Theory Analysis of Total Factor Productivity, Real Business Cycle Model and Economic Policy

Anyalezu, N. Kirk Guthlac, PhD
University of Phoenix
USA

Abstract

This paper analyses the theoretical importance of macroeconomic variables and the response to shocks. It explains the technological disturbances (or supply) as the main source of macroeconomic fluctuations given rational choice and perfectly flexible prices. Furthermore, the analysis assume productivity disturbances motivate rational agents to adjust savings and investment to smooth consumption and to adjust employment in response to changes in relative price of leisure and the productivity of labor in real business cycle (RBC) models. In addition, the assumption of capacity utilization is deemed endogenous thereby give rise to a gap between true technology shock (non-observable) and total factor productivity (TFP) measures (Observable). This study evaluates the economic policy effects with respect to labor, productivity and technology shocks.

Keywords: technology shocks; real business cycles; TFP; structural, policy

1.0 Introduction

The study analyses the fundamental theories behind technology shock and employment. It theoretically evaluates the estimation of Total Factor Productivity (TFP hereafter), and the relationship between technology and employment. The paper is in sections as follows: The introduction is in section 1.0 and 1.1 the literature review. Section 1.2 discusses the definitions and explanations associated with TFP and real business cycle (RBC) models. Section 1.3 examines the economic policy implications. Section 1.4 evaluates the RBC model predictions, while, section 1.5 looks at the critiques of RBC model, technology shocks and aggregate fluctuations, and section 1.6, the conclusion.

1.1: Literature Review

The growth accounting and the structural vector autoregressive models are the two approaches normally used. The first method measures technology directly and the later through imposing a restriction on the long run impulse response (Anyalezu (2011)). This section provides a literature review to this study. The reference to RBC model is important because of the model's predictions on the effects of technological improvement employment after a positive technology shocks.

For RBC model, a starting point will be by examining the seminal works of Kydland and Prescott (1982, 1990), Lucas (1977, 1980), Long and Plosser (1983), Mankiw (1989), McCallum (1989), Plosser (1989), Stadler (1994), Cooley, et al (1995), King and Rebelo (1999). This is just to name a few leading RBC theorist. In terms of the TFP, the empirical task of modelling it at aggregate and firm level for any economy is a complicated process. The reason is that TFP can act as the source of the cause as well as the consequence of the evolution of dynamic system operating in the economy. Thus, measuring and explaining it at the microeconomic and macroeconomic levels requires dismantling of many complex factors.

RBC theorists assume technological shocks are an influential source of business cycle volatility. For example, the model emphasizes supply or technology disturbances as the main source of macroeconomic fluctuations in a world with rational firms (individuals)[1] and perfectly flexible prices.

[1] Begg, Fischer, and Dornbusch, (1994), provided good interpretations of the terms trade, individual and business cycles. Trade in Victorian time refers to industry while individual means firms. In UK, short run fluctuations refers to as trade cycles while for the Americans the term business cycles are used. However, modern economists now use the term business cycle.

The theoretical approach stance is an adoption of better-than-average growth in the economy's technological capability, which induces firms to invest in new productive resources (plants and equipment). With an increase in investment, the demand for investment goods and employment growth rises. These in turn lead to growth in consumer spending. In addition, Kydland and Prescott (1991) estimation of the variations in Solow technology parameter as a source of aggregate fluctuations, show that it could account for about 70 percent of the variance in US post-war cyclical fluctuations.

TFP on the other hand can determine labour productivity through capital per employee. The usual approach to measure TFP has been to distinguish between shifts in aggregate production function. In other words, measuring technical change and the activities on production function and factor accumulation (see for example Hulten, (1975))[2]. To explain the distinctions in long-run economic performance, it is necessary to use a different approach. For example, the application of the Solow (1957) productivity analysis to differences in levels of output per worker across countries (Hall & Jones (1996))[3]. GDP growth explains economic improvement. It never-the-less tends to overstate the improvement in economic welfare and fails to measure the depletion of natural resources and the negative spill over externalities that associate with rapid GDP growth (see for example Hulten (2000))[4].

This study examines the TFP approaches advocated by Basu and Fernald ((BF), (1997), (2002), and BFK (2004)), Anyalezu (2011), including Hall (1986, 1988). Equally, it looks at the three approaches used for technology shocks, namely, Gali (1999), Christiano, Eichenbaum and Vigfusson (2003), and Chang and Hong (2006). This study therefore, assumption of the possibility to identify the gap between productivity and technology using the accounting framework. Productivity at some intervals may lie above technology and vice versa, thus implying, the gap between them reflect friction in output and factor markets. For example, Lipsey and Carlaw (2001), assesses the contributory qualities of TFP and the extent to which it represents the measure of an economy's technological change or dynamism and the interrelationships that underline the process of long-term growth. On this note, the next section examines some conceptual definitions with current TFP and RBC measurements.

1.2 The Definitions and Explanations of TFP and RBC Models

1.2.1 Total Factor Productivity

Productivity is a key performance benchmark and has profound implications for industrial and regulatory policies such as central banks, investment banks and governments. Hence, a rising productivity indicates increased profitability, lower costs and sustained competitiveness. For firms, the most commonly used productivity indicator is the labor productivity, that is, units of output or value added per employee. This measure has some drawbacks and the important one is the failure to show the reason labor productivity has risen. Thus the question, is it due to increased investment in technology or economies of scale such as improved efficiency? The Solow (1957) model indicates possible solution to this question. For instance, the model found that many countries economic growth are attributable to "technical change", or "total factor productivity growth", and as such, proposed measuring it as a "residual", based on "production function approach".

Following Solow (1957), the production function became the standard platform for measuring the rate of return to net investment in research and development (R&D) for firms (Griliches (1986)) and industry aggregates (Griliches (1979, 1994), Griliches and Lichtenberg (1984), Scherer (1982)). Recognizing importance of TFP, improvements to the method of measurements will continue. For example, in considering the return to scale and TFP, Caves, Christensen and Swanson (CCS (1981), proposed estimating a variable cost function rather than a total cost function.

The CCS approach applies to empirical measurement of scale economies in the presence of quasi-fixed inputs (Oum, Tretheway and Zhang (1991)). The wide use of TFP in macroeconomics and microeconomics studies also refers to as multiple or joint factor productivity (MFP) dates back to the 1930s (see Griliches (1995))[5].

---

[2] See also, Christensen, L and Jorgenson, D (1970), Denison, E (1972), and Jorgenson, D and Griliches, Z (1972a, b).
[3] Hall, R.E and Jones, C.I. (1996) 'The productivity of Nations', NBER Working Paper Series 5812
[4] Hulten, C (2000), 'Total factor productivity: A short biography', NBER.
[5] According to Griliches, (1995), some of the early studies on TFP measurement commenced with the output-over-input in Copeland (1937) to its codification in Solow (1957). Other studies include those by Tinbergen (1942), Stigler (1947), Schmookler (1952), Fabricant (1954), Kendrick (1955 and 1956), and Abramovitz (1956).

Nevertheless, using Solow's approach and the hypothesis of TFP as a microeconomic tool may be feasible to analyse and differentiate labour productivity change at firm level. In addition, it can indicate whether firm level labour productivity gains are determined principally by capital investment or by technology and knowledge.

The conventional definition of TFP defines it, "as the residual growth of real product not accounted for by the growth of real factor input" (see Hulten (1978)). In other words, it represents and/or explains that part of output growth not accounted for by the growth in inputs. It implies a reflection of the productivity of all inputs in producing an output. For example, if we assume there are only two categories of inputs, capital and labour, TFP is the weighted average of capital and labour productivity, adjusted for the additional input available due to increased factor efficiency. Therefore, a simple model derivation will show TFP as:

$$TFP = \frac{VA}{\left(K^{1-\alpha} L^{\alpha}\right)} \qquad (1.1)$$

Where TFP is the Total Factor Productivity, VA is the Value Added; K denotes Capital and L as the Number of Employees, or Total Annual Labor Hours or Hours Worked. The term α is a fraction or share of VA attributable to labour.

Thus, $\alpha = L(VMP_L)/VA$, where VMP_L is the value of the marginal product of labour. In addition, the term $1-\alpha$ is a fraction of value added attributable to capital. Hence, $1-\alpha = K(VMP_K)/VA$, where VMP_K is the value of the marginal product of capital. Therefore, dividing through by L yields the expression:

$$TFP = \frac{(VA/L)}{[(K/L)^{1-\alpha}]} \qquad (1.2)$$

Taking the logarithms of both sides of equation (1.2), gives the expression:

$$\ln(TFP) = \ln\left(\frac{VA}{L}\right) - \frac{(1-\alpha)\ln\left(\frac{K}{L}\right)}{t} \qquad (1.3)$$

Therefore, differentiating with respect to time $\left(\frac{\delta}{\delta t}\right)$ yields:

$$\frac{\delta \ln(TFP)}{\delta t} = \frac{\delta \ln\left(\frac{VA}{L}\right)}{\delta t} - \frac{(1-\alpha)\delta \ln\left(\frac{K}{L}\right)}{\delta t} \qquad 1.4$$

Hence, the percentage change in TFP is equal to the percentage change in value added per employee less $(1-\alpha)$ (percentage change in capital per employee). This implies that the change in TFP when computed for individual firms or firm level will show the underlying factors that drive labour productivity. TFP provides a method to quantify the contributions to growth of the different factors (Stiglitz and Driffill (2000)). In addition, a rising TFP relates directly to higher output, and can stand as an essential tool in measuring economic progress.

1.2.2 Real Business Cycle Model

The term economic cycle is by definition a periodic fluctuation of economic activities especially with respect to its long-term growth trend. The cycle represents a shift over time between periods of relatively rapid growth of output, commonly referred to as boom and periods of relative stagnation or decline, implying a contraction or recession as in figures 1.0 and 1.1 below. The measure of these fluctuations usually uses the real gross domestic product (GDP), while the government role is to smooth out the business cycle and control its fluctuations.

The cycles do not repeat at regular time intervals therefore, their length or peak to peak, or trough to trough varies. The concern is whether similar mechanisms that generate recessions and/or expansions exist in the economies so that the dynamics that appear as a cycle can occur repeatedly, for example, Sorensen and Whitta-Jacobsen (2005). According to Long and Plosser (1983), "business cycle refers to joint time-series behaviour on a wide range of economic variables such as prices, output, employment and investment.

In actual economies, this behaviour is characterised by two regularities. First, as a measure of deviation from trend, the up and down in individual time series exhibiting a considerable amount of persistence. Second, the measures of various economic activities (e.g. output in different sectors) co-move.

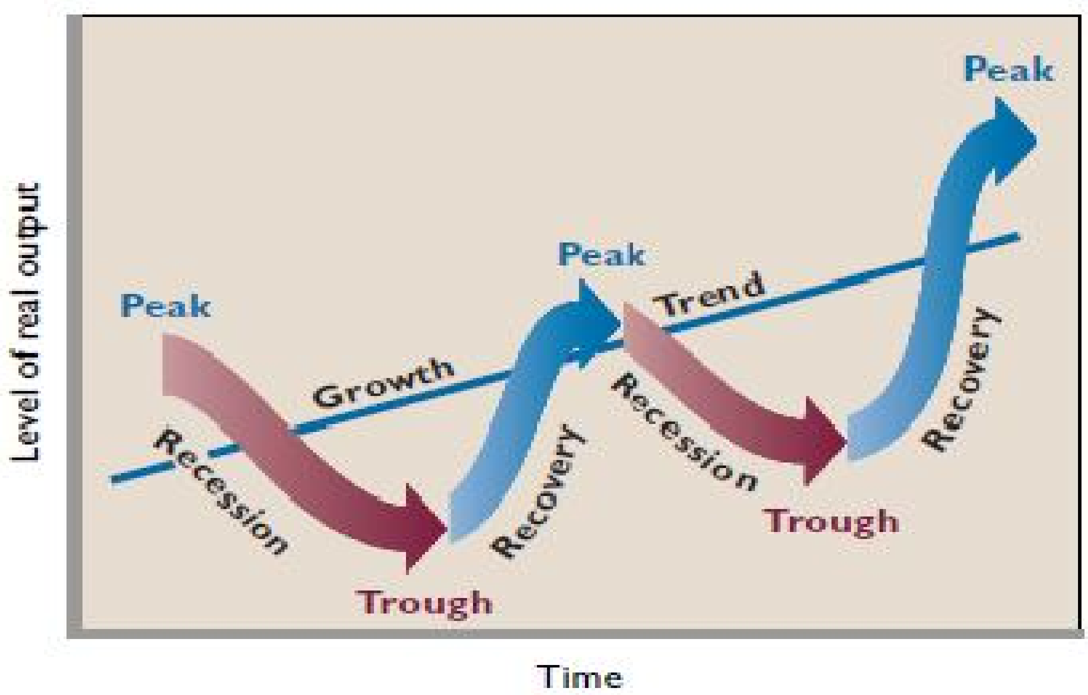

Figure 1.0: Business Cycle

Therefore, "Contractionary effects" is a contraction arising due to technology shocks and price stickiness. The Contractionary effect of technology shocks stronger in firms with stickier prices. For example, Marchetti and Nucci (2005) analysis on the Italian manufacturing sector. Basu and Fernald (BF, (1997)) and Gali (1999), reported negative correlation between technology shocks, identified under different assumptions and several measures of labour and other inputs. They interpreted the findings, which is difficult to reconcile with predictions of standard flexible-price model, as evidence in favour of sticky price models. Gali (1999) on the other hand, argued that in a model economy with sticky prices and a money supply less than fully responsive to technology shocks, a technology innovation has a negative short run effect on hours. Under rising technological expansion, nominal rigidities prevent prices from falling while aggregate demand does not increase. It implies firms can produce the same amount of output with smaller volume of inputs, which have become more productive. Furthermore, the results depend on the response of the monetary authorities to technological shocks. For example, if the central bank follows the optimal monetary policy as in Dotsey (2002) or a Taylor (1993) or Clarida et al. (2000) rule, then the effect of technology shocks on employment is no longer negative. This is because monetary policy by responding to deviations of inflation from target and to deviations of output from its natural level would reduce the policy rate to accommodate the shock fully.

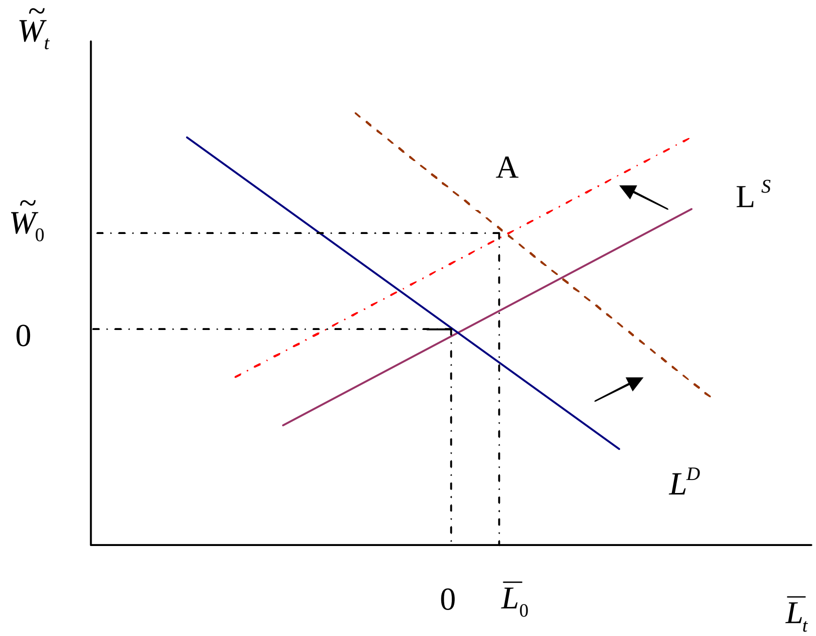

Figure 1.1: Technology Shock and Labour market

According to Lucas (1977), business cycles are an attempt to construct a model in the most literal sense: "a fully articulated artificial economy which behaves through time so as to imitate closely the time series behaviour of actual economies". In addition, Keynes (1936) through the "General Theory" attempted to achieve this explicitness and empirical accuracy advocated by the RBC model. The concern of these models to imitate actual economies has been the capacity to make accurate conditional forecasts, and evaluating how behaviour would have differed had some policies been different in specified ways. Therefore, in the next section is an examination of the economic policy implication, by categorizing technology shocks into two forms: transitory (purely temporary) shocks and a permanent shock.

1.3 The Economic Policy Implication

1.3.1 A Transitory (temporary) shock ($\rho z = 0$)

This exposition adopts the approaches postulated by Heijdra and Van der Ploeg (2002), and King and Rebelo (1999) by considering the effects of a temporary shock with a labour market and technology shock as depicted in figure 1.1 above. It assumes shock does not exhibit any serial correlation, implying $\rho z = 0$, where ρz is the autoregressive parameter. In addition, the assumption enables the response to technology shock to be represented as $\widetilde{Z}_t = \varepsilon_t^z$ and $\widetilde{Z}_t = 0$ for t = 1, 2… where Z_t is the general productivity parameter, ρ is a pure rate of time preference. The economic policy implication is that, with transitory shock there is no long-run effect on the macro economy. This is because technology only deviates in the impact period from its steady state level as a result the effect on consumption and other variables are non-zero. This means a transitory shock will cause consumption and the other variables to rise. Thus, the expression in equation (1.5) as:

$$\widetilde{C}_t = \frac{\phi[\lambda_2 + \varsigma(\phi - 1)]\varepsilon_t^Z}{(1+\lambda_2)[\omega_C + \phi - 1]} > 0. \qquad (1.5)$$

Where, $\widetilde{C}_t$ denotes consumption, ϕ is instantaneous utility (or felicity), representing the parameter for the effects of intertemporal substitution in labor supply, in which case $1 \le \phi = \dfrac{1+\omega_{LL}}{1+\omega_{LL}(1-\varepsilon_L)} < \dfrac{1}{1-\varepsilon_L}$. The term ς represents the output effect and as such satisfies $0 < \varsigma(\phi - 1) < 1$ while the term λ_2 denotes the unstable (positive) characteristic root of Δ_I, i.e. $\lambda_2 > 0$., the term $\omega_C = C/Y$.

That is, the output shares of private consumption. Finally, $\omega_{LL} = (1-L)/L$ denotes the wage elasticity of labour supply, given by $\sigma_L \omega_{LL}$. In other words, it represents the ratio between leisure and labour. For any given ω_{LL} the elasticity rises with σ_L, also, ε_L represents the efficiency parameter of labor.

In figure 1.1, the labour supply curve shifts up to the left. Instantaneously, the shock raises labour productivity thus labour demand. Under this scenario, irrespective of the capital stock being predetermined in the impact period, the labour demand curve shifts up and to the right. The impact effect on the wage rate is unambiguously positive, while the effect on employment appears to be ambiguous. From equation (1.5) and $\tilde{Z}_t = \varepsilon_t^z$, the analytical expression for $\tilde{L}_t$ (labor), $\tilde{W}_t$ (real wage), and $\tilde{Y}_t$ (output) as:

$$\tilde{L}_t = \left(\frac{\phi - 1}{\varepsilon_L}\right)\left[1 - \frac{\phi[\lambda_2 + \varsigma(\phi - 1)]}{(1+\lambda_2)[\omega_C + \phi - 1]}\right]\varepsilon_t^Z, \tag{1.6}$$

On the other hand, (Heijdra et al, (2002)), using a calibration approach showed that the labor-demand effect dominates the labor-supply effect, such that employment increases in the impact period as demonstrated in figure 1.1. In addition, the wage rate increases on impact irrespective of the parameter values as the labor-demand and supply effects co-move in the same direction. Although employment effect is ambiguous, output effect is unambiguously positive.

$$\tilde{W}_t = \left[\frac{1 - \phi(1 - \varepsilon_L)}{\varepsilon_L}\right]\varepsilon_t^Z + \left[\frac{(\phi - 1)(1 - \varepsilon_L)}{\varepsilon_L}\right]\tilde{C}_t > 0, \tag{1.7}$$

$$\tilde{Y}_t = \left[\frac{(1+\lambda_2)\omega_C + (\phi - 1)[1 - \varsigma(\phi - 1)]}{(1+\lambda_2)[\omega_C + \phi - 1]}\right]\phi\varepsilon_t^Z > 0. \tag{1.8}$$

Furthermore, given that output rises and capital is predetermined on impact, the immediate effect on the interest rate is positive, while the impact effect on investment is derived from equation (1.5) and setting $\tilde{Z}_t = \varepsilon_t^z$ and $\tilde{G}_t = 0$ (government consumption). Thus, yielding the expression:

$$\tilde{I}_t = \left[\frac{1 - \varsigma(\phi - 1)}{\omega_I(1+\lambda_2)}\right]\phi\varepsilon_t^Z > 0, \tag{1.9}$$

Where $\tilde{I}_t$ denotes investment, whereby $0 < \varsigma(\phi - 1) < 1$ and $\omega_I = I/Y$ that is, the output shares of investment, thus $\omega_C + \omega_I + \omega_G = 1$. Therefore, the transition paths for the capital stock $\tilde{K}_t$ and consumption $\tilde{C}_t$ will be:

$$\begin{bmatrix} \tilde{K}_t \\ \tilde{C}_t \end{bmatrix} = \begin{bmatrix} \left(\frac{\delta}{1-\lambda_1}\right)\tilde{I}_t \\ \tilde{C}_t \end{bmatrix}(1-\lambda_1)^t, \text{ For t = 1, 2, 3 …} \tag{1.10}$$

Where the term $-\lambda_1$ is < 0, and denotes the stable (negative) characteristic root Δ_I. Therefore, with respect to the impulse response for transitory shock, technology would return to its steady state level (($\tilde{Z}_t = 0$) for t = 1, 2 ...) one period after the shock occurred. In which case, from equation (1.10), the economy would have a relatively higher capital stock in period 1 (because $\tilde{K}_1 = \delta\tilde{I}_t > 0$) and subsequently declines over time. Similarly, consumption would gradually return to its original steady-state value. Concerning investment and employment, they are likely to fall below their respective steady-state levels during transition, given that $(\tilde{I}_t < 0)$ and $(\tilde{L}_t < 0)$ for t = 1, 2 …, including the real interest rate $(\tilde{r}_t < 0)$.

1.3.2 Permanent Shock $(\rho z = 1)$ and the Economic Policy Implications

The contrast to transitory technology shock is the permanent shock. This type of technology process features a unit root $(\rho z = 1)$. Therefore, the impact on consumption is as follows:

$$\tilde{C}_t = \frac{\phi[\lambda_2 - \xi\omega_C]\varepsilon_t^Z}{\lambda_2[\omega_C + \phi - 1]} > 0 \ . \tag{1.11}$$

This explains the condition in the event of consumption rising on impact as the permanent technology shock leads to the representative agent getting wealthier. Equally, the effects for employment, the wage and output are as follows:

$$\tilde{L}_t = \left(\frac{\phi - 1}{\varepsilon_L}\right)\left[1 - \frac{[\lambda_2 - \varsigma\omega_C]}{\lambda_2[\omega_C + \phi - 1]}\right]\varepsilon_t^Z, \tag{1.12}$$

$$\tilde{W}_t = \left[\frac{1 - \phi(1 - \varepsilon_L)}{\varepsilon_L}\right]\varepsilon_t^Z + \left[\frac{(\phi - 1)(1 - \varepsilon_L)}{\varepsilon_L}\right]\tilde{C}_t > 0, \tag{1.13}$$

$$\tilde{Y}_t = \left[\frac{\lambda_2 + \varsigma(\phi - 1)}{\lambda_2[\omega_C + \phi - 1]}\right]\phi\omega_C\varepsilon_t^Z > 0. \tag{1.14}$$

For investment, the derivation is from equation (1.11) and setting $\tilde{Z}_t = \varepsilon_t^z$ and $\tilde{G}_t = 0$, thus yielding the expression:

$$\tilde{I}_t = \frac{\varsigma\phi\omega_C\varepsilon_t^Z}{\omega_1\lambda_2} > 0. \tag{1.15}$$

Therefore, by setting $(\rho z = 1)$ allows for the analytical expressions for the transition paths of capital stock and consumption as:

$$\begin{bmatrix} \tilde{K}_t \\ \tilde{C}_t \end{bmatrix} = \begin{bmatrix} 0 \\ \tilde{C}_t \end{bmatrix}(1 - \lambda_1)^t + \begin{bmatrix} \tilde{K}_\infty \\ \tilde{C}_\infty \end{bmatrix}\left[1 - (1 - \lambda_1)^t\right], \tag{1.16}$$

Where the term $\tilde{C}_t$ definition is in equation (1.11) above, with $\tilde{K}_\infty$ and $\tilde{C}_\infty$ defined as:

$$\tilde{K}_\infty = \left(\frac{\omega_C}{1 - \omega_1}\right)\tilde{C}_\infty = \frac{\phi\omega_C\varepsilon_t^Z}{\omega_G(\phi - 1) + \phi\omega_C\varepsilon_L} > 0\,. \tag{1.17}$$

In addition, $\tilde{K}_t$ and $\tilde{C}_t$ in equation (1.16) are also the weighted average of the relevant impact and long-run effects, with the transition speed of the economy, $(1 - \lambda_1)$ determining the time varying weights. For the permanent productivity shock, consumption and the capital stock increasing in the long term. Thus given the steady state $\tilde{I}_\infty = \tilde{K}_\infty$ and $\tilde{r}_\infty = 0$, meaning that $\tilde{Y}_\infty = \tilde{K}_\infty$, such that $\tilde{K}_\infty - \tilde{L}_\infty = \tilde{W}_\infty = (1/\varepsilon_L)\tilde{Z}_\infty$, where $\tilde{Z}_\infty = \varepsilon_t^Z$. Therefore, with constant government spending $\tilde{G}_t = 0$, the steady state for $\tilde{C}_\infty$ and $\tilde{Y}_\infty$ as well as $\tilde{L}_\infty$ can be as:

$$\tilde{Y}_\infty = \left(\frac{\omega_C}{\omega_C + \omega_G}\right)\tilde{C}_\infty = \frac{\phi\omega_C\tilde{Z}_\infty}{\omega_G(\phi - 1) + \phi\omega_C\varepsilon_L} > 0\,. \tag{1.18}$$

$$\tilde{L}_\infty = \frac{\tilde{Y}_\infty - \tilde{C}_\infty}{1 + \omega_{LL}} = -\left(\frac{\omega_G}{\omega_C + \omega_G}\right)\left(\frac{\tilde{C}_\infty}{1 + \omega_{LL}}\right) \le 0\,. \tag{1.19}$$

This implies that in the long-term, a permanent productivity improvement would make a representative agent or firm better off, thus inducing an increase in consumption. Under such circumstances, the investment-capital ratio and the output-capital ratio will remain unaltered but the capital-labor ratio would rise including the real wage.

Therefore, given absence of government consumption $(\omega_G = 0)$ the income and substitution effects in labor supply will cancel out and employment remain unchanged. Equally, with positive government consumption, the income effect dominates the substitution effect and labor supply goes down (more leisure consumption by the household).

1.4. RBC Predictions

The RBC model predictions emphasizes on mechanisms, which involves propagation over time of the effects of shocks. In addition, it focuses on the extent to which shocks that initiate the cycles are real as opposed to monetary in origin. Furthermore, the RBC model has been successful in explaining some of the empirical regularities associated with economic fluctuations (see for example, McCallum (1989) and Plosser (1989)). Furthermore, it explains the technology disturbances (or supply) as the main source of macroeconomic fluctuations in a world characterised by rational individuals and perfectly flexible prices. In other words, in RBC models, productivity disturbances motivate rational agents to adjust savings and investment to smooth consumption and to adjust employment in response to changes in relative price of leisure and the productivity of labor.

In terms of the merits of the RBC, the derivation of its structural equation is from an optimization (Minford and Sofat (2004)). The parameters of the model, that is, preferences or technology is structural. Equally, the model is an equilibrium model and by definition, its construction is to predict how firms with a relatively stable tastes and technology will decide to respond to known economic shocks or changes in economic structure. These permit the use of the model to analyse how important macroeconomic variables are likely to respond to shocks and to identify the economic shock. The early RBC models of Kydland and Prescott (1982), Long and Plosser (1983) and Hansen (1985), were based on closed economy models, hence the assumption of no externalities, taxes, government expenditure or monetary variables. This has since substantial extensions have made to the traditional RBC models, especially on the role of government (Mankiw (1989), Christiano and Eichenbaum (1992), McGrattan (1994) and Cooper (1997)), the role of money, (King and Plosser (1984), Cooley and Hansen (1989)). The model has also incorporated distortionary taxes (Braun (1994)) and open economy extensions (Mendoza (1991), and Correia, Rabelo and Naves (1995)).

As for the criticisms of RBC, the original Kydland and Prescott model was set in non-monetary world, (hence the "real") with efficient markets. The model neglected the impact of monetary policy on business cycles, downplayed the role of market inefficiencies and minimized the importance of unemployment. However, subsequent studies have introduced monetary policy, market inefficiencies and unemployment into modifications of the Kydland and Prescott paradigm.

1.4.1 The Theory Synthesis

The RBC hypothetical postulation is that output movements are behind the productivity shocks, which affect an economy and lead to shifts in its production function. Although these shocks can be both quick and temporary, they can result to persistent movements in output. The New Keynesian view on the contrary is that cyclical output movements are predominately the result of demand shocks which have a long lasting although temporary effect on output. In essence, booms and recessions are therefore, regarded as periods of excess demand or supply. To generate cycles in output, the disequilibria cannot adjust quickly by movements in wages or prices. In which case, it is the slow market clearing that explains the persistent output movements. The New Keynesian theory in essence is concerned about accounting for why wages and prices move more sluggishly – implying that in the short run, demand shocks will have significant effects on output.

Stabilization policy is the method the government and the central bank, via monetary and fiscal policies, controls the cycles; that is, demand management. It implies the fluctuations are a consequence of aggregate demand. Therefore, any policy, which cancels out these movements in aggregate demand, will be successful in controlling output. RBC model predictions focus on the importance of 'real' factors in determining cycles. This is due to the perception that markets clear and information is close to perfect. In other words, the source of output fluctuations will come from 'real' factors, which alter an economy's production function.

These are predominately technology or productivity shocks[6]. A crucial part for the explanation of business cycles is to account for how a given shock can generate a sustained movement in output. The cycle dynamics also indicates that cycles have duration of at least several quarters or years. The RBC model response is to consider cycles as generated by the combination of two elements – the impulse and propagation. The impulse is the initial productivity or technology shock. This is a sudden and very short run innovation.

The propagation mechanism on the other hand, explains how the shock generates a persistent movement in output. The propagation mechanism is the key to understanding real business cycles (RBC). This is because, without it, there will be no real explanation of the business cycle. A temporary shock would lead to a change in the equilibrium level of output and a shift in the long-run aggregate supply curve. Once the shock disappears or reverses, the economy would return to its original level. In terms of the propagation mechanism, one approach is to follow the seminal models of Ramsey (1928), which argues that the persistence in output movement results from sustained increase in capital movements following a productivity shock. The propagation mechanism therefore is the consumption smoothing[7]. To summarise the two models, RBC model argues that output fluctuations are the result of productivity shocks. The New Keynesian approach suggests that cycles are the result of price and wage rigidities, which prevent markets from clearing. Once we acknowledge that output can persistently deviate from its equilibrium level (assume this is the trend level of GDP or appropriately the TFP), we then have a basis for explaining cycles or the resultant influence on employment.

1.5. Critiques of RBC Model, Technology Shocks and Aggregate Fluctuations

It follows that, despite the identified effects of technology shocks, several studies have criticized its role in generating fluctuations, for example, Mankiw (1989). Some of the criticism is due to the presumption that a technology shock initiates expansions, and therefore, difficult to explain recessions or downturns by resorting to RBC theoretical reasoning. Gali and Rabanal (2004) provided a sceptical perspective to whether RBC predictions links well with technology shocks by suggesting demand factors as the real force behind the strong positive co movement between output and labour input measures. Among those advocating for the RBC model and its important pivotal impact include Kydland and Prescott (1982), and Prescott (1996). The proponents of the model assume RBC as the equilibrium responses to exogenous variations in technology, given perfect competition and intertemporal optimising agents. This makes the role of nominal friction and monetary policy secondary. Cooley and Prescott (1995), view was that because of the use of calibrated version of the neoclassical growth model augmented with consumption – leisure choice including a stochastic change in (TFP) as the main source accounting for the majority of economic fluctuations. Still on the subject, King and Rebelo (1999) regarded the RBC model as overstated

1.6 Conclusions

This study has provided a comprehensive literature survey covering TFP and RBC models. Through this process, there is a perception of an acceptance that TFP is important. This is more so given that increasing productivity relates to increased economic growth, lower costs and sustained competitiveness. For example, the most widely used productivity indicators for firms are labour productivity – units of output, or value added, per employee. Nevertheless, these measures have drawbacks. The most important one being the failure to account for the reason labour productivity increased in accordance with RBC models predictions. A crucial part for the explanation of business cycles is to account for how a given shock can generate a sustained movement in output. The RBC model response is to consider cycles as generated by the combination of two elements – the impulse and propagation. Equally, the proponents of the model assume RBC as the equilibrium responses to exogenous variations in technology, given perfect competition and intertemporal optimising agents. This makes the role of nominal friction and monetary policy secondary. Some of the criticisms levelled against RBC model is due to the presumption that a technology shock initiates expansions, and therefore, difficult to explain recessions or downturns by resorting to RBC theoretical reasoning.

[6] The nominal factors include price and money shocks. They have no impact on the real economy when information is complete and prices are flexible. In other words, they have no important role in generating cycles. See Chamberlin and Yueh – Macroeconomics, 2006

[7] A positive productivity shock would increase current income, but if households are permanent income consumers, they will rationally attempt to spread this gain over time to maximise their lifetime utility. To achieve this, is to invest some of the present income gain in capital, which will then lead to higher income generation in subsequent periods.

On the contrary is that, cyclical output movements are predominately the result of demand shocks which have a long lasting although temporary effect on output. In essence, booms and recessions are therefore, regarded as periods of excess demand or supply. To generate cycles in output, the disequilibria cannot adjust quickly by movements in wages or prices. In which case, it is the slow market clearing that explains the persistent output movements.

Acknowledgement

I would like to thank my darling wife, Dr Chibuzor Guthlac Anyalezu and our kids, Zizi and Zara for unwavering support and encouragement while I research for this study.

Author Information

Dr Anyalezu, Nkem Kirk Guthlac,
Economics Professor, University of Phoenix, and Economics Professor at Austin Community College, Austin TX; I am a Visiting Professor of Economics – DeVry University & Keller Graduate Management School, Houston Texas, USA.
Business Development Analyst, Capital City Mortgage, Austin TX
Ph.D. Economics (University of Surrey, UK),
M.Phil. Economics and Political Economy (SOAS-University of London, UK),
M.Sc. Economics Mathematics (Birkbeck College, University of London, UK),
BA (Combined Hons) Accounting and Economics, London Metropolitan University,
PGC Business Management and Information Technology, Middlesex University, UK,
P/Q ACCA: The Chartered Association of Certified Accountants, Thames Valley University-UK,
MABE, Member - The Association of Business Executives,
M.Inst.Am, Member – The Institute of Administrative Management,
MRES, Member-The Royal Economics Society,
ACIB, Associate Member-The Chartered Institute of Bankers.

References

Anyalezu, N. K. Guthlac, (2011), The Aggregate Technology and Contractionary Effects: An Empirical Estimation, International Business, and Economics Research Journal, July (2011), Volume 10, Number 7, 47 – 66.

Basu, S., Fernald, J., and Kimball, M, (2004), Are Technology Improvements Contractionary? NBER Working Paper Series10592

Basu, S and Fernald, J. G (2002), Aggregate Productivity and Aggregate Technology, *European Economic Review* 46, 963 – 991.

Braun, R, A., (1994), Tax Disturbances and Real Economic Activity in the Post War U.S., Journal of Monetary Economics, Vol.33, 441 - 462

Caves, D.W; Christensen, L.R; and Swanson, J.A, (1981), Productivity Growth, Scale Economies and Capacity Utilization in U.S. Railroads, 1955-74, The American Economic Review, Vol.71, No.5 Dec., (1981), 994-1002

Chang, Y and Hong, J.H, (2006), Do Technological Improvements in the Manufacturing Sector Raise or Lower Employment. *The American Economic Review*, Vol. 96 No.1, 352 – 368. -.04

Chang, Y and Hong, J.H, (2006), On the Employment Effect of Technology: Evidence from U.S. Manufacturing for 1958 – 1996, Federal Reserve Bank of Richmond Working Paper 03 – 06, 1-32

Christiano, L. J., Eichenbaum, M and Vigfusson, R., (2004), The Response of Hours to a Technology Shock: Evidence Based on Direct Measures of Technology, *Journal of the European Economic Association*, 2(2 – 3), 381 – 95.

Christiano, L.J., Eichenbaum, M and Vigfusson, R., (2003), What Happens After A Technology Shock? NBER Working Paper 9819; Board of Governors of the Federal Reserve System, International Finance Discussion Paper, No. 768, June 2003, 1-52.

Clarida, R, Gali, J. and Gertler, M., (2000), Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory, Quarterly Journal of Economics, 115, 147 - 180

Cooley, T.F. and Hansen, G.D. (1989), The Inflation Tax in a Real Business Cycle Model, The American Economic Review, Vol.7, No.4, 733-748

Cooley, T.F. and Prescott, E.C, (1995), Economic Growth and Business Cycles, in Thomas F Cooley, ed., Frontiers of Business Cycle Research, Princeton, Princeton University Press

Cooper, R.W., (1997), Business Cycles: Theory, Evidence, and Implication, NBER working paper, No. 5994, 1-44

Correia, I., Rabelo, S., and Naves, J.C., (1995), Business Cycles in a Small Open Economy, CEPR Discussion Paper No. 996.

Dotsey, M., (2002), Structure from Shocks, Federal Reserve Bank of Richmond, Economic Quarterly, 88(4), 37- 47

Gali, J., (1999), Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations? American Economic Review 89, 249 – 271.

Gali, J. and Rabanal, P., (2004), Technology Shocks and Aggregate Fluctuations: How well does the RBC Model fit Postwar U.S. data, NBER Macroeconomics Annual, 2004, 2-66; IMF WP/04/234, 2004

Griliches, Z. (1986), Productivity Puzzles, and R & D: another non-explanation, Journal of Economic Perspectives, 2(4), 9-21; see also (1979 & 1994)

Griliches, Z. and Lichtenberg, F. (1984), Inter-industry Technology Flows and Productivity Growth: A Re-examination, the Review of Economics and Statistics, Vol. 66, No.2, (May 1984), 324-329

Hall, R.E., (1988), the relation between price and marginal cost in U.S. industry. Journal of Political Economy, 96, 921 – 947.

Hall, R.E., (1990), Invariance properties of Solow's productivity residual, In: Diamond, P. (Ed.), *Growth, Productivity, Employment*, MIT Press, Cambridge MA.

Hulten, C. (1978), Growth accounting with intermediate inputs, Review of Economic Studies 45, 511 - 518

Heijdra, B.J., and Van der Ploeg, F., (2002), Foundations of Modern Macroeconomics, Oxford University Press, 477 – 539

Hansen, G.D., (1985), Indivisible Labor and the Business Cycle, Journal of Monetary Economics, Vol.16, 309-327

Jorgenson, D.W., and Griliches, Z., (1967), the Explanation of Productivity Change, Review of Economic Studies, 34 (1967), 249 - 283

King, R.G., and Rebelo, S. (1999), Resuscitating Real Business Cycles. In Woodford M, and Taylor, J (eds.), Handbook of Macroeconomics, Vol. 1B, Elsevier Science, North-Holland, Amsterdam, p. 927-1007.

Kydland, F.E. and Prescott, E.C., (1991), Hours and Employment variation in Business cycle theory, Journal of Economic Theory, vol.1, no.1, (March, 1991), 63-81

Kydland, F.E. and Prescott, E.C., (1982) Time to build and Aggregate Fluctuations, Econometrica, vol.50, no. 6, Nov. (1982), 1345 - 1370

Lipsey, R.G. and Carlaw, K. (2001), What does Total Factor Productivity Measures?, Manuscript Study Paper Version 02, 1 - 52

Long, J.B., and Plosser, C.I. (1983), Real Business Cycles, The Journal of Political Economy, vol. 91, no.1 (Feb. 1983), 39 - 69

Lucas, R.E., (1977), Understanding Business Cycles, Journal of Monetary Economics, Supplement, (1977), Carnegie-Rochester Conference series, vol.1

Mankiw, N.G., (1989), Real Business Cycles: A New Keynesian Perspective, The Journal of Economic Perspectives, vol.3, no.3, (Summer 1989), 79 - 90

Marchetti, D. J. and Nucci, F., (2005), Price Stickiness and the Contractionary Effect of Technology Shocks, European Economic Review, (2005), 49(5), 1137 – 1163.

McCallum, B.T., (1989), Real Business Cycles in R. J. Barro, (ed.), Modern Business Cycles, Basil Blackwell, Oxford

McGrattan, E. R. (1994), The Macroeconomic Effects of Distortionary Taxation, Journal of Monetary Economics, vol.33, 573 - 601

Mendoza, E. (1991), Real Business Cycles in a Small Open Economy, The American Economic Review, vol.81, 797 - 818

Minford, P and Sofat, P., (2004), an Open Economy Real Business Cycle Model for the UK, Manuscript, CASS, 1 – 80

Oum, T.H., Tretheway, M.W., and Zhang, Y. (1991), A Note on Capacity Utilization and Measurement of Scale Economies, Journal of Business & Economic Statistics, Vol.9, No.1 (Jan., 1991), 119-123

Plosser, C.I., (1989), Understanding Real Business Cycles, the Journal of Economic Perspectives, Vol.3, No.3 (Summer 1989), 51 - 77

Ramsey, F.P., (1928), A Mathematical Theory of Saving, Economic Journal, 38, 543 - 559

Scherer, F.M. (1982), Inter-industry Technology Flows and Productivity Growth, the Review of Economics and Statistics, Vol.64, No.4 (Nov; 1982) 627-634

Solow, R. (1957), Technical Change and the Aggregate Production Function, Review of Economics and Statistics, 39 (1957), 312 – 320.

Sorensen, P.B., and Whitta-Jacobsen, H.J., (2005), Introducing Advanced Macroeconomics: Growth and Business Cycles, McGraw-Hill Companies, London 397 - 428

Stadler, G.W. (1994), Real Business Cycles, Journal of Economic Literature, Vol. XXXII, 1750 - 1783

Stiglitz, J.E., and Driffill, J., (2000), Economics, 647 – 671, W.W. Norton & Company, New York, London

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

Vigfusson, R.J., (2004), The Delayed Response to Technology Shock,: a Flexible Price Explanation, Board of Governors of the Federal Reserve System, International Finance Discussion Papers, N0. 810, 1 – 44.