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Letting the speculative and the news views of the Japanese business cycle compete

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Abstract

This note uses a dynamic stochastic general equilibrium model with direct preferences for financial wealth to explore how stock price booms and busts relate to the real side of the economy. It evaluates the 'speculative' (sunspots) and 'news' (anticipated future changes in productivity) explanations of the Japanese stock market bubble and economic business cycle in 1986-1999. Depending on parameter configurations, the model yields either a unique equilibrium or multiple equilibria. The note calibrates two versions of the model: (i) a version with multiple equilibria, driven solely by sunspot shocks, and (ii) a version with a unique equilibrium, driven by surprise and news shocks to productivity. In both cases, expectations shocks are estimated to perfectly match the historical path of the Nikkei stock market average. Simulation results show that, from the perspective of the model, both the speculative and the news views can explain equally well empirical investment. The two views, however, differ in their predictions for consumption, output and real wages. These differences could be explored in further work on disentangling empirical importance of sunspot and news shocks.

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1. Introduction

Time and again, rapid run-ups of stock prices end in crashes. Yet, the exact causes of booms and busts of asset prices remain somewhat a mystery. Are they bubbles, mainly driven by market speculations? Or are they a result of downward revisions of optimistic beliefs about current and future economic fundamentals? How do stock price booms and busts relate to the real side of the economy? This note attempts to answer these questions by examining the joint behavior of stock prices and key macroeconomic variables.

In contrast to the previous empirical research on asset price bubbles,[1] this note uses a dynamic stochastic general equilibrium model as an evaluation tool. The model can accommodate two views on the stock market and business cycles. According to the first, 'speculative' view, exogenous changes in beliefs of investors, or animal spirits, drive the stock market and fluctuations in real activity. According to the second, 'news' view, stock prices reflect anticipations of future economic conditions. Fluctuations in the stock market and in the real economy are the responses to changing economic fundamentals. In the model, market speculations are formalized as sunspot shocks, while signals about future values of total factor productivity (TFP) represent news.

The model is applied to the Japanese economy in the period 1986-1999. Japan provides an interesting case study. In the late 1980s, asset prices increased dramatically, investment and output grew rapidly, but prices of goods and services were relatively stable. The crash of the Nikkei, Japan's most widely watched stock index, in 1990 was followed by a sharp decline in investment and output. The performance of the Japanese economy in the 1990s was poor, to say the least. Hayashi and Prescott (2002) characterized the 1990s as a 'lost decade' of economic growth.

The existing literature suggests that both the stock market speculations and the perceptions of future productivity growth likely played a significant role in Japan. Shiller et al. (1996) conducted a survey of market expectations in Japan and in the U.S. about the performance of the Nikkei stock price average between 1989 and 1992. The survey results supported the presence of speculative attitudes toward stock price movements at the time of the crash in 1990. However, a significant fraction of the Japanese respondents believed that even at the time of the crash, the Nikkei average reflected the fundamentals of the Japanese economy. More formally, Nakajima (2003) and Nadenichek (2007) demonstrated the importance of sunspot shocks based on business cycle models. Using a structural vector autoregression framework, Beaudry and Portier (2005), Ko et al. (2012) and Ko (2012) found that TFP news shocks were a significant source of fluctuations in asset prices and macroeconomic variables in Japan. Beaudry and Portier (2006) identified two large negative TFP news shocks in 1990 and 1992. These downward revisions of future TFP could explain about "one half of the stock market fall in the 1990s" (p. 649). Fujiwara *et al.* (2011) established the importance of TFP news shocks in Japan in the estimated New Keynesian model.

While there is some empirical support for both sunspot and news shocks in Japan, the contributions of these shocks have been evaluated separately. The objective of this note is to let the speculative and the news views of the Japanese business cycle compete. The evaluation of the two views is conducted from a perspective of a model with direct preferences

[1] For example, Diba and Grossman (1988), Jin *et al.* (2006), Clark and Coggin (2011).

for financial wealth and costly capital accumulation.[2] The model has two desirable features. First, the model can have indeterminacy of equilibria, and hence admit sunspot shocks. Second, the model can replicate the empirical responses of macroeconomic aggregates to TFP news shocks, derived in Beaudry and Portier (2005) and Beaudry and Portier (2006).

I consider two versions of the model. In the first version, the parameters are such that there are multiple equilibria. Sunspot shocks, representing stock market speculations, are the sole driving force of stock prices, as in Nakajima (2003). In the second version, the stochastic equilibrium is unique. Stock prices are determined by TFP surprise and news shocks, consistent with bivariate identification schemes of Beaudry and Portier (2005).[3] Based on the estimated shocks, I construct the sample paths for investment, consumption, output, hours worked and real wages, predicted by the two versions of the model. I then compare the predicted paths with the actual Japanese series, and with each other.

From the perspective of the model, both the speculative and the news views can explain equally well a boom-bust cycle in the Japanese investment, even though the timing of the cycle in the model is shifted forward relative to the actual data. Consistent with the data, consumption is predicted to grow at the time of investment and stock market crash. Nevertheless, sunspot and news shocks affect the real side of the economy through different channels. As a result, there are noticeable differences in the predicted sample paths for consumption, output and real wages across the two versions of the model.

2. The model

The consumer's problem A representative consumer has the expected life-time utility defined over consumption C_t, the index of social status X_t and hours worked H_t,

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[V\left(C_t, X_t\right) \left(1-H_t\right)^{\psi} \right]^{1-\sigma}, \ \sigma > 0, \ \psi > 0. \tag{1}$$

E_t is the expectation conditional upon the information available in period t. The discount factor $\beta \in (0,1)$. Consumption and status are aggregated via

$$V\left(C_t, X_t\right) = \left[(1-\omega) C_t^{\theta} + \omega X_t^{\theta}\right]^{1/\theta}, \ 0 < \omega < 1, \ \theta < 1. \tag{2}$$

Preferences for status relative to consumption are governed by ω and θ. A higher value of ω means a stronger status-seeking motive, and $1/(1-\theta)$ represents the elasticity of substitution between consumption and status. The value of σ is related to the intertemporal elasticity of substitution. It is implied that $\sigma = 1$ and $\theta = 0$ correspond to logarithmic functions. Status is defined as the value of financial assets held at the end of each period,

$$X_t \equiv S_t \kappa_t. \tag{3}$$

S_t is the period t price of a claim to future profits of a representative firm, and κ_t is the share of the firm owned by the consumer at the end of period t.

[2] Nakajima (2003), Karnizova (2010), Karnizova (2012) study variants of the model.

[3] Karnizova (2012) shows that such a model is able to explain several puzzling features of the boom-bust cycle in the U.S. in 1995-2003.

The consumer chooses consumption, hours worked and asset holdings to maximize the lifetime utility subject to the definition of status and a sequence of budget constraints

$$C_t + S_t \kappa_t = W_t H_t + (S_t + D_t)\,\kappa_{t-1} - \tau_t, \tag{4}$$

where W_t is the hourly wage, D_t is the dividends and τ_t represents lump-sum taxes.

The firm's problem The representative, perfectly competitive firm owns the stock of capital K_t. Capital becomes productive after one period and depreciates at the rate $\delta \in (0,1)$. Installing new capital is subject to adjustment costs

$$K_{t+1} = Q\left((1-\delta) K_t, I_t\right) = \left[b_1 (1-\delta)^{\phi} K_t^{\phi} + b_2 I_t^{\phi}\right]^{1/\phi},\ t \geq 0, \tag{5}$$

with $\phi \leq 1, b_1 > 0, b_2 > 0$. No adjustment cost case corresponds to $\phi = 1$, and $1/(1-\phi)$ defines the elasticity of substitution between capital and investment. The value K_0 is given.

Output Y_t is produced using a Cobb-Douglas function with the capital share α

$$Y_t = F(K_t, A_t L_t) = K_t^{\alpha} (A_t L_t)^{1-\alpha},\ 0 < \alpha < 1, \tag{6}$$

where L_t denotes labor input. A stochastic technological process A_t is described below.

The firm hires labor and makes investment to maximize its value to the owners. The firm does not issue new shares, and the number of shares is normalized to one. Profits are paid as dividends $D_t = Y_t - W_t L_t - I_t$. The profit maximization conditions are

$$F_L(K_t, A_t L_t) = W_t, \tag{7}$$

$$P_t = \frac{1}{Q_2\left((1-\delta) K_t, I_t\right)}, \tag{8}$$

$$P_t = E_t \frac{1}{R_{t+1}} \left[F_K(K_{t+1}, A_{t+1} L_{t+1}) + (1-\delta)\, Q_1\left((1-\delta) K_{t+1}, I_{t+1}\right) P_{t+1}\right]. \tag{9}$$

The variable P_t is the firm's internal shadow price of a unit of capital at the end of period t. The value $R_{t+1} \equiv (S_{t+1} + D_{t+1})/S_t$ is the gross return on holding equity from period t to period $t+1$. At an optimum, the period t market value of the firm is equal to the the value of the capital it owns, $S_t = P_t K_{t+1}$. It can be shown that the price P_t is equal to the present value of the expected future dividends per unit of capital. Output is used for consumption C_t, investment I_t and government expenditures G_t,

$$C_t + I_t + G_t = Y_t.$$

The government expenditures are a constant fraction of output, as in Nakajima (2003).

Productivity, news and sunspot shocks Three types of shocks are considered in the model economy: surprise TFP shocks, TFP news shocks and sunspot shocks. Consumers and firms are assumed to know the true structure of the model and to observe the current and past realizations of the shocks.

The productivity shock A_t is random walk with drift $\gamma > 1$,

$$\ln A_t = \gamma + \ln A_{t-1} + \varepsilon_t,\ t \geq 0,\ A_{-1} = 1, \quad (10)$$
$$\varepsilon_t = u_t + \xi^1_{t-1} + \xi^2_{t-2} + ... + \xi^n_{t-n},\ n > 0. \quad (11)$$

The innovations u_t and ξ^j_t have zero means and finite variances. They are uncorrelated over time, but can be correlated with each other in period t. More precisely, vector $\chi_t = [u_t, \xi^1_t, ..., \xi^n_t]$ is such that $E(\chi_t) = 0$, $E(\chi_t\chi'_{t-i}) = 0, i \neq 0$, but the variance-covariance matrix $E(\chi_t\chi'_t)$ is not restricted to be diagonal. A 'surprise' productivity shock u_t has a contemporaneous effect on productivity. The innovation ξ^j_t is the period t 'news' or 'signal' about the changes in the level of the productivity shock $j > 0$ periods ahead. The optimal forecasts about future TFP growth are

$$E_t(\ln A_{t+m} - \ln A_{t+m-1}) = \gamma + \sum_{j=1}^{m} E_t\varepsilon_{t+j},\ m > 0, \quad (12)$$
$$E_t\varepsilon_{t+j} = \sum_{i=j}^{n} \xi^i_{t+j-i} \text{ for } 1 \leq j \leq n,\ E_t\varepsilon_{t+j} = 0 \text{ for } j > n. \quad (13)$$

Standard real business cycle theory considers only surprise productivity shocks. In this case, $E_t\varepsilon_{t+j} = 0$, $j > 0$. With news shocks, the forecasts are also influenced by the signals about future TFP growth. When $\xi^j_t > 0$, TFP growth is expected to be above average in period $t + j$. Similarly, when $\xi^j_t < 0$, the TFP growth is expected to be lower. The productivity shock specification allows modelling unfulfilled expectations. If a signal ξ^j_{t-j} turns out to be incorrect, its value can be offset by the current realization of u_t.

Sunspot shocks ς_t are modelled as i.i.d. innovations to stock prices in period t, following Nakajima (2003). These shocks are orthogonal to productivity shocks. They exist only in the region of equilibrium indeterminacy, when multiple equilibria are possible.

3. Solution and its properties

A rational expectations equilibrium is the sequences of prices $\{W_t, R_t, P_t, S_t\}^{\infty}_{t=0}$ and allocations $\{H_t, C_t, X_t, I_t, Y_t, L_t, K_{t+1}, D_t, \kappa_t\}^{\infty}_{t=0}$ such that (1) the allocations are optimal given the prices and (2) the markets for labor, goods and assets clear, given K_0 and the shock processes $\{A_t, \varepsilon_t, u_t, \xi^1_t, ...\xi^n_t, \varsigma_t\}^{\infty}_{t=0}$. In equilibrium, $\kappa_t = 1$, and the market value of the capital stock determines status, $X_t = P_t K_{t+1}$. The model is solved numerically using a log-linear approximation of a stationary representation of the model around its unique non-stochastic steady state. To achieve stationary, the trending variables are divided by the level of technology.

Depending on parameter configurations, the model can have either a unique equilibrium or multiple equilibria, as established by Nakajima (2003). I consider two versions of the model. The first version MSUN focuses on the region of indeterminacy, and includes only sunspot shocks. TFP surprise and news shocks are shut down in this case. The second version MNEWS works with a unique equilibrium. It evaluates the effects of surprise and news TFP shocks.

Solution under indeterminacy In the case of equilibrium indeterminacy, there is no stochastic variation in productivity, $lnA_t \equiv \gamma(t+1)$. The model solution takes the form

$$\hat{k}_{t+1} = Z_{kk}\hat{k}_t + Z_{kp}\hat{p}_t, \quad (14)$$

$$\hat{p}_{t+1} = Z_{pk}\hat{k}_t + Z_{pp}\hat{p}_t + \varsigma_{t+1}, \quad (15)$$

for $t \geq 0$, with $\hat{k}_t = \hat{k}_0$, $t = 0$ and $E_t\varsigma_{t+1} = 0$. The carets denote the percentage deviations from the deterministic steady state, such as $\hat{p}_t = \ln p_t - \ln p^*$. Any other endogenous variable $\hat{v}_t$ is a function of $\hat{k}_t$ and $\hat{p}_t$: $\hat{v}_t = Z_{vk}\hat{k}_t + Z_{vp}\hat{p}_t$, $t \geq 0$. The coefficients Z_{ij} are non-linear functions of the preference and productivity parameters.

Solution under determinacy Under equilibrium determinacy, the solution is unique. The model is solved numerically by applying Blanchard and Kahn (1980)'s algorithm. Karnizova (2012) explains that the effects of news shocks on the endogenous variables of the model can be summarized by a single variable φ_t, called 'productivity prospects'. This variable is equal to the discounted sums of the expected future productivity impulses,

$$\varphi_t \equiv \sum_{j=1}^{\infty} \lambda^{-j} E_t\left(\varepsilon_{t+j}\right). \quad (16)$$

The discount factor λ is the unstable eigenvalue of the model. The forecasts $E_t\varepsilon_{t+j}$ are linear functions of news shocks. The solution for the capital stock and stock prices is

$$\hat{k}_{t+1} = M_{kk}\hat{k}_t + M_{k\varepsilon}\varepsilon_t + M_{k\varphi}\varphi_t, \quad (17)$$

$$\hat{p}_t = M_{pk}\hat{k}_t + M_{p\varepsilon}\varepsilon_t + M_{p\varphi}\varphi_t, \quad (18)$$

for $t \geq 0$, with $\hat{k}_t = \hat{k}_0$, $t = 0$. Any other endogenous variable is a function of $\hat{k}_t$, ε_t and φ_t : $\hat{v}_t = M_{vk}\hat{k}_t + M_{v\varepsilon}\varepsilon_t + M_{v\varphi}\varphi_t$, $t \geq 0$. The coefficients M_{ij} are non-linear functions of preference and productivity parameters, independent of the contemporaneous variance-covariance matrix of u_t and ξ_t^j, $1 \leq j \leq n$.

The equilibrium paths of stock prices in the two versions of the model are influenced by exogenous changes in expectations. However, these changes have different interpretations. The stock prices are driven solely by market speculations ς_t in (15). By contrast, they are determined by the current and future productivity fundamentals ε_t and φ_t in (18).

4. Parameter calibration, data description, and shock estimation

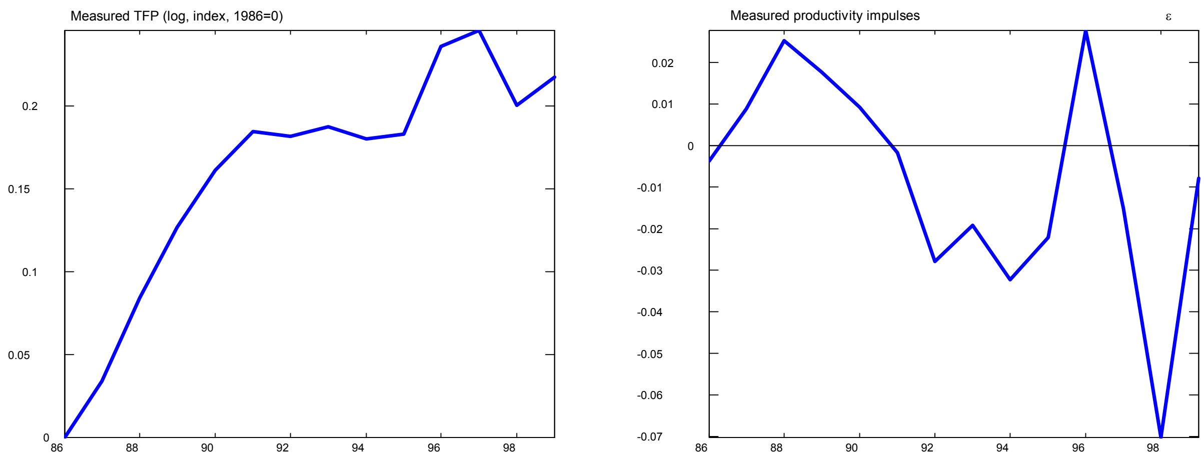
Parameters The model is calibrated to the annual Japanese data. Most of the parameters are from Nakajima (2003). The capital depreciation rate, the capital share and the discount factor are $\delta = 0.10$, $\alpha = 0.30$ and $\beta = 0.90$. The values of ϕ and θ are such that the elasticity of substitution in the production of capital is 0.4 and the elasticity of substitution between consumption and status is 0.7. The weights b_1 and b_2 are chosen to have no adjustment costs in the steady-state. The value of ψ sets the steady-state hours worked per person to 1/3. The weight ω is set to yield the consumption share in output of 0.58. The government share in output is 0.21. The average annual growth $\gamma = 1.025$ is estimated based on the TFP series from Hayashi and Prescott (2002).

Given the calibration above, the intertemporal elasticity of substitution determines if the model has a unique equilibrium or multiple equilibria. The value $\sigma = 7$ for the MSUN version with multiple equilibria is from Nakajima (2003). The value $\sigma = 0.185$ for the MNEWS version is from Karnizova (2010).

Data All data come from Hayashi and Prescott (2002). The data are annual, for the period from 1986 to 1999. Private consumption, private fixed capital investment and gross national product (GNP) are deflated by the GNP deflator. The stock price is measured by the end-of-year Nikkei 225 divided by the GNP deflator. All series above and total hours of work are expressed per capita, using the population aged 20-69. The real wage is measured by the real total compensation per hour. To derive empirical analogues of theoretical series for deviations from the deterministic steady state, the actual data are detrended with the trends suggested by the model. A linear TFP trend is used for the MSUN version. The actual level of TFP is used for the MNEWS version.

Shock estimation The productivity impulses ε_t are estimated from the empirical TFP measure following (10). Figure 1 plots the measured TFP and productivity impulses. The productivity growth is above the average in the 1980s, but falls below the trend in the 1990s (with an exception of 1996). Negative TFP shocks may have been responsible for the Japanese lost decade, as argued by Hayashi and Prescott (2002).

Figure 1 Measured TFP and productivity impulses



The estimation of sunspot shocks and productivity prospects is based on the equilibrium equations of the model. The stock of capital in Japan is assumed to take its steady state value in 1986. The sunspot shocks are measured as in Nakajima (2003). Given the actual time-series of values of equity, the series for ς_t is recovered by iterating equations (14) and (15). As in the case of sunspot shocks, productivity prospects are constructed to match the behavior of real Nikkei average, adjusted by the size of population and the technological trend. This is achieved by a successive iteration of equilibrium equations (17) and (18) for $\hat{k}_t$ and $\hat{p}_t$. Figure 2 plots the estimated sunspot shocks ς_t and the productivity prospects φ_t. Both series follow a boom-bust cycle, observed in the stock prices. The two measures are highly positively correlated. This resemblance may not be very surprising, since both series are estimated to match the actual path of the Nikkei average.

Figure 2 Estimated sunspot shocks and productivity prospects

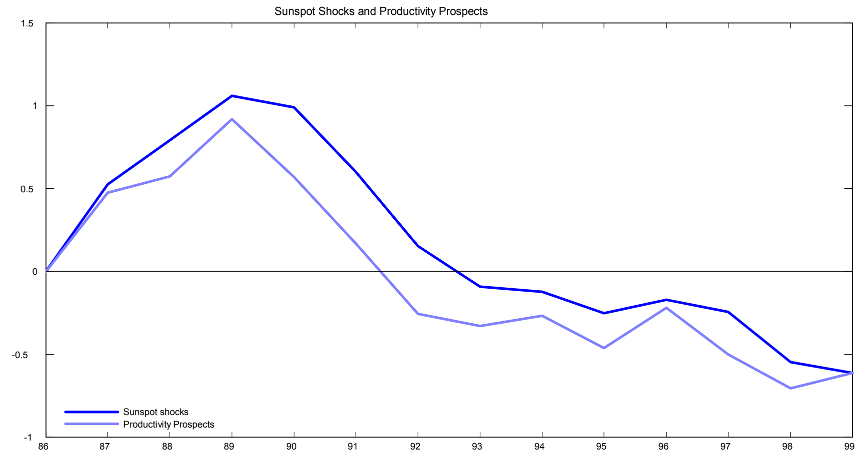
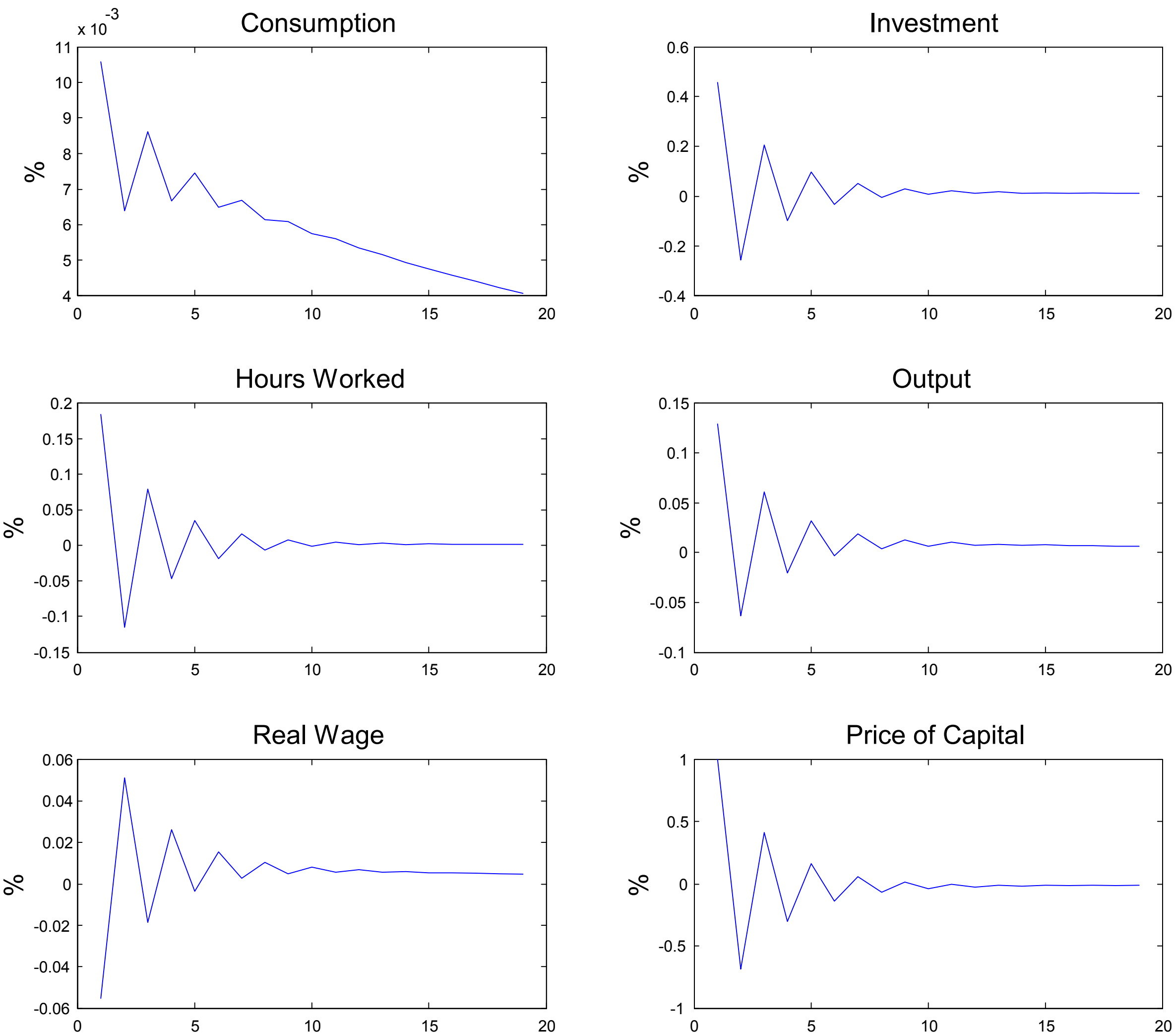


Figure 3. Responses to a positive sunspot shock



Notes: All variables are in percent deviations from the steady state.

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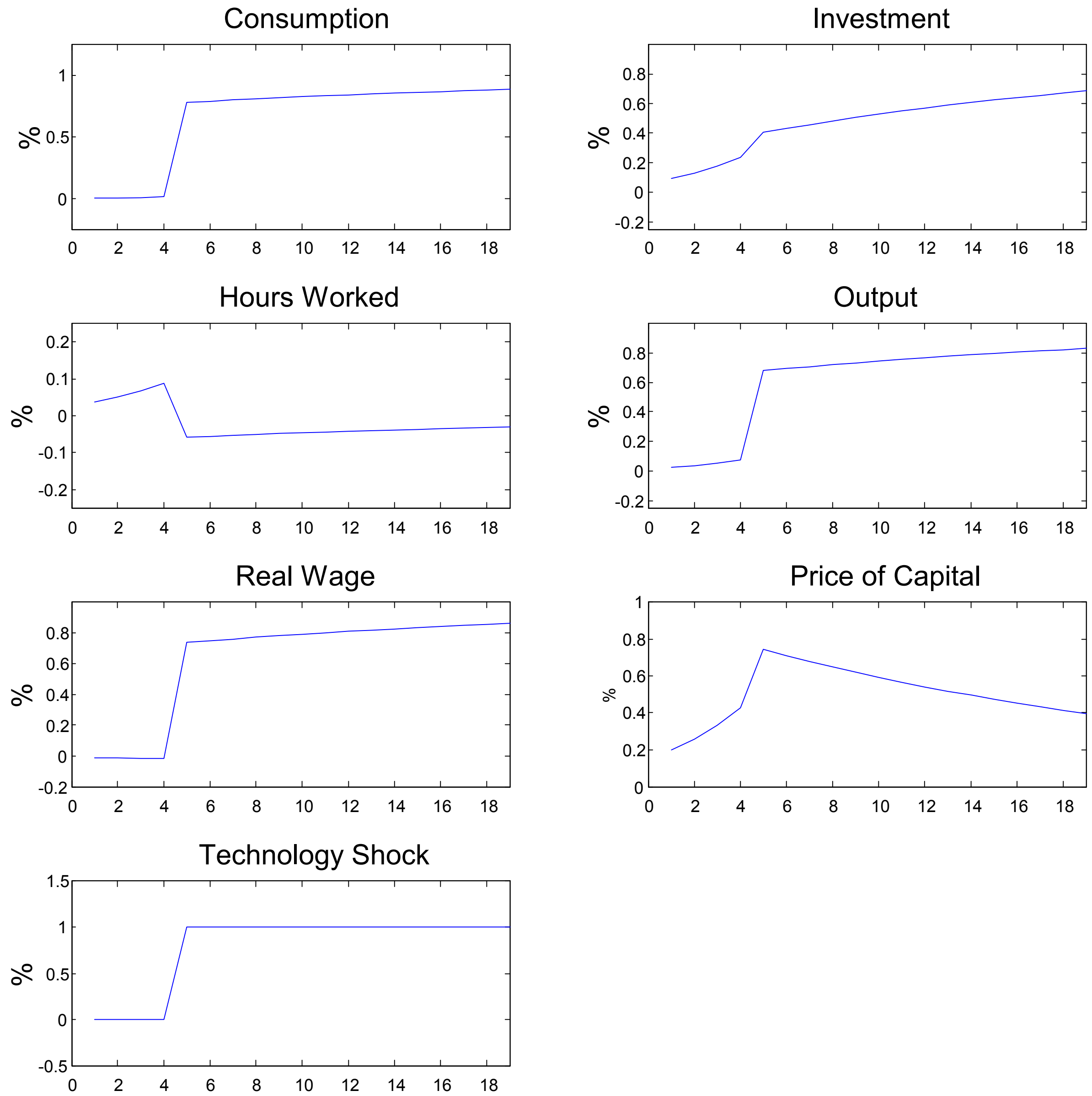
5. Results

Before discussing the results of estimations and simulations, it is useful to examine the dynamic responses of the model to sunspot and news shocks. Figure 3 reports the impulse responses to a positive sunspot shock of one percent. Such shock increases stock prices, and leads to an immediate increase in investment, consumption, output, and hours worked. There are self-fulfilling oscillatory dynamics.

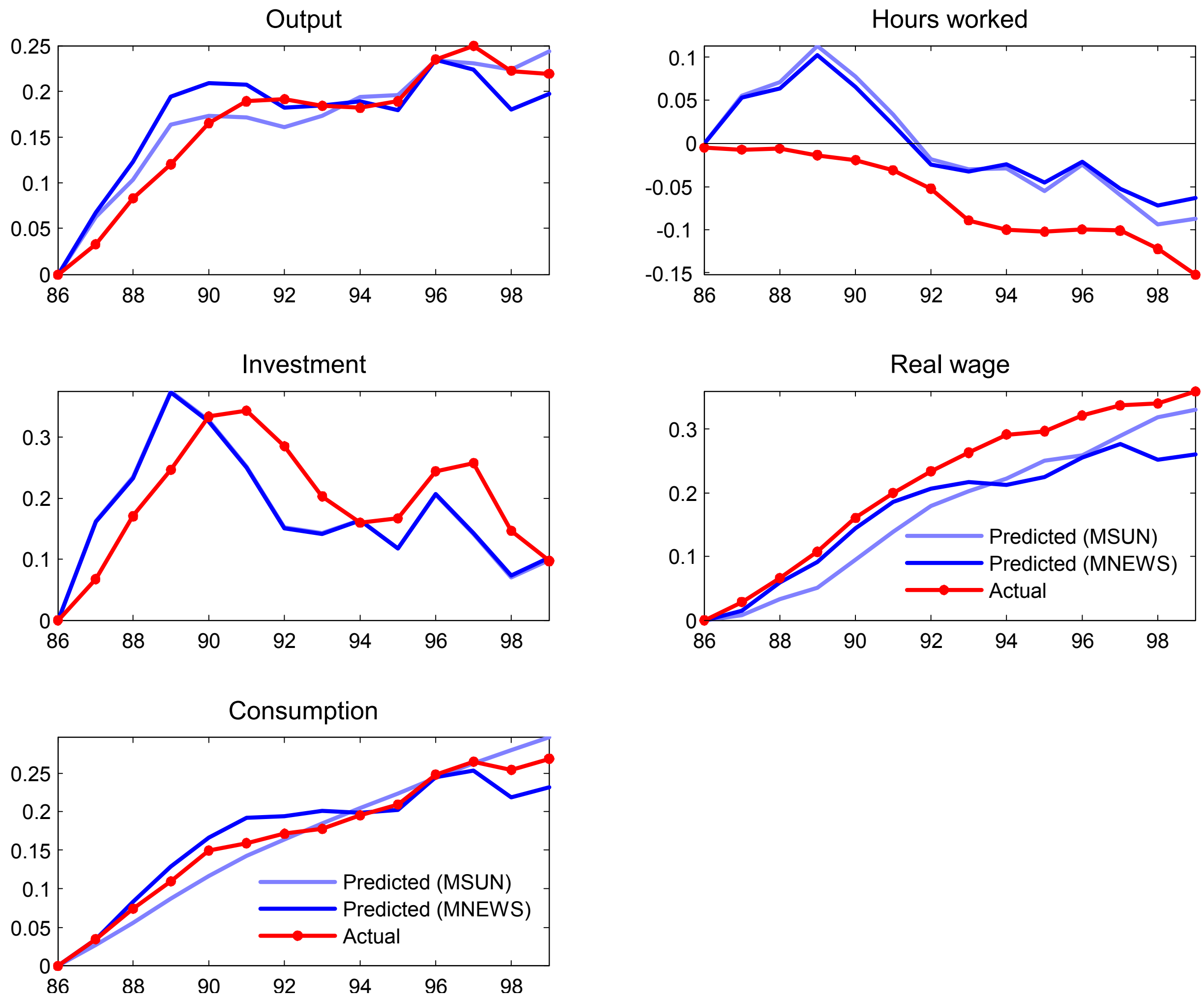
Figure 4. Responses to an anticipated increase in TFP



Notes: In period one there is an announcement that TFP will be one percent higher in period five ($\xi_1^5 = 1$). This announcement is validated in period five. All variables are in percent deviations from the steady state.

Figure 4 plots the impulse responses to an anticipated productivity improvement. Specifically, the agents learn in period 1 that the level of TFP will be one percent higher in period 5. In period 5, the TFP is one percent higher. Like the sunspot shock, the news shock triggers a boom in the stock market and in the real economy. However, the dynamic responses to two types of expectation shocks are quite different. Nakajima (2003) and Karnizova (2012) provide the intuition for the transmission mechanisms of the model.

Figure 5 Predicted and actual paths of macroeconomic variables



Notes: The MSUN version ($\sigma = 7$) is simulated with sunspot shocks only. The MNEWS version ($\sigma = 0.185$) is simulated with the productivity shocks and productivity prospects. The data are in log-levels, normalized to zero in 1986.

To assess impacts of the sunspot and news shocks on the Japanese economy, the model is simulated with the estimated shock series. The first column of Figure 5 plots the paths of output, investment and consumption predicted by the MSUN version with sunspot shocks only, and of the MNEWS version with the realized productivity shocks and productivity prospects. It also shows the actual Japanese data. Several observations can be made about the results. First, output and investment experience a boom-bust cycle in both versions of the model, albeit the timing of the cycle is shifted forward relative to the actual data. Second, the predicted paths of investment are virtually identical in the two versions. Both the model and the data point to a tight link between investment and stock price movements. Third, consumption is predicted to grow at the time of investment and stock market crash, as was the case in Japan. The predicted path for consumption is too smooth in the MSUN version. By contrast, it is more sensitive to shocks in the MNEWS version.

Figure 5 extends the analysis of Nakajima (2003) to include hours worked and the real wage. Both versions of the model predict a boom in hours, similarly to the boom in investment and output. The average hours worked in Japan, however, are falling from 1986 onward. A number of government regulations of labor standards at the end of the 1980s and early 1990s may provide a possible explanation for the absence of the boom in hours.[4] There are noticeable differences in wages predicted by the two versions of the model. The wage in the MNEWS versions tracks closely the behavior of TFP. In contrast to TFP, the Japanese real wages are increasing in the 1990s.

An interesting comparison can be made between the business cycles of the Japanese and U.S. economies. The U.S. went through a boom-bust cycle in stock prices and investment in 1995-2003. Changes in expectations, either through sunspot shocks or TFP news shocks, are viewed as a likely cause of that cycle, as argued by Xiao (2004) and Karnizova (2012). Similarly to Japan, consumption in the U.S. had a positive growth during the 2001 recession that followed the boom of the 1990s. Yet, the labor market dynamics were rather different. McGrattan and Prescott (2010) document that hours in the U.S. boomed in the 1990s, while the wages were below the trend. A more detailed comparison of the apparently expectation-driven boom-bust episodes in Japan and the U.S. is left for further analysis.

6. Concluding comments

Understanding the linkages between financial markets and the real economy has become particularly important in the aftermath of the financial crisis of 2008, which brought about the largest world-wide recession since the Great Depression. This note analyzed the Japanese economy from a perspective of a business cycle model to gain insights on the role of market speculations and productivity fundamentals. Overall, the results suggested that expectation changes, be they speculative or productivity-related, may have been critical in explaining the Japanese boom in the late 1980s and the lost decade of the 1990s. The estimated series of sunspot shocks and productivity prospects were very highly positively correlated. The paths for output and investment predicted by the model driven by sunspot shocks only and by TFP realized and news shocks were largely consistent with the data.

Further work would be desirable to differentiate the speculative and the news views of the Japanese business cycle. The differences in the model predictions for consumption and real wages could be exploited. Another fruitful avenue of research would be to construct alternative measures of sunspot and TFP news shocks, and evaluate their performance in the context of the model. The data on expected growth rates of the Nikkei and corporate earnings from Shiller et al. (1996) could be used to derive sunspot shock measures. Alternative measures of TFP news shocks could be constructed with the method of Beaudry and Portier (2005), based on vector autoregressions.

[4] According to Hayashi and Prescott (2002), changes in government regulations include a reduction of the statutory workweek and the number of workdays per week, and an increase in days of paid vacations.

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