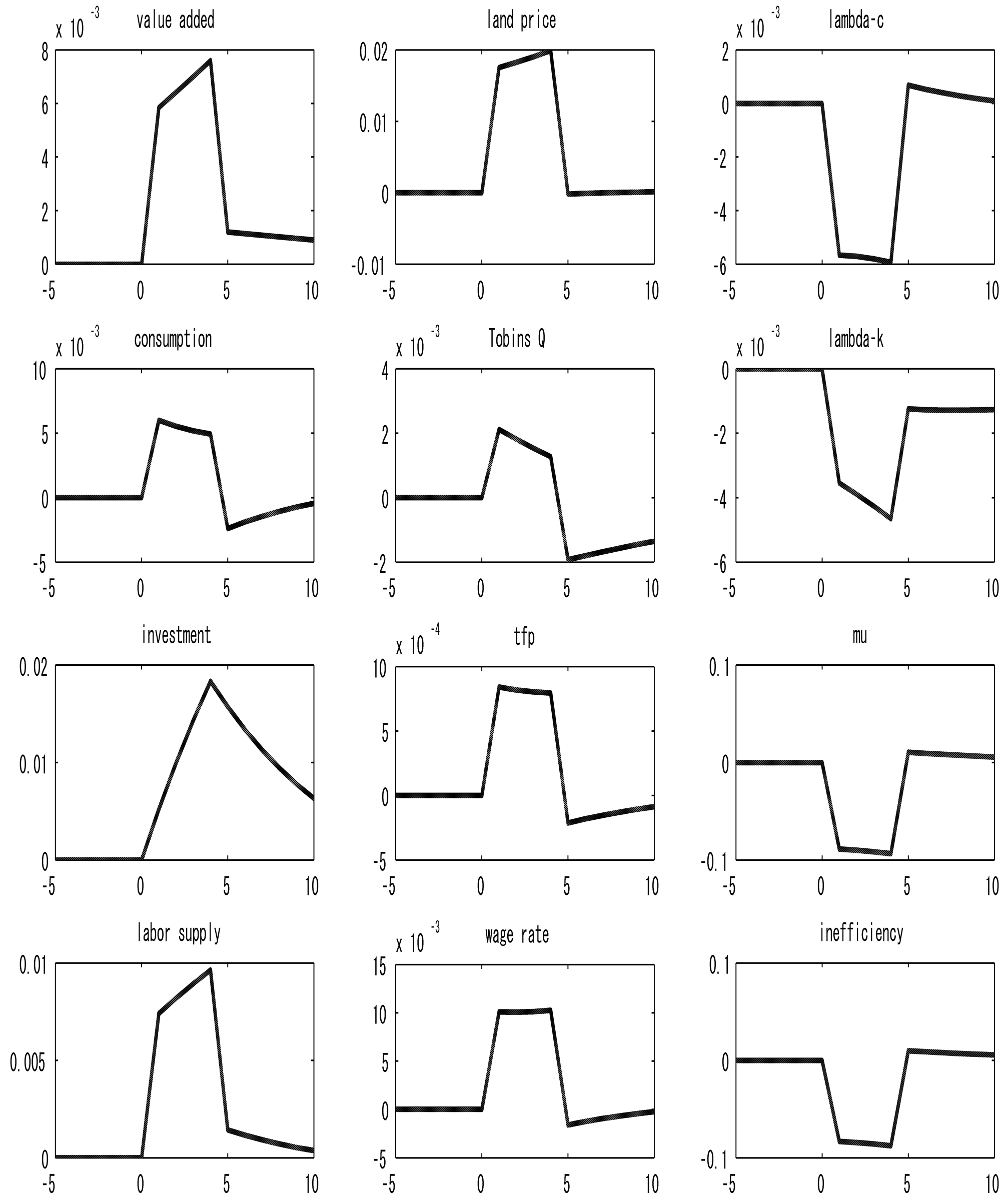

Figure 5: Model 1 with the flow specification of adjustment cost: The case where the news turns out to be false.

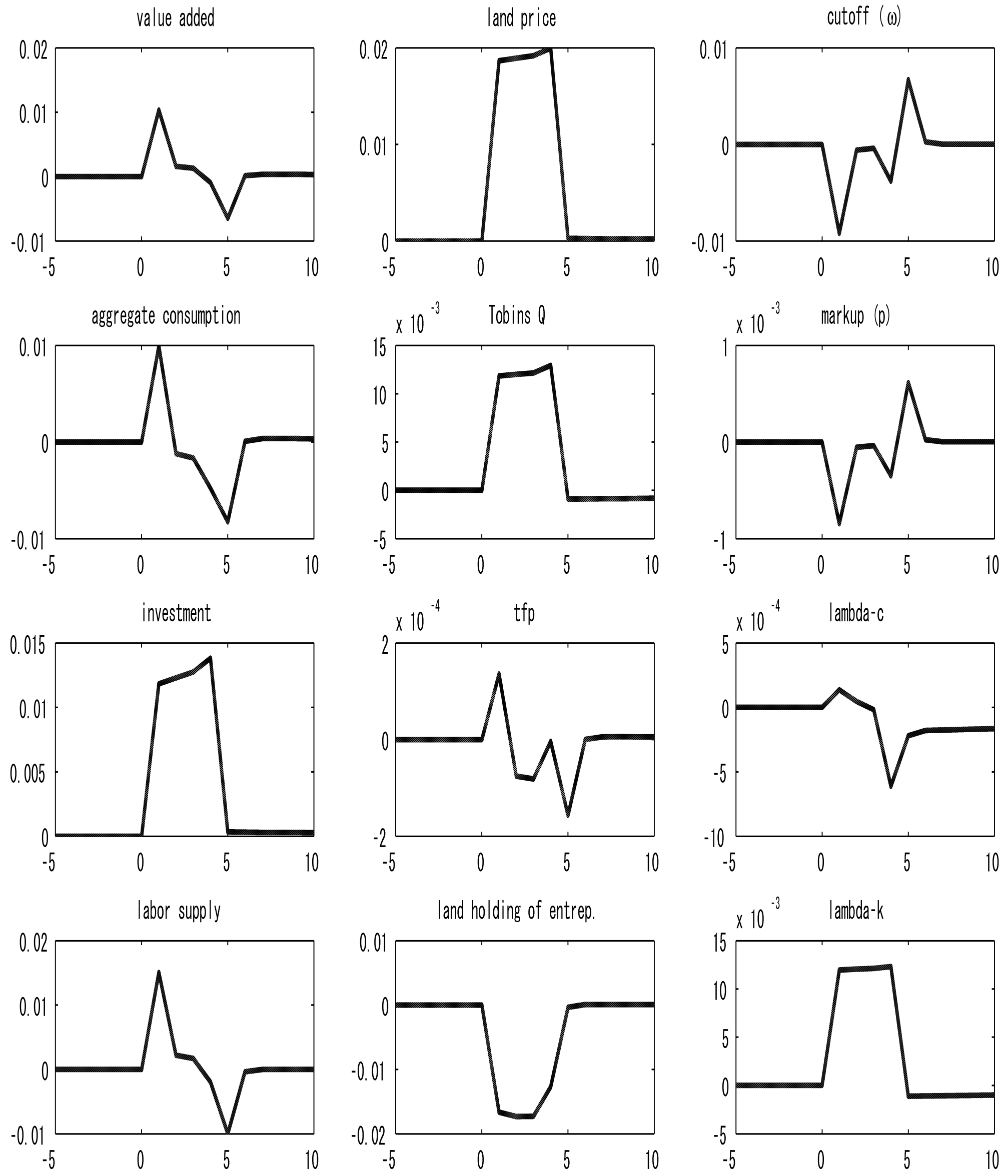

Figure 6: Model 2 with the level specification of adjustment cost: The case where the news turns out to be false.

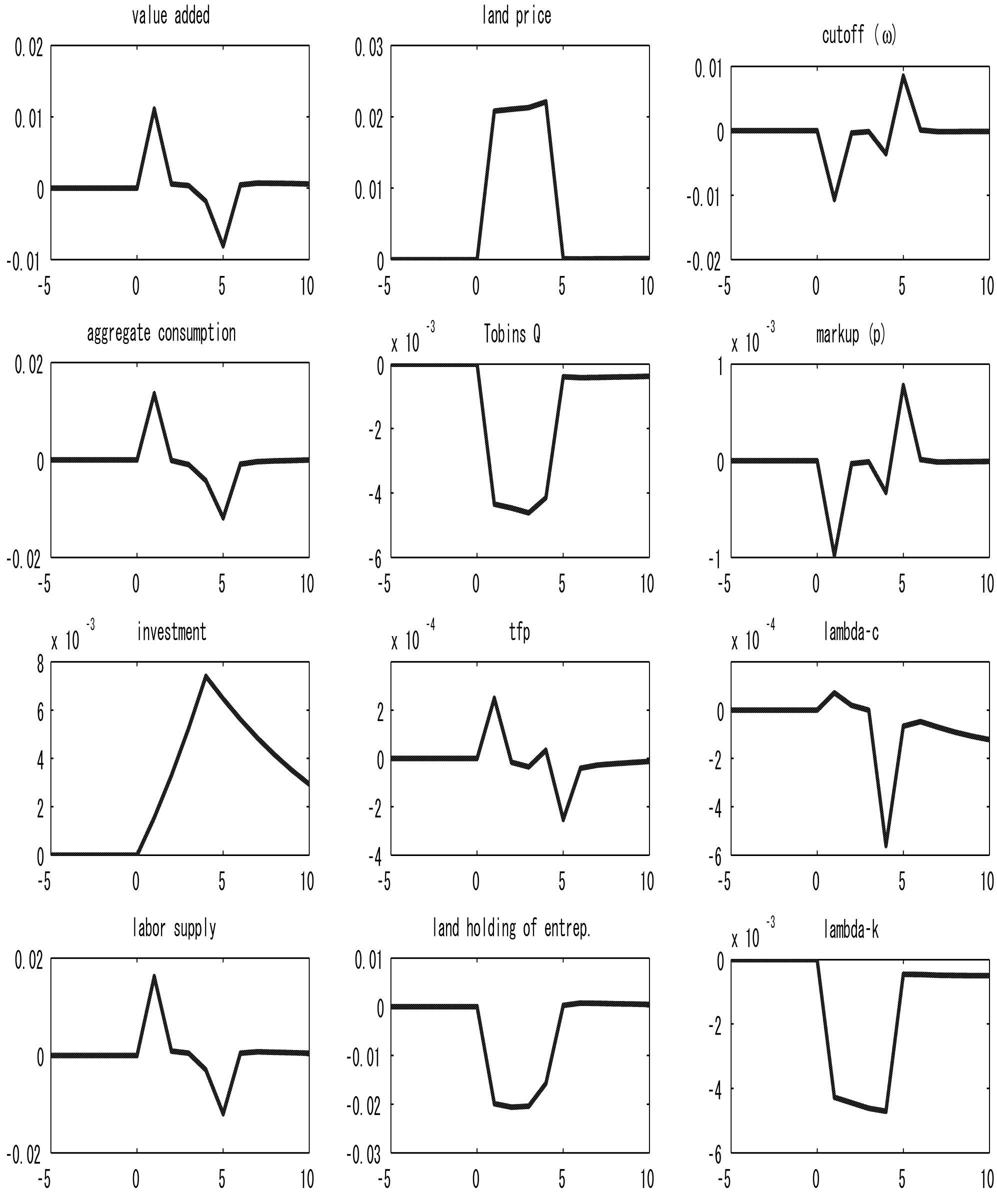

Figure 7: Model 2 with the flow specification of adjustment cost: The case where the news turns out to be false.