Modern Business Cycle Research: A Survey

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1. Introduction

Most economists view the set of fluctuations and co-movements that characterize the business cycle as the result of unforeseen shocks to the economic system. While this is not the only view about how business cycles arise, it is certainly the most durable. This way of thinking about business cycles has its origins in the work of Slutsky (1937) and others who found it useful to regard fluctuations in aggregate output as the consequence of shocks to the set of difference equations that characterize aggregate economic outcomes. Macroeconomic theories have been divided over the years on whether the impulses that cause these fluctuations are shocks to demand or are supply shocks.

Kydland and Prescott (1982) changed the direction of macroeconomic thinking by showing that a simple neoclassical growth model, parameterized on the basis of existing microeconomic evidence and perturbed by shocks to technology, could replicate many of the features of the U.S. business cycle. In the aftermath of their important contribution, much business cycle research has been based on models where the driving forces of the real economy are shocks to technology and where monetary factors play no role. This line of research characterizes the business cycle researches in late 1980s.

Many additional features were introduced in dynamic stochastic general equilibrim framework to improve the performance of the model and the developments were summarized in a special issue of the *Journal of Monetay Economics* in 1988. In the issue, King, Plosse and Rebelo (1988a, 1988b) put out a model and a numerical solution method, which have been used and referred numerous time in the literature. They presented the neoclassical model of capital accumulation augmented by choice of labor supply as the basic framework of modern real business cycle analysis. Preferences and production possibilities were restricted so that the economy displays steady state growth. Then we explored the implications of the basic model for perfect foresight capital accumulation and for economic fluctuations initiated by impulses to technology. They argued that the neoclassical approach held considerable promise for enhancing our understanding of fluctuations. Nevertheless, the basic model did have some important shortcomings. In particular, substantial persistence in technology shocks was required if the model economy was to exhibit periods of economic activity that persistently deviated from a deterministic trend. Then they outlined new directions for investigations of real business cycle models: consideration of stochastic growth of exogenous and endogenous forms, analysis of suboptimal outcomes arising due to externalities of distorting taxes, and implications of labor market heterogeneity.

However, The extensive exploration of models driven solely by technology shocks had lead to the conclusion that the latter, by themselves, could not provide a complete description of the business cycle phenomena. The role of monetary shocks in driving these fluctuations was very much an open question. Kydland (1989) and Cooley & Hansen (1989) had explored the quantitative implications of introducing monetary shocks into standard real business cycle models, but neither found much effect of such shocks at the business cycle frequencies. These findings were inevitable since the neoclassical growth model on which these economies were based contained no mechanism to propagate monetary shocks.

The possibility that nominal contracts play an important role in the propagation of monetary shocks has been a prominent theme in business cycle research. Initially, price rigidity resulting from contracts was thought to be most important in the labor market because of the prevalence of wage agreements observed in labor markets: a relatively large portion of the labor force consists of salaried workers and a significant portion of the manufacturing labor force participate in long term contracts. The importance of wage contracts is also often inferred from the observation that aggregate hours fluctuate more than wages. More recently, attention has shifted to the importance of rigid goods prices. Mankiw (1985), Parkin (1986), Akerlof & Yellen (1985) and others have stressed the importance of price rigidities that arise as a consequence of the costs of changing prices. Here as well, the importance of the phenomenon is frequently inferred from the observation that, in the aggregate, quantities seem to fluctuate more than prices. Common to all of this literature is the view that nominal rigidities are the important vehicle by which monetary shocks get propagated.

Nominal contracts were first introduced in a dyanmic stochstic general equilibrium (DSGE) model by Cho (1993) and Cho and Cooley (1995), following the lead by Gray (1976) and Fischer (1977). Yun (1996, 2005) introduced Calvo (1983) type price setting in a DSGE framework. The advantage of Calvo price setting is that since a certain fraction of firms set prices each period, persistent effects of price setting can be acquired in the model. Once money and nominal rigidities are introduced in the framework, the resulting models are not of real business cycle. Now money has very strong effects on real variables. The nominal rigidities are the key element of monetary business cycle models.

Since Robert Lucas(1987) obtained the upper bound estimate of the welfare gain from eliminating consumption risk by replacing postwar U.S. consumption with a consumption series without fluctuations, the cost of the business cycle has been one of the central issues in business cycle research. Lucas assumed a representative agent with a constant relative risk aversion (CRRA) utility function. His estimates of the welfare cost of consumption fluctuations were very small, no more than 0.00008 percent of aggregate consumption assuming logarithmic preferences. The fact that these estimates were so small stimulated interest in the issue of whether other features of the economy would significantly increase the estimated magnitude of the cost of business cycle fluctuations. Imrohoroglu (1989) and Krusell and Smith (1999) introduced incomplete markets and uninsurable individual risk and found higher welfare costs. Cho, Cooley and Phaneuf (1997) calculated the welfare cost of business cycle fluctuations in a model with nominal wage contracts. In their model, the welfare loss derives entirely from labor supply risk and the costs are higher than those found by Lucas. Obstfeld (1994) and Dolmas (1998) introduced non-expected utility type preferences and found much larger welfare costs associated with business cycles.

In sum, since the major contribution made by Finn Kydland and Edward Prescott (1982), we have seen enormous shifts in the research of economic fluctuations toward small stochastic dynamic general equilibrium models. We can summarize these efforts in a few categories. One group of models adds various shocks in the prototype real business cycle model. The other group of models tries to add more realistic propagation mechanisms of shocks to the model. However, these efforts have been partially successful, i.e. policy shocks such as monetary and fiscal activities play minor roles and the propagation of shocks in those models is not very strong. This is why the real busines cycle paradigm has been criticized as not having policy implications by Keynesian authors including Summers (1986) and Mankiw (1989). To have some role for policies, especially for monetary policies, is not an easy task in a small dynamic general equilibrium model. For that purpose, we need first to provide some reasons for agents to hold money. However, Cooley and Hansen (1989) showed that although they have some reason to hold money, money does not play any significant role in terms of aggregate fluctuations without some sort of rigidities.

This paper suveys the recent developments in the business cycle research. In the second section, the stylized facts of the business cycle in U.S. are summarized. They include the fluctuation characteristics of the real variables like output, consumption, investment, labour and of the nominal variables like price level and inflation. In the third section, a prototype real business cycle models is presented, specified and simulated to discuss the business cycle generated by the productivity shocks in the model. In the fourth section, the criticisms against the real business cycle theory are summarized, which are made mostly by Keynesian macroeconomists. In the sixth section, we discuss the recent development in the business cycle research and conclude in the last section.

2. The Stylized Facts of the Business Cycle

Following on the work of Burns and Mitchell (1946), business cycle researchers have thought that the business cycle is apparant deviations from a trend in which variables move together[1]. If we examine the time path of output for an industrialized economy, we quickly realize that output tends to fluctuate about a long run growth path. These fluctuations about trend are defined as the business cycle. The business cycle fluctuations are irregularly spaced and of varying amplitude and duration. However, there are very regular features of the buisness cycle. Especially manay variables move together and these comovements, which Burns and Mitchell worked so hard to document and Lucas (1975) emphasized as the defining features of the business cycle, are the key features which any good business cycle model would like to replicate. These comovements and some facts on volatilities are called as the stsylized facts of the business cycle.

If we would like to define the business cycle, we have to resolve the problem of how to represent those features of economic data that are associated with long run growth and those that are accosiated with the business cycle. Since the business cycle component of a variable is the deviations from the long term trend, defining a long run trend is equivalent to defining the business cycle. The early 20th century researchers like Kuznets (1926, 1953), Mitchell (1913, 1927, 1941, 1951), and Burns and Mitchell all employed techniques like moving average, piecewise trends, etc. to define the growth component of the data and then to extrcat the business cycle component.

[1] This section is largely based on Cooley and Prescott (1995).

However, whatever choice a researcher makes about the method of defining a trend is arbitrary. Hence there is no single correct way of representing the business cycle components.

There are many ways of extracting business cycle components from the data. The most widely used method is the Hodrick-Prescott filter (the H-P filter). The H-P filter defines the long term growth components by minimizing the following loss function.

$$\min_{\{y_t^g\}_{t=1}^T} \sum_{t=1}^{T} (y_t - y_t^g)^2 + \lambda \sum_{t=2}^{T-1} \left[(y_{t+1}^g - y_t^g) - (y_t^g - y_{t-1}^g)\right]^2, \quad (1)$$

where y_t is the logged data and y_t^g is the growth component, which has to be obtained by solving the minimization problem. λ is the relative variance of the growth component to the cyclical component.

The nature of the optimization is to trade off the extent to which the growth component tracks the actual data, which yields a smaller cyclical component, $y_t^c = y_t - y_t^g$, against the smoothness of the trend. If $\lambda = 0$, then the growth component id simply the data series. If $\lambda \to \infty$, the growth component is a lineat trend. For quaterly data, it is customary in the business cycle research to choose $\lambda = 1,600$ and for annual data, $\lambda = 200$. The motivation behind these numbers is that if the original series were stationary, then the H-P filter with the choice of λ would eliminate fluctuations at frequencies lower than about thirty two quarters, or eight years. We usually think of the business cycle as fluctuations about the growth path that occur with a frequency of three to five years, which Burns and Mitchell(1946) characterized as the usual business cycle frequency, and hence H-P filter suppresses really low frequency fluctuations.

Once the cyclical components of a set of variables are obtained by applying the H-P filter, the business cycle facts can be represented by several statistics calculated from the H-P filtered data. The statistics include the amplitudes of the fluctuations of the aggregate variables, which help us to assess their relative magnitudes, the correlations of aggregate variables with real output, which capture the extent to which variables are procyclical or countercyclical, and finally the cross correlations over time, which show whether there is any phaseshift. Cooley and Prescott (1995) summarized the stsylized facts from U.S. data following the above procedure. Here are some important business cycle facts from the U.S. real economy.

1) The magnitude of fluctuations in output and aggregate hours of work are nearly equal.

2) Employment fluctuates almost as much as output and total hours of work, while average weekly hours fluctuate considerably less.

3) Consumption of nondurables and services is smooth, fluctuating much less than output.

4) Investment in both producers' and consumers' durables fluctuates much more than output.

5) The capital stock fluctuates much less than output and is largely uncorrelated with output.

6) Productivity is slightly procyclical but varies considerably less than output.

7) Wages vary less than productivity.

8) The correlation between average hourly compensation and output is essentially zero.

9) Government expenditures are essentially uncorrelated with output.

10) Imports are more strongly procyclical than exports.

A salient feature of the business cycle in many industrialized countires including the United States, Japan, and others is the striking coherence between the movements in monetary aggregates and aggregate output. The strength of the association between monetary and real variables over the cycle is such that many economists have viewed the cycle as a purely monetary phenomenon. The influential historical findings of Friedman and Schwartz (1963) and the embodiment of those findings in the work of Lucas (1972, 1973) resulted in much of the emphasis in business cycle research being placed on the exploration of economies in which shocks to demand originating in monetary policy generate business cycle fluctuations. Friedman and Schwartz documented a very strong association between the periods of severe economic decline they observed over ninety three years of U.S. history and sharp declines in money stock. It would be difficult to firmly establish the direction of causality in the association. Nevertheless, the association is interpreted by the authors, as well as others, as evidence that monetary forces are important for aggregate fluctuations in real quantities[2]. The following facts from U.S. economy regarding the monetary fluctuations are documented by Cooley and Hansen (1995).

[2]The following is largely based on Coolry and Hansen (1995).

1) There is a pronounced phase shift in the correlation between output and monetary aggregates. Monetary aggregates lead output.

2) There is a negative correlation between output and prices.

3) There is a positive correlation between output and inflation.

4) There is a positive correlation between output and nominal interest rates.

5) There is a negative correlation between M1 growth and both output and hours.

6) There is a contemporaneous negative correlation between money growth and nomonal interest rates.

Among the above facts, the second one, which has been discussed in Kydland(1989), Cooley and Ohanian (1991), and Kydland and Prescott 91991), is the most confusing. If we look into macroeconomics textbooks, we find that many textbooks lead on to suspect that the concensus view is that prices are procyclical. This is a confusion caused by the carelessness of the profession. Although price level is countercyclical, inflation rate is procyclical over the post war period. The inflation rate is lagging output in U.S.

The first fact documented above by Cooly and Prescott shows that the business cycle is most clearly manifested in the labour market. In other words, the aggregate production function, which relates the nation's output of goods and services to inputs of labour and capital, is central to business cycle theory as well as growth theory. For growth, output changes are mostly explained by changes in technology and in capital. However, the behavior of the labour input is of the prime importance to the business cycle theory and hence understanding the facts in the labour market is a key to understanding the business cycle and to building a good model. The followings are the fact from U.S. aggregate labour market by Finn E. Kydland (1995).

1) Total hours, whether measured by the household or the establishment survey, is alsmost as volatile as real GNP, which is the first facts documented above by Cooley and Prescott.

2) The household survey indicates that approximately two-thirds of the total hours fluctuation is in the form of variation in employment and one third is in hours per worker.

3) Total hours are highly procyclical.

4) Emploment lags output, wheras hours per worker displays almost no phase shift.

5) Average labour productivity is somewhat procyclical and leads the cycle.

6) The statistics for average real hourly compensation in the business sector, which explains about 85% of GNP, are quite similar to those for productivity. If, on the other hand, we divide total employees' compensation from the national income accounts by total hours from either survey, the correlations with real GNP are much lower.

7) Real labour income is procyclical, but labour income as a fraction of GNP is countercyclical.

8) Over time, real hourly compensation has risen dramatically while hours worked per household has remained about constant. Cross-sectionally, however, there is a clear positive correlation between hours worked and the real wage. Moreover, the volatility of annual hours of work is much higher for wage earners in the two lowest quantiles than in the two highest. (see Kydland (1984), Rios-Rull (1993))

These lists of business cycle stylized facts are not exhaustive. There are many other facts discussed in the literature. However, for any good model to be considered to be good many of the facts listed above have to be explained by the model.

3. **Real Business Cycle Theory**

It was Brock and Mirman (1972) who first studied the real business cycle in the literature. Their model has growth with stochastic productivity shocks. However, their idea had not been made further use of until Kydland and Prescott (1982) utilized it in their more elaborate dynamic stochastic general equilibrium model. The reason that Brock and Mirman's idea had not been pursued further for a decade was the prejudice that the model as simple as theirs could not explain any of the business cycle facts. The most important contribution by Kydland and Prescott is their stubbornness of pursuing to the limit the idea that the very simple stochastic growth model may explain some busness cycle facts. To see the original contribution by Kydland and Prescott, let's look at a prototype real business cycle model.

3.1 The Economy

The following economy is a very standard real business cycle model. The representative agent is endowed with initial capital stock k_0 and with one unit of time each period. The preferences of the agent are:

$$U_0 = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{[c_t^{\alpha}(1-n_t)^{1-\alpha}]^{1-\sigma}}{1-\sigma} \right\}, \quad 0 < \alpha < 1, \ \sigma > 0, \tag{2}$$

where E_0 is the conditional expectations operator, where the subscript denotes the information set in the initial period. β is the utility discounting factoe and α and σ are the preference parameters. c_t and n_t are consumption and hours of work in period t, and total endowment of time is normalized to be 1.

Production takes place with the Cobb-Douglas technology.

$$y_t = e^{z_t} k_t^{\theta} n_t^{1-\theta}, \tag{3}$$

where y_t and k_t are outpur and capital stock in period t, and z_t is the productivity shock. θ is the share of the capital in production, which is assumed to be fixed. We assume that the productivity shock follows an AR(1) process:

$$z_t = \rho z_{t-1} + \varepsilon_t, \tag{4}$$

where ε_t has an *i.i.d.* normal distribution $N(0, \tau^2)$. Output is consumed or saved as capital. Capital follows the following law of motion:

$$k_{t+1} = (1-\delta)k_t + i_t, \tag{5}$$

where i_t is the investment in period t and δ is the rate of capital depreciation.

For later reference, we write the problem facing the representative agent using the Bellman equation as:

$$\begin{aligned} V(A_t, k_t) = \quad & \max \quad \left\{ \left(\tfrac{1}{1-\sigma}\right) [c_t^{\alpha}(1-n_t)^{1-\alpha}]^{1-\sigma} + \beta E_t \left[V(A_{t+1}, k_{t+1}) \right] \right\} \\ & \text{s.t.} \quad (1)\ c_t + i_t = e^{z_t} k_t^{\theta} n_t^{1-\theta} \\ & \qquad\ \ (2)\ k_{t+1} = (1-\delta)k_t + i_t \\ & \qquad\ \ (3)\ z_t = \rho z_{t-1} + \varepsilon_t \\ & \qquad\ \ (4)\ c_t, \ i_t \geq 0, \ \ 0 \leq n_t \leq 1, \ k_0 \text{ is given.} \end{aligned} \tag{6}$$

Note here that we are invoking the second welfare theorem to get the equilibrium allocation by solving a programming problem.

3.2 Calibration

The parameter values are set by looking at the long run growth experience and cross-section studies. The reason that they borrow the values from growth and cross-section studies is that they would like to have objective assessment. If you want to assess the model objectively, you should not calibrate the model in a way that the model explain the data better. If we use the parameter values from business cycle studies, we can say that the model is calibrated in a way that the model explain the business cycle facts better.

We set the parameter values as in Kydland and Prescott's paper. We assume that a period is a quarter. The utility discounting factor is assumed to be $\beta = 0.99$, which implies 4% real interest rate per annum, and the preference parameter determining the substitution between consumption and leisure is set to be $\alpha = 0.33$, which implies the hours of work to be about one third of the total endowment of time. σ is assume to be 2, which is the number used in the literature numerous time. The value of the capital share parameter in production is assumed to be $\theta = 0.36$, which is roughly the share in U.S. economy. Capital depreciates at the rate that $\delta = 0.012$, which means 4.8% capital depreciation per annum. The remaining parameters are related to the technology shock. We assume that $\rho = 0.95$ when we vary $\tau_\varepsilon = 0.007$. These numbers are used by many authors in the real business cycle literature including Kydland and Prescott (1982), Prescott (1986), Hansen (1985), and Cooley and Prescott (1995).

3.3 Steady State

The steady state of the economy can be obtained from the first order conditions.

$$\frac{1-\alpha}{1-n} = \alpha(1-\theta)Ak^{\theta}n^{-\theta} \cdot \frac{1}{c} \tag{7}$$

$$\theta Ak^{\theta-1}n^{\theta-1} = \frac{1}{\beta} - 1 + \delta \tag{8}$$

$$c + \delta k = Ak^{\theta}n^{1-\theta}, \tag{9}$$

where we used the fact that $i = \delta k$ in a steady state and the variables without time subscript are the steady state values[3]. We need to obtain the steady

[3] The steady state does not depend on the parameter σ, since intertemporal substitution does not takes place in a steady state.

state since we cannot have the closed form solution and hence have to obtain a numerical solution. If we would like to obtain a numerical solution for the model, we need to have a reference point around which we can have an approximation to the model. That reference point is the steady state.

3.4 Numerical Simulation

The simulation method used for the calculation is the one developed by Kydland and Prescott (1982), which substitutes the non-linear constraints into the preferences, approximates the temporal utility around the steady state with a quadratic function and then invokes certainty equivalence[4]. That is if we approximate the model around the steady state using a quadratic objective function and linear constraints, we can ignore the random factors to get the control rules.

3.5 Results

The result from the simulation can be summarized as in table 1 and in figure 2. Table 1 reports the the volatility and the correlation with output of the business cycle components of output(y), consumption(c), investment(i), labour hours(n) and labour productivity(y/n)[5]. The volatility in table 1 is the standard deviation of the business cycle component. The most important fact in the table which has been emphasized by Prescott[6] over and over is the volatility of output. According to the table, the output volatility of output in the model is 1.34 and the conterpart in U.S. economy is 1.81. Hence the business cycle component of output in the model is 74% as volatile as in U.S. economy. In other words, the model explains the three quarters of the volatility of U.S. business cycle fluctuations. Prescott has argued that this is a great success considering the simplicity of the model.

[4] For an excellent survey of solution method for dynamic stochastic general equilibrium model, see Hansen and Prescott (1995).

[5] We do not report the statistics on capital stock since it does not play a significant role over the business cycle frequency.

[6] For example Prescott (1986).

Table 1. Volatility and Comovement

		y	c	i	n	y/n
Volatility	U.S.	1.81	1.35	5.30	1.79	1.02
	Model	1.34	0.42	5.21	0.68	3.23
Correlation	U.S.	1.00	0.88	0.80	0.88	0.55
	Model	1.00	0.97	0.99	0.99	0.99

Source: U.S. statistics from King and Rebelo (1999)

Considering the fact that we are trying to explain the fluctuations in U.S. economy using a very simple model with one type of shocks, I agree that it is indeed a great success. In addition, the model match very well the relative volatility of the income components. Consumption in the data is much less volatile than output, whereas investment is much more volatile than output. This relative volatility is very well mimicked in the model.

However, the model is far short in many aspects of explaining the actual fluctuations. First, we think that the business cycle is mainly manifested in labour market. However, the model is not very successful in explaining the aggregate labour market. Compared to the actual fluctuations in the labour market, aggregate hours in the model fluctuate too little and the labour productivity fluctuates too much. The ratio of volatility of aggregate hours relative to that of labour productivity in U.S. data is 1.75, whereas the ratio in the model is 0.21. This is a serious failure. Furthermore, the correlations in the model are at odd with those from the data. Compared to those from U.S. data, the correlations are too high in the model. Especially the labour productivity in the model is correlated with output too closely, which is a natural consequence of stochastic singularity, i.e. explaing all fluctuations using one shocks. In addition to these failures, there are numerous criticism against the model, which will be discussed in the next section.

4. Criticisms

Since the seminal contribution by Kydland and Prescott (1982), we have witnessed the explosion of research on real business cycles (RBC). The initial success was summarized in Prescott (986) and Plosser (1989). The basic RBC approach insists on the construction of dynamic stochastic general equilibrium models. The approach of using the stochastic growth model is accepted across a wide range of research areas. The basic RBC model has provided a coherent framework integrating growth and business cycle research. Although many researchers are skpetical of the key role of the productivity shocks, they have come to believe that the methodology adopted by the RBC research can be a relevant model in which monetary shocks play a greater role (see Rogoff (1986)).

However, the striking performance of the basic RBC model drew strong criticisms from Keynesian researchers. (see Summers (1986) and Maniw (1989)). Their criticisms focused on four main points. First, they questioned the parameter values used in the simulation of the model. Especially they have criticized the fact that the elasticity of intertemporal substitution assumed in the model is about 4, which is much larger than the ones obtained in the labout economics literature. Second, they have argued that the RBC approach implies conterfactual movement in relative and absolute prices. They observed that the strongly procyclical character of the model's real wage rate was inconcictent with the findings of many studies. In addition, they pointed out that as Mehra and Prescott (1985) found out, standard preferences such as the CRRA form are imcompatible with the risk premium in the U.S. economy. Furthermore, they suggested that a productivity shock implies a strongly countercyclical price level. Third, they argued that the volatility of the productivity shocks are too much excessive. Fourth, it is argued that a business cycle model wothout the fluctuations of various prices was not conceivable. In other words, the fluctuations in nominal variables like price level, nominal interest rate, nominal wage rate etc. are as much important in the business cycle as those in real variables.

Among these criticisms, the third criticim is the most important. The first two criticims have had no deep impact on the RBC research, since the RBC models are very resilient to variations in its parameters. The RBC model does not need to rely on a high degree of intertemporal substitution of labour. Some RBC model like Greenwood, Hercowitz and Huffman (1988) assumes that this elasticity is zero[7]. The fourth criticism has been dealt with the monetary models in the literature loike Cooley and Hansen (1989) and Kydland (1989). However, the third criticism has remained the Achilles heel of the RBC research. The productivity shocks measured as the Solow

[7]In their model, the elasticity of intertemporal substitution is zero but that of intratemporal substitution is large enough to generate substantial fluctuations in labour market.

residual is problematic in the sense that it is hard to identify the macroeconomic shocks as large as the ones used in the RBC research. In addition, the endogeneity of the productivity shocks cannot be overlooked. Since the production function like the Cobb-Douglas form, which has been used numerous times in the RNBC literature, ignores many aspect in actual production. For example, Summers and mankiw emphasized the importance of labour hoarding, i.e. the unmeasured variation in labour effort over the business cycle. In addition, we know that there are cyclical variations in factor utilization. If we do not consider these factors in production function, the Solow residual contains the productivity variations due to these factors and is exaggerated by that extent. Hence the Solow residual measured without considering the labour hoarding and factor utilization over the business cycle tends to be more volatile and procyclical than true shocks to technology[8].

5. Recent Developments in the Business Cycle Research

As was mentioned above, there are not many controversies now regarding the idea that the methodology used in the RBC research is an excellent and coherent framework integrating growth and business cycles. Although we still have the philosophical disagreement on many macroeconomic issues, the severity of the disagreement has been diminishing significantly. Many RBC researchers have introduced Keynesian features like nominal rigidities in RBC models and many Keynesians are now using the RBC framework to better organize their research. Since the seminal contribution by Kydland and Prescott (1982) and Long and Plosser (1983), there have been fundamental changes in macroeconomic thinking. Recalling that growth researchers were initially horrified when they saw the measure of the residual they could not explain recast as the main impulse to the business cycle, we are witnessing the colossal changes research strategy in the growth and the business cycle research.

The recent business cycle research has extended the basic RBC framework in many directions. Especially, the extensions have been intended mainly to resolve the criticisms discussed above. In addition, they have quantitatively assessed the Keynesian ideas in the RBC framework. Hence many of the extended models are not of real business cycle tradition any more. However,

[8] See King and Rebelo (1999). They discussed the peblems with large productivity shocks in the RBC research and how to resuscitate the paradigm.

if the extensions are to be summarized in a few categories, they are related to either the impulses or the propagation mechanism of the business cycle.

The impulses of the basic RBC model is the technology shocks and hence it has the problem of stochastic singularity. In other words, they have tried to explain fluctuations of many variables with only one type of random shocks. However, the fuctuations in an actual economy are caused by many types of impulses, some of which are known and others are not, and hence there should have been many deep discrepancies between the fluctuations in the model and those in the actual data. In addition to the productivity shocks, they have considered other types of impulses to improve the performance of the model, especially the demand shocks like monetary innovations, fiscal shocks, preference changes, and the shocks to foreign demand. These impulses have been considered to be very important in the Keynesian literature. Furthermore, they can be easily observed compared to the illusive productivity shocks.

On the other hand, the basic RBC model has only one propagation mechanism, namely capital accumulation. If there is a favorable productivity shock in a period, they will produce more and save some fraction of the higher current output, which produces the cyclical comovements that we can see in the actual economy. The propagation of the effect of a favourable productivity shock into the future depend on many factors, especially the elasticity intertemporal substitution of labour. However, the elasticity required in a model to match the size of actual fluctuations is too large. I sum, the propagation mechnism of the basic RBC model is too simple and based on some unrealistic parameter values. Hence introducng realistic propagation mechnisms in addition to capital formation was urgent.

5.1 Additional Impulses

(1) Monetary Shocks

Among the impulses other than the productivity shock, monetary innovations are the most important shocks in the literature. The strength of the association between monetary and real variables over the cycle is such that many economists have viewed the cycle as a purely monetary phenomenon. The influential historical findings of Friedman and Schwartz (1963) and the embodiment of those findings in the work of Lucas (1972, 1973) resulted in much of the emphasis in business cycle research being placed on the exploration of economies in which shocks to demand originating in monetary policy generate business cycle fluctuations.

Monetary shocks were introduced in RBC framework by the authors like Kydland (1989) and Cooley and Hansen (1989). Kydland introduced money through shopping time technology and Cooley and Hansen through cash in advance constraint. After they used numerical solution method to solve the problem, they found that money plays no role over the business cycle. In other words, the fluctuations in real variabls including output, consumption, investment and labour are not affected at all by moneatry shocks.

This is quite a contradiction to the common sensical wisdom that money may play a key role for the fluctuations in the real variables as well as in nominal ones. However, the first results from the RBC model with monetary shocks do not confirm the intuition in the profession. However, the models studied by Kydland, and Cooley and Hansen are very rudimentary and hence considered to be a first step toward more realistic models. More realistic monetary models should include at least some frictions in labour and/or commodity market. Among such frictions are Keynesian elements like wage and price rigidities. Since early 1990s, we have witnessed dynamic stochastic general equilibrium models embodied Keynesian nominal rigidities in them. Once such Keynesian elements are introduced in a model, they may not be called real business cycle models. We will discuss the developments belong to this category later.

(2) Fiscal Shocks

Fiscal shocks including government expenditures and taxes are traditionally considered to be one of the most important impulses causing the business cycle. Since the fiscal shocks influence directly either the demand for goods and services or the consumers' budget, the policy effects are directly, which differs from the effect of monetary shocks. Wynn (1987) tried to measure how large the effect of fiscal shocks is in a dynamic model. However, his model is of perfect foresight. Christiano and Eichenbaum (1992) introduced fiscal policy shocks in a RBC framework. They introduced the shocks with an urgent goal of better matching the labor market fluctuations in the model. That is, Hours worked and the return to working are weakly correlated. Traditionally, the ability to account for this fact has been a litmus test for macroeconomic models. Existing real-business-cycle models failed this test dramatically. They put the government spending in the utility function, which influences labor-market dynamics in a nontrivial way, and introduced stochastic variations in government expenditures and taxes. This modification could bring the models into closer conformity with the data and their empirical results indicated that it did.

Baxter and King (1993) introduced government's investment in public overhead capital. Hence there two types of capital, private and public and the government spends tax revenue for two purposes, consumption and public investment. With the modification they studied four classic fiscal-policy experiments within a quantitatively restricted neoclassical model. Their main findings were as follows: (i) permanent changes in government purchases could lead to short-run and long-run output multipliers that exceeded 1; (ii) permanent changes in government purchases induced larger effects than temporary changes; (iii) the financing decision was quantitatively more important than the resource cost of changes in government purchases; and (iv) public investment had dramatic effects on private output and investment. These findings stemed from important dynamic interactions of public capital and labor absent in earlier equilibrium analyses of fiscal policy.

Cooley and Ohanian (1997) compared the effect of fiscal policies in U.K. and U.S. during World War II. That is, the policies used by Britain to finance World War II represented a dramatic departure from the policies used to finance earlier wars and were very different from the policies used by the United States during the war. Following Keynes's recommendations, Britain taxed capital income at a much higher rate than the United States during the war and for much of the postwar period. They analyzed quantitatively the policies designed by Keynes using an endogenous growth model and the neoclassical growth model. They also evaluated the implications of tax-smoothing policies. They found that the welfare costs of Keynes's policies were very high relative to a tax-smoothing policy and argue that Britain's poor macroeconomic performance in the early postwar period was a consequence of the high tax rates levied on capital income.

However, one conclusion after these exercises is that fiscal shocks cannot by themselves produce realistic patterns of comovement among macroeconomic variables[9]. This is due to the fact that an increase in government

[9]See King and Rebelo (1999).

expenditures financed by lump sum taxes gives rise to a negative welath effect that forces consumption to decrease at the same time that labour input and output increase. In other words, if we have only the government expenditure shocks, consumption is inevitably countercyclical. Changes in income taxes affect the economy in a similar way to the productivity shocks. But the changes income tax code are not that frequent enough to generate realistic fluctuations.

(3) Foreign Shocks

Modern economies are open and hence shocks from foreign transactions cannot be ignored. Backus and Kehoe (1992) documented the stylized facts of the industrialized economies. They contrasted properties of real quantities with those of price levels and stocks of money for ten countries over the last century. Although the magnitude of output fluctuations had varied across countries and periods, relations among real quantities had been remarkably uniform. Properties of price levels, however, exhibited striking differences between periods. Inflation rates were more persistent after World War II than before, and price-level fluctuations were typically procyclical before World War II and countercyclical afterward. Fluctuations in money were less highly correlated with output in the postwar period but were no more persistent than in earlier periods

Backus, Kehoe and Kydland (1992) modeled the international business cycle in a two-country real business cycle framework. They questioned whether a two-country real business cycle model could account simultaneously for domestic and international aspects of business cycles. With this question in mind, they documented a number of discrepancies between theory and data. The most striking discrepancy concerned the correlations of consumption and output across countries. In the data, outputs were generally more highly correlated across countries than consumptions. In the model they reported the opposite.

Baxter and Crucini (1993) probed the important issue of investment and saving correlation across countries. That is, national saving and investment rates are highly positively correlated in virtually all countries. This is puzzling, as it apparently implies a low degree of international capital mobility. Baxter and Crucini showed that the observed positive correlation between national saving and investment rates arised naturally within a quantitatively restricted equilibrium model with perfect mobility of financial and physical capital. Their model was consistent with the fact that saving–investment correlations were larger for larger countries but were still substantial for small countries. Further, their model was consistent with the finding that current-account deficits tend to be associated with investment booms.

Backus and Smith (1993) examined the possibility that non-traded goods may account for several striking features of international macroeconomic data: large, persistent deviations from purchasing power parity, small correlations of aggregate consumption fluctuations across countries, and substantial international real interest rate differentials. A dynamic, exchange economy was used to show that non-traded goods in principle could account for each of these phenomena. In the theory there was a close relation between fluctuations in consumption ratios and those in bilateral real exchange rates, but they found little evidence for this relation in time-series data for eight OECD countries.

(4) Tastes Shocks

Bencivenga (1991) investigated preference shocks, which might be interpreted as deriving from shocks to household production or changes in relative prices, as a mechanism for generating hours variation within a one-sector stochastic optimal growth model without intertemporal substitution or indivisibilities. She estimated the preference parameters using maximum likelihood method and then obtained statistics summarizing simulations of the estimated model. Comparison with post-war U.S. data showed that her model generates sufficient variation in hours relative to productivity, and in consumption relative to output, as well as predicting a negative correlation between hours and productivity.

Stockman and Tezar (1995) introduced taste shocks in an international environment. That is, trade on international financial markets allows people to insure country-specific risk and smooth consumption intertemporally. Equilibrium models of business cycles with trade on global financial markets typically yield international consumption correlations near 1 and excessive volatility of investment. To correct the problem, they incorporated nontraded goods in the model and find that the implications for aggregate consumption, investment, and the trade balance were consistent with business-cycle properties of industrialized countries. However, the model driven by technology shocks alone yielded counterfactual implications for comovements between consumption and prices at the sectoral level. Taste shocks in their model produced price–quantity relationships more consistent with the data.

(5) Investment Shocks

Greenwood, Hercowitz and Huffman (1988) adopted Keynes' view that shocks to the marginal efficiency of investment were important for business fluctuations, but incorporated it in a neoclassical framework with endogenous capacity utilization. Increases in the efficiency of newly produced investment goods stimulated the formation of "new" capital and more intensive utilization and accelerated depreciation of "old" capital. Their theoretical and quantitative analysis suggested that the shocks and transmission mechanism studied here might be important elements of business cycles.

5.2 Additional Propagation Mechnisms

The two weaknesses of the basic RBC model like (6) are the smaller amplitude of the fluctuations ans the correlations with output which are too high. Demand shocks which we considered above improve the correlations of the model as well as the the amplitude. In other words, additional shocks resolve the problem of stochastic singularity and at the same time increases the amplitude of the fluctuations. However, introducing additional shocks are not enough for the model economy to match the actual fluctuations perfectly in many directions. That is, we have considered in mind the statistics like standard deviations and the concurrent correlations. But sometimes we need to have other features like phase shift matching the actual economy. In sum, we need to increase the responses of the model to shocks and at the same time improve the concurrent and corss correlations. Introducing new shocks in addition to the real shock is one way of achieving the goal and introducing propagation mechnisms additional to capital accumulation is the other way. There are two types of propagation mechanisms. One is the type of progpagation mechnisms increasing the responses and the other is the type of tansmitting the effect of shocks over time.

(1) Indivisibility of Labor

Motivated by the inability of the model mimicking the size of the fluctuations in output in the data, Rogerson (1988) introduced the indivisibility of labour supply. He considered an economy where labor is indivisible and hence all variability in hours worked is due to fluctuations in the number employed and agents are identical. Although the discontinuity in labor supply at the individual level disappeared as a result of aggregation, it was shown that indivisible labor has strong consequences for the aggregate bahavior of the economy. It was also shown that optimal allocations involve lotteries over employment and consumption. Hansen (1985) utilized the Rogerson's theory of indivisible labour in an RBC framework. He found that, unlike previous equilibrium models of the business cycle, his model economy displayed large fluctuations in hours worked and relatively small fluctuations in productivity. This finding was independent of individuals' willingness to substitute leisure across time. This and other findings were the result of studying and comparing summary statistics describing this economy, an economy with divisible labor, and post-war U.S. time series.

(2) Propagation Mechanisms in Kydland and Prescott (1982)

Kydland and Prescott (1982) introduced three other propagation mechnisms other than capital accumulation. They were non-time-separable preferences, time-to-build investment technology, and inventory accumulation. That is, the non-time-separable utility function admits greater intertemporal substitution of leisure and time-to-build means that more than one time period is required for the construction of new productive capital. These two features were propagating the effect of the productivity shocks in their model into the far future. In addition, they introduced inventory as a productive input. Inventory investment is another way of saving in their model and the stock of inventory is not different from capital. Hence inventory is another channel transmitting the effects of today's events into the far future.

(3) Cyclical Factor Utilization

Cyclical factor utilization is a traditional propagation mechnism emphsized in the Keynesian tradition. It includes labour horading and variable capital utilization. Procyclical factor utilization has been studied many times in the literature. Especially, King and Rebel (1999) argued that cyclical factor utilization may save the RBC paradigm. Although there were increasing skepticism that technology shocks were a major source of business fluctuations, a RBC model with varying capital utilization yielded realistic business cycle from small changes in technology. In addition, cyclical factor utilization may be helpful in explaining the phase shift.

Burnside, Eichenbaum and Rebelo (1993) investigated the sensitivity of Solow residual based measures of technology shocks to labor hoarding behavior. Using a structural model of labor hoarding and the identifying restriction that innovations to technology shocks were orthogonal to innovations in government consumption, they estimated the fraction of the variability of the Solow residual that was due to technology shocks. Their results supported the view that a significant proportion of movements in the Solow residual were artifacts of labor hoarding behavior. Specifically, they estimated that the variance of innovations to technology were roughly 50 percent less than that implied by standard real business cycle models. In addition, their results suggested that existing real business cycle studies substantially overstated the extent to which technology shocks accounted for the variability of postwar aggregate U.S. output.

Bils and Cho (1994) introduced procyclical labor and capital utilization, as well as costs of rapidly increasing employment, into a business-cycle model. Plausible variations in factor utilization enabled them to explain observed variability of real GNP with considerably smaller economy-wide disturbances. The costs of adjustment created very interesting and realistic lead and lag relationships: employment did not peak until a full quarter after output; workweeks, effort, capital utilization and productivity all sharply lead the business cycle.

(4) Labour Market Search

Andolfatto (1996) evaluated the quantitative implications of labor-market search for economic fluctuations in the context of a real-business-cycle model. Incorporating labor-market search into the model was found to improve its empirical performance along several dimensions. In particular, hours now fluctuated substantially more than wages and the contemporaneous correlation between hours and productivity fell. In addition, the model replicated the observation that output growth displays positive autocorrelation at short horizons. Overall, the empirical results suggested that the labor-market-search environment embodid a quantitatively important propagation mechanism.

Merz (1995) noted existing models of the business cycle had been incapable of explaining many of the stylized facts characterizing the US labor market. The standard real business cycle model was modified by introducing two-sided search in the labor market as an economic mechanism that propagates technology shocks. This new analytical environment could explain many phenomena of the business cycle that the standard model either had resolved in an unsatisfactory manner or had not been able to address at all.

5.3 Market Frictions and Keynesian Business Cycle Theory

Cho (1993) introduced a modified version of the one -period nominal contract developed by Gray (1976) and Fischer (1977) in a general equilibrium model with money which had been used in the real business-cycle literature. Money was introduced in the model through cash-in-advance constraint. Two kinds of contracts were examined, namely, a nominal wage contract and a nominal price contract. The nominal wage contract improved the fit of the model in many respects. The nominal price contract increased the output volatility enormously, but it had some unrealistic features.

Cho and Cooley (1995) we studied the quantitative implications of multi-period nominal wage contracts for business cycle fluctuations. They addressed this issue using a model economy based on the neoclassical growth model supplemented by the assumption that cash was needed to purchase goods. They considered a variation of the standard recursive competitive equilibrium concept that was intended to capture the important features of wage contracting. They used this equilibrium construct to address three issues. First, they considered whether monetary shocks, propagated by nominal contracts, constituted a viable alternative to technology shocks as a source of aggregate fluctuations. Their results suggested that, while monetary shocks and nominal rigidities succeeded in causing output volatility of the required magnitude, the resulting data had properties that were inconsistent with several key features of U.S. data. Second, they considered how the behavior of the economy varied with contract length. They found that the volatility induced by both monetary and technology shocks increased sharply with contract length. Finally, they considered how much rigidity would be necessary to match the volatility of U.S. output. They found that only a very small amount of rigidity would be necessary to cause output volatility of the magnitude observed.

Yun (1996) investigated the ability of nominal price rigidity to explain the co-movement of inflation with the cyclical component of output observed in the post-war U.S. data. A dynamic general equilibrium model was constructed with the introduction of monopolistic competition and nominal price rigidity in a standard real business cycle model, allowing for an endogenous money supply rule. It was then demonstrated that sticky price models could explain the observed associations between movements in inflation and output much better than flexible price models. This result depended little on whether money supply was assumed to be endogenous or not. In a related paper, Yun (2005) analyzed optimal monetary policy in a sticky price model with Calvo-type staggered price-setting. In the paper, the optimal monetary policy maximized the expected utility of a representative household without having to rely on a set of linearly approximated equilibrium conditions, given the distortions associated with the staggered price-setting. It showed that the complete stabilization of the price level was optimal in the absence of initial price dispersion, while optimal inflation targets responded to changes in the level of relative price distortion in the presence of initial price dispersion.

Christiano, Eichenbaum and Evans (2005) presented a model embodying moderate amounts of nominal rigidities that accounts for the observed inertia in inflation and persistence in output. They seeked to understand the observed inertial behavior of inflation and persistence in aggregate quantities. Their model had two key features. First, it embeded Calvo-style nominal price and wage contracts. Second, the real side of the model incorporated four departures from the standard textbook, one-sector dynamic stochastic growth model. These departures were motivated by recent research on the determinants of consumption, asset prices, investment, and productivity. The specific departures that we included were habit formation in preferences for consumption, adjustment costs in investment, and variable capital utilization. In addition, they assumed that firms had to borrow working capital to finance their wage bill.

Their key findings were as follows. First, the average duration of price and wage contracts in the estimated model was roughly two and three quarters, respectively. Despite the modest nature of these nominal rigidities, the model did a very good job of accounting quantitatively for the estimated response of the U.S. economy to a policy shock. In addition to reproducing the dynamic response of inflation and output, the model also accounted for the delayed, hump-shaped response in consumption, investment, profits, and productivity and the weak response of the real wage. Second, the critical nominal friction in their model was wage contracts, not price contracts. A version of the model with only nominal wage rigidities did almost as well as the estimated model. In contrast, with only nominal price rigidities, the model performed very poorly. Consistent with existing results in the literature, the version of the model with only price rigidities could not generate persistent movements in output unless they assumed price contracts of extremely long duration. The model with only nominal wage rigidities did not have this problem.

5.4 Heterogeneities

Heterogeneties are very important for some issues like income distribution, aggregation of labour inputs of differing quality, and the incidence of the costs of the business cycle. Heterogeneties are very hot topic in the business cycle liteature. However, They are very difficult to deal with in dynamic stochastic general equilibrium models. However, the techniques which can be used to solve the models od heterogeneities have been developed recently and hence hence heterogeneities are now modeled in the environment of dynamic stochsatic general equilibrium. In a few recent empirical surveys, Javier Díaz-Giménez, Vincenzo Quadrini, and José-Victor Ríos-Rull (1997), and Santiago Budría, Javier Díaz-Giménez, Vincenzo Quadrini, and José-Victor Ríos-Rull (2002) have found various interesting facts on the U.S. distributions of labour earnings, income, and wealth. According to their findings, U.S. labour earnings, income and wealth are unequally distributed across the households. The distributions obviously depend on many factors like age, employment status, education, marital status, and financial trouble. Furthermore the households do not stay in the same earnings, income and wealth groups forever. They move up and down the economic scale.

Until recently, the distributional issues have been studied in depth neither in the business cycle research nor in the growth research. Krusell and Smith (1998), introduce purely temporary individual productivity shocks together with a borrowing constraint in a stochastic dynamic general equilibrium model to study the wealth and income inequality. In the beginning, the hoseholds in their model are identical. They face the same productivity distribution. However, their productivity realizations may differ as time passes by. Hence there can be households with a sequence of good lucks and also with a sequence of bad lucks. Those with a sequence of good lucks may accumulate wealth, but the others with a sequence of bad lucks may face the borrowing constraint in the market. Although Krusell and Smith have some difficulty in mimicking the top tail of the U.S. income and wealth distribution, they are successful in reproducing the other aspects.

Castaneda, Diaz-Gimenez and Rios-Rull (2003) showed that a theory of earnings and wealth inequality, based on the optimal choices of ex ante identical households that faced uninsured idiosyncratic shocks to their endowments of efficiency labor units, accounted for the U.S. earnings and wealth inequality almost exactly. Compared to Krusell and Smith, they had income tax in their model to improve the model.

In an interesting paper, Chatterjee (1994) studies the transitional dynamics and the distribution of wealth in a neoclassical growth model. Contrary to the model by Krusell and Smith, the model has a permanent heterogeneity in individual share of the firm in the initial period. For the study, three forms of preference have been assumed, namely log linear, constant relative risk aversion, and exponential preference. The distribution of wealth in the model does not affect the aggregate dynamics of the model but these dynamics do affect the evolution of the distribution of wealth.

Chang and Kim (2005, 2006) studied the aggregation issues in labour market. They showed that at the aggregate level, the labor-supply elasticity depends on the reservation-wage distribution. They presented a model economy where workforce heterogeneity stems from idiosyncratic productivity shocks. Their model economy exhibited the cross-sectional earnings and wealth distributions that were comparable to those in the micro data. In additopn they demonstrated that, at the aggregate level, the labor supply elasticity could significantly depart from the microelasticity. In an economy where households made decisions on labor market participation, the slope of the aggregate labor supply curve was determined by the distribution of reservation wages rather than by the willingness to substitute leisure intertemporally. They found that the aggregate labor supply elasticity of such an economy was around 1.0–despite the low intertemporal substitution elasticity of leisure, assumed to be 0.4. The equilibrium approach of business cycle analysis has been criticized on the grounds that it requires an elasticity higher than the intertemporal substitution elasticity estimated from the microdata. Their analysis shows that, while the aggregate labor elasticity can depart from a microelasticity, it remains in a moderate range as the reservation wage distribution is dispersed.

5.5 Policy Design and Forcasting

The business cycle models embeded in dynamic stochstic general equilibrium model have progressed enough to address the policy issues in it. There have been two developments for the policy analyses. First, numerical solution methods have been developed enough to solve very complicated stochastic dynamic models. Second, market frictions including wage and price rigidities have successfully been modeled in the framework and hence money has nontrivial real effect. In this context, monetary policy has been extensively probed in the framework.

Peter Ireland (1996) analyzed monetary policy in a DSGE framework, but the model did not have capital accumulation in it. Using the model Ireland showed that when firms set nominal prices in advance, optimal monetary policy insulated aggregate output against shocks to demand. It could do so, however, by following the constant money growth rule advocated by Milton Friedman; it needed not respond to the shocks in an actively countercyclical way. In addition, to the extent that output fluctuations were driven by shocks to supply, money growth should have been procyclical.

McCallum (1999) studied a number of important preliminary issues including the distinction between rules and discretion in monetary policy; the feasibility of committed rule-like behavior by an independent central bank; and optimal control vs. robustness strategies for conducting research. He then took up the choice among alternative target variables – with the most prominent contenders including price level, nominal income, and hybrid (inflation plus output gap) variables – together with the issue of growth-rate vs. growing-level target path specifications. One conclusion was that inflation and nominal income growth targets, but not the hybrid target, would had induced fairly similar policy responses in the US economy over 1960-1995. With regard to instrument choice, McCallum argued that both nominal interest rate and monetary base measures were feasible; this discussion emphasized the basic conceptual distinction between nominal indeterminacy and solution multiplicity. Accordingly, root-mean-square-error performance measures were estimated for interest rate and base instruments (with nominal income target) in the context of a VAR model. Other topics emphasized in the chapter included the operationality of policy-rule specifications; stochastic vs. historical simulation procedures; interactions between monetary and fiscal policies; and the recently-developed fiscal theory of the price level.

Chari, Christiano and Kehoe (1994) developed the quantitative implications of optimal fiscal policy in a business cycle model. In a stationary equilibrium, the ex ante tax rate on capital income was approximately zero. There was an equivalence class of ex post capital income tax rates and bond policies that supported a given allocation. Within this class, the optimal ex post capital tax rates could range from close to independently and identically distributed to close to a random walk. The tax rate on labor income fluctuated very little and inherited the persistence properties of the exogenous shocks; thus there was no presumption that optimal labor tax rates followed a random walk. Most of the welfare gains realized by switching from a tax system like that of the United States to the Ramsey system came from an initial period of high taxation on capital income.

Chari and Kehoe (1999) provided an introduction to optimal fiscal and monetary policy using the primal approach to optimal taxation. They used this approach to address how fiscal and monetary policy should be set over the long run and over the business cycle.They found four substantive lessons for policymaking: Capital income taxes should be high initially and then roughly zero; tax rates on labor and consumption should be roughly constant; state-contingent taxes on assets should be used to provide insurance against adverse shocks; and monetary policy should be conducted so as to keep nominal interest rates close to zero.They began by studying optimal taxation in a static context and then developed a general framework to analyze optimal fiscal policy. Finally, they analyzed optimal monetary policy in three commonly used models of money: a cash-credit economy, a money-in-the-utility-function economy, and a shopping-time economy.

Based on these progress in policy anayses, forcasting models using DSGE framework are now developed especially by the central banks like European Central Bank, Sveriges Riksbank, Norges Bank, and the Board of Governors[10]. The models are exclusively designed to be used for the forcating business and a kind of melting pot of numerous features studied in the literature. Looking at the booming in the construction of forcasting models, we can confirm that the business cycle model using DSGE framework have progressed so much that they passed the test of stability which is required

[10]See Adolfson, Laseen, Linde and Villani (2005), The modellong team of Norges Bank, Smets and Wouters (2002), Edge, Kiley, and Laforte (2006), and Erceg, Guerrieri, and Gust (2006).

for the forcating business.

5.6. Costs of the Business Cycle

Robert Lucas(1987) obtained the upper bound estimate of the welfare gain from eliminating consumption risk by replacing postwar U.S. consumption with a consumption series without fluctuations. He assumed a representative agent with a constant relative risk aversion (CRRA) utility function. His estimates of the welfare cost of consumption fluctuations are very small, no more than 0.00008 percent of aggregate consumption assuming logarithmic preferences. The fact that these estimates were so small stimulated interest in the issue of whether other features of the economy would significantly increase the estimated magnitude of the cost of business cycle fluctuations. Imrohoroglu (1989) and Krusell and Smith (1999) introduced incomplete markets and uninsurable individual risk and found higher welfare costs. Cho, Cooley and Phaneuf (1997) calculated the welfare cost of business cycle fluctuations in a model with nominal wage contracts. In their model, the welfare loss derives entirely from labor supply risk and the costs are higher than those found by Lucas. Obstfeld (1994) and Dolmas (1998) introduced non-expected utility type preferences and found much larger welfare costs associated with business cycles.

Cho and Cooley (1998) considers the welfare consequences of the shocks that generate business cycles. They argue that the technology shock in the real business cycle literature is not always detrimental to economic welfare. Since there are no distortions in prototype real business cycle models like Kydland and Prescott (1982), Long and Plosser (1983), and Hansen (1985), aggregate fluctuations in these models still result in Pareto optimal allocations. It may seem natural to think that these fluctuating economies obtain lower welfare than their steady state counterparts, because the latter does not suffer from any uncertainty while the former does. However, They argue that this is not always correct. That is, economies with business cycle fluctuations may enjoy higher welfare than their steady state counterparts.

We understand that the last statement sounds counterintuitive. But, if we think of the way productivity shocks enter real business cycle models, the result is quite natural. The key to understanding how welfare could increase with uncertainty is to realize that the shocks to production are multiplicative and productive inputs like labor are variable . If there is a favorable productivity shock, output increases one-for-one, given the inputs. In addition, firms may employ more inputs with an increase in productivity so output can increase further. In other words, an increase in productivity will raise output more than proportionally and thus the reduced form (equilibrium) production function is convex with respect to the shock. Accordingly, introducing uncertainty through multiplicative productivity shocks increases the expected value of production implying that increasing the uncertainty *raises* average output.

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