Global Economy and Finance Journal
Vol. 3 No. 1 March2010, Pp. 111-126

Innovation, Hawk-Dove Games and Business Cycles

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This study formalizes Joseph Schumpeter's creative destruction business cycle theory. We introduce Hawk-Dove games into an otherwise standard Real Business Cycle model. Starting from an equilibrium with 0 profits, there is no entry or exit in the economy. Positive shocks, such as innovations drive up profits attract new entries. Entrepreneurs make entry decisions simultaneously, which is a Hawk-Dove game. If the outcome of the game is too much investment, then profits will be squeezed, forcing entrepreneurs to exit. It is another Hawk-Dove game and could end up with too many exits. Business cycles therefore emerge. These Hawk-Dove games provide a rational foundation to "animal spirits" in Keynes' term. Our analysis reasserts two old consensuses: (1) There is no such thing as a general glut; (2) Crises are an essential part of the capitalistic process. We can show the co-movement of consumption, investment, output, employment and asset prices, which matches several features of business cycles. We also prove that a recession is not necessarily the result of negative shocks; positive shocks could trigger a complete business cycle.

Field of Research: Macroeconomic Theory

1. Introduction

The fact that the economy is cyclical is well documented. Economists also agree on what a cycle looks like. As early as in 1860, French economist Clement Juglar already identified the fluctuations. Austrian economist Joseph Schumpeter A. later described a Juglar cycle as in four stages: (i) expansion; (ii) crisis; (iii) recession; (iv) recovery. In 1946, Burns, Arthur F., and Wesley C.Mitchell stated, "a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle."

It is also well documented that the output is closely correlated with other variables, among which the most notable ones include:

1. *Consumption is procyclical but with less variation.*
2. *Investment is procyclical and is more volatile.*
3. *Employment and real wage are procyclical.*
4. *Stock prices are procyclical and usually are a leading indicator.*

A variety of theories have been proposed to explain the cyclical behavior of these variables. The most prominent theories are Keynesian, Neoclassical Real

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Business Cycle theory, Austrian and Maxian. Keynesians believe that the demand side shocks and the market failure combined cause fluctuations. Neoclassical Real Business Cycle theory believes that the supply side shocks are accountable for most of the fluctuations. Austrians, such as Schumpteter, see business cycles as processes of "creative destruction" and "are...an essential element of the capitalistic process and not merely occasional breakdowns to be individually explained by accidents different in each case". Maxians also think that crises are inevitable in capitalism but believe that they will lead to the collapse of the capitalistic system.

In this paper, we submit a new explanation to a complete business cycle, namely, the expansion, recession and the revival. It has the following characteristics: (1) The market structure is monopolistic competition rather than perfect competition; (2) Agents make decisions in a game theory context; (3) Prices are endogenously determined by market clearing conditions.

Our results are in line with Schumpeter's explanation in that (1) A positive shock can cause a business cycle; (2) Fluctuations are inevitable as the economy adopts innovations in a capitalistic system. Initially, the economy is on the long run trend, which is an equilibrium. Then a positive shock, such as a technological advance or low interest rates, can drive up the profits. Agents[i] respond to the positive shock optimally and new firms enter the market. As firms enter the market, both investment and employment will increase. At the same time, consumption will increase because of higher income and/or a better expectation of the future. We will see a Boom in the economy.

However, because of the decentralized nature of the system, the firms play a Hawk-Dove game[ii] which may lead to too many entries. If it happens, then the price of the product will drop and profits become negative. We call it a Crisis. Firms have to exit. Investment and employment will decrease. Consumption will also decrease but not as much as investment does. It is because the individuals make consumption decision based on the life time expected income, not just the income in one particular period. This is a Recession. The exit process is also a Hawk-Dove game, which may result in too many exits. An overshoot in the correction process prolongs and deepens the downturn of the economy. There will be another correction process and new firms enter the market. Both employment and real wage start to rise. The economy will rebound. It is the Recovery. Eventually, the economy can achieve a new equilibrium.

The pursuit of profits and the decentralized decision making process are nature of the market system. Business cycles created by them are then inevitable. Changes in output, consumption, employment, real wage and stock prices in business cycles found in out paper are consistent with the stylized facts.

The rest of this paper is organized as follows. Section 2 reviews the existent explanations of business cycles. Section 3 is the methodology. Section 4 offers the findings and discussion. The main theorem and two propositions are in this section. Section 5 concludes the paper.

2. Literature Review

The Existing Explanations of Business Cycles

Ever since the 19th century, economists have been trying to understand business cycles and offer policy suggestions. In this section, we will survey several schools, including the classical economists, Keynesian economists and Real Business Cycle model and contrast their explanations with the one we offer in this paper.

Business Cycle Is An Essential Element Of The Capitalistic Process

In his "The Explanation of the Business Cycle", Schumpeter pointed out two results established by the classical economists as a response to the recurring crises. The first, there is no such thing as a general glut. The second, crises are an essential part of the capitalistic process. He put his emphasis on innovations and argued that "These booms consist in the carrying out of innovations in the industrial and commercial organisms." while "'depression' can'... be understood... as the movement of business life toward a new state of equilibrium conforming to the data created by the boom". He termed this as "normal" depression. Entrepreneurs, in the pursuit of profits, would carry out innovations and create a boom. The business community does not proceed to new methods in line. Those who lag behind are forced onwards or ruined by competition.

We are in line with Schumpeter's argument except for one point. In our model, not only the creative destruction---the destruction created by innovation, but the overcrowding of "newmen"will lead to a recession. When too many entrepreneurs carry out the innovation, the competition among them drives down the price and squeeze the profit. Some of them have to exit and this exiting process will lead to a recession and could lead to a depression if the coordination breaks down.

Animal Spirit Or Rational Expectation?

In Keynesian theory, business cycles were demand driven. The fluctuations in the economy mainly came from the instability in the private sectors. The instability in the private sectors was partly "due to the characteristic of human nature that a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation" "if the animal spirits are dimmed and the spontaneous optimism falters, leaving us to depend on nothing but a mathematical expectation, enterprise will fade and die;" This theory has no microeconomic foundation and is not consistent with the most fundamental assumption---rationality, in economics. Our model can provide a rational behavior foundation for this seeming "animal spirit". In our model, we find that the simultaneous entry and exit are not due to spontaneous optimism or pessimism. It is indeed based on a "mathematical expectation". The problem here is a true uncertainty about "a weighted average of quantitative benefits multiplied by quantitative probabilities". Agents have incomplete and imperfect information.

They do not know exactly how many players are in the market and they do not know what they other players will choose. When the expected profit is equal to 0, agents can choose to enter or not. Nobody knows others' choice. When too many agents decide to enter, there will be overproduction. When too few choose to enter, there will be underproduction. They are just different realizations of the outcome. It is consistent with optimization.

In Keynesian theory, business cycles are caused by demand side shocks and market failure resulted from price stickiness. In our model, the shock is a supply side shock. The market failure is embedded in Hawk-Dove game decision making process.

What Are The Sources Of Technical Regress?

Real business cycle economists believe that business cycles are caused by technological shocks, i.e., random fluctuations in the productivity level that shifted the constant growth trend up or down. Examples of such shocks include innovations, bad weather, imported oil price increase, stricter environmental and safety regulations, etc. Prescott, Edward C. characterized economic fluctuations as "optimal responses to uncertainty in the rate of technological change" (Prescott, E. "Theory Ahead of Business Cycle Measurement"). It is intuitive to believe that positive shocks, such as innovations will lead to booms. The challenge is how to really understand recessions, even depressions. First, there are advancements in technology, but not setbacks. We have the same question as Summers asked "What are the sources of technical regress?", in his "Some Skeptical Observations On Real Business Theory". Second, technological changes do not account for the 1982 recession, nor the current one. Third, although higher oil prices are often hand in hand with recessions, they do not happen before every recession. Such an example is the Great Depression. Moreover, sometimes, the oil price increase is not the shock itself but caused by other shocks, which could be positive. The recent increase in oil price was obviously due to the expansion in the economy of China, India and the US and thus an increase in the demand for oil. Thus, a model is needed to explain why there are recessions even without a negative shock. Our model will show that positive shocks can lead to recessions.

The second difference is that in the Real Business Cycle model, exogenous shocks are solely responsible for fluctuations. In our model, an exogenous shock, together with simultaneous decision making process contribute to the fluctuations. The simultaneous decision making process is endogenous in the market economy.

Recent Studies On Business Cycles

Many recent studies on business cycles are still in the framework of Real Business Cycle model. They modify the standard RBC model in order to fix some shortcomings of it, e.g. the need of shocks to the fundamental and the failure to show the positive co-movement between consumption and investment in business cycles. One branch of these studies explores the relationship between firms' expectations and the subsequent entry-exit decisions in response to

shocks/fluctuations in the economy. Beaudry and Portier (2007) identifies the conditions under which expectation driven business cycles are possible in simple neoclassical settings. Christiano, LLut, Motto and Rostagno (2008) adds nominal frictions---sticky nominal wages and an inflation targeting central bank, to a standard Real Business Cycle framework and argues that the boom-bust cycles are the outcome of the monetary policy. Jaimovich and Rebelo (2009) introduces three elements into the neoclassical growth model that together generates comovement in response to news shocks, including variable capital utilization, adjustment costs to investment and a weak short-run wealth effect on the labor supply. Another branch uses multi-equilibria and indeterminancy to explain business cycles (Benhabib & Wen, 2004; Jaimovich, 2007). Although their papers successfully fix the problems they aim at, they still need a trigger--a negative shock, for a recession. This is the problem we want to fix in our paper.

There are papers that build the microeconomic foundation of business cycles, the same as our purpose in this paper. Bernanke and Gertler (1989) incorporates a revelation game in the analysis of economic fluctuations. Dos Santos Ferreira and Dufourt (2006) uses Cournot equilibrium with free entry and "animal spirits" as the microeconomic foundation for business cycles. As in other papers with indeterminacy, it also requires some kind of bad signals or negative animal spirits to trigger recessions.

Papers on Schumpeter's "creative destruction" theory emphasize "growth", not business cycles. Francois and Lloyd-Ellis (2003) focuses on the fundamental linkages between short-run fluctuations and long-run growth. In their paper, the process of entrepreneurial innovation is responsible for the regular short-run fluctuations in economic activity. The boom is a consequence of clustering of implementation of innovations. After the boom, there is a slowdown because the present value of engaging in innovation falls below the wage and no new innovations come on line. As time passes by, the previous relationship between the present value and wage reverses and labor flows out of production and into innovation. This is the downturn since both consumption and output decline. Therefore, there is no real damage in a recession. It is more like the darkness before the dawn---a new boom is coming when the firms implement the innovations. In our paper, however, the boom is a result of entries due to positive profit. A recession follows if there are too many entries. There is a real damage to the economy because some investments are wasted. While their paper emphasizes economic growth and considers business cycles as inevitable effects of implementing innovations, we focus on business cycles and consider innovation as one of the positive shocks that can trigger business cycles.

Beaudry, Collard and Portier (2006) shows that business cycles may sometimes be driven by a positive shock, i.e. phenomenon akin to a gold rush. A transitory positive shock, such as the opening of new markets causes an economic expansion as firms rush to become a monopoly in the new market. Investment and employment increase in this process. However, after the rush, there is a shakeout period where in each new market, only one of the startups secures the monopoly position. It is the recession. In that paper, consumption does not

increase in the expansion, which is different from our finding. The profit is always equal to 0 so it cannot explain the change in stock prices in business cycles. Moreover, their model only explains the boom and bust, not the recovery afterwards thus the business cycle is not a complete one.

3. Methodology

3.1 The Setup

3.1.1 Preference

The economy is populated with identical, everliving agents whose mass is normalized to 1. They maximize their expected lifetime utility (*U*) defined over sequence of consumption (c_t) and hours (l_t) worked.

$$U_i = E_0\{\sum_{t=0}^{\infty} \beta^t u(c_{it}, h_{it})\} \quad (1)$$

$$u(c_{it}, h_{it}) = \frac{(c_{it} - \psi h_{it}^{\theta})^{1-\sigma} - 1}{1-\sigma}$$

where $1 > \beta > 0, \psi > 0, \theta > 1, 1 > \sigma > 0$

3.1.2 Technology

The consumption is based on the output of the final good Y, which is produced by a final goods firm. The firm is a price taker in input and output markets.

Final good production: The economy uses intermediate inputs x to produce a final good Y. The production of Y is governed by

$$Y_t = N_t\{\sum_{n-1}^{N_t} \frac{1}{N_t} x_{nt}^{\rho}\}^{\frac{1}{\rho}} \quad (2)$$

Commodities ($x_1, x_2, x_3 \ldots$) are good substitutes among each other. N_t is the range of intermediate inputs produced in period t and is determined by the entry/exit decisions made by firms in previous periods.

Intermediate goods production: Each potential commodity involves some fixed set-up cost (k_n) and fixed operational cost (f_{n_t}) in every period. The only variable input is labor (l_{n_t}). The production function of x_{n_t} is

$$x_{nt} = \mu_{nt} k_n^{\alpha} l_{nt}^{1-\alpha} \quad (3)$$

3.1.3 The Timeline

Time is discrete. At the beginning of each period t, the state variables are $\{\mu_{n_t}, S_t, P_t\, s_{it}, b_{it}\}$.

S_t is the capital stock in the economy. P_t is the price of the capital. s_{it} is individual i's stocks. b_{it} is the bonds that she owns (when it is positive) or issued

(when it is negative). Dividends and interests are paid at the end of period t. No default is allowed.

Individual i chooses her labor supply $h_{it}$and firm n chooses x_{n_t}.

At the end of each period, wages, dividends and interests are paid. No default is allowed. Individual i allocates her resource on consumption $c_{it}$and investment i_{it}.

It is an open economy therefore people can borrow and lend at a fixed interest rate, r=(1/β)-1.

Evolution of the state variables

1. *Capital stock is accumulated through investment.* $S_{t+1} = S_t + I_t, s_{it+1} = s_{it} + i_{it}$;
2. *Productivity is constant unless there is a shock.* $\mu_{nt+1} = \mu_{nt}$
3. *Savings/Debts are the residual after consumption and investment decision.* $b_{it+1} = (1+r)b_t + (1+\pi_t)s_{it} + w_t h_{it} - i_{it} I(i_{it} > 0) - i_{it}\delta I(i_{it} < 0) - c_{it}$

π_t is the margin rate. I(·) is the index function. δ is the discount rate when a specific investment is transformed into a general consumption. w_t is the competitive wage level.

3.2 The Analysis

For simplicity and tractability, we make three additional assumptions before we solve the model.

Assumptions:

1.Risk neutral agents: σ=0;

2.Constant returns to scale: ξ=1;

3.Free exits: δ=1.

In our model, the systematic uncertainty arises from simultaneous entry/exit. If the individual agents are risk averse, they will require a premium to enter the market. It is very difficult, if not impossible to deal with such an uncertainty. Assumption 1 does not change the nature of the coordination problem in the Hawk-Dove game so it will not affect our results. We can allow increasing returns to scale to a certain extent as long as the market does not explode[iii]. Free exits assumption makes the budget constraint continuous which assures a unique equilibrium. This assumption will not change the nature of the coordination problem in the Hawk-Dove game either.

The representative agent chooses consumption and labor supply to maximize her lifetime utility. Firms are in a monopolistic competitive market and choose their prices to maximize profits.

The representative agent's problem

$$\begin{aligned} & \max_{\{c_t,h_t\}} E_0\{\sum_{t=0}^{\infty}\beta^t u(c_t,h_t)\} \\ s.t\ c_t &= (1+r)b_t + (1+\pi_t)s_t + w_t h_t - s_{t+1} - b_{t+1} \\ s_{t+1} &= s_t + i_t \\ (1+\pi_t)s_t &= (1+r)P_t s_t \end{aligned}$$

s_t is the capital stock, which is equal to $N_t F_0$; P_t is the price of capital; b_t is savings(when it is positive, which we use bonds to denote) or debts (when it is negative); r_t is the risk free interest, which we assume is constant in an open economy; i_t is the investment.

First order conditions (FOCs) are:

$$\begin{aligned} b_{t+1} &: -\frac{\partial u(c_t,h_t)}{\partial c_t} + \beta\frac{\partial E_t u(c_{t+1},h_{t+1})}{\partial c_{t+1}}(1+r) = 0 \\ s_{t+1} &: -\frac{\partial u(c_t,h_t)}{\partial c_t} + \beta\frac{\partial E_t u(c_{t+1},h_{t+1})}{\partial c_{t+1}}E_t P_{t+1}(1+r) = 0 \\ h_t &: -\frac{\partial u_{it}/\partial h_{it}}{\partial u_{it}/\partial c_{it}} = w_t = \theta\psi h_{it}^{\theta-1} \end{aligned} \tag{4}$$

Given r=(1/β)-1, the first equation in FOCs becomes

$$\frac{\partial u(c_t,h_t)}{\partial c_t} = \frac{\partial E_t u(c_{t+1},h_{t+1})}{\partial c_{t+1}} \tag{5}$$

Given (5), the second equation becomes

$$E_t P_{t+1} = 1 \tag{6}$$

The intermediate good producer's problem

In a CES setup of the production, firms charge a constant markup, with

$$p_{it} = \frac{MC}{\rho}$$

The cost function

$$\begin{aligned} l_{nt} &= (\frac{x_{nt}}{\mu_{nt}k_n^{\alpha}})^{\frac{1}{1-\alpha}} \\ TC(x_{nt}) &= w_t l_{nt} + f_{nt} \end{aligned}$$

The marginal cost

$$\begin{aligned} MC(x_{nt}) &= \frac{\partial TC(x_{nt})}{\partial x_{nt}} \\ &= \frac{1}{1-\alpha} w_t \frac{1}{\mu_{nt} k_n^{\alpha}} l_{nt}^{\alpha} \end{aligned}$$

We focus on a symmetric case, where $l_{nt} = l_t, x_{nt} = x_t, k_{nt} = k_t, f_{nt} = f_t$, for all n=1,2,...N_t.

Since the mass of agents is 1.

$$H_t = N_t l_t = h_t$$

$$p_y \equiv 1$$

From the economy's budget constraint, $N_t p_t x_t = p_y\ Y_t$ and $Y_t = N_t x_t$, we have

$$\frac{MC}{\rho} = p_{it} = p_t = 1 \qquad (7)$$

We can use (7) to find the economy's employment level H_t as a function of the number of firms.

$$H_t = [\frac{\rho(1-\alpha)\mu_{nt} k_n^{\alpha} N_t^{\alpha}}{\theta\psi}]^{\frac{1}{\theta-1+\alpha}}$$

As long as α>0, H_t increases with N_t.

Since

$$w = \theta\psi h_t^{\theta-1} = \theta\psi H^{\theta-1}$$

w_t also increases with N_t .

The profit of each firm is given by

$$\begin{aligned} \pi &= px - TC(x) - rk \\ &= [\frac{1}{(1-\alpha)\rho} - 1]\theta\psi N^{\frac{\alpha\theta}{\theta-1+\alpha}-1}[\frac{\rho(1-\alpha)\mu k^{\alpha}}{\theta\psi}]^{\frac{\theta}{\theta-1+\alpha}} - f - rk \end{aligned}$$

Definition 1 *Equilibrium: the economy is in an equilibrium if the firm's profit is 0 and there is no investment. The stock price is equal to 1. Accordingly, consumption, employment and wage stay constant in every period.*

$$I = 0, \pi = 0, i = 0, B = 0, C = Y - f = wH + rNk$$

Given the equilibrium condition, we can find the optimal number of firms, the employment, wage and consumption.

$$
\begin{aligned}
N^* &= [\frac{\frac{1}{(1-\alpha)\rho}-1}{f+rk}]^{\frac{\vartheta-1+\alpha}{(\theta-1)(1-\alpha)}}(\theta\psi)^{\frac{\alpha-1}{(\theta-1)(1-\alpha)}}[\rho(1-\alpha)\mu k^{\alpha}]^{\frac{\theta}{(\theta-1)(1-\alpha)}} \\
H^* &= [\frac{\rho(1-\alpha)\mu k^{\alpha}}{\theta\psi}]^{\frac{1}{\vartheta-1+\alpha}}N^{*\frac{\alpha}{\vartheta-1+\alpha}} \\
w^* &= \theta\psi H^{*\theta-1} \\
C^* &= rN^*k + w^*H^*
\end{aligned}
$$

4. Findings and Discussion

Business Cycles

In this section we will discuss how a complete business cycle can be triggered by positive shocks. Positive shocks drive up profits and attract new entries. Entrepreneurs make decisions simultaneously, which is a Hawk-Dove game. If the outcome of the game is too much investment, then profits will be squeezed, forcing entrepreneurs to exit. It is another Hawk-Dove game and could end up with too many exits. Business cycles therefore emerge. We divide a cycle into 6 stages: (0) The equilibrium; (1) The Shock, there is a positive shock so the productivity increases. (2) Boom: simultaneous entry; (3) Crisis: overinvestment, negative profits and simultaneous exit; (4) Recession; (5) Recovery: a new equilibrium. We will show that certain realizations of these Hawk-Dove games will drive the economy through these stages.

When the economy deviates from the equilibrium, the individual believes that the equilibrium will be restored with a welfare loss associated with the adjustment process. Let the cost be k, k>0 and follows a distribution f(k). In this stage, the individual's problem becomes

$$
\begin{aligned}
V_t &= \max_{\{c_t,h_t\}} u(c_t,h_t) + \beta E_t V_{t+1}(s_{t+1},b_{t+1}) \\
s.t. c_t &= (1+r)b_t + (1+\pi_t)s_t + w_t h_t - s_{t+1} - b_{t+1} \\
s_{t+1} &= s_t + i_t \\
(1+\pi_t)s_t &= (1+r)P_t s_t
\end{aligned}
$$

and

$$
E_t V_{t+1}(s_{t+1},b_{t+1}) = \int [V^e(s_{t+1},b_{t+1}) - \kappa] f(\kappa) d\kappa \qquad \text{iv}
$$

In our model, σ=0, so that individuals do not care when to get the utility. Without loss of generality, we assume that they still want to smooth their consumption

and equalize the utility from each period, as is in the conventional consumer's behavior model.

$$c_t = r(a^e - E\kappa) + w^e h^e - \psi h^{e\theta} + \psi h_t^{\theta} \tag{8}$$

Theorem 1 In response to a positive shock, the capitalistic system, in which individual entrepreneurs make simultaneous and decentralized investment decisions, could create a business cycle in the process of adjustment from the old and low level equilibrium to the new and high level equilibrium. The economy was in an equilibrium and positive shock drives up the profit and attracts entrepreneurs into the market. This hawk-dove game may end up with overinvestment, which will squeeze the profit and force firms to exit. This is another hawk-dove game. If too many firms exit, then the economy will undergo another correction. Eventually, the positive shock will be digested and the equilibrium is restored.

We can show that a business cycle will emerge if the realizations of the afore mentioned series of hawk-dove games is of the following pattern. In the old equilibrium and when the shock happens, $N = N^*$. Entrepreneurs invest in new firms and the economy enters into a Boom with $N = \widetilde{N} \in (N^*, \bar{N})$, $\bar{N} > N^e$, the number of firms in the new equilibrium. Investment keeps increasing till $N = \bar{N}$ and the profit becomes negative. The economy is in a Crisis. Firms exit the market due to negative profits and $N = \underline{N}, \underline{N} < N^e$. It is a Recession. The profit becomes positive again. The economy will rebound and new firms enter the market, $N = \widehat{N} \in (\underline{N}, N^e)$, $\bar{N} > N^e$. We call it a Recovery. In the end, the economy achieves a new equilibrium, $N = N^e$.

Stage 1 The Shock

In the old equilibrium, the profit is equal to 0 and thus the investment is equal to 0. A positive shock to the productivity happens which we denote by a larger μ. For each firm, the profit will become positive since $\frac{\partial \pi}{\partial \mu} > 0$. It takes time for others to enter the market, so that the number of firms N^* remains unchanged. Total output Y_t will increase. H and w both increase with μ. As new firms enter the market, the economy will enter into a Boom.

Stage 2 The Boom

Proposition 1 In a Boom, output, consumption, business fixed investment, employment, real wage and stock prices will increase.

Proof. (omitted)[v]

Stage 3 The Crisis

In the Boom, the number of firms is still smaller than that in the new equilibrium. The profit is positive. More firms enter the market and economy moves to the next stage---the Crisis. There are too many firms in the market and the profit becomes negative. The stock price will drop. It is a leading factor which signals that a recession might be on the way.

Stage 4 The Recession

Negative profits in the Crisis forces firms to exit the market. It is another Hawk-Dove game. The realization could be too many exits and the economy enters into a recession.

Proposition 2 In a Recession, output, consumption, business fixed investment, employment and real wage decrease. Stock price starts to increase since it is a leading factor.

Stage 5 The Recovery

The economy reaches the bottom of this business cycle in the Recession and will rebound. The profits of the survival firms are positive. New firms will decide to enter, which leads to a recovery. Employment and wage will increase. Eventually, the economy achieves a new equilibrium with a higher productivity μ.

Corollary 1 In a business cycle, output, consumption, business fixed investment, employment and real wage are procyclical. Stock price is a leading factor.

Summary

If the economy evolves from the old equilibrium ($N = N^*$) to a new equilibrium ($N = N^e$) through the following path:

$$N^* \to \widetilde{N} \in (N^*, N^e) \to \overline{N} > N^e \to \underline{N} < N^e \to \widehat{N} \in (\underline{N}, N^e) \to N^e$$

then we can see it experience a complete business cycle. The movement of variables in the business cycle is summarized in the table below.

The Business Cycle

	Old Equil	Shock	Boom	Crisis	Recession	Recovery	New Equil
N	N^*	N^*	$\widetilde{N} \in (N^*, N^e)$	$\overline{N} > N^e$	$\underline{N} < N^e$	$\widehat{N} \in (\underline{N}, N^e)$	N^e
π	0	$+$	$+$	$-$	$+$	$+$	0
Y	Y^*	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	Y^e
C	C^*	$\uparrow$	$\uparrow$	?	$\downarrow$	$\uparrow$	C^e
I	0	$\widetilde{N} - N^*$	$\overline{N} - \widetilde{N}$	$-(\overline{N} - \underline{N})$	$\widehat{N} - \underline{N}$	$N^e - \widehat{N}$	0
H	H^*	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	H^e
w	w^*	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	w^e
P	1	> 1	> 1	< 1	> 1	> 1	$= 1$

Discussion

Positive Shocks

The positive shock is not necessarily an improvement of the marginal productivity, as we introduced in our model.

Any shock leading to more fixed investment can trigger a Hawk-Dove game. Such shocks might come from the supply side: (1) Marginal productivity increases; (2) Entry cost decreases due to less regulation and/or easy money. The shocks can also come from the demand side: (1) Income increases because of changes in other sectors in the economy and drive up demand in the sector we are interested in (e.g. the real estate); (2) The market expands as shown in international trade. There are other nominal and non-substantial shocks: (1) Change of tastes; (2) Credit expansion; (3) A prevailing optimistic mood.

The Government's Role

The financial system, as the middleman of the economy, can amplify shocks. It enables speculative investment in the Boom and causes rampant panic shutdowns in the Recession. Both will increase the altitude of the cycle. Bernanke and Gertler (1989) provided one channel of the amplifying effect. In a boom, firms' profits increase, which improve net worth, lower agency costs, and stimulate investment. This propagates the good times. On the contrary, in the crisis, firms' profits decline and net worth decreases. The consequent higher agency cost reduces investment and reinforces the decline in output. Proper monetary policies surely can mitigate the severity of the fluctuations. In practice, a tight monetary policy is usually not popular in a Boom. An expansionary monetary policy is more proper in a Recession.

The Stock Price

In our model, we find that the stock price will bounce back in the Recession. This is true under our assumption of free exits. In the real world, investments are specific in most cases and liquidation will be very costly. If the recovery rate is $\delta<1$, then there are multiple equilibria. The equilibrium stock price can be anywhere in between $[\delta,1]$. At these prices, no entry or exit will happen.

5. Conclusion

In this paper, we incorporated monopolistic competition market structure and individuals' strategic behavior into a real business cycle model. We showed that in the process of adopting a positive shock, the economy could experience a business cycle. However, due to the characteristics of the extended Hawk-Dove games, which sit in the core of our analysis, the magnitude and span of the fluctuations are unlikely to be predicable. The results in our paper are in line with Joseph Schumpeter's explanation of the business cycle but we offered an explicit explanation for the observed market failure in this adopting process. We also endogenized the so called "animal spirits" in Keynesian theory in a game theoretic framework where people behave rationally.

We did not discuss nominal factors in this paper. It will be an extension in the future. We believe that the inclusion of the money market is essential to the understanding of the monetary policy. It is also a promising direction to explicitly

model the interaction between the financial sector and the industry (the middleman and the producer). Thus we can do policy analysis. A more difficult but more relevant to policy analysis direction is the study of the extended Hawk-Dove game in this model. To know how to tune the economy through fiscal/monetary policies, we need to understand how individuals in a decentralized market economy aggregately respond to technology and price information in a dynamic process.

End-Notes

[i] In this paper, we use entrepreneurs and agents interchangeably.

[ii] The hawk-dove game is also commonly known as the game of chicken. Two hooligans with something to prove drive at each other on a narrow road. The first to swerve loses faces among his peers. If neither swerves, however, a terminal fate plagues both. In the hawk-dove version of the tale, hooligans are replaced by armies considering going to war.
There are two pure strategy equilibria. A different pure strategy equilibrium is preferred by each player. Both equilibria are Pareto optimal. A mixed strategy equilibrium also exists.

		Driver 2	
		Stay	Swerve
Driver 1	Stay	-100, -100	1, -1
	Swerve	-1, 1	0, 0

(www.gametheory.net)

In the mixed strategy equilibrium, the realization could be {stay, stay}
The games in our paper are extended version of this game and are far more complex. First, they are incomplete games. We do not know the exact number of players, nor do we know their characterisitcs. Second, they are repeated games. In this situation, it is very di¢ cult, if not impossible to construct a problisitc description of the outcomes. From this point of view, it is a true uncertainty in Frank Knight.s term.

[iii] We need $\partial\pi/\partial N<0$. The condition for this is $\xi<2-\alpha-((1-\alpha)/\theta)$. Since $\theta>1$, $0<\alpha<1$, $2-\alpha-((1-\alpha)/\theta)$ lies between (1,2).

[iv]
$$V^e(s_{t+1}, b_{t+1}) = \frac{c^e - \psi h^{e\theta} - 1}{1-\beta} = \frac{ra^e + w^e h^e - \psi h^{e\theta} - 1}{1-\beta}$$

and $a^e = b^e + P^e s^e$ and is the individual's net asset.

[v] All proofs are omitted due to space limitations. They are available upon request.

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