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Application of the Neoclassical Model to the Saudi Economy

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Abstract. This article uses real GDP growth statistics to investigate the determinants of real business cycles in the Saudi economy from 1970 to 2019. To find the origins of the business cycles, we used Stata 17 and the King and Rebelo model, which was published in 1999 and had six equations. We utilized Strata's "sbbq" module to detect the turning points. We computed the model parameters using Bayesian dynamic stochastic general equilibrium. The results revealed six turning points, divided into three peaks and three troughs. Furthermore, the findings show that our estimates nearly match those of King and Rebelo. According to theory, productivity shock is the most important element influencing behavior.

Keywords: business cycles, peaks, troughs, driving forces, shocks

Introduction

Research on the business cycle took place in the 1920s, employing microeconomic methodologies. It attained prominence during the Great Depression. In 1956, it achieved notable advancements with Solow's residuals, suggesting that unforeseen fluctuations in productivity drive typical business cycles. The performance of macroeconometric models in the 1970s revealed the inadequacy of Keynesian economics, which had prevailed for fifty years. In 1976, Lucas improved the study of business cycle models. This influenced many areas and led to the use of methods based on real business cycles (King and Rebelo 1999). Kydland and Prescott (1982) proposed a theory of business cycle fluctuations that synthesized long-term economic development with short-term macroeconomic variations. They said that changes in technology might cause short-term cycles and that slow improvements in production methods might lead to periods of slower output growth. They demonstrated that supply shocks may produce the qualitative characteristics of economic cycles, and their model might provide quantitatively substantial cycles. This was the first attempt to establish the general equilibrium of a dynamic and stochastic macroeconomic model, which was based on microeconomic principles.

The real business cycle theory posits that technology shock, such as poor harvests or surges in oil prices, frequently initiates business cycles. These shocks influence pricing, decision-making, and investment choices, creating a ripple effect across the economy. Adverse events diminish the economy's capacity to generate additional commodities and services, thereby sustaining the cycle. These cycles are incorporated inside dynamic stochastic general equilibrium models. Real business cycles are part of dynamic stochastic general equilibrium models. The robustness of the genuine business cycle hypothesis lies in its applicability to 99 percent of all business cycles throughout human history. Since the 20th century, real business cycle theory has often been less important than the aggregate demand model because it requires examining the reasons behind negative technology changes. What is the magnitude and extent of the adverse effects of technological shock? These include the oil, financial, and real estate crises. The idea posits that business cycles originate from technological developments and resource availability, which affect output and aggregate supply and

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hence cause economic fluctuations. There are many ways to separate business cycles, and one of them is to use the Baxter-King filters for frequency filtering. The Hodrick-Prescott filter is another instrument utilized to assess business cycles. Another method used is the Bry and Boschan (1971) programmed strategy. This approach starts by creating moving averages that focus only on the trend and cycle parts. These reasonably smooth curves form the foundation for identifying expansions and contractions, as well as for picking the approximate vicinity of prospective peaks and troughs.

The Saudi economy faced many business cycles, where government participation (41% of total consumption and a 22% ratio to GDP) and oil price levels both had the greatest influence. El-Baz (2018), in his study on Saudi business cycles, suggests shifting financial policy against the economic cycle to lessen its severity. The recovery phase is often longer than the recession, and the intensity of rallies and top levels is greater.

This paper aims to apply the King and Rebelo model to Saudi data to identify the main drivers of business cycles. The main question we try to answer is: Is productivity the main driver of real business cycles in the Saudi economy, as the theory posits?

This paper, as usual, starts with the introductory section, followed by a literature review, model description, results, discussion, and conclusion.

2. Literature Review

Venter and Woulhuter (2023) stated that Venter (2005) identified the business cycle for the period 1946–2013. Due to numerous negative global events and internal structural limitations in the period 2013-2022, the South African economy has faced prolonged uncertainty and a gradual decrease in the potential economic growth rate. SARB identified reference turning points in the business cycle according to the definition of the growth cycle. Growth cycles denote the variations surrounding the long-term trajectory of aggregate economic activity, commonly known as trend-adjusted business cycles. They synthesized various economic indicators into a unified index to create a composite business cycle indicator. The current diffusion index was constructed using a methodology that mirrors business cycle indicators.

Colombo (2021) used a method from Harding and Pagan (2002) along with the Bry-Boschan (1971) approach to find turning points in the seasonally adjusted quarterly GDP data for Brazil. The B.B. algorithm automates the cycle dating process according to the practices of the National Bureau of Economic Analysis (NBER) in the United States. The approach applies certain principles governing the series' behavior to categorize peaks and troughs. A recession transpires from peak to trough, while an expansion transpires from trough to peak. A minimum time is necessary for a phase of the cycle (from peak to trough or from trough to peak—parameter p). Third, the method necessitates a value for the minimum duration of the entire cycle (peak to peak or trough to trough—parameter c). We will now implement the aforementioned methods with Stata 15. You can apply the same method to other statistical applications.

Ibrahima (2019) utilized seasonally adjusted quarterly data from the Euro Area spanning 1987Q1 to 2007Q4, concentrating on the Great Moderation Period to circumvent problems associated with other high volatility phases of the business cycle. According to the DSGE model in Dynare, his results show that the Nominal GDP Targeting Rule, which was introduced in 1978, is much better than the Taylor Rule. He performed multiple robustness checks to ensure the validity of the results. He also examined the impulse response functions for the two monetary policy rules.

Technium Business and Management (TBM)
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www.techniumscience.com

Omotosho (2019) used Bayesian DSGE for Nigeria to conclude that monetary policy and oil are mostly responsible for the variation in Nigerian output. Both domestic supply and monetary shocks explain 70% of the short-run fluctuations. Taylor's policy responses displayed aggressive monetary policy; fiscal policy offers proof of a rather subdued and pro-cyclical policy.

Al-Baz (2018) examined Saudi Arabia's commercial and financial cycles from 1970Q1 to 2016Q4. He disclosed that financial upturns had a longer lifespan than economic expansions. Upturns have a larger amplitude and a steeper slope than expansions. He discovered that the state of the economy depends on the financial situation. The promotion of economic growth can be significantly aided by fiscal policy.

Andrle, Bruha, and Solmaz (2017) employed dynamic principal component analysis to investigate economic determinants in advanced economies. They identified substantial patterns in the co-movement of macroeconomic variables, with real variables and inflation exhibiting considerable correlations. Their research proposes a theoretical framework for shock magnitude and structural shock attributes.

In 2016, Jegajeevan investigated what causes business cycles in Sri Lanka. The model outperformed BVAR by precisely replicating the data through DSGE. He built a medium-sized DSGE model that took oil contribution into account in both consumption and production, as well as the import and export of intermediate and final items. He found that shocks to the domestic supply primarily caused that country's business cycles.

Pesaran and Xu (2013) examined the relationship between credit shocks, firm defaults, and volatility to determine how credit shocks influence the way the business cycle operates. The results reveal that in a steady state, a firm's default likelihood grows with its leverage ratio and the level of economic uncertainty. An increase in the loan ratio to deposits boosts output, consumption, hours, and productivity while narrowing the disparity between loan and deposit rates.

Milani's study from 2006 constructed a monetary DSGE model that uses infinite-horizon learning and includes things like how spending habits change over time and how inflation is measured. He used Bayesian methods to estimate the basic parameters of the economy and the main learning parameter. He then applied these estimates to the DSGE model estimation process. The results show that giving up on the idea of reasonable expectations in favor of learning might get rid of the need for mechanical sources of persistence. Learning seems to be a pivotal factor in inflation inertia.

3. The Model

In his seminal work of 1956, Solow articulated the concept of net investment, or capital development, as a constant ratio of total output. He posited that savings and investments exert an influence on the capital stock, while production demonstrates constant returns to scale. He asserted that the growing population and swift expansion would require modifications to the workforce. Solow's long-run development model illustrates that the capital-labor ratio facilitates a more sustained expansion of capital stock in comparison to the labor force. The total product curve delineates the relationship between the capital-to-labor ratio and the number of laborers, taking into account adjustments for population growth. Capital accumulation is not dependent on the expansion of the workforce, as evidenced by the capital-labor ratio.

King and Rebelo (1999) expanded upon Solow's research by examining the dynamics of business cycles. They started with three basic ideas from the neoclassical model: people's preferences, the

Technium Business and Management (TBM)
Vol. 11, pp.78-87 (2025)
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www.techniumscience.com

resources they have, and their technology skills. These ideas helped them create six equations. The primary factors involved include consumption, capital, labor, and real income. It further posits a Cobb-Douglas production function that demonstrates sustained growth alongside a stochastic enhancement in productivity that exceeds unity.

We will employ six equations derived from dynamic stochastic general equilibrium (DSGE) models to estimate actual business cycles. Anticipated future consumption (c) and future interest rates (r) influence the presented equations. They explain that investment depends on output, labor hours depend on wages and consumption, and real GDP growth shows how production is influenced by the relationship between capital and labor, productivity, real wages, and interest rates. We also seek to estimate three states: future capital stock as a function of investments and current capital stock (k), productivity, and government expenditure (g).

Below is the linearized model:

$$c_t = E_t(c_{t+1}) - (1 - \beta + \beta\delta)E_t(r_{t+1}) \quad (1)$$

$$\eta h_t = w_t - c_t \quad (2)$$

$$\phi_1 x_t = y_t - \phi_1 c_t - g_t \quad (3)$$

$$y_t = (1 - \alpha)(z_t + h_t) + \alpha k_t \quad (4)$$

$$w_t = y - h \quad (5)$$

$$y_t = w_t - k_t \quad (6)$$

$$k_{t+1} = \delta x_t + (1 - \delta)k_t \quad (7)$$

$$z_{t+1} = \rho_z z_t + \epsilon_{t+1} \quad (8)$$

$$g_{t+1} = \rho_g g_t + \xi_{t+1} \quad (9)$$

4. Results and discussion

4.1 Data: Penn World Tables offered data on the growth of real GDP from 1970 to 2019. The growth rate reflects business cycles, as illustrated in the chart below. The variable y is procyclical, meaning that it rises during a boom and falls during a recession. The Saudi economy increased at an average rate of 7%, with a median growth rate of 3%. The growth rate did not follow an upward or downward trend; it oscillated throughout the study period. It is evident that the growth rate reflects real business cycles. The SBBQ package, which uses the Bry and Boschan (1971) algorithm to find turning points (peaks and troughs), was applied to the growth of real GDP from 1970 to 2018. The results display three peaks in the years 1974, 1991, and 2011, and three troughs in the years 1985, 1998, and 2015. Nonetheless, the application of the Baxter-King filter in Figure (1) exhibits more peaks and troughs compared to SBBQ. When we compare our results with AlBaz's, who used the same method, we see that changing the yearly growth rate to a quarterly rate showed more highs and lows than what we found.

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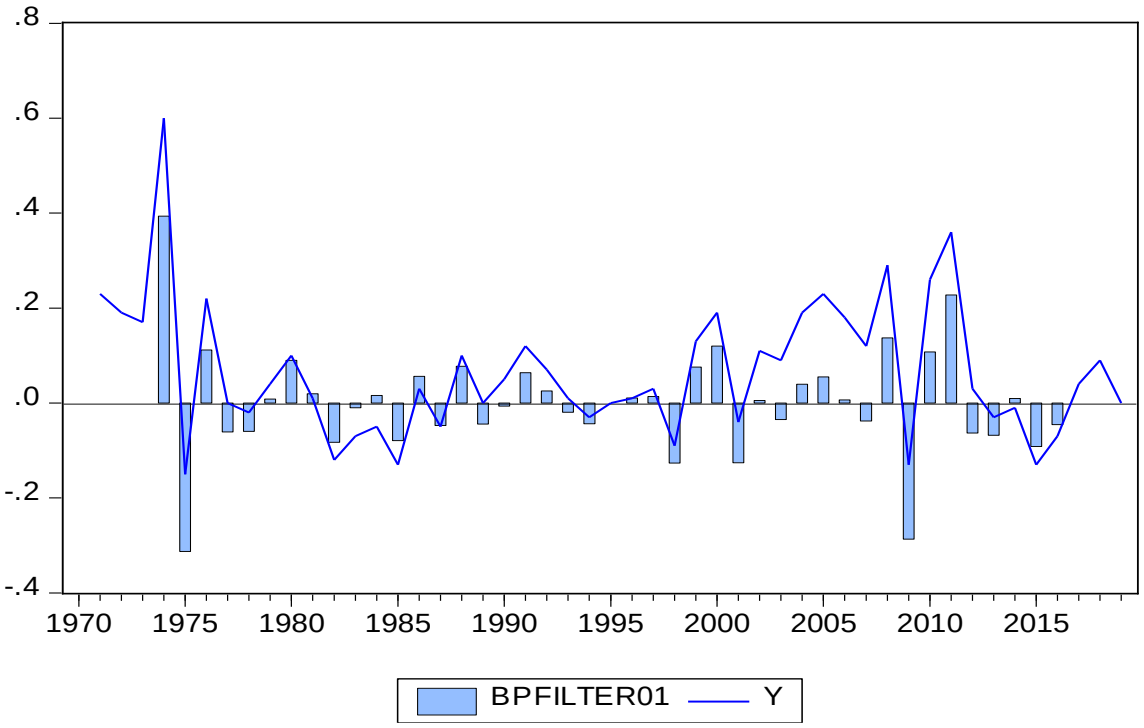
ISSN: 2821-4366
www.techniumscience.com

Figure (1) GDP Growth and Baxter-King Filter



Bayesian linear DSGE model MCMC iterations = 12,600
Random-walk Metropolis-Hastings sampling Burn-in = 2,600
MCMC sample size = 10,000
Sample: 1971 thru 2019 Number of obs = 49
Acceptance rate = .2609
Efficiency: min = .006344
avg = .02353
Log marginal-likelihood = 2.5479568 max = .07046

	Mean	Std. dev.	MCSE	Median	Equal-tailed [95% cred. interval]	
beta	.9553522	.0173608	.001336	.9562813	.9155614	.9841349
delta	.0550747	.0134386	.000506	.0536606	.0317612	.0833341
eta	.5830892	.1574964	.016345	.5890856	.2458472	.8688656
phi1	.3259372	.0425913	.00344	.3241725	.249552	.4180697
phi2	.7454616	.0887428	.008456	.7530026	.5410156	.897674
alpha	.2958323	.0396792	.002424	.295609	.2186297	.3713771
rhoz	.7506185	.0288854	.001517	.7509263	.6920763	.8085071
rhog	.2912604	.0725914	.003883	.2859683	.1596551	.4467215
sd(e.z)	.0254603	.017965	.002012	.0205586	.004475	.0710571
sd(e.g)	1.215262	.1427512	.017923	1.222844	.8964574	1.460919

Technium Business and Management (TBM)
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To reduce autocorrelation and achieve the adaptation rate, we increased the number of iterations for the MCMC burn-in time to 2600. The adaptation rates of all estimated parameters exceed 0.01. The acceptance rate falls within the normal range. The estimated parameters, beta (discount rate), alpha (share of capital in GDP), rhoz, and rhog (autoregressive parameters), are almost identical to those in the King and Rebelo model. Phi1 (share of investment in GDP) and Phi2 (share of consumption in GDP) are similar to King-P parameters. The estimated parameter eta (slope of the labor supply curve) is roughly 0.6, whereas that in King and Rebelo is 1. The depreciation rate delta is double that in King and Rebelo (1999), although it remains within acceptable limits. The process is saddle-path stable. The difference between this study and King & Rebelo's study is that we estimated the parameters according to the data set of income while they used actual ratios.

5. Discussion

The policy matrix analysis determines the responses of the variables by increasing the state variables by one unit. An increase in capital stock (k) and productivity (z) increases control variables. While an increase in capital increases both consumption and the real wage, at the same time it decreases the other control variables. A one-unit shock to government spending (g) increases working hours, income, and interest rates while decreasing the other variables. While the capital stock declines, productivity, and government spending rise above their short-term equilibrium levels in response to increases in output, working hours, and interest rates. The increase in productivity results in the most significant change compared to all other state variables. Its greatest impact is on investment, amplifying it six times compared to two times on income and interest rates, and one and a half times on working hours. Additionally, it increases real wages by fifty percent and thirteen percent, respectively, with implications for consumption.

The elements of the state transition matrix are merely the persistence in the model, as the state variables are uncorrelated. The value of the state variable g is solely determined by its value in the current period. However, the capital stock in the subsequent period is contingent upon the current values of all three state variables. Additionally, productivity is contingent upon the current values of only two state variables. This feature implies that a shock to the g state variable has two effects: it increases the future value of g, as g is autoregressive, and it also increases the future value of k.

The reactions of the model variables to perturbations in g and z are depicted in the same graph (Figure (2) in the annex). Additionally, the name of the IRF, the impulse variable, and the response variable are all included in each graph separately. The responses to states g and z are displayed alongside the control variables that we have constructed. Except for investment, which has a negative influence in the early years before stabilizing, the control factors exhibit a shock to state g that is nearly identical to the other variables. On the other hand, the sudden change to state z caused all of the control variables to be altered. It was the investment of the control variable that had the most significant impact, followed by the interest rates and income variables.

The impacts of a one-standard-deviation shock on productivity, capital stock consumption, and wage rates are increasing at a falling rate. However, the shock's impacts on work hours, investment, income, and interest rates are all negative. The shock to g, on the other hand, has a negative influence on the consumption rate, investment rate, wage rate, and capital stock. Work hours, income, and interest rates all increased at a slower pace as a result of the shock, which had a positive impact on all three of these variables. When both the effects of controls on state variables and the influence of changes in state variables on control variables are taken into consideration, it becomes clear that capital investment and productivity were the primary factors that brought about the change.

Technium Business and Management (TBM)
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www.techniumscience.com

Conclusion

The purpose of this paper is to test real business cycle theory using Saudi data. The idea claims that technological shocks, such as poor harvests or spikes in oil costs, typically cause business cycles. These shocks affect prices, decisions, and investments, causing changes throughout the organization. Adverse events limit the economy's ability to produce extra goods and services, worsening the situation. These cycles are part of the dynamic stochastic general equilibrium model. We applied King and Rebelo's model to six key variables: consumption, labor demand, labor supply, investment, output, and interest rates. This is due to a high correlation between real economic cycles and dynamic stochastic general equilibrium. We also examined three critical indicators: productivity, capital stock, and government spending. Surprisingly, King Rebelo's anticipated parameters based on the US economy roughly match six of eight. This raises the question of whether US business cycles influence the Saudi economy. This could be a topic for further inquiry. The Saudi economy's fluctuations were largely caused by productivity shocks.

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Annex

Annex (1) Policy Matrix

	Delta-method				
	Coefficient	std. err.	z	P>|z|	[95% conf. interval]
c					
k	.938155	.	.	.	.
z	.1373025	.	.	.	.
g	-.0975478	.	.	.	.
h					
k	-1.71664	.	.	.	.
z	1.541157	.	.	.	.
g	.2268555	.	.	.	.
x					
k	-5.995828	.	.	.	.
z	6.471302	.	.	.	.
g	-2.511612	.	.	.	.
y					

Technium Business and Management (TBM)
Vol. 11, pp.78-87 (2025)
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k	-1.173312	.	.	.	.	.
z	2.032926	.	.	.	.	.
g	.1814844	.	.	.	.	.
w						
k	.5433279	.	.	.	.	.
z	.4917686	.	.	.	.	.
g	-.0453711	.	.	.	.	.
r						
k	-2.173312	.	.	.	.	.
z	2.032926	.	.	.	.	.
g	.1814844	.	.	.	.	.

Note: Standard errors are reported as missing for constrained policy matrix values.

Annex (2) Transition matrix of state variables

	Delta-method				
	Coefficient	std. err.	z	P>|z|	[95% conf. interval]
F.k					
k	.8628269	.	.	.	.	.
z	.1268883	.	.	.	.	.
g	-.0492473	.	.	.	.	.
F.z						
k	0	(omitted)				
z	.3	.	.	.	.	.
g	-1.39e-17	.	.	.	.	.
F.g						
k	0	(omitted)				
z	0	(omitted)				
g	.4	.	.	.	.	.

Note: Standard errors are reported as missing for constrained transition matrix values.

Annex (3) Stability results

	Eigenvalues
stable	.8628
stable	.3
stable	.4
unstable	4.696e+17
unstable	1.046
unstable	-1.022e+16

Technium Business and Management (TBM)
Vol. 11, pp.78-87 (2025)
ISSN: 2821-4366
www.techniumscience.com

unstable | -4.790e+16
unstable | 5.647e+32
unstable | .

The process is saddle-path stable.
Figure (2) Impulse Response Function