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An Estimated New Keynesian Model for the Egyptian Economy

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Abstract

This paper aims to identify the drivers of Egypt's aggregate macro fluctuations during the period 2002-2013. In particular, the paper will empirically investigate the effects of the unexpected shocks to consumers' preference, cost-push, technology, and monetary policy on the dynamic behavior of output growth, inflation, and short-term nominal interest rate. The paper estimates a dynamic stochastic general equilibrium (DSGE) model with sticky prices for Egypt within a New Keynesian framework. The paper uses maximum likelihood, with quarterly data of key macroeconomic variables: GDP, inflation rate, and nominal interest rate from year 2002q1 until 2013q4. We have found that preferences shocks are a major source of instability in output growth. Cost-push shock is the most important contributor to movements in inflation and short-term nominal interest. It appears to be that the preference, cost-push, and monetary policy shocks are more important than the technology shock in explaining the dynamic behavior of the macroeconomy.

I. Introduction

Sustainable economic growth is essential for stimulating economic development, which is the primary goal for many developing countries. Economic growth can result in increasing the country's wealth and income, as well as improving standards of living and lifting people out of poverty. For the purpose of improving economic performance, the Egyptian government has announced the start of a recent comprehensive economic reform agenda. Following the UN Sustainable Development Goals footsteps, the government of Egypt has proclaimed the Sustainable Development Strategy: Egypt's Vision 2030. The 2030 Strategy, aims for sustainable growth of 7% on average while maintaining an inflation rate between 3% and 5%, increasing the share of the service sector to 70% of GDP, and bringing down the unemployment rate to 5% with the creation of approximately 11.5 million new jobs (Zaki, 2017).

In order to put the Egyptian economy on the right path towards a more stable and resilient economy, we have to first determine the structure of the Egyptian economy, analyze what mostly drives fluctuations in the aggregate macroeconomy, and draw the path for the suitable policy decisions needed to achieve these targets. Since 2002, the Central Bank of Egypt (CBE) has adopted a series of economic reform programs in order to attain sustainable economic growth and keep inflation under control. Also, the Egyptian economy has experienced several political and socioeconomic disturbances that have caused macroeconomic imbalances and have played a significant role in shaping the nature of the country's economic troubles today.

The motivation behind this paper is analyzing what mostly drives fluctuations in the aggregate macroeconomy considering the nature of the Egyptian economy during the period 2002-2013 using the Dynamic Stochastic General Equilibrium Model (DSGE). The DSGE models are widely used to develop forecasts paving the way for governments to formulate fiscal and monetary policies. These policies in return impact consumer behaviors, provide illuminating insights for investors to have a clear vision to set future plans, and encourage sustainable development and rising living standards.

The Dynamic Stochastic General Equilibrium (DSGE) model is a data-based, quantitative method of observing the fluctuations in macroeconomic variables such as output growth and inflation using microeconomic foundations (Christiano, Eichenbaum, and Trabandt, 2018). It is estimated as a system of equations not as an equation by equation. The DSGE is a methodology for many macroeconomics models such as the real business cycle and the New Keynesian model. The real business cycle is one of the earliest DSGE models: it consolidates the effects of technology shocks in explaining the fluctuations in the aggregate economic activity (Francis and Ramey, 2005) with less emphasis on the importance on the monetary shocks (Cooley and Hansen,1989), or even not accounting for it at all (Long and Plosser, 1983). However, the New Keynesian Model is derived from the real business cycle model but allows for a wider set of shocks to be embedded in the DSGE models beside the technology shock to form the dynamic behavior of key macroeconomic variables.

The current generation of DSGE models has a very time dependent analysis considering various structural shocks that trigger economic instability of the economy as a whole (Smets and Wouters, 2003). The New Keynesian approach of the DSGE Models is built on the basic micro-foundations that gives special importance to optimizing agents' behaviors putting into consideration their budget constraints, equilibrium conditions, and the notion of price stickiness in the short run (Schmidt and Wieland, 2012). In the New Keynesian Model, monetary policy plays a significant role in the short-run due to the notion of sticky prices and wages. Because prices and wages slowly adapt to economic fluctuations, the dynamic effects of a shock to monetary policy would have a significant impact on the economic macro-variables of the economy such as the aggregate output, rate of inflation, and the short-term interest rate.

The foundation of the New Keynesian model is built upon 3 pillar equations that describes the dynamic behavior of the aggregate output, rate of inflation, and the short-term interest rate. The first pillar equation is the IS curve, which determines the interest rate is based on decisions made by the households regarding their level of consumption, decisions made by firms regarding the level of investment, and the aggregate output (Kerr and King, 1996). The second pillar equation is the Phillips curve, which captures how firms set their prices in a monopolistic competitive market. Since nominal prices do not adjust quickly, firms' face explicit costs of price sickness. Some of these costs are coming from printing new menu prices or internalizing the nominal price adjustment costs by firms for not losing their customers (Rotemberg, 1982). The third pillar in the New Keynesian model is the monetary policy rule equation, which emphasizes that in order to achieve stability in prices and output, the central bank should determine the level of the short-term nominal interest rate in response to fluctuations in output and inflation (Taylor, 1993). The New Keynesian models puts these primary equations together in a system the results in a complete framework for adequate macroeconomic analysis that describes the economy as a whole.

The main objective of this paper is to analyze the economic fluctuations that the Egyptian economy experienced between 2002 and 2013 in a New Keynesian framework. To a further extent, the paper will examine the factors that mostly drive these fluctuations. In particular, the paper will examine the relative importance of shocks to consumers' preference, the cost-push inflation, technology, and monetary policy in accounting for the dynamic behavior of output growth, inflation, interest rates, and output gap.

The remainder of this paper is structured as follows. The next section is an overview of the major changes in the aggregate macroeconomy and the monetary policy rules. Section III is a literature review of how different macroeconomic models have been used to analyze macro fluctuations in Egypt and around the world. In Section IV we develop a baseline DSGE model describing the Egyptian economy. Lastly, Section V is our conclusion and findings summary.

II. Overview of the Macro Story of Egypt

II. 1 Fluctuations in Macro-variables:

After a long period of a government-managed closed economy, in the early 1980s the Egyptian market economy became internationally integrated through the process of trade liberalization and privatization of state-owned companies (Weinbaum,1985). This translated afterwards into an expansion in the private sector from 34% in FY91 to more than 60% in FY08. The increase in private investment resulted in an increase in GDP by almost 4% per annum between 1995 and 2008 (Zaki, 2017). From 2000 until 2008, the country experienced great economic performance. Arbatli and Moriyama (2011) attributed the economic performance to flourishing financial market conditions globally; strong external demand; a domestic series of structural reforms that resulted in devaluing of the currency and boosting productivity, which raised the level of competitiveness in the global market; and strong capital inflows as a result of the augmented capital returns in Egypt. Between 2005 and 2008, the average annual growth rate was 6.4%, peaking at 7.2% by the end of 2008.

Egypt’s economic growth switched from being driven mainly by consumption in the 80’s and 90’s to become more investment and export oriented by the beginning of the 21st century. In the years leading up to 2008, the physical capital share of economic growth saw upward trend while the share of human capital and total factor productivity haven’t shown a significant improvement (Herrera et al, 2011). With the upward trend in the private sector, unemployment declined from 11.7% in 1998 to 8.3% in 2006 with a fundamental change in the age structure of a country's labor force as the youth unemployment rate declined. From this change it was anticipated that Egypt would benefit from a demographic dividend in the job market (Assad, 2009). In theory, increasing the number of workers compared to dependents in the economy would imply an increase in the saving rates, investment, and thus total and per capita output.

Despite the glorious economic years that the Egyptian economy had experienced starting from the 21th century until 2008, the economic performance took a dip in the wake of the 2008 global financial crisis followed by the domestic political uprising of 2011. These economic and political negative forces had a devastating impact on an economy that was seeing such high growth rates so recently. Starting in 2009, real GDP growth showed a significant decline, reaching an all-time low record of 1.8 percent in 2011. Recovery became hard to manage: GDP growth did not surpass 3.3% until 2014 (Lemaire, 2018). Furthermore, the average annualized change in CPI, which had stabilized around 10% in 2005-08 increased to 23% in 2008, then stabilized again at 9.7% from 2011 until the devaluation of the pound in 2016 (Al-shawarby and El Mossallamy, 2019). Furthermore, in 2011, investment declined by 31% leading to an increase in the unemployment rate over 13% (Haq and Chahir, 2015).

II. 2 A Brief Descriptive Analysis of Some of Monetary Policy in Egypt:

As monetary policy lacked an explicit nominal anchor which complicated approaching targets, the Economic Reform and Structural Adjustment Program in 1996 declared an abolition of the de-jure exchange rate peg and announced a monetary policy of an exchange rate as the nominal anchor (Al-Mashat and Billmeier, 2007). At the beginning, the program achieved the desired aim of decreasing inflation and achieving a growth rate of about 5% (Hassan, 2003). However, by the early 2000s, Egypt had suffered from an increase in the inflation rate which was reflected in an undesired rapid real appreciation of the Egyptian pound of 40% (Moriyama, 2011). Moreover, the level of the international reserves declined leading to unfavorable increase in the current account deficit. Therefore, the central bank's monetary policy aimed to increase economic activity, e.g., instead of having the exchange rate as a nominal anchor, the interest rate became the nominal anchor in 2003, which is a mechanism that enables to stabilize inflation and real output without impacting the exchange rate (Selim, 2012).

Before 2003, the interest rate had no response to exchange rate fluctuations; however, in 2003, the central bank shifted the official exchange rate regime in Egypt, and the de jure float was introduced. This implied that the central bank would only interfere in the foreign exchange market in the case of major oscillations in the exchange rate market (Selim, 2012). The floating of the exchange rate was essential at that time because of the lack of political will to use international reserves to support the peg to the dollar, as well as the urge to reduce the interest rate to boost the economy (Amar and Bakardzhieva, 2003).

Furthermore, until 2005, bank excess reserves were the operational target and growth in M2 was the intermediate target in efforts to achieve high economic growth, low inflation, and a stable exchange rate. However, in 2005, as inflation was relatively high and volatile (as it was influenced by changes to the dollar exchange rate), and in order to boost the country's connection with the rest of the world, the central bank started its transition towards an inflation targeting regime by adopting a monetary policy that relies on the interest rate as an instrument to maintain price stability as a policy objective (Al-Mashat and Billmeier, 2007). Taking account of the notion of nominal price rigidities is crucial to maintaining price stability and mitigating short-term fluctuations of employment and output, which are the main drivers of economic growth (Clarida, Gali, andGertler 1999; and McCallum 1999a). Before 2005, the central bank did not have a monetary policy characterized by an explicit interest rate; however, in 2005, the CBE formulated an operational target of an overnight interest rate facility allowing it to fluctuate within a certain corridor. This means that in periods of high inflation, the Central Bank can adopt a policy tightening that tends to raise nominal short-term rates.

After the 2011 political and economic disturbance, the Central Bank put great effort to defend the Egyptian pound chopping down international reserves by approximately 50% within one year from December 2010 to December 2011 (Al-shawarby and El Mossallamy, 2019). Moreover, with the dramatic capital outflow, the international reserves collapsed from $36 billion in December 2010 to $15.4 billion in January 2015. This strain on international reserves led the central bank to declare an Economic reform program that aimed to rebuild economic performance in 2016 by moving to a full liberalization of the exchange rate regime

III. Macroeconomic Models in the Literature

III. 1 Application of the New Keynesian Model Internationally

Countries with different size economies around the world have been using the New Keynesian model in order to analyze their economic performance and how their macroeconomies react to different shocks. For example, in a New Keynesian model estimates for the Australian economy, the authors found that the domestic demand and supply shocks are the main drivers of the Australian business cycle, and the monetary policy shocks do not drive fluctuations in the macroeconomy (Buncic and Melecky, 2008). Another New Keynesian model estimated to examine the South African economy, they found that inflation and real wage fluctuations are extensively explained by supply shocks and to a lesser extent by productivity shocks. The nominal interest rate is primarily driven by demand shocks. (Steinbach, Mathuloe, and Smit, 2009). Moreover, in a New Keynesian model of the US economy, the author suggests that monetary policy shocks are what mostly drives instability in output growth. Cost-push shock contributes to movements in inflation. The preference shock has a key role in driving fluctuations in the short-term nominal interest (Ireland, 2004). Finally, estimating a DSGE model of the Japanese economy, it has been mentioned that cost-push shocks and technology shock have the same importance in driving the Japanese business cycles. Inflation fluctuates greatly in response to a monetary policy shock (Sugoyand and Uedaz, 2006).

III. 2 Macroeconomic Models of the Egyptian Economy

Moving forward to see the economic literature on the Egyptian economy using different macroeconomic models, Moursi, Mossallamy, and Zakareya (2007) estimated a structural VAR measuring the monetary policy stance during the 90's, emphasizing the minimal direct impact of monetary policy shocks on real output. Furthermore, Al-Mashat & Billmeier (2007) applied the VAR baseline specification for the period 1996-2005. They emphasized that the exchange rate channel intensifies the impact of policy shocks and is powerful in transmitting the monetary stance, while the interest rate channel is ineffectual. However, after shifting away from the exchange rate as the nominal anchor and moving towards an inflation targeting regime in 2005, this effect of the interest rate channel should be strengthened.

Moursi and El Mossallamy (2010) built a small, open economy forward-looking DSGE model to using the economic performance over the period 2002 to 2008. They emphasized that the effects of monetary policy shocks on domestic output fluctuations are greater than the effects of technology shock. The level of openness to trade does not affect the dynamic behavior of the macro-variables, nor the policy decisions regarding variations in the nominal exchange rate.

Arbatli and Moriyama (2011) used data from 2005 to 2010 using the Global Projection Model (GPM) of the IMF. They found that variation in output growth was driven by demand shocks as well as the monetary policy shocks, and variation in inflation is mainly explained by supply shocks. Notwithstanding that the interest rate channel is weak, a significant part of the fluctuations of output growth were based on the magnitude of the policy rate shocks. In other words, fluctuations in output might have been magnified in that period because of the pro-cyclicality feature of the nominal interest rates in Egypt.

Lemaire (2018) pointed out some features of the Egyptian economy in light of the monetary policy rules over the period 2002 to 2017 using a simultaneous equations approach and a VAR model. The author concluded that using a new Keynesian IS curve in the Egyptian economy is appropriate as it provides a clear interpretation of the expectations of factors used in the business-cycle. Also, the author mentioned that the level of output was irresponsive to any changes in the flow of capital suggesting that the Egyptian economy's dependence on the external sector was likely still minimal in that period.

Finally, very recent research by Al-shawarby and El Mossallamy (2019) evaluates the impact of both monetary and fiscal policies on economic performance using a New Keynesian small, open economy (DSGE) model for Egypt using 2004-2016 data. They found that the CBE attributes a great value to anti-inflationary and output targeting policies relying significantly on interest rate smoothing decisions, with an infirm response to fluctuations to the nominal exchange rate.

IV: A Baseline DSGE Model Describing the Egyptian Economy

1. Data:

Quarterly Egypt data from 2002:1 through 2013:4 has been obtained from the International Financial Statistics (IFS) for GDP to measure output growth, CPI to measure of inflation, and Treasury bill rate to measure the nominal interest rate.

2. The Model:

In this paper a New Keynesian DSGE model is developed for the Egyptian economy. Specifically, this paper follows the micro-founded DSGE model approach presented by Ireland (2004), who have used quarterly United States data from 1948:1 through 2003:1 to reveal the relative importance of technology shocks compared to other different shocks in a new Keynesian framework. Since in this paper, we will adopt Ireland (2004) stylized model, we will only present a concise overview of the model.

Based on the adopted model, in the absence of shocks, all the variables converge to its steady-state levels, where all of the stationary variables are constant over time. Throughout the following equations, all the variables in question is measured as a percentage deviation from its steady-state level.

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_{at} \qquad (1)$$

$$\hat{e}_t = \rho_e \hat{e}_{t-1} + \varepsilon_{et} \qquad (2)$$

$$\hat{z}_t = \varepsilon_{zt} \qquad (3)$$

Equations (1-3) govern the behavior of the preference, cost-push, and technology variables that captures the shocks. $\hat{a}_t$, is the variable that captures the consumer's preference shock. The consumer preference shock is a sudden change in the patterns of consumption spending and thus affects consumers' aggregate demand. It actually appears when optimizing the representative household agents' utility function subject to their budget constraints. $\hat{e}_t$, is the variable that captures the cost-push shock. It is a shock to the firm's desired markup as a result of a sudden increase in the costs of factors of production. This happens in the short run because of the price stickiness and costly price adjustments. Both the consumer preference and cost push shock follow an autoregressive process and ρ_a, ρ_e are the estimates of the behavior of $\hat{a}_t, \hat{e}_t$ respectively. Furthermore, $\hat{z}_t$ is the variable that captures the technology shock in the New Keynesian model, which directly affects firms' price determination through increasing productivity and lowering marginal costs (Ireland, 2004). ε_{at}, ε_{et} , and ε_{zt} are serially uncorrelated innovations with zero-mean and normally distributed with SD σ_a,σ_e, and $\sigma_z$respectively.

$$\hat{x}_t = \alpha_x \hat{x}_{t-1} + (1+\alpha_x) E_t \hat{x}_{t+1} - (\hat{r}_t - E_t \hat{\pi}_{t+1}) + (1-\omega)(1-\rho_a)\hat{a}_t \quad (4)$$

Equation (4) is the IS curve, which determines the current output gap deviation from its steady state $\hat{x}_t$. $\hat{x}_{t+1}$ is the expected output gap, $\hat{r}_t$ is the short-term nominal interest rate, and $\hat{\pi}_{t+1}$ the expected rate of inflation. ω measures the magnitude to which the preference shock $\hat{a}_t$impacts the output gap $\hat{x}_t$.

$$\hat{\pi}_t = \beta[\alpha_\pi \hat{\pi}_{t-1} + (1-\alpha_\pi) E_t \hat{\pi}_{t+1}] + \psi \hat{x}_t - \hat{e}_t \quad (5)$$

Equation (5) is the Phillips curve that captures the dynamics of the inflation. $\hat{\pi}_t$ is the percentage of change of inflation. $\hat{\pi}_{t+1}$ is the percentage change of expected inflation. $\hat{x}_t$ is the percentage change in output gap. In this equation the cost-push shock $\hat{e}_t$appears explicitly, while the preference $\hat{a}_t$ and technology shock $\hat{z}_t$ enter indirectly through the definition of the output gap $\hat{x}_t$.

Note that, the lagged output gap term α_x in the Is curve and lagged inflation term α_π in the Phillips curve, which both lie between zero and one, are included in the equations to capture the significance of backward-looking elements in the economy. Including them would protect the model from the possibility of wrongly specifying the forward-looking variables estimates. Also will avoid falsely ascribing the data dynamics to the shocks serial correlation instead of being the product of additional frictions that influence households and firms backward-looking behavior.

$$\hat{x}_t = \hat{y}_t - \omega \hat{a}_t \quad (6)$$

$$\hat{g}_t = \hat{y}_t - \hat{y}_{t-1} + \hat{z}_t \quad (7)$$

Equation (6) and (7) are to describe the output gap $\hat{x}_t$and the growth rate of output $\hat{g}_t$. $\hat{y}_t$and $\hat{x}_t$ are stochastically detrended unobservable variables of output and the output gap respectively. Furthermore, $\hat{x}_t$ is the ratio between the actual and efficient levels of output, which is closely related to the representative household's welfare. $\hat{g}_t$ is the observable variable output growth.

$$\hat{r}_t - \hat{r}_{t-1} = \rho_\pi \hat{\pi}_t + \rho_g \hat{g}_t + \rho_x \hat{x}_t + \varepsilon_{rt} \qquad (8)$$

Equation (8) is the modified Taylor (1993) monetary policy rule equation. In the New Keynesian Model, monetary policy plays a significant role in the short-run due to the notion of sticky prices and wages. In order to achieve stability in prices and output, the central bank should determine the level of the short-term nominal interest rate in response to fluctuations in output and inflation. In this equation, the central bank changes the short-term nominal interest rate $\hat{r}_t$ according to the divergence of inflation $\hat{\pi}_t$, output growth $\hat{g}_t$, and the output gap $\hat{x}_t$ from their steady-state levels. In other words, the central bank opts for the steady-state inflation rate π, and selects response parameters ρ_π, ρ_g, and ρ_x.Moreover, both the output growth $\hat{g}_t$ and output gap $\hat{x}_t$ are included in the equation to capture the real economic activity of the economy. Distinguishing between the two variables would help in analyzing how the central bank reacts to fluctuations in the directly observed output growth and the output gap that is associated with the representative household's welfare. ε_{rt} is a monetary policy shock that occurs when the central bank changes its interest rate without any previous warning. It is serially uncorrelated innovation with zero-mean and normally distributed with standard deviation σ_r .

3. Results

Based on the previous equations (1) through (8), there are three observable variables– output growth $\hat{g}_t$, inflation $\hat{\pi}_t$, and the short-term nominal interest rate $\hat{r}_t$. There are two stochastically detrended unobservable variables output $\hat{y}_t$ and the output gap $\hat{x}_t$, and four unobservable shocks–to preferences $\hat{a}_t$, cost-push $\hat{e}_t$, technology $\hat{z}_t$, and monetary policy ε_{rt}. The next step would be estimating the model's parameters based on the three observables variables using the maximum likelihood. Then, draw inferences about the behavior of the unobservable elements of the model, and farther assess how each shock would contribute to fluctuations in the model's observable and unobservable variables.

The empirical model has 16 parameters: $Z, \pi, \beta, \omega, \psi, \alpha_x, \alpha_\pi, \rho_\pi, \rho_g, \rho_x, \rho_a, \rho_e,$ $\sigma_a, \sigma_e, \sigma_z,$ and σ_r . Z and π have no effect on the dynamics of the model, and they are only used to establish the steady state levels of output growth and inflation. Z is set equal to the average output growth rate, and π is equal to the average inflation rate in the data. Moreover, β is the value of the representative household's discount factor that is used to determine the interest rate is set to be fixed β =0.99 allowing for the steady state nominal interest rate to be equalized to the average nominal interest rate in the data. De-meaning the output growth, inflation, and the interest rate (predetermining the steady-state levels) before applying the maximum likelihood estimation for the rest of the parameters would protect the estimated model from exaggerating the persistence of the exogenous shocks while trying to account for structured divergence of the variables from their steady state levels. Furthermore, the coefficient of the output gap in the Philips curve is set fixed ψ =0.1.

Table1 exhibits the maximum likelihood estimates, standard deviation, t-stat, and the p-value of the 12 estimated parameters. ρ_a = 0.08697 is small and insignificant estimate implies that preference shock is not persistent over time. ρ_e= 0.52867 large and significant estimate suggests that the cost-push shock is highly persistence, especially when compared to the preference and technology shock. ω=0.6964 large and significant estimate suggests that the output gap is largely affected by the preference shock. ρ_π= 0.122 small but significant estimates suggesting that the central bank monetary policy mildly responds to inflation. ρ_g=ρ_x =0.0 suggests that the output growth and output gap do not play any role in shaping the central bank's policy decision making. α_x= 0.0 and significant suggesting that consumers' forward-looking behavior is important in explaining the data and also ρ_{π} = 0.1617 is small and insignificant which supports the forward-looking versions of the IS and Philips curve. σ_a=3.7244, σ_e= 0.34699, σ_z= 0.8405, and σ_r= 0.1489 all significant and larger than their standard errors, suggesting that the preference shock, cost push shock, technology shock, and monetary policy shock respectively contribute to some extent in explaining the fluctuations in the macro-variables.

Figure 1 plots the impulse responses of output, inflation, the nominal interest rate, and the output gap to consumer's preference shocks, cost-push shocks, technology shock, and monetary policy shocks. After 1-standard deviation positive preference shock, the output growth increases by 40% in the first month right after the shock; however, this change in output growth is not persistence, and it then quickly converges to its steady state level. The rate of Inflation also increases by about 0.7%, but it takes longer time going back to the steady state level compared to the output growth. These upward movement in the output growth and inflation would increase the nominal interest rate (using the policy rule estimation) by 0.3%, and interest rate would stay above its steady state for around 9 months until the impact of the shock goes away. The output gap also increases by more that 9%.

A 1-standard deviation cost push shock increases output growth by around 9% and has a negative impact of inflation. As a result of the fall of inflation by 14%, the central bank would take an expansionary policy action allowing the nominal interest rate to fall by 1.5% and stays far from its steady state for almost a year. Both the output growth and the expansionary monetary policy farther translates into a large positive impact on the output gap.

A 1-SD technology shock Output growth increases by 30% right after A 1-SD technology shock; however, this great impact is not persistence and it goes away in 1 month. Furthermore, it appears that technology stocks have no impact on the inflation rate, nominal interest rate, and the output gap, they all stay at their steady state levels. This can be translated as the technology shock has an insignificant role in this estimated Keynesian model using Egypt's data.

A 1- SD monetary policy shock increases the short-term nominal interest rate by 1.5%. This monetary tightening causes output growth to fall by a little more than 11% and inflation to fall by 3.5%, thus the output gap shrinks. None of the impacts is persistence over time. This can be explained by the idea that when the central bank attempts to increase the interest rate, it hurts the economy as soon as the shock begins as the output growth decreases, but this negative impact on output growth is not consistent and the output growth soon converges to its steady-state.

4. Discussion

A deep intuitive understanding about how the four shocks act as a source of aggregate fluctuations can be provided by looking across the impulse responses. Beside the monetary policy shock, the positive preference shock appears to have a great influence increasing the nominal interest rate. The preference shock increases the nominal interest rate but at a slower rate than the increase in output growth and inflation. However, monetary policy shock would increase the interest rate causing the output growth and inflation to fall.

The cost push shock and technology shock results in increasing the output growth. The positive impact on output growth after a cost-push shock is countervailed by an extended period of slightly below-average output growth, while the sharp positive impact on output growth right after a technology shock was not inverted: it is a spiked growth that nullifies shortly after the shock. Furthermore, a cost push shock reduces the inflation rate, the nominal interest rate, and hence positively widens the output gap; however, the technology shock has no effect on the inflation rate, and interest rate leaving the output gap unchanged.

According to the data used in this paper, the preference shock generates the most sizable fluctuation in output growth, and the technology shock appears to be a significant driving force for that variable as well. However, the technology shock plays an inconsiderable role in explaining any other variable in this estimated New Keynesian model. A cost-push shock has the greatest tendency to influence the rate in inflation and short-term nominal interest rate which the central bank set consequently as a response to the shock.

5. Data Heterogeneity

Examining the macro history of the Egyptian economy during the years in question, there exists a major structural economic breakpoint in 2008. Also, the monetary policies adopted by the CBE were not entirely the same through the whole period in question 2002-2013. Thus, it is reasonable to suspect the possibility that different set of shocks would have hit the Egyptian economy before and after the economic crisis in 2008, which would have affected the dynamics of the economy differently. Thus, a small sample size has been used for this section and the results will only serve as a reference to the whole sample data analysis. In other words, dividing the whole sample into two subgroups of before and after 2008 economic crisis could help to test the data heterogeneity analysis by showing how the macroeconomy behaved in response to the shocks when the economy experienced high economic activity verses when the economy was slowing down. The pre-crisis sub-sample is from 2002: q1 through 2008: q4 represents Egypt's high economic prosperity years, and the post-crisis sub-sample from 2009: q1 through 2013: q4 represents the years when the country suffered from an economic turmoil the most.

Table 2 shows the results when the model is re-estimated with the pre-crisis data and the post-crisis data. The consumer preference shocks ρ_a=0.0 is significantly indifferent from zero for the pre-crisis period, but it becomes considerably persistence ρ_a= 0.82 moving to the post-crisis period. On the contrary, the cost push shocks appear to be significantly more persistence ρ_e = 0.88 in the pre-crisis period and it becomes less persistence moving to the second sub-sample period. ω =1 is large and significant which means that the output gap is considerably affected by the preference shock during the pre-crisis period; however, during the post-crisis period, ω =0 indicated that the preference shock does not impact the deviation of output gap from its steady-state level. ρ_π, ρ_g, and ρ_x also changes across sub-samples, which signals that the CBE decision making process has become slightly more responsive to fluctuations in inflation, output gap and output growth during the post-crisis period compared to the former period. In the pre-crisis sub-sample α_x= 0.66 is large and significant, this implies that the data from the pre-crisis sub-sample is explained importantly through the consumers' backward-looking behavior.

Figure 2 represents the impulse responses when estimating the model using the pre-2008 data, and Figure 3 represents the impulse responses for the post-2008 data. Comparing the two figures reveals that the preference shocks and technology shocks drove more aggregate fluctuations during the post-2008 period compared to when the economy was booming during the pre-2008 period. Cost push shocks have greater effect on movements in inflation and interest rate when the economy is booming, while contributes to more fluctuation in output growth and output gap when the economy is slowing down.

In figure 2, during the pre-2008 period the policy shock showed a pattern in the monetary policy decision making. The impulse response function shows that the central bank first adopted a tightening policy to curb inflation and then followed straightaway by an expansionary policy trying to redeem the negative effects on output. This suggests that the monetary policy had a major contribution to the economic growth during the period 2002-2008, which align with the CBE strong economic reforms in 2005. On the contrary, the policy shocks contributed greatly to the aggregate macro fluctuations during the post-2008 period when the economy experienced socioeconomic and political dire ramifications.

V. Conclusions and Implications

This paper attempts to research the structure of the Egyptian economy as well as the forces that drives economic fluctuations in the Egyptian macroeconomy during the period 2002-2013 according to the New Keynesian Model. In particular, the paper estimates a New Keynesian model in which four competing shocks to households' preferences, cost-push, technology, and the central bank's monetary policy rule explains aggregate fluctuations. To estimate the model's parameters, maximum likelihood estimation has been utilized. The impulse responses are used to depict the relative importance of each shock exclusively in explaining the dynamic behavior of output growth, inflation, interest rates, and output gap. The empirical results allow to draw some conclusions on the nature of the Egyptian macroeconomy over the period in question. Firstly, the consumer preference shocks and technology shock are a major source of instability in output growth. Secondly, cost-push shock is what mostly drives fluctuations in inflation. Only the cost-push shock confronts the central bank with a painful trade-off between stabilizing the inflation rate and the output gap, but the technology shocks do not lead to that tension. This result actually aligns with Clarida, Gali, and Gertler (1999); Gali (2002); and Ireland (2004) results using USA data. Thirdly, monetary policy shocks and cost-push shocks have a great influence on movements in the nominal interest rate. Finally, although technology shock drives movements in the output growth, it does not explain any movements in inflation, interest rate, or output gap. It appears to be that the preference, cost-push, and monetary policy shocks are all more important than the technology shock in explaining the dynamic behavior of the Egyptian macroeconomy.

Ultimately, some policy recommendations can be grounded on the previous conclusions. Since the preference shock and the cost push shock play a key role in driving the business cycle, the government of Egypt should track the consumers sector and the producers sector for economic forecasts. Also, policy makers should construct monetary policies that concur the impact of these shocks and neutralize their effects in order to have more stable economy in the long run. Further research could aim to integrate the financial factors and investment variables to the modeling of the overall economy, as it has been clear that after the 2008 financial crisis, the financial sector can be a source of dysfunction in the macroeconomy. Doing so may help reaching a better understanding of the dynamics of the Egyptian macroeconomy.

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Table 1. Maximum Likelihood Estimates and Standard Errors

Parameter	**Estimate**	**Standard Error**	**T-Statistics**	**Significance**
$\boldsymbol{\rho_a}$	0.0870	0.17651	0.4927	0.6222
$\boldsymbol{\rho_e}$	0.5287	0.1526	3.4653	0.0005
$\boldsymbol{\omega}$	0.6964	0.2403	2.8973	0.0038
$\boldsymbol{\rho_\pi}$	0.1218	0.0314	3.8785	0.0001
$\boldsymbol{\rho_g}$	0.0000	0.0000	0.000	0.0000
$\boldsymbol{\rho_x}$	0.0230	0.0205	1.1201	0.2627
$\boldsymbol{\alpha_x}$	0.0000	0.0000	0.0000	0.0000
$\boldsymbol{\alpha_\pi}$	0.1617	0.1326	1.2199	0.2225
$\boldsymbol{\sigma_a}$	3.7244	0.4502	8.2722	0.0000
$\boldsymbol{\sigma_e}$	0.3470	0.0850	4.0834	0.0000
$\boldsymbol{\sigma_z}$	0.8405	0.3270	2.5695	0.0102
$\boldsymbol{\sigma_r}$	0.1489	0.0207	7.2035	0.0000

Figure1

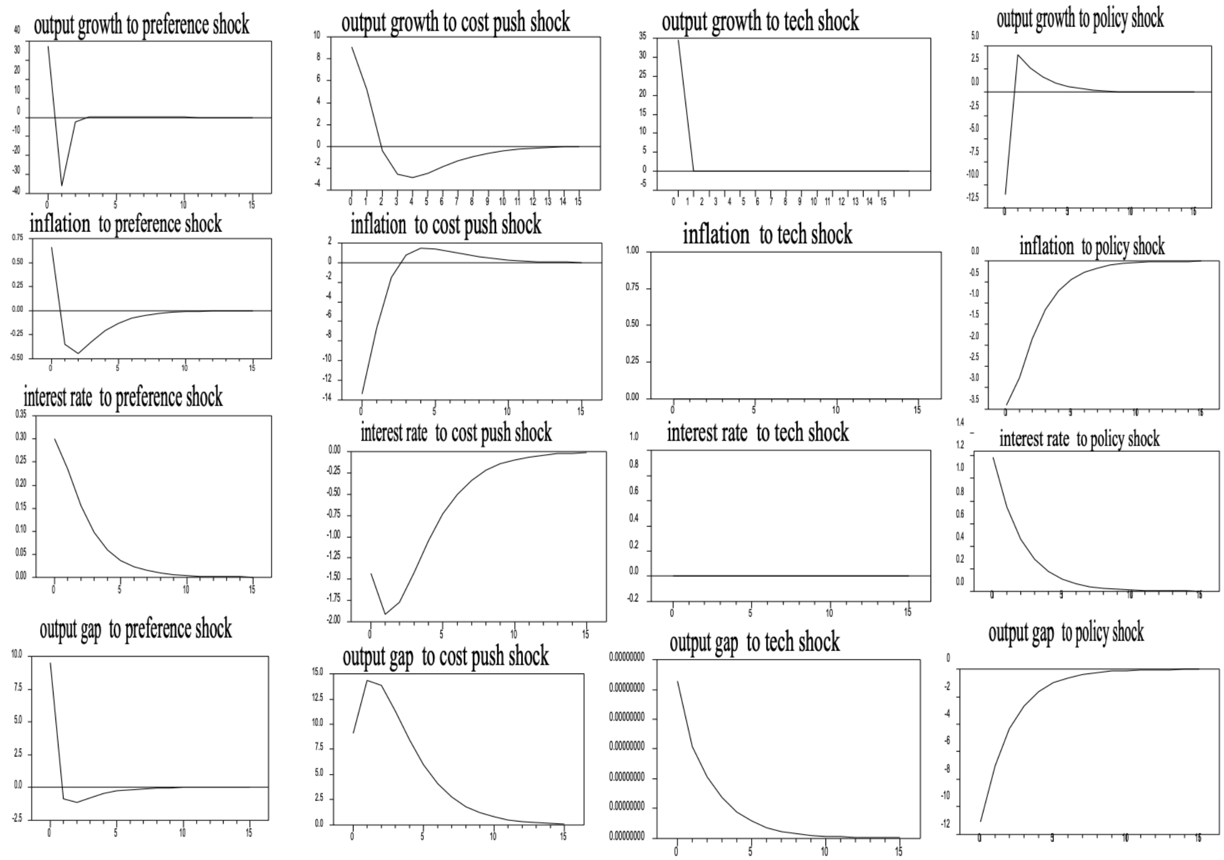

Figure 1. Impulse Responses. Each column shows the percentage response of one of the model's variables to a one-standard-deviation shock.

Table 2: Subsample Maximum Likelihood Estimates and Standard Errors

Parameter	Pre-2008 Estimate	Standard Error	T-Statistics	Significance	Post-2008 Estimate	Standard Error	T-Statistics	Significance
ρ_a	0.0000	0.0000	0.0000	0.0000	0.8227	0.1097	7.5002	0.0000
ρ_e	0.8782	0.1086	8.0874	0.0000	0.5214	0.1241	4.2008	0.0000
ω	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ρ_π	0.1317	0.0545	2.4181	0.0156	0.1392	0.0270	5.1523	0.0000
ρ_g	0.0015	0.0056	0.2743	0.7839	0.0066	0.0047	1.4110	0.1582
ρ_x	0.0168	0.1162	1.0828	0.2789	0.0279	0.0069	-4.053	0.0000
α_x	0.6615	0.1547	5.6951	0.0000	0.0000	0.0000	0.0000	0.0000
α_π	0.0918	0.0578	0.5933	0.5529	0.0000	0.0000	0.0000	0.0000
σ_a	3.4007	0.5782	8.8594	0.0000	2.2116	0.4872	4.5392	0.0000
σ_e	0.1541	0.0230	3.0233	0.0025	0.7287	0.1558	4.6779	0.0000
σ_z	0.4009	0.5782	0.6933	0.4881	1.4961	0.8321	1.7979	0.0722
σ_r	0.1541	0.0230	6.6940	0.0000	0.0621	0.0200	3.1021	0.0019

Figure2: Pre-Crisis Subsample

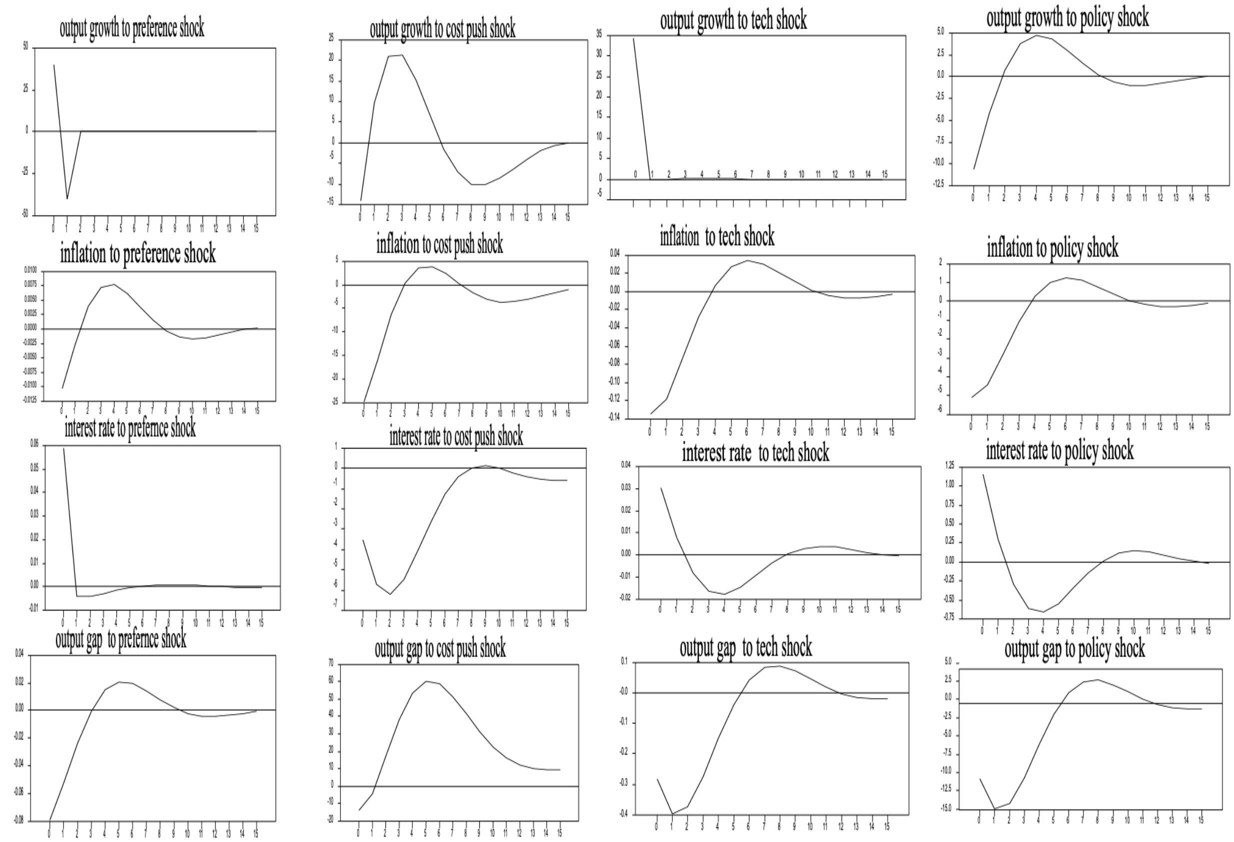

Figure 2. Impulse Responses: Pre-2008 Subsample. Each column shows the percentage response of one of the model's variables to a one-standard-deviation shock.

Figure3: Post-Crisis Subsample

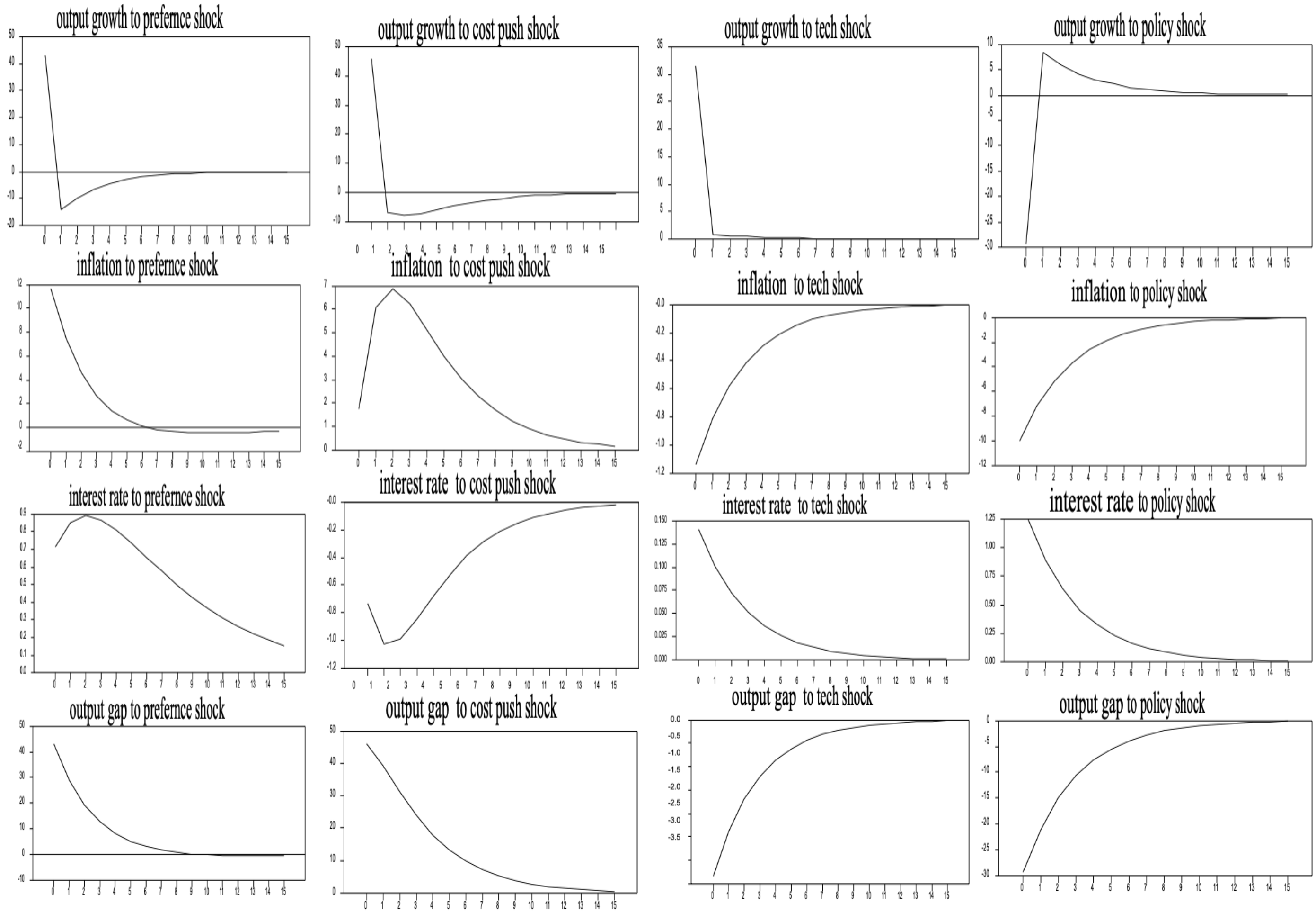

Figure 3. Impulse Responses: Post-2008 Subsample. Each column shows the percentage response of one of the model's variables to a one-standard-deviation shock.