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(I) Proposed Title

Creative Destruct, Endogenous RBC model and Business Cycle in China

(II) Problems, Main Idea and Significance of Research

1) Problems:

Three main problems in traditional real business cycle (RBC) model are summarized as below. Creative Destruct of new technology may be the solution of these problems.

a) Amplifier of productivity shock

According to traditional RBC model, productivity shock must be large and persistent. But data in reality often doesn't satisfy this strict requirement. Therefore, it's necessary to modify traditional RBC model in this field. The best famous improvement is to introduce capacity utilization into RBC model to construct a high substitution economy, such as Burnside (1995) [9], Shapiro (1993) [46], Greenwood (1998) [19], and King (2000) [33]. This way is basic successful, especially for King's (2000) [33] paper, but not perfect. There are some problems about this method, such as whether it's rational to hold idle resource, how to decide the optimal capacity utilization and some difficulties in empirical evidence. Moreover, is there another amplifier of productivity shock? Creative destruct may be.

b) Propagation mechanism and dynamic property of output

From most RBC model, we know that the fluctuation in output is mainly explained by productivity shock, rather than model itself. To solve this problem, economists find plenty of propagation mechanism, such as "time to build" (Kydland 1982 [34]), fatigue effect (Kydland 1982 [34], Rouwenhorst, 1991 [44]), capacity utilization (Greenwood, 1998 [19]), distortionary taxation (Braun, 1994 [7]), homework (Benhabib, 1991 [4]), and labor hoarding (Burnside, 1993 [8]). However, according to the conclusion made by Cogley and Nason (1995) [12], few RBC models are satisfying. Chakraborty (2005) [11] think technology shock as propagation mechanism important. Therefore, if we can endogenize technology change in RBC model, the dynamic property of output will be explained by RBC model itself and the success won't be the so-called "illusion" in King's (1995) [29] paper.

c) Asymmetric effects of expansion and recession for RBC model

There are asymmetric effects when RBC model explain different economic changes such as expansion in economy and recession in economy. It is easy to explain

expansion for RBC model, but it very difficult to explain recession for the same RBC model, because there are few reasons to explain the backward change in technology. So, how to solve this problem and find the exact mechanism about recession is a big issue to RBC model. Economists consider a myriad of reasons which cause the recession, such as strict laws to constrain the profitable technology for protecting environment (Hansen, 1993 [23]), governmental regulation (Stadler, 1994 [48]) and the cost of innovation (Corriveau, 1994 [14]). Creative destruct may be another answer: recession will happen when destruct effect of technology development is larger than the benefits they bring forward.

2) Basic Intuition:

My main idea is that creative destruct caused by technology progress can be the amplifier of productivity shock and the mechanism of recession and expansion. The emergence of a new technology can promote the productivity; meanwhile cause depreciation of the old technology, which is still used in production. If destruct effect of technology development is larger than the benefits they bring forward, the aggregate effect of the emergence of a new technology will be recession in a certain period, which ends when enough many firms or workers use the new technology. Through the expansion of new technology, a new amplifier of technology shock will be gotten. These are very helpful to explain dynamic property of output. Naturally, the prerequisite condition is to build an endogenous RBC model with creative destruct.

3) Significance of Research:

As mentioned as above, endogenous RBC models with creative destruct will bring forward a huge progress in RBC model and improve performance in empirical analysis. It is reasonable to believe that Schumpeter's thoughts of creative destruct replace neo-classical thoughts, which take technology progress as a natural process. Endogenous RBC model maybe have a better explanation and better reasons, compared with traditional RBC model. In theory of RBC model, it is more easy, conducive and clear to analysis technology progress and its effects. Endogenous RBC model may become the mainstream method in business cycle research, because propagation mechanism and amplifier can be explained better. In empirical test, endogenous RBC model with creative destruct as a new amplifier is at least as good as other RBC models of a high substitution economy. And it maybe explains recession and the dynamic property of output better than before. In a word, the change in economic growth theory, which is caused by endogenous economic growth, maybe happens in business cycle theory again.

(III) Works Review

Firstly, let's conclude the development of RBC model. Since Kydland and Prescott built the first RBC model in 1982 [34]. After that, there are uncounted improvements about RBC model. The famous progress of them contains the indivisible labor assumption that Hansen (1985) [21] added to RBC model, money in RBC model which was introduced by King and Plosser (1984) [30] at first and the extension under

the guidance of open economy which is the contribution of Backus, Kehoe and Prescott (1992) [3]. Although these innovations bring forward a huge progress in RBC model and change RBC model very much from the original version, the basic framework of RBC model never change. There are three steps to build a RBC model. Firstly, conclude the stylized facts precisely. The stylized facts can be represented by correlations between different macro economic series and variance of themselves. How to get precise stylized facts is a big issue for RBC model. Whether it is reasonable to use HP filter to get stylized facts last almost 20 years as one of hottest topics, just because some economists believe HP filter change the stylized facts that we get from the reality. We can get more information from Hodrick's (1997) [27], Hartley's (1998) [24] and Harvey's (1993) [25] paper. Secondly, build a general equilibrium model which contain consumer, investment and technical change and solve it to get the equations which show how macro economic series are determined by technical change. Thirdly, calibrate all parameters in this RBC model and simulate this artificial economy. We can test this RBC model through comparisons between the stylized facts and the results from the artificial economy.

Secondly, let's conclude the development of endogenous RBC model. Although, some economists begin research on endogenous RBC model after the first endogenous economic growth model which was brought forward in 1986, endogenous RBC model is not the mainstream method for all time, which is beyond the forecast of some famous economists. The reason may be that endogenous RBC model cannot explain the world better or more, compared to the result of RBC model under the guidance of neo-classical theory. Stadler (1990) [47] began to compare endogenous technology and exogenous technology. Cassing (1991) [10] established a endogenous cycle in a testable way. Corriveau (1994) [14] built a RBC which is endogenous consequences of the decisions taken by entrepreneurs on the allocation of their resources between production and innovation in a Markovian sequence of one-period games. Boileau (1996) [6] studies a two-country real business cycle model with endogenous growth, which is similar with Hercowitz's (1991) [26] and Pelloni's (1997) [43] paper. Goldstein (1997) [18] called resuscitating of endogenous business cycle model. Stephanie (2000) [49] built a two-sector endogenous business cycle model with increasing returns to scale. Kiley (2000) [28] endogenized price stickiness in RBC model.

The thought of creative destruct was brought forward by Schumpeter in 1939 [45]. Owing to difficulties, economists never introduce creative destruct into mathematic model until Aghion and Howitt (1992) [1] introduce it to endogenous economic growth model. But no one introduce creative destruct into RBC model. Therefore, my work is original.

(IV) Brief Outline of Research, and Methodology

1) Embody Schumpeter's idea of creative destruct:

The whole economy is separated into two sectors. One is to manufacture commodity,

the other is to product technology or knowledge. Every family is identical and devotes some fracture of their time and labor to product knowledge. So, technology progress is endogenous in this model. Then, let's suppose a distribution $Q(T) = \int_{t=t_0}^T q(t)dt$ to

stand for the process of technology propagation, which is the quota of families using the new technology. Naturally, faster technology is disseminated and developed, the more workers product. Meanwhile the capital belonged to those who don't use the new technology will depreciate more. So, this is the effect of creative destruct. The optimal rate of technology progress is determined by benefits and destruct of technology. When these two powers are not balanced, economy will be in recession or expansion. An endogenous RBC model with creative destruct is built as above.

2) Build an endogenous RBC model with creative destruct:

A simple version:

a) Preference

The preference of every family is: $E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, H_t)$, C_t, H_t, β, u are consumption, the leisure time, psychological discount rate and utility function, respectively. The indivisible labor assumption will be added, if necessary.

b) Technology and production

Let's assume that there are $\alpha_K K_t, \alpha_L L_t$ in manufacture commodity sector, $(1-\alpha_K)K_t, (1-\alpha_L)L_t$ in the other sector. Two parameters α_K, α_L are supposed as constant number and less than 1, but they can be endogenized in this model if necessary.

Manufacture commodity sector: $Y_t = A_t F(g_t, \alpha_K K_t, \alpha_L L_t, Q_t(T))$, F, A_t, L_t, K_t, g_t are production function, knowledge level, labor, capital and technology progress rate, respectively. $g_t = \frac{dA_t}{A_t}$.

Product technology sector: $dA_t = A_t G((1-\alpha_K)K_t, (1-\alpha_L)L_t)$

c) Capital accumulation

$K_{t+1} = I_t + (1-\delta(g_t, Q_t(T)))K_t$, I_t is investment. $\delta(g_t, Q_t(T))$ is discount rate of capital, which is related with $g_t, Q_t(T)$. Faster technology is disseminated and developed, the more the capital belonged to those who don't use new technology depreciate.

d) Resource constraint

We normalize aggregate time as 1. So, $H_t + L_t = 1, Y_t = C_t + I_t$.

e) Solution and intuitive meaning in economics

If we suppose the suitable function for $F, u, \delta, Q(x)$, we will get the solution by dynamic programming to maximize with constraint conditions - .

$$C^* = C^*(\bar{K}), \quad I^* = I^*(\bar{K}), \quad L^* = L^*(\bar{K}), \quad H^* = H^*(\bar{K}),$$

$$g^* = g^*(\bar{K}) = \frac{dA_t}{A_t} = G((1-\alpha_K)K_t^*, (1-\alpha_L)L_t^*), \quad *, * \text{ stands for steady state.}$$

But we can get another optimal technology progress rate g_t^{**} . If we assume F is Cobb-Douglass function, $Y_t = A_t F(g_t, \alpha_K K_t, \alpha_L L_t, Q_t(T)) = A_t (g_t \cdot Q_t(T) \cdot \alpha_K K_t)^\alpha (\alpha_L L_t)^{1-\alpha}$,

The marginal revenue of g_t is $A_t \frac{\partial F(g_t, \alpha_K K_t, \alpha_L L_t, Q_t(T))}{\partial g_t}$. The marginal cost of g_t is $\frac{\partial \delta(g_t, Q_t(T)) K_t}{\partial g_t}$. Therefore, $\alpha A_t g_t^{**\alpha-1} (Q_t(T) \alpha_K K_t)^\alpha (\alpha_L L_t)^{1-\alpha} = \frac{\partial \delta(g_t^{**}, Q_t(T)) K_t}{\partial g_t^{**}}$.

If $g_t^{**} < g_t^*$, the benefits of technology progress will be larger than the effects of destruct, economy is in expansion. If $g_t^{**} > g_t^*$, the benefits of technology progress is less than the effects of destruct, economy will be in recession. From , we know g_t^{**} is determined by a

distribution $Q(T) = \int_{t=t_0}^T q(t) dt$. In different terminal time T, $Q(T)$ is different, then g_t^{**}

is different. As g_t^{**} changes, the relation between g_t^{**} and g_t^* will change, economy will be in a cycle of expansion and recession. So, this is intuitive meaning in economics of endogenous RBC model with creative destruct. In addition, we can find that this economy is a kind of a high substitution economy, which have a good performance in empirical analysis.

3) An innovation on empirical analysis

a) Reconstruct the stylized facts.

The stylized facts by method of calculating correlations between two macroeconomic series cannot conform to the reality, because the stylized facts themselves can change. Let's take one example in paper of Jim Lee (2006) [39]. The correlation between output and price before the Second World War is contrary to the postwar that in sign. If we have a long enough series which contains both the period before the Second World War and the postwar period, the traditional method lost its effect naturally.

Fortunately, the Nobel Prize winner Robert Engle provides the new tool. In paper [15], [16] and [17] Engle introduces a method to calculate the dynamic conditional correlation (DCC). Different from the constant number: the result of calculating correlations, Dynamic conditional correlation is composed by a series of numbers, one number in each period. This method is popular more and more, but seldom found in RBC model. In paper [38], [39] and [52], we will find the application of this method. Similar method is brought forward by Den Hann (2000, [20]), who uses VAR model. Because dynamic conditional correlation is more complex than correlation and it is a series of numbers, it is a little hard to express stylized facts. The mean number, median number and variance of dynamic conditional correlation hold important information of stylized facts. Therefore, the new stylized facts are consisted of the mean number, median number and variance of dynamic conditional correlation. In my working paper in 2007 [52], I have reconstructed the stylized facts by the method of dynamic conditional correlation with the data of China.

Table 1 comparison between dynamic correlation and correlation

Macroeconomic series & GDP	Mean of $\rho(t)$	Std Variance of $\rho(t)$	correlation
Consumer	0.4667	0.0918	0.5746
Investment	0.4148	0.0778	0.4920
Governmental expenditure	0.4479	0.0228	0.5502
Average income in city	0.4166	0.1669	0.5913
Average income in rural	-0.1725	0.0448	0.0332
Net export	0.3365	0.1290	0.5945
CPI	0.1856	0.1924	0.1985
M2	0.3802	0.0760	0.4382
Nominal exchange rate to American Dollars	-0.4021	0.1323	-0.7290
Nominal exchange rate to Japanese Dollars	-0.0717	0.3652	-0.1590

This table is from my working paper [52].

From this table, it is easy to find that the stylized facts by the method of dynamic conditional correlation are basically similar with that by the method of correlation, except the sign of correlation between GDP and average income in rural. However, the stylized facts from DCC can provide more information than before. For example, from this table, we can know the relation between governmental expenditure and GDP is most stable, because the standard variance is the least. Stability, not only the strength which is measured by correlation or the mean of dynamic conditional correlation, stand for another kind of stylized facts.

b) Calibration

Owing to taking the new stylized facts, the criteria of calibration will change. Although Kydland and Prescott define “Kydland-Prescott variance Ratio” in paper [34], [36], [37] as the criteria, the criteria is not good enough. We just know closer, the better. There is no objective number to help us make judgment. After Kydland and Prescott, Christiano (1992, [11]) and Watson (1993, [51]) make huge contribution to test whether a RBC model is good. But their methods are not perfect. If we take the mean number, median number and variance of dynamic conditional correlation as stylized facts, these methods cannot be used. Fortunately, if we take the mean number, median number and variance of dynamic conditional correlation as stylized facts, the problem of testing will become easier than before. The method is to test whether these two samples come from the same distribution. One of these two samples is the numbers of dynamic conditional correlation from real data. The other is the numbers of dynamic conditional correlation from artificial economy. In econometrics, this process is not hard to handle. Moreover, econometrics provides us objective criteria to make judgment.

(V) Plan

First four months: reading papers and collect data, under the direct of professor

Middle four months: finish working paper and discuss with others

Last four months: accomplish paper submit it

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