An Empirical Investigation of the Exogenous Growth Model in Egypt

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Abstract:

This research paper provides a practical examination of the exogenous growth model in Egypt from 1990 to 2022. As the exogenous growth models, including the Harrod-Domar classical model and the Solow-Swan neoclassical models, explain the main determinants of economic growth in developing countries, The focus of this study is to examine the validity of the exogenous growth model in Egypt and analyze its implications for the country's economic performance. In line with the exogenous growth theory, the paper highlights the significance of direct investment, labor force growth, and technological advances in achieving output growth.

The concept of conditional convergence is introduced, suggesting that countries with similar economic conditions will reach the same steady state of growth in the long run. The paper explores the idea of absolute convergence, where underdeveloped countries have the potential to grow faster than developed ones by enhancing human capital and benefiting from diminishing returns to capital.

The empirical studies discussed in the paper provide insights into the applicability of exogenous growth models in different countries by analyzing economic growth determinants and examining the relationships between variables such as government expenditure, population growth, labor force participation, foreign investments, and technological progress. This study aims to evaluate the exogenous growth model's validity in the Egyptian context by focusing on Egypt. To assess the model's explanatory power, it investigates the relationships between key variables, such as output, capital, labor force, and technological progress. The findings of this study contribute to the understanding of Egypt's economic growth dynamics and provide insights for policymakers.

Keywords: exogenous growth model, Harrod-Domar classical model, Solow-Swan neoclassical models, Economic growth, conditional convergence, absolute convergence, underdeveloped countries, human capital, government expenditure, population growth, labor force participation, foreign investments, and technological progress, output, capital

1. Introduction:

According to the classical economic theory pioneered by Adam Smith, minimal government intervention and free markets allow for better economic performance and contribute to rapid economic growth rates. A higher savings rate, which leads to higher investments, allows capital accumulation and, thus, higher labor productivity, which will be translated into higher wages. According to Say's law, supply creates demand (Roll (1938). Hahn and Matthew (1964), and Madison (1991). Subsequent generations of economists started to set a mathematical framework for these classical ideas. For instance, in 1928, Ramsey, Solow, Cass (1965) Koopman (1966).

The great depression in 1929 made many economists, pioneered by John Maynard Keynes in 1936 and followed by Harrod (1939) and Domar (1946, 1947), analyze short-run business cycle fluctuations. This Keynesian model assumed a constant saving rate and capital-output ratio. Also, Harrod-Domar's models determined the required saving rate to achieve the planned economic growth rate. Many countries have applied these formulas during the post-World War II period. However, the difference between the real GDP growth rate and the planned one and the resulting unemployment rates showed the defects of these models, and this encouraged Solow (1956) to present a production function, either Cobb-Douglas or CES, that reflects substitutability between capital and labor assuming a constant saving rate.

According to the exogenous models, output growth is achieved mainly through increased direct investment, labor force growth, and technological advances. Likewise, in classical economic thinking, an increase in savings leads to an increase in investments and, hence, a capital increase, which means higher capital per worker and, thus, output per worker. However, without technological progress, output per worker will eventually decline due to the diminishing returns to capital. Therefore, countries with similar macroeconomic conditions will go through the same steady state of growth and will reach the convergence stage in the long run. The Solow model also assumes absolute convergence, where underdeveloped countries can grow faster than developed ones.

Therefore, the primary aim of this paper is to evaluate the validity of the exogenous growth model in Egypt from 1990 to 2022. The subsequent sections of the paper are organized as follows: Section 2 provides a comprehensive review of the fundamental theoretical framework, empirical studies, and notable limitations associated with exogenous growth models. Section 3 assesses the applicability of the exogenous growth model specifically in the context of Egypt. Lastly, Section 4 presents a concluding summary.

2. Exogenous Growth Models:

2.1 Theoretical Background:

Frank Ramsey (1928), a British mathematician and philosopher, published an article from which most development studies have evolved. He examined optimal economic growth under certain conditions that are satisfied on the optimal consumption path across different periods. Following his views, the classical Keynesian scholars Harrod (1939) and Domar (1946) investigated the growth theory using their Harrod-Domar exogenous economic growth model. According to their model, economic growth relies mainly on output and capital stock, and the saving rate equals the investment. However, the long-term economic growth in this model was unstable.

Later, Robert Solow (1956) and Trevor Swan (1956) extended the Harrod-Domar model by adding labor as a crucial factor of production and by justifying that the capital-output ratios fluctuate. This model assumes that the saving rate, population growth, capital depreciation, and level of Technology are all constant in the short run and variable over the long term. The model is a mixture of old Keynesian and modern dynamic macroeconomic models. The model solved stable steady-state economic growth. Before the Solow-Swan model, Tobin (1955) presented a similar growth model focused on money growth but failed to solve long-term stability.

Cass (1965) and Koopmans (1965) improved and extended Ramsey's mathematical model to present their Ramsey-Cass-Koopmans model that determined stable long-term economic growth through an aggregate production function. All these economists and researchers initiated and modified the exogenous growth theory through long-term economic models within a neoclassical context that believes that exogenous factors determine economic growth. According to this theory, GDP, capital accumulation, factor productivity, population growth, and technological improvement are the main determinants of long-term economic growth.

For the economy to grow, we can't depend solely on increasing savings; when savings increase, the output per worker also increases due to increasing capital per worker; however, that does not affect the output growth rate. Besides, with no technological progress, output per worker will eventually decrease due to the diminishing returns to capital.

The exogenous growth theory introduced the concept of conditional convergence. In an absolute form, this theory anticipates that in the long term, countries with similar economic statuses, such as saving rate, population growth rate, and technological level, will ultimately reach the same steady state of growth rate. If the economic conditions are different, government policies

According to the neoclassical model, this convergence property can allow poor-developing economies to catch up with the advanced–developed ones due to diminishing capital returns. Developing countries have lower capital per worker in the initial stage, and thus, enhancing human capital through education and health allows these countries to have higher human-to-physical capital and thus will grow faster.

Empirical studies on countries with homogeneous economic conditions, such as the level of Technology, political institutions, and labor force, have proven consistent with absolute convergence. For instance, the OECD countries (1960 -1990), USA (1880 - 1992), and Japan (1930 - 1990) have all reached similar levels of steady-state and realized converge in the long run. On the other hand, countries experiencing heterogeneous economic conditions will take different periods to adjust to steady states.

2.2 Empirical Studies:

Empirically, exogenous growth models have been tested in several countries; for instance, the study of Imrul Hossain Chowdhury (2020) attempted to analyze the determinants of long-term economic growth in Bangladesh by applying an Autoregressive Distributed Lag (ARDL) model between 1985 and 2018. The study found a stable long-term relationship among the model variables. The study also found that government expenditure, fertility rate, inflation rate, and agricultural sector growth positively affected economic growth, whereas population growth had a negative effect. However, this contradicts Barro's extended exogenous growth model (1996).

Likely, the study of Llambi Prendi and Armira Lazaj (2023) to investigate the effect of foreign investments, gross capital formation, and labor force on GDP growth in Balkan countries in the period 2008-2021 through a log-log Cobb-Douglas production function. The study found that the labor force participation rate is the most influential, which coincides with the Solow model; also, the amount of capital per employee positively affects economic growth by increasing productivity. However, FDI was found to have an insignificant effect on the economic growth of Balkan countries.

Boyko et al. conducted a study in 2016 to examine the Solow growth model in the Russian economy over the period 1999-2019 by applying the Cobb – Douglas production functions. The study examined the effect of innovations, technological level, labor, and capital on long-term aggregate output in Russia and found a strong positive relationship between the model variables. Besides, the coefficients' values in Cobb-Douglas production functions prove an increasing return on labor and capital. Eventually, the study's main findings lie in attributing the growth in aggregate production to the scientific and technological progress achieved by the country over the study period.

The study of Nkalu et al. in 2018 used the OLS method to investigate the validity of the Solow model using cross-country panel data. The output-side real GDP represents the dependent variable to show the cross-country and over-time differentials in productive capacities. The independent variables include population, stock of capital, and employment. The results reveal that population and capital stock positively and significantly impact aggregate output, which coincides with the Solow growth model. On the contrary, employment is found to have a statistically significant negative effect, which violates economic theory.

The study of Chirwa and Odhiambo in 2019 examined the relevance of the original Solow, the augmented Solow, and the World Bank Exogenous growth models applying the Autoregressive Distributed Lag (ARDL) approach in three African countries: Malawi, Zambia, and South Africa over the period 1970 to 2013. The study findings confirm the expectations of both the original Solow growth and augmented Solow models and that the convergence hypothesis holds over the three countries. However, by adding more explanatory variables, as suggested by the World Bank growth model, the convergence hypothesis no longer holds, which reflects the importance of macroeconomic stability in reaping the benefits of investments in labor and capital.

2.3 Criticism of exogenous growth models:

Many scholars and researchers have criticized exogenous growth theories. For instance, Mankiw et al. (1995) argued that the Solow neoclassical growth model failed to explain per capita disparities between countries that can reach several times what is predicted by the model. That reveals how the exogenous growth models suffer from omitted variable bias. Besides, the Solow model also failed to precisely explain the increase in total factor productivity relative to inputs used. This unexplained portion of the output is gathered in the Solow residual, which implicitly neglects the role of efficiency in utilizing inputs (Mosley et al. 1987).

The Solow residual also absorbs all the other macroeconomic variables that can affect the economic growth path of the economy, which are not mentioned explicitly in the model. For example, inflation rate, exchange rate, tax rules, and government regulations. (World Bank 1990, p. 100), to fix the problems, the Solow model has been modified by several researchers to include additional explanatory variables of economic growth. For example, human capital accumulation, trade policies, openness, and return on invested capital (Easterly and Wetzel 1989, p. 10; Knight et al. 1993, p. 515).

Besides, the model proposed an oversimplified "closed economy" assumption to explain the convergence hypothesis among a group of countries with homogenous economic conditions, which has been extensively criticized by many scholars and not entirely approved by empirical examination due to the contradicting results. For instance, a study made to test for convergence for 14 countries of the European Union over the period 1970-2000 showed no evidence of absolute convergence and little evidence for conditional convergence. That made Mankiw and other economists modify the model in 1995 and allow for assuming an open economy by presenting an augmented Solow Growth model. This open-economy version of the Solow theory expects higher convergence across countries.

Moreover, the Solow growth model failed to differentiate between capital share and labor share of aggregate income, which explains the difference between data used by the model and the national accounts. However 1988, Lucas modified the model by subdividing capital into physical and human.

Despite the Solow growth model's and exogenous growth models' drawbacks, these models offered valuable contributions to economic growth modeling.

3. Exogenous Growth Model in Egypt:

In 1990, the World Bank offered additional variables that formulate healthy macroeconomic conditions for sustainable economic growth, such as a low and stable inflation rate, a competitive exchange rate, a well-developed financial system, and transparent tax rules. These variables are crucial to channel savings to finance investments and to reap the benefits of investments in capital and labor. According to the Exogenous growth models, these macroeconomic efficiency variables were added to the Solow residual. For this reason, the paper uses an augmented Solow growth model by adding several macroeconomic variables that may affect long-run economic growth.

$$\mathbf{Y_t = A_t * f_t (K_t , L_t)\text{………}(1)}$$

The traditional growth model offered by Solow in 1956 assumed neutral technical change (A_t). In Equation (1), Y is the net national product, K is capital stock, and L is labor stock. From this Equation, an augmented exogenous growth model can be deduced for Egypt:

$$\mathbf{Y_t= K^{\alpha}_t L^{\beta}_t (A_t \{AID_t, FDI_t, EX_t, INF_t, GOV_t \} L_t)^{1-\alpha-\beta} \text{…………}(2)}$$

Where:

Symbol	Variable	Proxy	Code
Y_t	Economic Growth	Real GDP at constant prices for 2015 in US dollars	lnEg
A_t	Technology	Total factor Productivity	lnTe
K_t	Physical Capital Stock	Real Gross Capital Formation	Lncs
α	The elasticity of output concerning physical capital	Capital income share of GDP	Lnehc
L_t	Human Capital	Years of Schooling	Lnhc
B	Elasticity of output concerning human capital	Labor income share of GDP (1- capital income share of GDP)	Lnecs
AID_t	Foreign aids		lnAID
FDI_t	Foreign direct investment		lnFDI
EX_t	Real Foreign exchange		lnEX
INF_t	Inflation rate		lnInf
GOV_t	Government effectiveness		lnGOV

A_t is labor augmenting and represents also Solow residual, which includes other exogenous variables unaffected by capital accumulation or labor input. After inserting the natural logarithm into Equation No (2), the following regression equation is driven from it.

$$\mathbf{LNEG = ß_0 + ß_1\,LNTE + ß_2\,LNCS + ß_3\,LNHC + ß_4\,LNEHC + ß_5\,LNGOV + ß_6\,LNECS + ß_7\,LNEX + ß_8\,LNFDI + ß_9\,LNINF + ß_{10}\,LNAID \ldots\ldots\ldots (3)}$$

3.1unit root test

To test the stationarity of the time series, the Dickey-Fuller test has been performed, which uses the following null and alternative hypotheses:

- H0: The time series is not stationary. In other words, its structure depends on time, and its change is not constant.
- H1: The time series is stationary.

If the p-value of the test is less than the significance level of a=5%, we can reject the null hypothesis and conclude that the time series is stationary. Below are the results of the Dickey-Fuller test for the study variables.

Table 1: Results of the Dickey-Fuller unit root test

Variable	At level				1st difference				Co.
	Intercept		Trend and intercept		Intercept		Trend and intercept		
	t-statistic	Prob.*	t-statistic	Prob.*	t-statistic	Prob.*	t-statistic	Prob.*	
lnEg	-0.509	0.876	-2.955	0.160	-3.355	0.020	-3.309	0.083	I(1)
lnTe	-0.651	0.844	-2.968	0.160	-5.280	0.000	-5.998	0.000	I(1)
Lncs	-0.705	0.891	-3.089	0.181	-5.825	0.000	-5.737	0.000	I(1)
Lnehc	-1.961	0.370	-1.848	0.745	-1.295	0.688	-3.635	0.000	I(1)
Lnhc	-1.442	0.623	-3.571	0.077	-7.109	0.000	-7.025	0.000	I(1)
lnGOV	-1.668	0.512	-3.380	0.110	-7.124	0.000	-7.121	0.000	I(1)
lnInf	-0.585	1.007	-3.398	0.184	-3.858	0.023	-3.805	0.000	I(1)
lnFDI	-0.749	0.971	-3.413	0.184	-6.072	0.000	-6.898	0.000	I(1)
lnEX	-0.765	0.967	-3.351	0.197	-6.319	0.000	-6.224	0.000	I(1)
lnAID	-2.128	0.401	-2.004	0.808	-1.405	0.746	-3.943	0.000	I(1)
Lnecs	-1.564	0.676	-3.874	0.084	-7.713	0.000	-7.621	0.000	I(1)

Source: from E-views v13 output

The results of Table 1 indicate that the time series for all the model variables became stationary after taking the first difference and had a significance level of less than 0.05, which indicates that the time series is stable over time.

3.2**Results of study model analysis**

The results of estimating the study model show that the value of the F-statistic = 364, with a significance level of less than 5%, which indicates the significance of the estimated study model, and the value of the coefficient of determination R^2 =

0.89. That means that any change in the dependent variable is 89% explained by the change in the explanatory variables. The Durbin-Watson test is a parametric statistical test to verify the presence of a first-order autocorrelation between the errors of the regression model. Its value for the estimated study model reached 1.68, which is close to 2, indicating no autocorrelation between Errors for the estimated model.

Table 2: Results of the study model test

Dependent Variable: LNEG
Method: Least Squares
Date: 03/09/24 Time: 18:32
Sample: 1990 2022
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTE	0.015936	0.016797	4.872624	0.0053
LNCS	0.222512	0.068589	3.244118	0.0037
LNHC	0.072065	0.173801	6.168348	0.0000
LNEHC	0.111411	0.164852	6.758262	0.0061
LNGOV	0.034873	0.076397	4.564851	0.0065
LNECS	0.168699	0.108569	5.538324	0.0044
LNEX	0.196615	0.031644	6.213386	0.0000
LNFDI	0.120797	3.54E-12	4.728980	0.0078
LNINF	0.038977	0.014647	6.611245	0.0143
LNAID	0.022333	0.009074	2.461256	0.0222
C	0.930509	1.954715	4.760331	0.0087

R-squared	0.894007	Mean dependent var	26.14768
Adjusted R-squared	0.871283	S.D. dependent var	0.424172
S.E. of regression	0.039601	Akaike info criterion	-3.358722
Sum squared resid	0.034501	Schwarz criterion	-2.859886
Log likelihood	66.41891	Hannan-Quinn criter.	-3.190879
F-statistic	364.9313	Durbin-Watson stat	1.680842
Prob(F-statistic)	0.000000		

Source: from E-views v13 output

It is also evident from the results of Table 2 that the prob values range from 0.00 to 0.0222, which is less than 0.05, indicating that the model's explanatory variables are statistically significant at the 5% significance level.

From the previous results, the multiple regression equation can be derived as follows:

LNEG = 0.93 + 0.015*LNTE + 0.22*LNCS + 0.07*LNHC + 0.11*LNEHC + 0.03*LNGOV + 0.16*LNECS + 0.19*LNEX + 0.12*LNFDI + 0.03*LNINF + 0.02*LNAID

The results also show a positive effect of Technology on real GDP, where the coefficient value of the variable Technology (lnTe) is 0.01, meaning that any 1% increase in Technology leads to an increase in economic growth by 0.01.

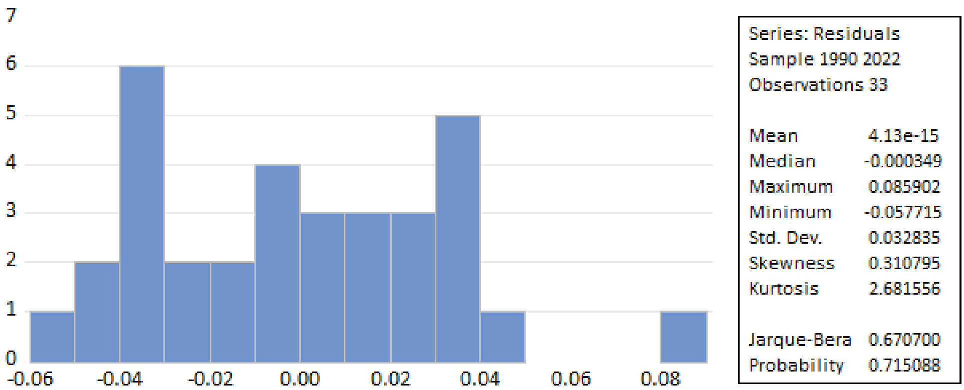
Likely, there is a positive effect for Physical Capital Stock (lncs) on economic growth, as the value of the coefficient for the variable Physical Capital Stock was 0.22, meaning that any 1% increase in Physical Capital Stock leads to an increase in economic growth by 0.22.

The explanatory variables (Human Capital (lnhc) - Elasticity of output concerning human capital (lnehc) - Government effectiveness (lnGOV) - Elasticity of output concerning physical capital (lnecs)) have a positive effect on economic growth, and the coefficient values for each variable were as follows (0.07 - 0.11 - 0.03 - 0.16), respectively. Also, the explanatory variables (Real Foreign exchange (lnEX) - Foreign direct investment (lnFDI) - Inflation rate (lnInf) - Foreign aids (lnAID)) have a positive effect on economic growth, and the coefficient values for each variable were as follows (0.19 - 0.12 - 0.03 - 0.02), respectively, so It is clear from these results that the exchange rate has the most impact on economic growth among these variables.

3.3Model diagnostic tests

We move on to the diagnostic tests for the estimated study model. The following figure shows the results of the jarque-bera test for the distribution of the residuals for the regression model. The results show that the value of the jarque-bera test for the normal distribution of the residual series is 0.670, with a probability value of P-value = 0.71, greater than 5%. That indicates the acceptance of the null hypothesis H0, which states that the residual series of the estimated regression model follows a normal distribution.

Figure 1: Results of the normal distribution test for regression model residuals



Source: from E-views v13 output

The results of the serial autocorrelation test for the residuals presented in Table (3) indicated acceptance of the null hypothesis, which is that the residuals do not have serial autocorrelation, and rejection of the alternative hypothesis that the residuals have serial autocorrelation. The significance value here was higher than 5%.

The results of the Heteroskedasticity test for the residuals also indicated the necessity of accepting the null hypothesis, which states that there is no difference in the variance of the residuals and rejecting the alternative hypothesis, which says that there is a difference in the variance of the residuals. The significance value was more than 5%.

Table 3: Heteroskedasticity and Serial correlation test

Model test	F-statistic	Prob
Serial correlation LM test	0.0770	0.9261
Heteroskedasticity	7.4846	0.2303

Source: from E-views v13 output

Table (4) shows test results after performing the variance inflation factor test, which reveals whether there is a linear relationship between the independent variables and each other or not. The test values for all independent variables in the model were less than 10, meaning there is no linear relationship problem between the independent variables.

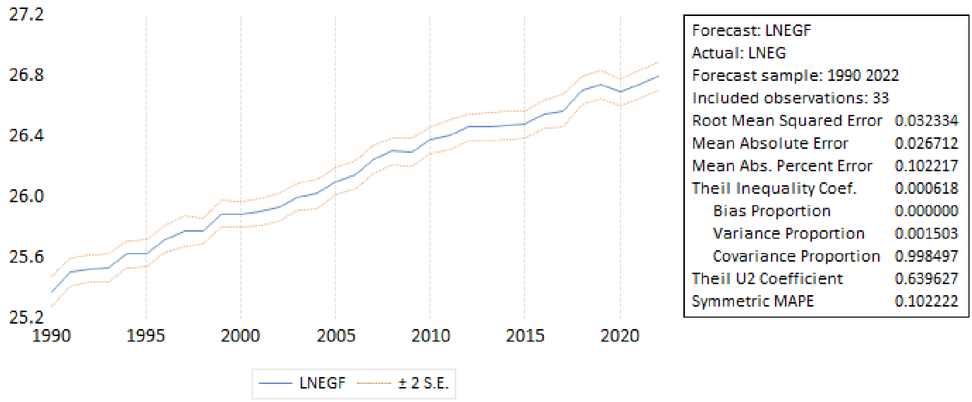
Table 4: variance inflation factor test

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
LNTE	0.000282	1971.744	3.971491
LNCS	0.004704	57888.29	25.76781
LNHC	0.030207	183485.9	31.78078
LNEHC	0.027176	593.7643	11.09148
LNGOV	0.005836	23.86703	2.781434
LNECS	0.011787	2108.725	5.948528
LNEX	0.001001	73.58017	7.942519
LNFDI	1.25E-23	7.102500	3.318562
LNINF	0.000215	22.12190	1.756894
LNAID	8.23E-05	786.5194	1.655626
C	3.820909	80402.18	NA

Source: from E-views v13 output

There is also the possibility of using the model in prediction, as the value of the Theil coefficient was less than 10%, and thus the possibility of using the model in predicting the future value of the dependent variable, as shown in the following figure:

Figure 2: Results of prediction test for regression model



Source: from E-views v13 output

4. Conclusion:

In conclusion, this study provides valuable insights into Egypt's economic growth dynamics and recommends that policymakers foster sustainable development. By examining the determinants of economic growth, such as direct investment, labor force growth, and technological advances, the study highlights the importance of policies that promote investment, enhance human capital, and foster technological progress.

The findings emphasize creating a favorable investment climate to attract domestic and foreign direct investment. Egypt can stimulate economic growth and generate employment by implementing policies that reduce bureaucratic hurdles, provide incentives, and ensure a stable business environment. Investing in education and healthcare systems is crucial for enhancing human capital development. By prioritizing these areas, Egypt can improve the skills and productivity of its workforce, expand access to quality education, and promote lifelong learning opportunities. Fostering technological innovation is another key recommendation.

Additionally, Encouraging research and development activities, promoting collaboration between academia and industry, and supporting technology startups will drive technological progress, increase productivity, and enhance Egypt's competitiveness in the global market. Infrastructure development is vital in creating an enabling environment for economic growth. Egypt can attract investments, facilitate trade, and improve productivity by investing in transportation, energy, and digital connectivity.

Implementing sound macroeconomic policies is crucial for maintaining stability. By ensuring fiscal discipline, controlling inflation, and managing public debt, Egypt can create a conducive environment for sustained economic growth.

Strengthening institutions and governance is essential for improving the business climate and attracting investments. Enhancing transparency, accountability, and the rule of law while addressing corruption will contribute to Egypt's economic growth and development. Promoting inclusive growth is a crucial consideration. By implementing targeted social policies, Egypt can reduce income inequality, alleviate poverty, and provide equal opportunities for all segments of society, ensuring that the benefits of economic growth are shared equitably. By embracing these recommendations, Egypt can tap into the potential of the exogenous growth model and create an environment conducive to sustained and inclusive economic growth.

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