News and Business Cycles in Open Economies

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1. Introduction

A key property of business cycle data is the presence of strong comovement among the major macroeconomic variables. Output, consumption, investment, and hours worked are highly correlated at business cycle frequencies. Comovement among these variables arises naturally in versions of the neoclassical model that are driven by contemporaneous shocks to productivity (Kydland and Prescott (1982), Barro and King (1984)). In contrast, the neoclassical model fails to generate comovement in response to news about future total factor productivity (TFP).[1] Good news about future TFP has a positive wealth effect that leads to a rise in consumption and leisure. Hours worked fall so output declines. Since consumption rises and output falls, investment also falls.[2]

News shocks are interesting to us for two reasons. First, new technologies are likely to be an important source of changes in productivity. And since technologies take time to diffuse, agents are likely to receive advance news about future productivity. Second, news shocks are similar to autonomous changes in agents' expectations about the future, which we think are worth exploring as impulses to the business cycle. These changes, which play an important role in the early business cycle literature (see Harberler (1937)), have recently received attention only in the context of multiple equilibrium models.

In this paper we compare a small-open economy that can borrow and lend in international capital markets with a closed economy. We study whether it is easier to generate comovement in response to news shocks in the open economy. In this economy it is easier for investment and consumption to comove, since consumption

[1] See Beaudry and Portier (2004, 2005), Christiano, Motto and Rostagno (2005), Denhaan and Kaltenbrunner (2005), Lorenzoni (2005), and Jaimovich and Rebelo (2006).

[2] For high levels of intertemporal substitution in consumption it is possible for consumption to fall and investment to rise in response to positive news about future productivity. There is also no comovement in this case.

and investment do not have to add up to domestic output. However, positive news shocks generate a larger fall in hours worked and output in the open economy. In a closed economy good news about future productivity leads to a rise in the real interest rate. This rise creates an incentive to intertemporally substitute and work more today. This effect, which helps to counteract the wealth effect on the labor supply, is absent in the small open economy.

In Jaimovich and Rebelo (2006) we show that a closed-economy version of the neoclassical model produces news-driven business cycles when we introduce three elements. The first element is variable capacity utilization, which increases the ability of the economy to respond to a news shock. The second is adjustment costs to investment, labor, or capital utilization. These adjustment costs provide incentives to respond immediately to future shocks. The third element are preferences that exhibit a weak short-run wealth effect on the labor supply. In this paper we study whether these elements work in an open economy. We find that a combination of weak short-run wealth effects on labor and adjustment costs to labor or investment generate comovement in response to news shocks in a small open economy. Variable capital utilization, which we find to be important in closed economy models, is not essential in an open economy.

Ideally we would like to identify model features that produce comovement among macroeconomic aggregates in response to different shocks. So we would like to know whether our open economy model generates comovement with respect to shocks other than contemporaneous TFP shocks and news about future TFP. To assess the robustness of the comovement properties of our model we consider contemporaneous shocks to investment-specific technical change, and news about investment-specific technical change. In addition, we consider a shock that is specific to open economies, a 'sudden stop,' which makes it more costly to role over the existing foreign debt. This shock, which has been emphasized by Calvo

(1998) is thought to generate a contraction. In a small open economy version of the neoclassical growth model sudden stops generate a fall in consumption and investment but a boom in output (Chari, Kehoe and McGratten (2005) and Kehoe and Ruhl (2007)). We find that there is a wide range of parameters for which the model we study in this paper generates comovement for both news shocks and sudden stops.

We organize the paper as follows. In section 2 we present a small-open-economy version of the neoclassical model and discuss the effects of news about future TFP and investment-specific shocks. In section 3 we study the effects of sudden stops. In section 4 we revisit the effects of these three shocks in the context of our benchmark model and discuss the range of parameters that are consistent with comovement. We study our model's implication for the dynamics of firm value in section 5 and summarize our main findings in section 6.

2. News in a small-open-economy

This economy is populated by identical agents who maximize their lifetime utility (U) defined over sequences of consumption (C_t) and hours worked (N_t):

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}\left(1-\psi N_t^{\theta}\right)^{1-\sigma}-1}{1-\sigma}.$$

The symbol E_0 denotes the expectation conditional on the information available at time zero. We assume that $0 < \beta < 1$, $\theta > 1$, $\psi > 0$ and $\sigma > 0$. Output (Y_t) is produced with a Cobb-Douglas production function using capital (K_t) and labor:

$$Y_t = A_t K_t^{1-\alpha}(N_t)^{\alpha}. \tag{2.1}$$

The variable A_t represents the exogenous level of TFP. The law of motion for capital is given by:

$$K_{t+1} = I_t + (1-\delta)K. \tag{2.2}$$

The economy can borrow and lend at a constant real interest rate r, subject to the flow budget constraint:

$$a_{t+1} = (1+r)a_t + Y_t - C_t - I_t/z_t, \tag{2.3}$$

and to the non-Ponzi game restriction:

$$E_0 \lim_{t\to\infty} \frac{a_{t+1}}{(1+r)^t} = 0. \tag{2.4}$$

The variable a_t represents the economy's net foreign assets. The variable $1/z_t$ represents the current state of technology to produce capital goods. We interpret increases in z_t as resulting from investment-specific technical progress as in Greenwood, Hercowitz, and Krusell (2000).

It is useful to define the economy's trade balance, TB_t, which is given by:

$$TB_t = Y_t - C_t - I_t/z_t.$$

We solve the model numerically by linearizing the first-order conditions of the planner's problem around the steady state. We calibrate the model with the following parameters. We set the discount factor, β, to 0.985 and assume that $\beta = 1/(1+r)$, so that there are no trends in the trade balance. We set the labor share, α, to 0.64, the depreciation rate, δ, to 0.0125, the coefficient of relative risk aversion, σ, to 1, and θ, the parameter that controls the elasticity of labor supply, to 1.2. We choose the level parameter in the utility function, ψ, so that $N = 0.2$ in the steady state.

Figure 1 shows the model's response to unanticipated news about future TFP. The timing is as follows. The economy is in the steady state at time zero. At time one agents receive unanticipated news that TPF will increase permanently by one percent from period three on. The solid line represents the response of the closed economy, while the dashed line represents the response of the open economy. The

positive news shock raises agent's wealth leading to a rise in consumption and leisure, and a decline in hours worked. In the closed economy the real interest rate rises, reflecting the high future marginal product of capital. This persistent rise in the real interest rate has two implications. The first implication is that consumption grows over time. In contrast, in the open economy consumption rises at time one and remains constant thereafter, reflecting the fact that the real interest rate is constant. The second implication is that hours fall by more in the open economy, producing a larger decline in output. In the closed economy the high real interest rate in period two creates an intertemporal substitution effect on the supply of labor which helps to partially offset the wealth effect. This intertemporal substitution effect is absent in the open economy.

In the closed economy consumption rises and output falls so investment falls in periods one and two. In the open economy investment falls in period one and rises in period two. The fall in period one occurs in response to the fall in the marginal product of capital that results from the decline in hours worked. The investment rise in period two occurs in anticipation of the TFP shock that materializes in period three. The economy's trade balance is dominated by these large investment swings. The economy runs a large trade surplus in period one and a large trade deficit in period two. In summary, neither the open nor the closed economy exhibit comovement in response to news about future TFP. In addition, positive news shocks produce a deeper fall in output in the open economy.

Figure 2 shows the response to news about future investment-specific technical change. The timing is the same as in Figure 1. At time zero the economy is in the steady state. At time one news arrives that z will increase permanently by one percent in period three, reducing the price of investment in units of consumption from that point on. The solid line represents the response of the closed economy, while the dashed line represents the response of the open economy. In the closed

economy consumption rises and hours, output, and investment fall for the same reasons discussed in the case of a TFP shock. There is one additional reason for the fall in investment that is absent in Figure 1. The anticipated fall in the price of investment creates an incentive to invest less now and more in the future. This incentive is greatly amplified in the open economy. We see a precipitous fall in investment in period 2 and a enormous rise in period three. The large fall in investment in period two leads to a sizable decline in the period three capital stock. So the marginal product of labor is very low in period three, leading to a large fall in hours worked. Comovement is absent both in the open and closed economies.

The large swings in investment that we observe in the open economy reflect the absence of adjustment costs in investment. We introduce these adjustment costs in section 4. But it is useful to understand the basic patterns generated by the model before incorporating new elements.

3. Sudden stops

To study the impact of sudden stops it is convenient to modify the assumption that the economy can borrow and lend at a fixed interest rate. Instead, we assume that real interest rate faced by the economy is a decreasing function of the level of net foreign assets. So, as the economy borrows more the real interest rate rises. We follow a modified version of the formulation suggested by Uribe and Schmidt-Grohe (2003). In the Uribe and Schmidt-Grohe (2003) formulation r_t is given by:

$$r_t = 1/\beta - 1 + \chi[\exp(a^* - a_t) - 1]. \tag{3.1}$$

For $\chi > 0$ the real interest rate is a decreasing function of the level of net foreign assets. In the model described in section 2 the steady state level of a_t is not

unique. This property can be a problem in terms of the accuracy of linearizations around the steady state, since we linearize the model around a steady state value of a_t to which the economy does not return. Formulation (3.1) is a mechanical fix for this problem. Consumption is constant only when $r = 1/\beta - 1$, so the only value of a_t compatible with the steady state is a^*.

However, two issues remain. The first is that hours worked are not stationary, both for $\chi = 0$, the case we considered in section 2, and for $\chi > 0$. The second is that for economies in which there is growth because increases in A_t and z_t are permanent, (3.1) implies a declining foreign debt to GDP ratio. Both issues can be resolved using the following modified version of (3.1):

$$r_t = 1/\beta - 1 + \chi[\exp(a^* A_t^{1/\alpha} z_t^{(1-\alpha)/\alpha} - a_t) - 1]. \tag{3.2}$$

We assume that a^* is negative. In the steady state the country is indebted vis-a-vis the rest of the world and runs a trade surplus to service this debt. The steady state level of output is proportional to $A_t^{1/\alpha} z_t^{(1-\alpha)/\alpha}$ so the economy's ability to borrow is scaled by trend GDP. To study the effect of a sudden stop we set χ = 0.25 so that the economy can reduce the cost of servicing its foreign debt by increasing the level of net foreign assets.

We assume that a^* is stochastic and follows an AR(1) process with first-order serial correlation equal to 0.9. We model a sudden stop as an increase in a^*.[3] Figure 3 shows an impulse response function to a one percent increase in a^*. The persistent increase in a^* that occurs at time one raises the cost of borrowing and generates a large increase in the time-one trade surplus. Sudden stops are thought to generate a recession. And, indeed, investment and consumption both fall. However, the sudden stop exerts a negative wealth effect that leads to an

[3] This formulation is different from that in Chari, Kehoe and McGratten (2005) and Kehoe and Ruhl (2007). Both of these papers model sudden stops as a reduction in the country's ability to borrow, so that the economy is forced to increase the level of a_t.

expansion in hours worked and output.[4]

4. Our model

We now introduce two new elements in the model of Section 3. The first element is the utility function proposed in Jaimovich and Rebelo (2006). Lifetime utility is given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \psi N_t^{\theta} X_t\right)^{1-\sigma} - 1}{1-\sigma}, \tag{4.1}$$

where

$$X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}, \tag{4.2}$$

The presence of the variable X_t implies that preferences are time non-separable in consumption and hours worked. These preferences nest as special cases the two classes of utility functions most widely used in the business cycle literature. When $\gamma = 1$ we obtain preferences in the class consistent with steady state growth discussed in King, Plosser and Rebelo (1988). When $\gamma = 0$ we obtain the preferences proposed by Greenwood, Hercowitz, and Huffman (1988), which feature zero wealth effects on the supply of labor but are not consistent with steady state growth. The preferences described by (4.1) and (4.2) are consistent with steady state growth as long as $0 < \gamma \leq 1$. The lower the value of γ the weaker are short-run wealth effects on the supply of labor (see Jaimovich an Rebelo (2006)).

The second element that we introduce are adjustment costs to both investment and labor. We replace equation (2.2) with the following capital accumulation

[4] A number of authors have suggested that a sudden stop can be accompanied by a fall in output when financing frictions are introduced at the level of the firm. Neumeyer and Perri (2004), assume that firms must borrow to pay for a fraction of the wage bill, while Christiano, Gust, and Roldos (2004) and Mendoza (2004), assume that firms must borrow to pay for imported intermediate inputs.

equation,

$$K_{t+1} = I_t \left[1 - \phi \left(\frac{I_t}{I_{t-1}} \right) \right] + (1 - \delta) K_t. \tag{4.3}$$

The function $\phi(.)$ represents adjustment costs to investment. We assume that $\phi(1) = 0$, $\phi'(1) = 0$, and $\phi''(1) > 0$. These conditions imply that there are no adjustment costs in the steady state and that adjustment costs are incurred when the level of investment changes over time. This adjustment cost formulation is proposed in Christiano, Eichenbaum and Evans (2004) and in Christiano, Motto and Rostagno (2005).[5]

We also introduce labor adjustment costs in the economy's flow resource constraint. We replace equation (2.3) with:

$$a_{t+1} = (1 + r_t)a_t + Y_t - C_t - I_t/z_t - N_t \Psi \left(\frac{N_t}{N_{t-1}} \right).$$

The trade balance is defined as:

$$TB_t = Y_t - C_t - I_t/z_t - N_t \Psi \left(\frac{N_t}{N_{t-1}} \right).$$

We assume the following properties for the labor adjustment cost function: $\Psi(1) = 0$, $\Psi'(1) = 0$, and $\Psi''(1) > 0$.

To evaluate the effects of different shocks in this economy we set $\phi''(1) = 1.3$, $\Psi''(1) = 2.0$, $\gamma = 0.0001$ and $\chi = 0.00001$. The value of a^* is chosen so that the steady state value of TB/Y is 5 percent. The remaining parameters are chosen as in section 2. Below we explore the robustness of our findings to different parameter values.

[5] Lucca (2006) shows that, for an appropriate choice of the parameter values, the linearized investment first-order condition is identical when adjustment costs take the form (4.3) and when there is time-to-build in investment. See Eberly, Rebelo, and Vincent (2007) for estimates of the parameters of this adjustment cost function obtained using Compustat data.

New about future TFP Figure 4 shows the response of our model to the same experiment considered in Figure 1. At time one the economy receives unanticipated news that there is a permanent, one percent increase in the level of TFP in period three. This news generates a boom in periods one and two. The rise in consumption, investment, and output is accompanied by a deterioration of the trade balance. The intuition for this result is as follows. The very low value of γ means that short-run wealth effects on the labor supply are very small. Hours should fall by a small amount so why do they rise in period one? This rise reflects the presence of adjustment costs to labor. It is optimal to increase N_t in period three to respond to the increase in TFP. Labor adjustment costs make it efficient to start raising N_t at time one in anticipation of further increases at time three. Adjustment costs to investment make it efficient to start investing in period one, instead of waiting for period two, as in Figure 1.

New about future z Figure 5 shows the response of our model to the same experiment considered in Figure 2. At time one the economy receives unanticipated news that there is a permanent, one percent increase in the level of investment-specific technical progress, z_t. Increases in consumption, investment, and output are accompanied by a deterioration of the trade balance. The presence of adjustment costs to labor and investment are essential to produce a rise in hours and investment in periods one and two.

Sudden stops Figure 6 shows the response of our model to the same experiment considered in Figure 3. As in section 3 we set $\chi = 0.25$ for this experiment. Figure 6 shows that the sudden stop leads to a fall in investment. This fall leads to a future temporary reduction in the stock of capital and to an associated temporary reduction in the future marginal product of labor. This temporary fall in the

marginal product of labor leads to a future reduction in hours worked. In the presence of labor adjustment costs it is optimal to smooth the reduction in N_t over time, so labor starts falling in period one.

Robustness We experimented with numerous parameter combinations to assess the robustness of our results. We find that when χ, the elasticity of the real interest rate to net foreign assets, is very small we need a very small value of γ to generate comovement with respect to news shocks and sudden stops. The other parameters are less crucial. We now report some results obtained by changing one parameter at a time relative to our benchmark numerical example.

In the case of news about future TFP we obtain comovement for any value of $\theta \geq 1$ and any value of $\Psi''(1) \geq 0.25$. We can dispense with adjustment costs to investment by setting $\phi''(1) = 0$ or replace the capital law of motion (4.3) with the following, more conventional, formulation:

$$K_{t+1} = \phi(I_t/K_t)K_t + (1-\delta)K_t. \tag{4.4}$$

In the case of news about z_t we obtain comovement for any value of $\theta \geq 1$ and for any value of $\Psi''(1) \geq 1.2$. In this case we need some adjustment costs to investment. These costs are necessary to prevent the swings in investment illustrated in Figure 2, which are associated with the anticipated fall in the price of investment in period 3. Any value of $\phi''(1) \geq 0.05$ is sufficient to generate comovement. We can also replace the adjustment cost formulation (4.3) with the more conventional formulation (4.4).

In the case of sudden stops we obtain comovement for any value of $\theta \geq 1$. We obtain comovement with both (4.3) and (4.4) work adjustment cost specification, and we can also dispense with investment adjustment costs altogether. In contrast, adjustment costs to labor are indispensable. We need $\Psi''(1) \geq 0.2$. As we discuss

above, without labor adjustment costs hours work tend to rise in period one by an amount that depends on the magnitude of the negative wealth effect produced by the sudden stop.

In Jaimovich and Rebelo (2006) we find that variable capital utilization plays a useful role in generating comovement in response to news shocks in a closed economy. We find that capital utilization is not an essential element in the open economy discussed in this section.

All the results described so far require a value of γ close to zero. However, it is possible to obtain comovement for larger values of γ if we abandon the assumption that the economy can borrow and lend at a fixed real interest rate. If we assume $\chi >> 0$ we can generate comovement with higher values of γ and, at the same time, obtain plausible real interest rate movements. For example, if we set $\chi = 5$ we can produce comovement with $\gamma = 0.35$.

5. The value of the firm

In this section we study the dynamics of firm value in our model. We assume that the representative firm own the stock of capital and make labor hiring and investment decisions to maximize their value, V. The firm's problem is:

$$\max V = E_0 \sum_{t=0}^{\infty} \frac{\Lambda_t}{\Lambda_0} \left[Y_t - w_t N_t - I_t / z_t - N_t \psi \left(\frac{N_t}{N_{t-1}} \right) \right],$$

subject to the law of motion for capital, (4.3). The variable w_t denotes the equilibrium spot real wage rate and Λ_t is the time t marginal utility of consumption.

We find that the value of the firm generally falls in response to a sudden stop. The value of the firm rises in response to news about future TFP or investment specific technical change provided that we introduce a small level of decreasing returns in production. This modification involves replacing (2.1) with:

$$Y_t = A_t K_t^{\alpha_1} (N_t)^{\alpha_2},$$

where $\alpha_1 + \alpha_2 < 1$. We can interpret the "missing factor" as organizational capital. The introduction of decreasing returns to scale in production does not affect qualitatively the comovement properties described is section 4. For our benchmark numerical example V rises in response to news about TFP when $\alpha_1 + \alpha_2 < 0.95$. V rises in response to news about z_t when $\alpha_1 + \alpha_2 < 0.90$. It is more difficult to generate an increase in the value of the firm in response to news about future investment-specific capital change because the future fall in the price of capital reduces the value of the capital owned by the firm. For this reason we need a higher level of decreasing returns to scale to obtain a rise in V in response to news about future z.

6. Conclusion

This paper is part of a research program in which we seek to identify model features that generate comovement among the major macroeconomic aggregates in response to different shocks. Here we investigate the comovement properties of a small-open-economy version of the closed-economy model that we propose in Jaimovich and Rebelo (2006). We consider both news about future productivity and sudden stops. Our main conclusions are that comovement is easier to generate in the presence of weak short-run wealth effects on the labor supply, adjustment costs to labor, and/or investment, and whenever the real interest rate faced by the economy rises with the level of net foreign debt.

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Figure 1: News about TFP in neoclassical model

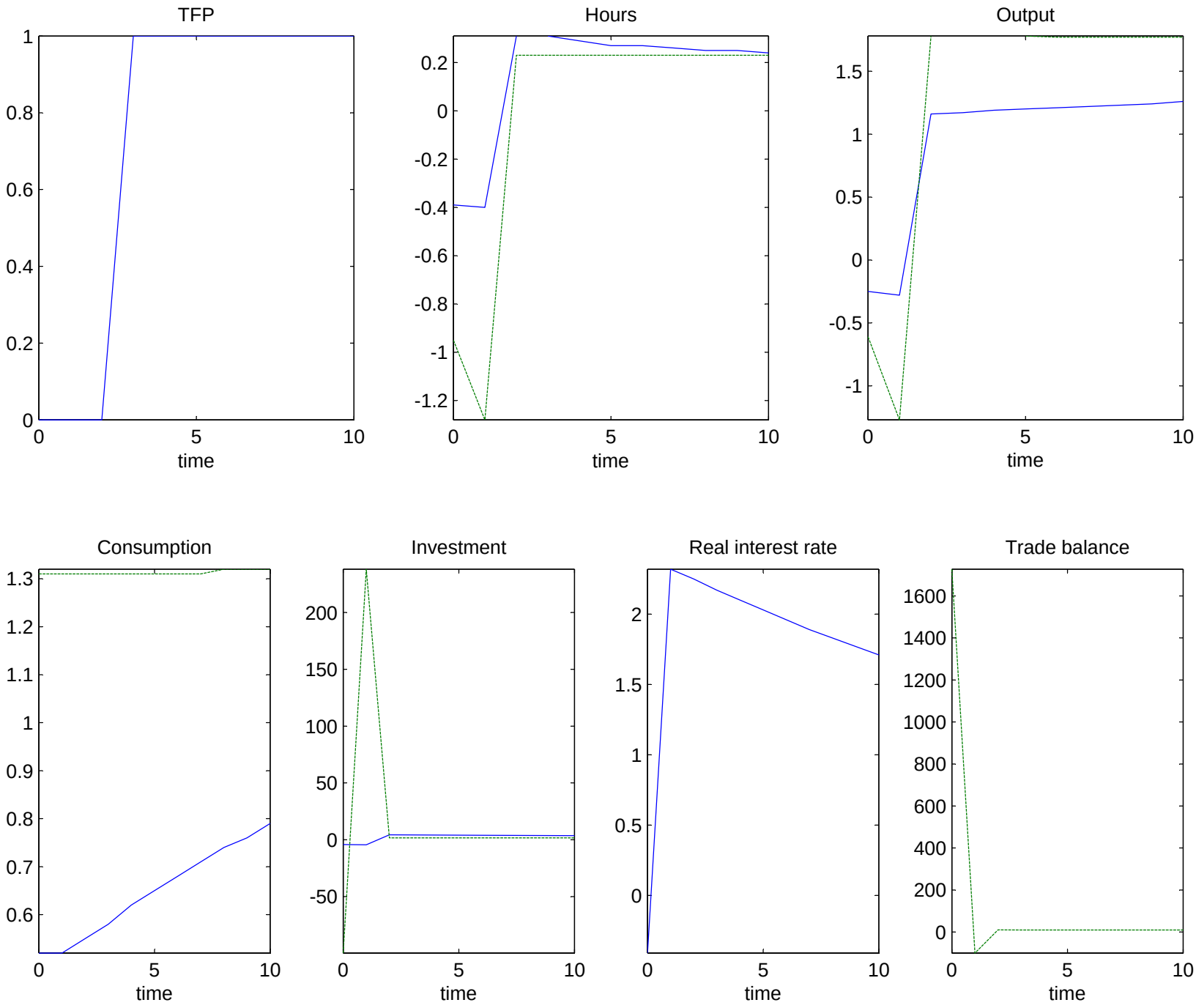

Figure 2: News about z in neoclassical model

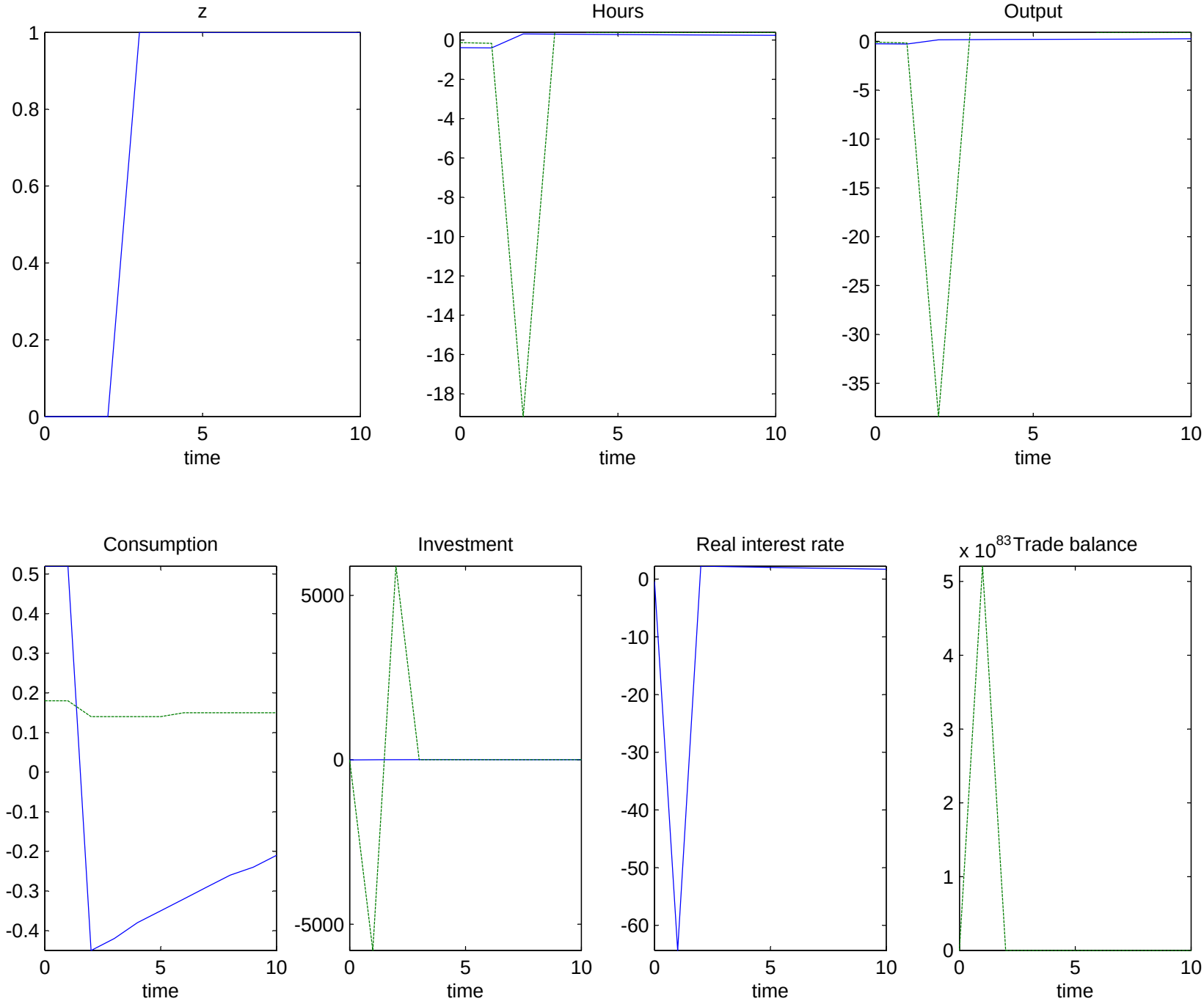

Figure 3: Sudden stops in neoclassical model

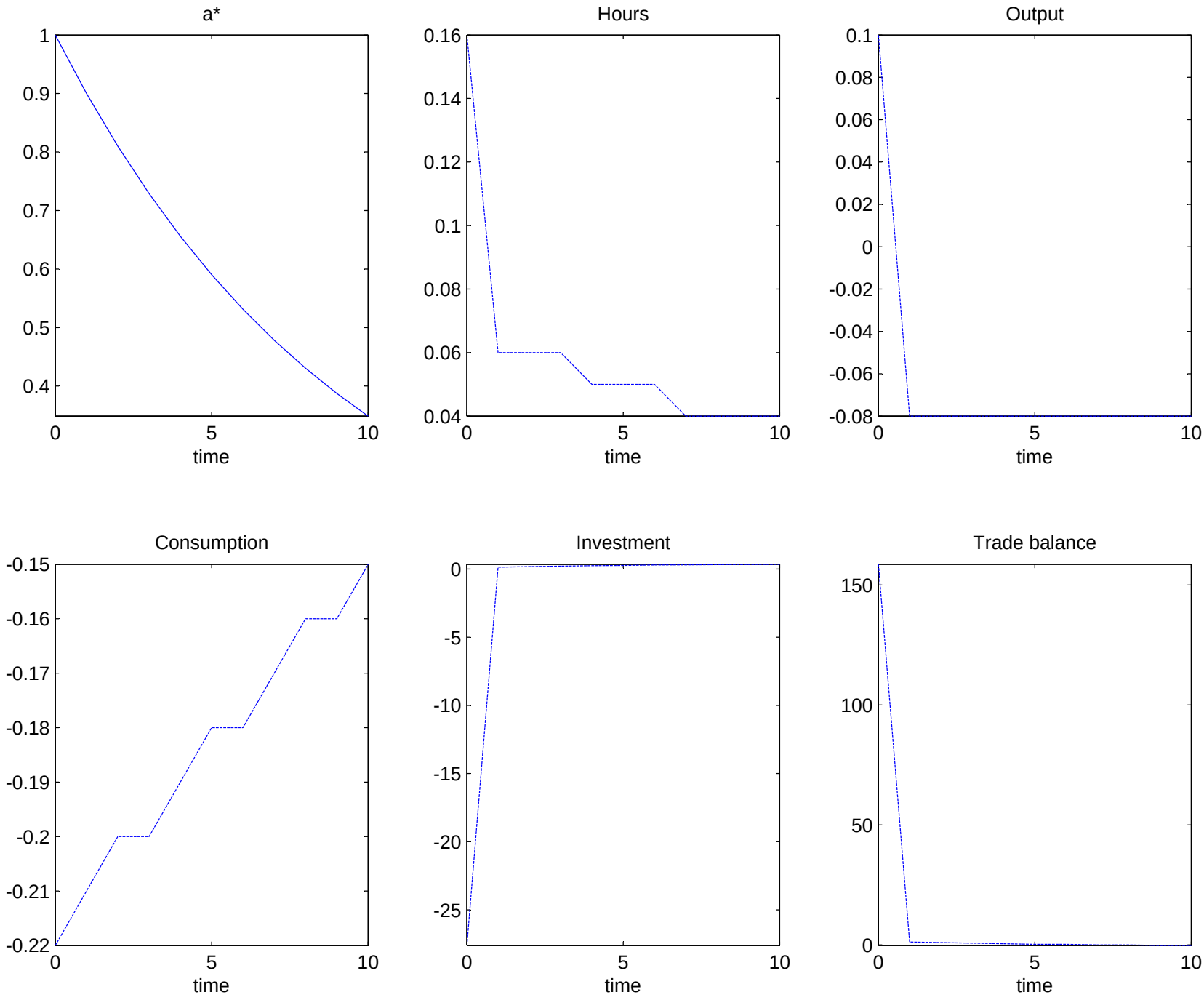

Figure 4: News about TFP in benchmark model

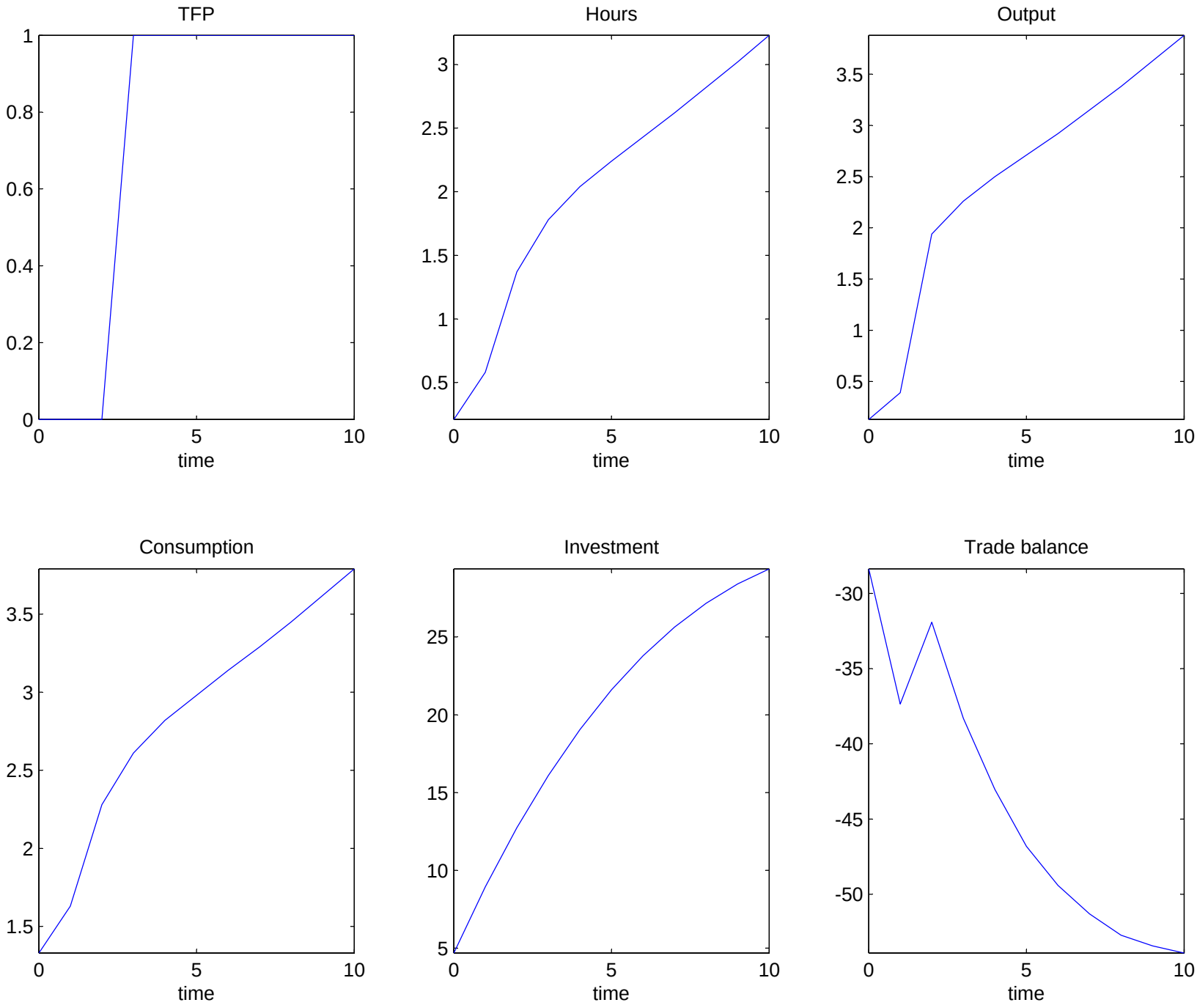

Figure 5: News about z in benchmark model

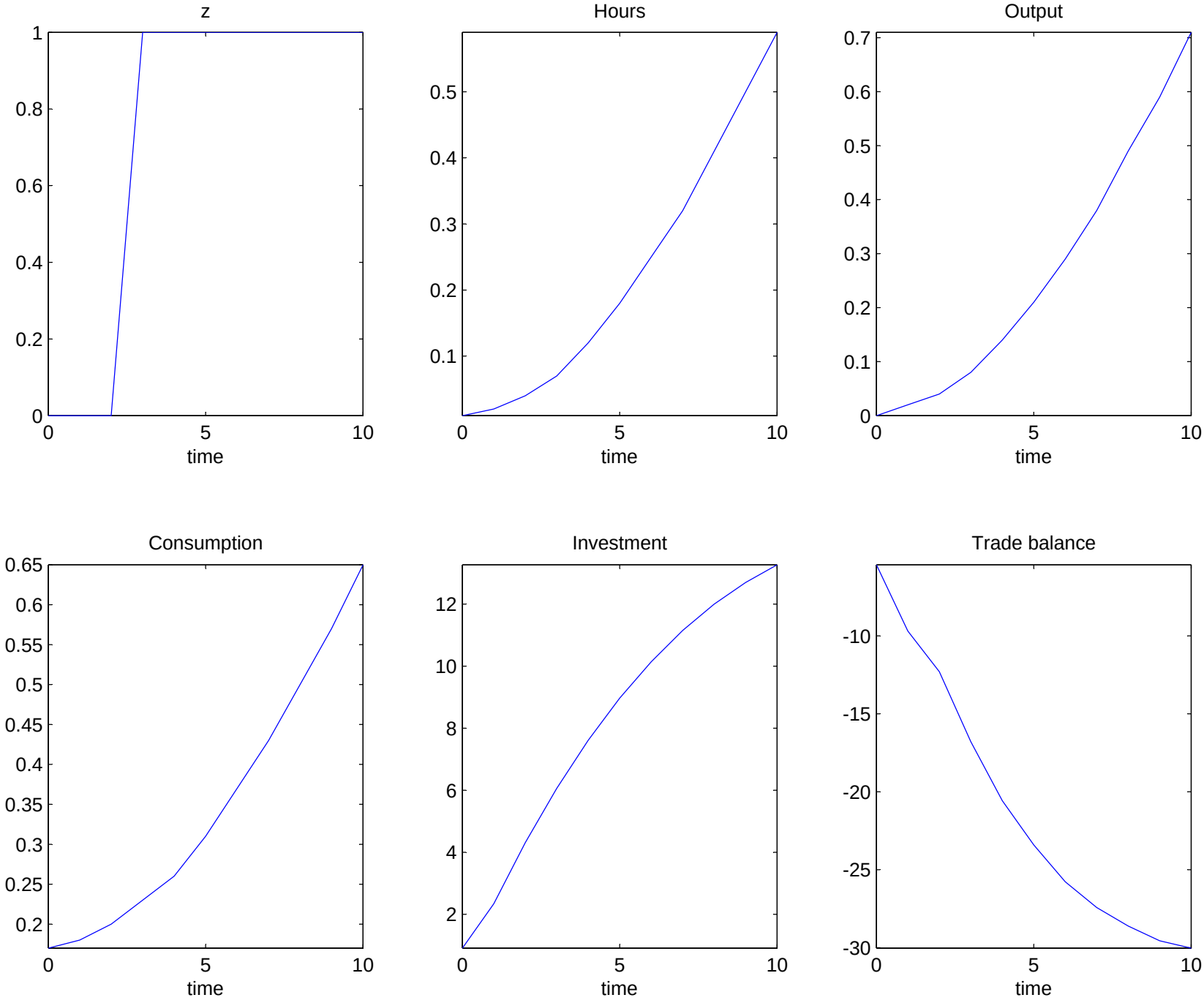

Figure 6: Sudden stops in benchmark model