Asian Journal of Economics and Business. 1(2) **2020 :** 95-109

ARF INDIA
Academic Open Access Publishing
www.arfjournals.com

The Taylor Rule and Business Cycles in the Solow-Tobin Model

Prof. Wei-Bin Zhang

Ritsumeikan Asia Pacific University, Japan, E-mail: wbz1@apu.ac.jp

Keywords:

business cycles; the Solow-Tobin model; the Taylor rule; periodic shocks;inflation; growth.

Received: 9 April 2020;
Revised: 16 April 2020;
Accepted: 10 June 2020;
Publication: 31 July 2020

Abstract: This paper extends Zhang's monetary growth model with the Taylor rule by allowing all constant parameters to be time-dependent parameters (Zhang, 2019). The original model is built on basis of the Solow model, the Tobin growth money with money, and the Taylor rule. This study examines effects of different time-dependent exogenous periodic shocks on the monetary growth economy. We show how various exogenous periodic shocks causebusiness cycles.

1. Introduction

The role of money is a key issue in the literature of theoretical economics. Tobin (1965) first proposed a formal monetary growth model by extending the Solow growth model (Solow, 1956). The Tobin growth model deals with an economy with the outside money printed by the government. Money and real capital are included in the portfolios of agents. Modelling of multiple portfolios, such as money, capital, bond, golden, and land, is difficult in theoretical economics on microeconomic foundation. In fact, Tobin failed to develop his model with an acceptable microeconomic foundation. A generalization of the Tobin model is the money in utility (MIU) function approach. Money is introduced into utility function (Patinkin, 1965; Sidrauski, 1967, and Friedman, 1969; Wang and Yip, 1992; Gomme, 1993; Jones and Manuelli, 1995; Dotsey and Starte, 2000; and Handa, 2009).Zhang deviated from the main approach by applying his concept of disposable income and utility function to include model in utility with portfolios choice Zhang (2008). Moreover, Zhang (2019) first introduces the Taylor rule to the Solow-Tobin growth model. The Taylor rule is a well-applied assumption about how central banks determine nominal interests, basing on economic conditions (e.g., Dupor, 2001; Meng and Yip, 2004; Schmitt-Grohe and Uribe, 2009). The rule was proposed by Taylor (1993) and Henderson and McKibbin (1993) to deal with issues related to price stability. Zhangintroduces the Taylor rules to the Solow-

Tobin model, using the MIU approach and including endogenous labor supply. This paper studies business cycles by generalizing Zhang's model.

To understand relations between inflation and growth is important. With many empirical studies over decades there are opposite answers to the question of whether growth is positively or negatively related to inflation (Aydin *et al.*, 2016; Akinsola and Odhiambo, 2017). This study addresses this issue in a model of endogenous money and growth built on microeconomic foundation. There are different economic mechanisms for explaining well-observed business cycles in the literature of economic dynamics (e.g., Zhang, 1991, 2005, 2006; Lorenz, 1993;Flaschelet al 1997;Chiarella and Flaschel, 2000; Shone, 2002; Gandolfo, 2005; Puu, 2011; Tian, 2015).For instance, the real business-cycle theory assumes that business cycles result from various exogenous shifts in the real economic variables, such as population growth and technological changes. Keynesian economics emphasizes dynamics of monetary policies and monetary variables as causes of business cycles. However, there are only a few formal models in the literature of business cycles, which is on microeconomic foundation. This paper introduces periodic shocks in monetary policies and real variables to demonstrate the existence of business cycles by extending Zhang's monetary growth model with the Taylor rule. The main difference between the model to be developed and the model by Zhang (2019) is that this paper makes all the exogenous time independentparameters as timedependentcoefficients. Section 2 proposes a monetary growth model. Section 3 studies dynamic properties of the model and gives themovement of the economy when all the coefficients are invariant in time. Section 4 shows effects of different exogenous periodic shocks, demonstrating business cycles to exogenous changes in monetary policies shocks. Section 5 concludes the paper.

2. The Monetary Growth Model with the Taylor Rule

The model basically follows the monetary growth model recently proposed by Zhang (2019), except that all the parameters in Zhang's model are time dependent in the model to be developed. This generalization makes the original model more robust as it can analyze effects of any exogenous shocks on economic growth with money. We have an economy with homogenous households, one production sector (the same as in the Solow model), and government. The number of households at time t is denoted by $\bar{N}(t)$. The Solow model and its extensions are referred to, for instance, Solow (1956), Burmeister and Dobell (1970); and Barro and Sala-i-Martin (1995).The role of government is similar to that in the Tobin growth model with money (e.g., Tobin, 1965; Nagatani, 1970), except about how to model money supply and demand. Capital and laborare used as inputs in production. We introduce money to utility function but neglect its possible role in production. All markets are perfectly competitive. There are three assets. They are respectively money, bond, and capital.Bond is issued by the government. Three assets are held by households. The nominal bonds pay the (positive) nominal interest rate $R(t)$. The rate is given by the Taylor rule. We use $P(t)$ to stand for the nominal price and $\pi(t)$ for the inflation rate. We have:

$$\pi(t) = \frac{\dot{P}(t)}{P(t)}.$$

Labor supply

The total labor supply $N(t)$ is given by:

$$N(t) = T(t)\bar{N}(t) \tag{1}$$

where $T(t)$ is the work time of the representative household.

The production sector

The sector's production function is taken on the following Cobb-Douglas form:

$$F(t) = A(t)\, K^{\alpha(t)}(t)\, N^{\beta(t)}(t), \;\; \alpha(t),\; \beta(t) > 0,\;\; \alpha(t) + \beta(t) = 1 \tag{2}$$

where $A(t)$, $\alpha(t)$, and $\beta(t)$ are time dependent. Each firm is faced with market-determined rate of interest $r(t)$ and real wage ratew $w(t)$. The marginal conditions of the industry are given by:

$$r(t) + \delta_k(t) = \frac{\alpha(t)F(t)}{K(t)},\;\; w(t) = \frac{\beta(t)F(t)}{N(t)} \tag{3}$$

where $\delta_k(t)$ is the time dependent depreciation rate of capital and

$$r(t) \equiv R(t) - \pi(t).$$

Disposable income

The utility function and disposable income in this study are proposed by Zhang (1993, 2005, 2008).They are applied to different fields of economics. The nominal government bond held by the household is denoted by $B(t)$. The household holds money $M(t)$. The government applies the real lump-sum tax $\bar{\tau}(t)$. The household current income is:

$$y(t) = r(t)\left(\bar{k}(t) + b(t)\right) + T(t)w(t) - \frac{\dot{B}(t)}{P(t)} - \frac{\dot{M}(t)}{P(t)} - \pi(t)m(t) - \bar{\tau}(t) \tag{4}$$

wherer $r(t)\,\bar{k}(t)$ is the interest payment, $T(t)\,w(t)$ is the wage payments, $\pi(t)\,m(t)$ is the cost of holding money, and

$$m(t) \equiv \frac{M(t)}{P(t)}, b(t) \equiv \frac{B(t)}{P(t)}.$$

We use $a(t)$ to stand for the total value of wealth of the representative household. That is

$$a(t) \equiv \bar{k}(t) + b(t) + m(t).$$

The disposable incomeis:

$$\hat{y}(t) = a(t) + y(t). \tag{5}$$

We use $\bar{T}(t)$ to represent the leisure time spent on leisure and T_0 the (fixed) total available time.We have:

$$T(t) + \bar{T}(t) = T_0. \tag{6}$$

Substituting (6) into (5) yields

$$\hat{y}(t) = \bar{y}(t) + m(t) - \bar{T}(t)w(t) - \pi(t)m(t), \tag{7}$$

where

$$\bar{y}(t) \equiv (1 + r(t))\left(\bar{k}(t) + b(t)\right) + T_0\, w(t) - \frac{\dot{B}(t)}{P(t)} - \frac{\dot{M}(t)}{P(t)} - \bar{\tau}(t).$$

Utility function and budget

The utility function is specified as follows:

$$U(t) - \bar{T}^{\sigma_0(t)}(t) m^{\varepsilon_0(t)}(t) c^{\xi_0(t)}(t) s^{\lambda_0(t)}(t), \ \sigma_0(t), \varepsilon_0(t), \xi_0(t), \lambda_0(t) > 0, \tag{8}$$

where the propensity to enjoy leisure time is denoted by $\sigma_0(t)$, the propensity to hold money by $\varepsilon_0(t)$, the propensity to consume $\xi_0(t)$, and the propensity to own wealth by $\lambda_0(t)$. Applications of this utility function to different economic issues are referred to Zhang (2005, 2008). As the disposable incomeis distributed to holding money, saving, and consumption, we have:

$$\left(1 + \mathrm{R}(t)\right) m(t) + c(t) + s(t) = \hat{y}(t). \tag{9}$$

Inserting (7) in (9), we have

$$w(t)\bar{T}(t) + \bar{\pi}(t)m(t) + c(t) + s(t) = \bar{y}(t), \tag{10}$$

where

$$\bar{\pi}(t) \equiv \pi(t) + \mathrm{R}(t).$$

Optimal behavior

The consumer problem is to choose current money, leisure time, consumption, and saving so that the utility is maximized. We maximize $U(t)$ under (10) to obtain the first-order conditions:

$$w(t)\bar{T}(t) = \sigma\,\bar{y}(t),\ \bar{\pi}(t)m(t) = \varepsilon\,\bar{y}(t),\ c(t) = \xi\,\bar{y}(t),\ s(t) = \lambda\,\bar{y}(t), \tag{11}$$

where

$$\sigma \equiv \rho\sigma_0,\ \varepsilon \equiv \rho\varepsilon_0,\ \xi \equiv \rho\xi_0,\ \lambda \equiv \rho\lambda_0,\ \rho \equiv \frac{1}{\varepsilon_0 + \xi_0 + \lambda_0 + \sigma_0}.$$

The money demand function in (11) is similar to that in the Baumol-Tobin model (Baumol, 1952, Tobin, 1956; Romer, 1986).

Change in wealth

We have the change as saving minus dissaving:

$$\dot{a}(t) = s(t) - a(t). \tag{12}$$

Fiscal and monetary policy

The original Taylor rule (Taylor, 1993) is:

$$R(t) = \pi(t) + r^*(t) + 0.5\,(\pi(t) - \pi^*(t)) + 0.5\,(y(t) - y^*(t)),$$

where is $r^*(t)$ an exogenous given real interest rate, $\pi^*(t)$ is an exogenous (desired) inflation rate, $y(t)$ is the logarithm of real GDP, and $y^*(t)$ is the logarithm of an exogenous potential real GDP. The rule tells that the central bank enhances the interest rate to lower inflationary pressure when output is higher than its full-employment level or inflation is higher than its target. Instead of the original Taylor rule, this study specifies the authority's interest rate feedback rule:

$$R(t) = R(\pi(t), t) \geq 0.$$

The policy is active (passive) at an inflation rate π if $R'(\pi) > (<) 1$. In particular, we generalize the rule suggested by Benhabib *et al.* (2001):

$$R(t) = q_0(t)e^{q(t)(\pi(t) - \pi^*(t))},\ q_0(t), q(t),\ \pi^*(t) > 0, \tag{13}$$

in which q_0, q and π^* are invariant in time in Benhabib *et al.,* but is time dependent in our study.

The budget constraint of the government

Let $M(t)$ and $B(t)$ stand for, respectively, the money and the nominal bonds. The government does not consume and supply public goods. The bonds of the government is paid with the nominal interest rate. The flow budget constraint of the government is:

$$\dot{B}(t) = R(t)B(t) - \dot{M}(t) - P(t)\bar{\tau}(t). \quad (14)$$

Capital accumulation

The change in capital stock is the output minus consumption and depreciation of capital stock:

$$\dot{K}(t) = F(t) - \bar{N}(t)c(t) - \delta_k(t)K(t). \quad (15)$$

The dynamic model is completed.It is a generalization of Zhang's model. The model is built on the basis of the three basic and most well-known models in economic growth theory, the Solow growth model, Tobin model with money, and the Taylor rule. The rest of the paper studies the properties of the model by simulation.

3. The Dynamics of the Model

We now show that the dynamics are given by two differential equations. The following lemma is checked in the Appendix.

Lemma

The motion of the economic system is given two differential equations with $\bar{k}(t)$ and $\pi(t)$ as the variables:

$$\dot{\bar{k}}(t) = \varphi_k\left(\bar{k}(t), \pi(t), t\right),$$

$$\dot{\pi}(t) = \varphi_\pi\left(\bar{k}(t), \pi(t), t\right), \quad (16)$$

where we give functions φ_k and φ_π of $\bar{k}(t)$ and $\pi(t)$ in the Appendix.We have the values of the other variables by following the procedure: $z(t)$ from (A3) $\rightarrow w(t)$ and $r(t)$ from (A2) $\rightarrow R(t)$ with (13) $\rightarrow K(t) = \bar{k}(t)\bar{N} \rightarrow b(t)$ with (A14) $\rightarrow m(t)$ with (A6) $\rightarrow P(t) = P_0 e^{\int_0^t \pi dx} \rightarrow \bar{y}(t)$ with (A5) $\rightarrow \rightarrow B(t) = P(t)\, b(t)\, \bar{T}(t)$, $s(t)$, and $c(t)$, by (11) $\rightarrow M(t) = P(t)m(t) \rightarrow T(t)$ from (6) $\rightarrow N(t)$ by (1) $\rightarrow F(t)$ with (A4).

We thus can determine and follow the movement of the economy with initial conditions. Althoughthe expressions are too tedious to provide a simple intuitive interpretation, we can illustrate behavior with computer.As we are concerned with impact of exogenous changes on the economy, we first simulate the case that all the time dependent parameters are constant - a case already simulated by Zhang (2019). Hence, the rest of the section summarizes the results by Zhang, which provide the reference point for comparative dynamic analysis. The parameters are taken on the following constant values:

$\bar{N} = 50$, $T_0 = 24$, $\alpha = 0.33$, $A = 1.5$, $\pi^* = 0.01$, $\bar{\tau} = 1$, $\lambda_0 = 0.6$, $\xi_0 = 0.1$, $\sigma_0 = 0.18$, $\varepsilon_0 = 0.005$, $q_0 = 0.01$, $q = 150$, $\delta_k = 0.03$.

The unique equilibrium point is identified as follows:

$$F = 846.1,\ N = 362,\ K = 3897.5,\ R = 0.201,\ r = 0.171,\ \pi = 0.03,$$

$$w = 1.57,\ m = 3.16,\ b = 6.4,\ \bar{k} = 78,\ a = 87.5,\ c = 14.6,\ T = 7.24.$$

The two eigenvalues are:

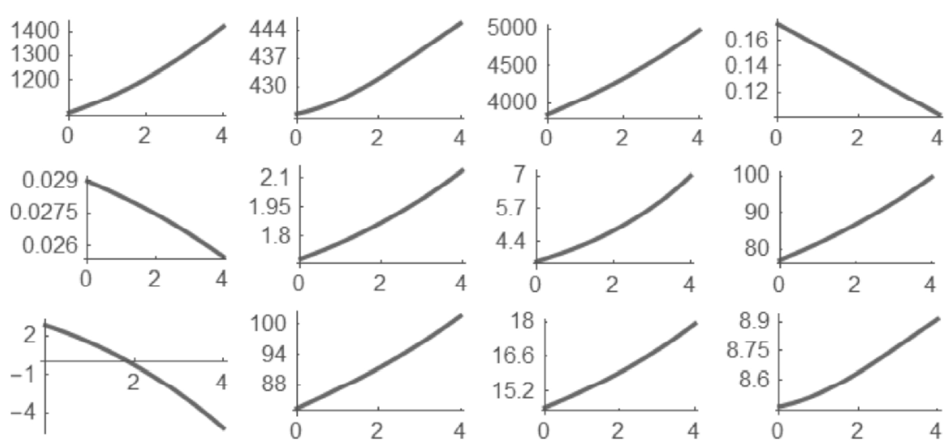
$$\{0.349, -0.234\}.$$

The saddle point implies that simulation is effective generally for short run.With the initial conditions as follows:

$$\bar{k}(0) = 77,\ \pi(0) = 0.029.$$

weplot the movement of the economy in Figure 1.

Figure 1: The Motion of the System with Wealth and Money



4. Comparative Dynamic Analysis

The previous section gave the short-run movement of the economic system. As mentioned before, our main concern is how time dependent variations in the economic environment affect the movement of the system. We define a symbol $\bar{\Delta}$ to stand for the change rate in term of percentage due to the parameter change with regards to the variable values in Figure 1.

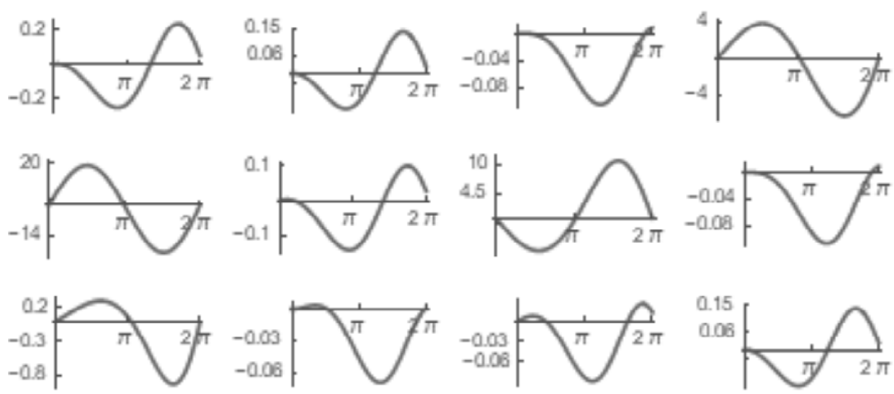
4.1. Periodic oscillatory perturbations in the targeted inflation rate

We now simulate the impact of the followingoscillatory perturbations in the targeted inflation rate on the movement of the system:

$$\pi_0(t) = 0.01+0.05\sin(t).$$

Figure 2 gives the simulation results. It should be noted that in the plot we use $\Delta b(t)$ to stand for the change in amount of $b(t)$. We don't present $\overline{\Delta} b(t)$ as $b(t)$ passedzero before the change in the parameter, which implies infinite change rate at the point. The nominal rate of interest is oscillatory in the same period as the exogenous shock. The national labor supply and capital stock oscillate but not with the same period as the exogenous shock. This also explains why the national output has not the same period as the exogenous shock. We see that all the variables oscillate with the exogenous periodic perturbations. We thus conclude that the government can affect performances of real economies by varying the targeted inflation rate.

Figure 2: Oscillatory Perturbationsin the Targeted Inflation Rate



4.2. Periodic oscillatory perturbations in the total factor productivity

We now simulate the impact of the followingoscillatory perturbations in thetotal factor productivity on the movement of the system:

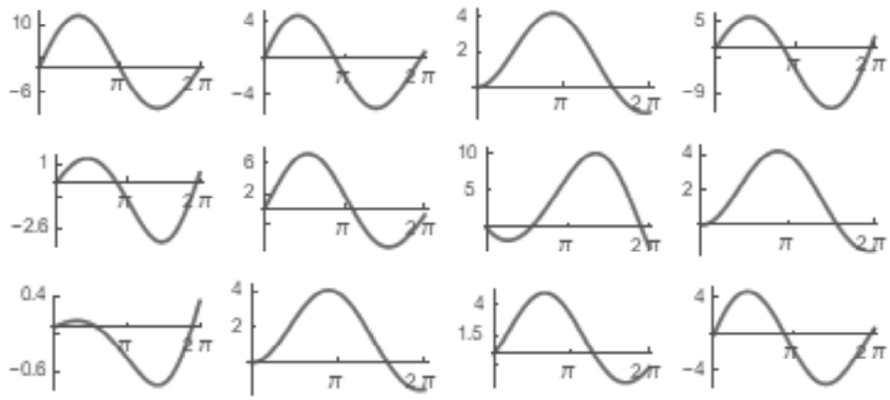
$$A(t) = 1.5 + 0.1\sin(t).$$

Figure 3 gives the simulation results. The nominal rate of interest is reduced. We see that technological changes also cause business cycles.

4.3. Periodic oscillatory perturbations in the propensity to hold money

We now simulate the impact of the followingoscillatory perturbations in the propensity to hold money on the movement of the system:

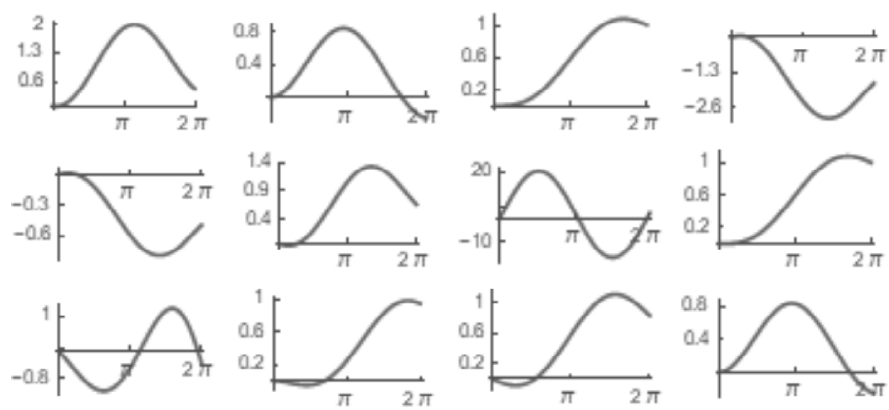
Figure 3: Oscillatory Perturbationsin the Total Factor Productivity



$$\epsilon_0 (t) = 0.005 + 0.001 \sin(t).$$

Figure 4 gives the simulation results. As the propensity to hold money experiences the exogenous shocks, the variables oscillate. As the system is unstable, the variables may not oscillate around a long-term equilibrium path.

Figure 4: Oscillatory Perturbationsin the Propensity to Hold Money



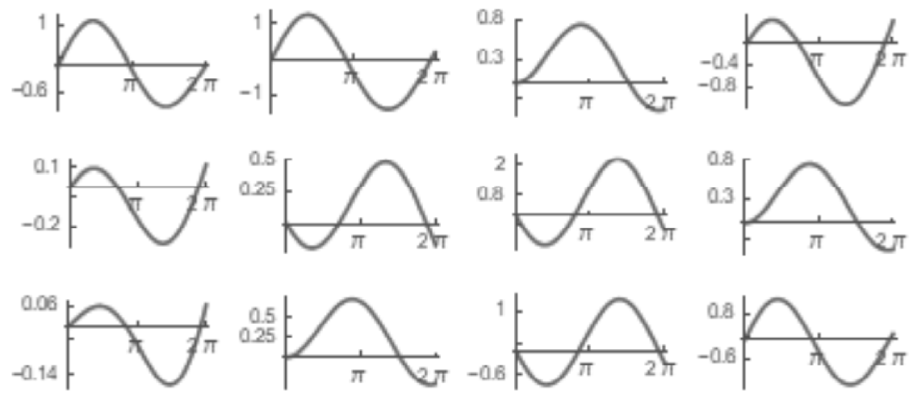
4.4. Periodic oscillatory perturbations in the propensity to save

We now simulate the impact of the followingoscillatory perturbations in the propensity to save on the movement of the system:

$$\lambda_0 (t) = 0.6 + 0.01 \sin(t).$$

Figure 5 gives the simulation results. The periodic perturbations in the propensity to save result aperiodic movement of the economic system. This result shows how preference changes lead to business cycles.

Figure 5: Oscillatory Perturbationsin the Propensity to Save



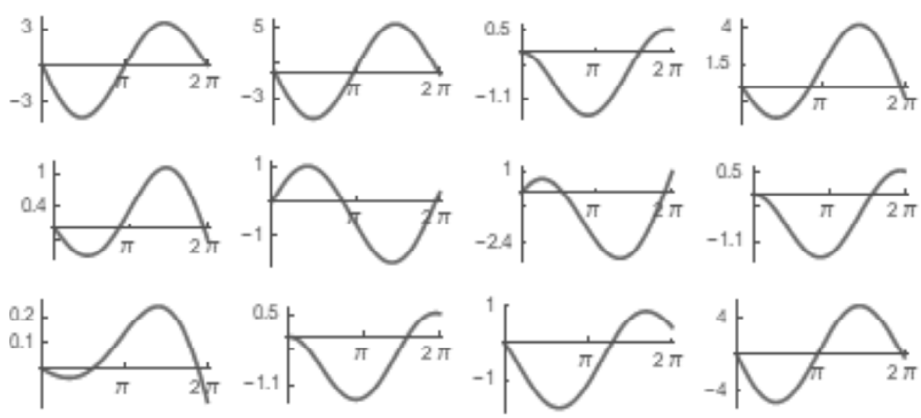
4.5. Periodic oscillatory perturbations in the propensity to use leisure time

We now simulate the impact of the followingoscillatory perturbations in the propensity to use leisure time on the movement of the system:

$$\sigma 0(t) = 0.18 + 0.01 \sin(t).$$

Figure 6 gives the simulation results.

Figure 6: Oscillatory Perturbationsin the Propensity to Use Leisure Time



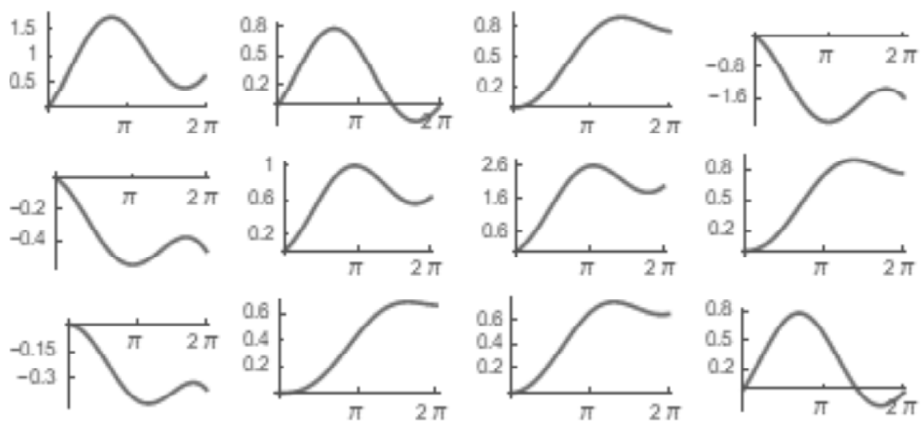
4.6. Periodic oscillatory perturbations in the tax

We now simulate the impact of the followingoscillatory perturbations in the tax on the movement of the system:

$$\overline{\tau}(t) = 1 + 0.1 \sin(t).$$

Figure 7 gives the simulation results.

Figure 7: Periodic oscillatory Perturbationsin the Tax



5. Conclusions

This study made a generalization of Zhang's model by allowing all the constant coefficients to be time dependent. We demonstrated how business cycles are caused by different real and monetary shocks. It shows that either real shocks or monetary shocks can result in appearance of business cycles. The model is quite general as it includes the basic economic mechanisms of the Solow-growth model, the Tobin model with money, and the Taylor rule. As there is a large amount of literature for extending each of these models, it is not difficult to generalize our model on basis of the literature.

Appendix: Checkingthe Lemma

With (3), we get:

$$z \equiv \frac{r + \delta_k}{w} = \frac{\bar{\beta} N}{K}, \tag{A1}$$

where $\bar{\beta} \equiv \alpha / \beta$. We suppress time index where there will be no confusion. By (3) and (A1), we get:

$$w = \beta A \left(\frac{\bar{\beta}}{z} \right)^{\alpha}, \; r = z w - \delta_k . \tag{A2}$$

The rate of interest and wage rate are thus uniquely determined as functions of z. By (2) we obtain:

$$z(\pi) = \bar{\beta}^{-\alpha/\beta} \left(\frac{r + \delta_k}{\beta A} \right)^{1/\beta}. \tag{A3}$$

By(3) we get

$$F = \frac{w N}{\beta}. \tag{A4}$$

Substituting (14) in the definition of $\bar{y}$, we get

$$\bar{y} = \varphi_0 + \pi b, \tag{A5}$$

In which

$$\varphi_0(\bar{k}, \pi, t) \equiv (1 + r)\bar{k} + T_0 w.$$

By (11) and (A5) we get:

$$m\left(\bar{k}, b, \pi, t\right) = \varphi + \frac{\varepsilon \pi b}{\bar{\pi}}, \tag{A6}$$

where

$$\varphi(\bar{k}, \pi, t) \equiv \frac{\varepsilon \varphi_0}{\bar{\pi}}.$$

By (6), (A5) and (11) we get:

$$T = (1 - \sigma)T_0 - \left(\frac{1 + r}{w} \right) \sigma \bar{k} - \frac{\sigma \pi b}{w}. \tag{A7}$$

From their definitions we obtain:

$$\dot{m} = \frac{\dot{M}}{P} - \pi m, \ \dot{b} = \frac{\dot{B}}{P} - \pi b. \tag{A8}$$

Inserting (A8) in (14), we get

$$\dot{b} + \dot{m} = \mathrm{R}\, b - \pi m - \pi b - \bar{\tau}. \tag{A9}$$

From(A4), (15), and $K = \bar{k}\bar{N}$, we get

$$\dot{\bar{k}} = \frac{wT}{\beta} - c - \delta_k \bar{k}. \tag{A10}$$

With (11) and (A10), we obtain:

$$\dot{\bar{k}} = \varphi_k \equiv \frac{wT}{\beta} - \xi\,\bar{y} - \delta_k \bar{k}. \qquad \text{(A11)}$$

With (11) and (12), we get:

$$\dot{\bar{k}} + \dot{b} + \dot{m} + \bar{k} + b + m = \lambda \bar{y}. \qquad \text{(A12)}$$

Substituting (A9) into (A12), we get

$$\dot{\bar{k}} + R\,b - \pi\,m - \pi\,b - \bar{\tau} + \bar{k} + b + m = \lambda \bar{y}.$$

This this equation and (A11), we have

$$W + R\,b + (1-\pi)m = \pi\,b + \bar{\xi}\bar{y} - b, \qquad \text{(A13)}$$

where

$$W(\bar{k},\pi) \equiv \frac{wT_0}{\beta} + (1-\delta_k)\bar{k} - \bar{\tau},\; \bar{\xi} \equiv \xi + \lambda + \frac{\sigma}{\beta}.$$

Inserting (A6) and (A5) in (A13), we have

$$b = \tilde{\varphi}(\bar{k},\pi) \equiv \frac{\bar{\xi}\,\varphi_0 - (1-\pi)\varphi - W}{\varphi_1}, \qquad \text{(A14)}$$

in which

$$\varphi_1(\bar{k},\pi) \equiv R + \frac{(1-\pi)\varepsilon\,\pi}{\bar{\pi}} + 1 - \pi - \bar{\xi}\pi.$$

Inserting (A14), (A5) and (A7) in (A11), we obtain

$$\dot{\bar{k}} = \varphi_k(\bar{k},\pi) \equiv \frac{wT}{\beta} - \xi\,\bar{y} - \delta_k \bar{k}. \qquad \text{(A15)}$$

With (A14) and (A6), we get

$$b + m = \Psi(\bar{k},\pi) \equiv \tilde{\varphi} + \varphi + \frac{\varepsilon\,\pi\,\tilde{\varphi}}{\bar{\pi}}. \qquad \text{(A16)}$$

Taking derivatives of (A16) in t,we have

$$\dot{b} + \dot{m} = \frac{\partial \Psi}{\partial \bar{k}}\dot{\bar{k}} + \frac{\partial \Psi}{\partial \pi}\dot{\pi} + \frac{\partial \Psi}{\partial t}. \qquad \text{(A17)}$$

Inserting (A15) and (A9) in (A17), we have

$$\dot{\pi} = \varphi_\pi\left(\bar{k}, \pi\right) \equiv \left(R\tilde{\varphi} - \pi m - \pi\tilde{\varphi} - \bar{\tau} - \varphi_k \frac{\partial \Psi}{\partial \bar{k}} - \frac{\partial \Psi}{\partial t} \right)\left(\frac{\partial \Psi}{\partial \pi} \right)^{-1}. \qquad \text{(A18)}$$

Equations (A18) and (A15) include two differential equations with two variables. We get $\bar{k}(t)$ and $\pi(t)$ by (A17) and (A9). After we have the values of $\bar{k}(t)$ and $\pi(t)$, we get the rest variables by the procedure in the Lemma.

References

Akinsola, F.A. and Odhiambo, N. M. (2017). Inflation and Economic Growth: A Review of the International Literature. *Comparative Economic Research* 20(3), 41-56.

Aydin, C., Esen, O., and Bayrak, M. (2016). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Turkish Republics in Transition Process. *Procedia - Social and Behavioral Sciences* 229, 196-205.

Barro, R.J. and X. Sala-i-Martin (1995). *Economic Growth*. New York: McGraw-Hill, Inc.

Baumol, W.J. (1952). The Transactions Demand for Cash: An Inventory Theoretic Approach. *Quarterly Journal of Economics* 66(4), 545-56.

Benhabib, J., Schmitt-Grohe, S, and Uribe, M. (2001). The Perils of Taylor Rules. *Journal of Economic Theory* 96, 40-69.

Burmeister, E. and Dobell, A.R. (1970). *Mathematical Theories of Economic Growth*. London: Collier Macmillan Publishers.

Chiarella, C. and Flaschel, P. (2000). *The Dynamics of Keynesian Monetary Growth: Macro Foundations*. Cambridge University Press, Cambridge.

Dotsey, M. and Sarte, P.D.G. (2000). Inflation Uncertainty and Growth in a Cash-in-Advance Economy. *Journal of Monetary Economics* 45, 631-55.

Dupor, B. (2001). Investment and Interest Rate Policy. *Journal of Economic Theory* 98, 85-115.

Flaschel, P., Franke, R., and Semmler, W. (1997). *Dynamic Macroeconomics*. The MIT Press, Mass., Cambridge.

Gandolfo, G. (2005). *Economic Dynamics*. Berlin: Springer.

Handa, J. (2009). *Monetary Economics*. London: Routledge.

Henderson, D.W. and McKibbin, W. (1993). A Comparison of Some Basic Monetary Policy Regimes for Open Economies: Implications of Different Degrees of Instrument Adjustment and Wage Persistence. *Carnegie-Rochester Conference Series on Public Policy* 39, 221-318.

Gomme, P. (1993). Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model. *Journal of Monetary Economics* 32, 51-77.

Jones, L.E. and Manuelli, R.E. (1995). Growth and the Effects of Inflation. *Journal of Economic Dynamics and Control* 19, 1405-28.

Lorenz, H.W. (1993). *Nonlinear Dynamic Economics and Chaotic Motion*. Springer-Verlag, Berlin.

Meng, Q.L. and Yip, C.Y (2004). Investment, Interest Rate Rules, and Equilibrium Determinacy. *Economic Theory* 23, 863-78.

Nagatani, K. (1970). A Note on professor Tobin's "Money and Economic Growth". *Econometrica* 38(1), 171-75.

Patinkin, D. (1965). *Money, Interest, and Prices:* An Integration of Monetary and Value Theory, 2nd edition. New York: Harper & Row.

Puu, T. (2011). Nonlinear Economic Dynamics. Berlin: Springer.

Romer, D. (1986). A Simple General Equilibrium Version of the Baumol-Tobin Model. *Quarterly Journal of Economics* 101(4), 663-86.

Schmitt-Grohe, S, and Uribe, M. (2009). Liquidity Traps with Global Taylor Rules. *International Journal of Economic Theory* 5, 85-106.

Shone, R. (2002). *Economic Dynamics - Phase Diagrams and Their Economic Application.* Cambridge University Press, Cambridge.

Sidrauski M (1967). Inflation and Economic Growth. *Journal of Political Economy* 75, 789-810.

Solow, R. (1956). A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics* 70, 65-94.

Taylor, J.B. (1993). Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

Tobin, J. (1956). The Interest Elasticity of the Transactions Demand for Cash. *Review of Economics and Statistics* 38(3), 241-47.

Tobin, J. (1965). Money and Economic Growth. *Econometrica* 33, 671-84.

Wang, P. and Yip, C.K. (1992). Examining the Long-Run Effect on Economic Growth. *Journal of Macroeconomics* 14, 359-69.

Zhang, W.B. (1991). *Synergetic Economics.* Springer-Verlag, Heidelberg.

Zhang, W.B. (1993). Woman's Labor Participation and Economic Growth - Creativity, Knowledge Utilization and Family Preference. *Economics Letters* 42, 105-110.

Zhang, W.B. (2005). *Differential Equations, Bifurcations, and Chaos in Economics.* Singapore: World Scientific.

Zhang, W.B. (2006). *Discrete Dynamical Systems, Bifurcations and Chaos in Economics.* Elsevier: Amsterdam.

Zhang, W.B. (2005). *Economic Growth Theory.* London: Ashgate.

Zhang, W.B. (2008). *Monetary Growth Theory: Money, Interest, Prices, Capital, Knowledge, and Economic Structure over Time and Space.* London: Routledge.

Zhang, W.B. (2019). Economic Growth and the Taylor Rule in the Solow-Tobin Model. *Asian Business Review* 9(2), 49-56.