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Does Public Investment Crowd Out Private Investment in Egypt?

A sectoral-level Analysis

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Abstract

This paper examines the long run cointegrating relationship between public and private investment in Egypt at both the gross and sectoral levels, taking into account other relevant factors such as the ratio of credit to the public sector, lending interest rate, and output. To address this question, the paper specifies two models using quarterly data spanning the last two decades. The first model examines whether gross public investment crowds out gross private investment. The second model features fourteen regressions that capture the impact of public investment on private investment in different economic sectors. While the paper finds evidence in favor of the crowding-out effect at the gross level, sectoral-level analysis shows evidence of discrepancies among different sectors. That is, public investment tends to crowd in private investment in sectors such as agriculture, construction, manufacturing, natural gas, and real estate. Yet, public investment tends to crowd out private investment in other sectors such as trade, and information and communications. The findings of this paper provide useful insights to policymakers in prioritizing public investment in sectors that complement, rather than compete with, private investment.

هل يزاحم الاستثمار العام الاستثمار الخاص في مصر؟ تحليل على مستوى القطاعات

أحمد الرخ

ملخص

تبحث هذه الورقة العلاقة طويلة الامد بين الاستثمار العام والخاص في مصر على المستويين الكلى والقطاعي، مع الأخذ في الاعتبار العوامل الأخرى ذات الصلة مثل نسبة الائتمان إلى القطاع العام، وسعر الفائدة على الإقراض، والإنتاج. وللإجابة عن هذا السؤال، تحدد الورقة نموذجين باستخدام البيانات الربع سنوية الممتدة على مدى العقدين الماضيين. يدرس النموذج الأول ما إذا كان إجمالي الاستثمار العام يزاحم إجمالي الاستثمار الخاص. أما النموذج الثاني فيتميز بأربعة عشر انحدارًا توضح تأثير الاستثمار العام على الاستثمار الخاص في مختلف القطاعات الاقتصادية. وفي حين وجدت الورقة أدلة لصالح تأثير المزاحمة على المستوى الكلى، فإن التحليل على مستوى القطاعات يظهر أدلة على وجود تناقضات بين القطاعات المختلفة. فالاستثمار العام يميل إلى دعم الاستثمار الخاص في قطاعات مثل الزراعة، والبناء، والتصنيع، والغاز، والعقار. وبالرغم من ذلك، فإن الاستثمار العام يميل إلى مزاحمة الاستثمار الخاص في قطاعات أخرى مثل قطاع التجارة، وقطاع المعلومات والاتصالات. توفر نتائج هذه الورقة رؤى مفيدة لصانعي السياسات في تحديد أولويات الاستثمار العام في القطاعات التي تكمل الاستثمار الخاص بدلاً من التنافس معه.

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1. Introduction

Investment plays a vital role in driving economic growth as it enables businesses to expand, create jobs, and develop new products and services. However, when investment declines, businesses struggle to achieve these objectives, leading to a slowdown in economic growth. Appendix 1 provides a historical overview of Egypt's annual GDP growth rate, along with the percentage of gross capital formation in relation to GDP. It clearly shows that the share of gross capital formation has decreased from over 30% in the 1980s to less than 20% in the past two decades. This decline in gross capital formation is closely associated with lower GDP growth rates, as evidenced by a correlation coefficient of 0.43 between the two series.

There are several factors that may contribute to the decline in gross capital formation in Egypt. One possibility is that businesses are becoming more cautious about investing due to the uncertain economic outlook. The Egyptian economy has faced numerous challenges in recent years, such as high inflation, increasing unemployment, and a depreciating currency. Another possibility that could be contributing to the decline in gross capital formation is a potential crowding out of private investment by public investment.

In their letter of intent to the International Monetary Fund, the Governor of the Central Bank of Egypt and the Minister of Finance stated that they will “give more footprint and space to the private sector to operate within a competitive environment. Our aim is to have the state play an enabling and supportive rather than a leading role in economic activities” (The IMF, 2021). This statement renews interest in the question of the relationship between public and private investment in Egypt.

The relationship between public and private investment is debatable in the literature. The impact of public investment on private investment can take one of two forms: a crowding-in effect or a crowding-out effect. The crowding-in effect (Aschauer, 1989) assumes that the relationship between public and private investments is complementary; that is, an increase in public investment, especially in infrastructure projects, encourages private investment, thus increasing productivity and promoting economic growth (Hatano, 2010).

The crowding-out effect assumes that resources are scarce, meaning that an increase in public investment reduces private investment and other components of aggregate expenditure. This effect can take place via the interest rate channel or credit channel. The interest rate channel suggests that an increase in public

investment will result in an increase in aggregate expenditure, pushing prices higher and increasing the demand for money, leading to a rise in interest rates. This, in turn, discourages private investment and other components of aggregate expenditure (Blanchard, 2008). The credit channel suggests that if the increase in public investment is financed through government borrowing, then both the private sector and public sector will compete for the available credit extended by banks. Furthermore, banks may prefer safe government assets over risky private sector opportunities, known as the lazy banks' hypothesis. Therefore, an increase in credit extended to the government reduces the available credit to the private sector (Haikal et al., 2021).

The question of whether public investment crowds in or crowds out private investment has profound policy implications. That is, if public investment crowds in private investment, then policymakers should focus on improving business conditions to increase the productivity of the private sector. Conversely, if public investment crowds out private investment, then policymakers should follow a countercyclical fiscal policy.

This paper investigates whether public investment crowds in or crowds out private investment in Egypt, taking into account the elasticity of private investment with respect to output and interest rate. Using quarterly data spanning the last two decades, this is the first paper to model the long-run relationship between private and public investment at both the gross and sectoral levels. To accomplish this, two models are estimated. The first is an Autoregressive Distributed Lags (ARDL) model which regresses gross private investment on gross public investment, the ratio of credit to the public sector, the lending rate, and GDP. The second model features fourteen ARDL regressions, which regress private investment in each economic sector on public investment in that sector, in addition to other control variables.

The paper finds evidence in favor of the crowding-out effect of public investment on private investment at the gross level. Additionally, extending credit to the public sector reduces private investment. The sectoral-level analysis reveals further insights into the relationship between private and public investment in Egypt. While public investment tends to crowd out private investment in some sectors, such as information and communications, there is evidence that public investment crowds in private investment in other sectors, such as agriculture and construction. The findings of this paper will help policymakers prioritize their public investment in sectors that complement private investment and reduce public investment in sectors that compete with the private sector.

Following this introduction, a literature review is provided in the next section. Section 3 presents research methodology. Data and descriptive statistics are presented in section 4. Econometric specification and results are presented in Sections 5 and 6, respectively. Section 7 concludes and provides policy recommendations.

2. Literature review

Whether public investment crowds in or crowds out private investment is a debatable question in the literature. This section presents some recent empirical work on this topic.

On the one hand, some previous research has found evidence of a crowding-out effect of public investment on private investment. Using panel data for 127 countries from 1980 to 2017, Liaqat (2019) estimated a panel vector autoregression model and found evidence for the crowding-out effect of government borrowing on the growth of capital formation. Funashima and Ohtsuka (2019) found evidence of the crowding-out effect of public investment on private investment in Japan from 2001 to 2013. However, after controlling for spatial spillovers of public investment, they found that the crowding-out effect tends to be negligible. Makuyana and Odhiambo (2019) examined the relationship between public and private investment in Malawi from 1970 to 2014. Using an ARDL model, they found evidence in favor of the crowding-out effect of public investment on private investment. However, infrastructural public investment tends to crowd in private investment. Zaheer et al. (2019) investigated the private sector credit response to the government borrowing in Pakistan for the period 1998 to 2015. They found evidence of the crowding-out effect of public investment on private investment and this relation has been stable. Using the asymmetric ARDL model Lau et al. (2020) found evidence of crowding out of public borrowing to private investment in Malaysia from 1980 to 2016. Mwakalila (2020) analyzed the impact of government expenditure and domestic borrowing on credit to the private sector in Tanzania. Using quarterly data from 2004 to 2018 and an ARDL model, they found that government expenditure and domestic borrowing crowd out credit to the private sector by increasing the lending rate in the long run. The study recommended the government reduce its spending and instead focus on improving private sector development.

On the other hand, some previous research has found evidence of a crowding-in effect of public investment on private investment Afonso and St. Aubyn (2009) evaluated the effects of public and private investment on output in 17 developed countries. Using a Vector Autoregression (VAR) model, they found evidence of the positive effects of public and private investment on output.

However, the crowding-in effects of public investment on private investment vary across countries. Andrade and Duarte (2016) investigated the effects of public and private investment on Portuguese GDP in the period 1960–2013 using an ARDL model. They found evidence in favor of complementarity between private investment and public investment rather than substitutability. Taking into account major structural changes that the Indian economy and policy reforms that started during the early 1980s, Bahal et al. (2018) found evidence that public investment has become complementary to private investment in the past three decades.

In Egypt, there has been a few studies that examines whether public investment crowds out private investment. For example, Fayed (2013) investigated the relationship between government borrowing and private credit in Egypt using a cointegration approach. She found that there is a positive effect of government borrowing on private credit, i.e., evidence in favor of the crowding-in effect. She, however, found that the positive impact of government borrowing on private credit is reversed if the T-bills rate is substantially higher than the lending interest rate, i.e., evidence in favor of the crowding-out effect. Shetta and Kamaly (2014) tested the lazy banking hypothesis for Egypt, i.e., whether government borrowing crowds out private investment through its dampening effect on private credit. Using a VAR model and quarterly data that covers 1970 to 2009, they found evidence for the lazy banking hypothesis. That is, as the Egyptian government finances its deficit via borrowing, banks shift their portfolio away from risky private loans and opt for government debt instruments. This in turn has an adverse effect on private investment. Haikal et al. (2021) tested the lazy banking hypothesis in Egypt using a Vector Error-Correction Model (VECM) model. They found that the elasticity of credit extended to the private sector with respect to credit extended to the public sector is negative and greater than one, in absolute terms. Elish et al. (2023) studied the relationship between economic growth in Egypt and the government's military-, education-, and health-spending. Using data spanning the period 1980 to 2021 and both the Granger causality test and an ARDL model, they found evidence supporting the Keynesian view that all government spending components enhance economic growth. They, however, found evidence that military spending crowded out government spending on health and education.

The reviewed literature suggests that whether public investment crowds in or crowds out private investment in Egypt is still an open question. Also, to the best of the author's knowledge, no sectoral-level analysis of this question has been conducted in Egypt. This paper is an attempt to fill this gap.

3. Methodology

Keynesian and neoclassical economists hold divergent views on the impact of government spending on private investment. Neoclassical economists contend that the public and private sectors compete for resources such as labor and capital, resulting in public spending crowding out private investment. They assert that as government expenditure rises, the demand for these resources also increases, driving up costs and rendering private investment more costly (Aschauer, 1989). Conversely, Keynesians maintain that government expenditure can actually crowd in private investment by bolstering aggregate demand. They argue that by providing infrastructure and other public goods that facilitate and enhance the profitability of business investment, government spending can attract private investment (Dornbusch et al., 2018). Neoclassical economists additionally posit that government spending can lead to higher interest rates as the government is compelled to borrow money to finance its expenditures. Consequently, this can escalate the cost of borrowing for private businesses, potentially dissuading investment.

This paper poses two main questions: first, does gross public investment crowd out gross private investment in Egypt? Second, does public investment in an economic sector crowd out private investment in that particular sector? To address the first question, this paper specifies Model One below, which examines the impact of an increase in gross public investment on gross private investment. The null hypothesis in this model is that gross public investment does not crowd out gross private investment. To address the second question, this paper specifies Model Two below, which examines the impact of an increase in public investment in an economic sector, k, on private investment in the same economic sector, k. The null hypothesis in Model Two is that public investment in sector k does not crowd out private investment in the same sector.

To estimate the impact of public investment on private investment, this paper controls for credit extended to the public sector and interest rates (Shankar & Trivedi, 2021; Shetta & Kamaly, 2014). It also controls for output, since the crowding out effect assumes that the economy operates at full employment (Ghali, 1998).

3.1 Model One: gross investment analysis

To address the first question, the following gross investment function is specified.

$$\ln privI_t = \beta_0 + \beta_1 \ln pubI_t + \beta_2\, credit_t + \beta_3\, r_t + \beta_4 \ln y_t + \epsilon_t \qquad (1)$$

where $privI$ is real gross private investment, $pubI$ is real gross public investment, $credit$ is the ratio of credit extended to the public sector relative to total credit, r is the lending interest rate, y is real GDP, $\ln(.)$ is the natural logarithm operator, ϵ is a random error term, and t designates the corresponding quarter of the year.

The elasticity of private investment with respect to public investment is captured by β_1. A positive β_1 provides evidence for the crowding-in effect, while a negative β_1 provides evidence for the crowding-out effect. A negative β_2 indicates that an increase in the ratio of credit to the public sector reduces private investment, which can be considered as evidence for the lazy banks' hypothesis. The expected sign for β_3 is negative since the lending interest rate represents a cost for financing investment. β_4 captures the elasticity of private investment with respect to output which is expected to be positive since investment is procyclical to output.

3.2 Model Two: sectoral-level analysis

To address the second question, equation 1 is re-estimated for each economic sector, k, for $k = 1,\ 2, \dots, 14$. More formally,

$$\ln privI_{k,t} = \beta_{0,k} + \beta_{1,k} \ln pubI_{k,t} + \beta_{2,k}\, credit_t + \beta_{3,k}\, r_t + \beta_{4,k} \ln y_t + \epsilon_{k,t} \quad (2)$$

The difference between equation 2 and equation 1 is the additional subscript k which designates sector k. That is, for each economic sector, equation 2 will be estimated using, on the left-hand side, private investment in an economic sector and, on the right-hand side, public investment in the same sector along with control variables, i.e., ratio of credit to public sector, lending interest rate, and output. The Central Bank of Egypt reports public and private investment data for 18 economic sectors. Four economic sectors, namely electricity, water, Suez Canal, and insurance and social solidarity, are excluded from the sectoral-level analysis (Model Two) since private investment in these four sectors is zero. Therefore, Model Two features fourteen different regression equations. Table 1 presents the included economic sectors in the analysis along with their adopted abbreviations.

Table (1): Economic sectors included in the analysis

Economic Sector	Abbreviation
Agriculture, Irrigation & Reclamation	Agri.
Crude Oil	Crude
Natural Gas	Gas
Oil Refining	Oil Ref.
Manufacturing	Manuf.
Construction & Building	Constr.
Transportation & Storage	Trans.
Communications	Comm.
Trade	Trade
Tourism	Tourism
Real Estate	R. State
Educational Services	Educ.
Health Services	Health
Others	Others

4. Data and descriptive statistics

4.1 Data

This paper uses quarterly data spanning the period from 2004Q3 to 2022Q4. Table 2 presents the data used for this study and their sources. All series are adjusted to remove seasonality. GDP at both current and constant prices is used to compute the GDP deflator, which will then be used to adjust the nominal data series for inflation. Gross private investment is calculated as the difference between gross capital formation and public investment. The credit ratio extended to the public sector is defined as claims on government and on the public business sector relative to total domestic credit.

Table (2): Data used and their sources

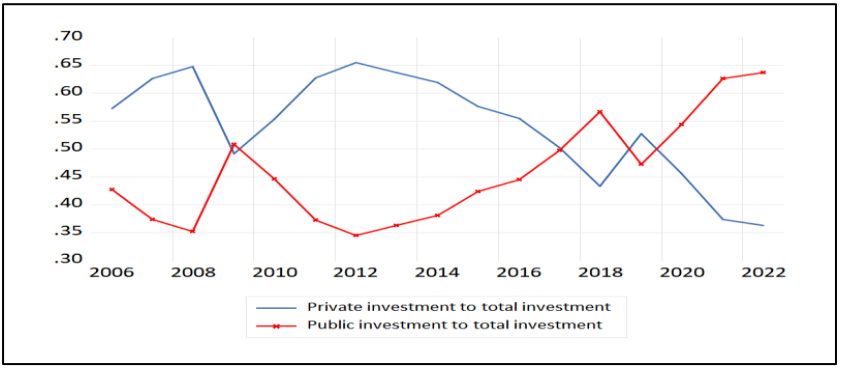
Source	Series	Notes
Ministry of Planning and Economic Development	GDP at current prices	Not seasonally adjusted; used to compute the GDP deflator
	GDP at constant prices	
	Public investment	Nominal series and not seasonally adjusted
	Gross capital formation	
Central Bank of Egypt	Components of public and private investments	Nominal series and not seasonally adjusted
	Total credit	Claims on government, public business sector, private sector, and households
	Public credit	Claims on government and public business sector
IMF (IFS)	Lending interest rate	

4.2 Descriptive statistics

This subsection provides a descriptive analysis of the following: first, the historical evolution of relative contributions of gross private investment and gross public investment; second, the historical evolution of the ratio of credit extended to the private sector relative to total domestic credit, and the ratio of credit extended to the public sector relative to total domestic credit; and third, the historical evolution of relative contributions of private investment and public investment in each economic sector. Lastly, a brief discussion of the correlation among the included variables in model one.

Figure 1 depicts the historical evolution of relative contributions of gross private investment and gross public investment. From the early 2000s through 2016, except for the financial crisis year, investment in Egypt was mainly denominated by the private sector, while the share of the public sector was below 45 percent. Since 2016, however, public investment has tended to dominate with a share that has exceeded 65 percent.

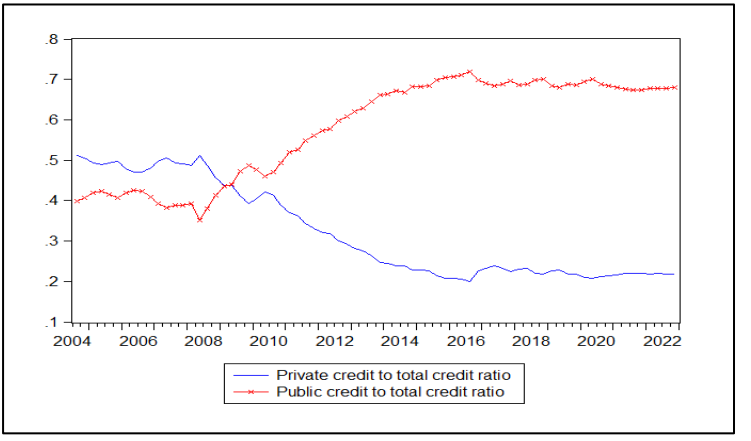
Figure (1): Contributions of gross private investment and gross public investment



Source: author's calculations

Second, a historical evolution of the ratio of credit extended to the private sector relative to total domestic credit compared with the ratio of credit extended to the public sector relative to total domestic credit is depicted in Figure 2 Before the financial crisis, banks' major borrower was the private sector. There is a clear declining trend in the ratio of credit extended to the private sector, which dropped from over 50% in 2004 to just over 20% in 2022. On the other hand, the ratio of credit extended to the public sector is steadily increasing, from 40% in 2004 to above 70% in 2022.

Figure (2): Credit ratios to public and private sectors



Source: author's calculations

Third, the historical evolution of the relative contributions of private investment and public investment in each economic sector is depicted in Appendix 2. Private investment plays a major role in the agricultural sector, though its share has slightly declined since 2016. The crude oil sector is mainly dominated by public investment, though private investment made a substantial contribution to this sector in the late 2000s. While private investment dominates the natural gas sector, their contribution to oil refining has completely abated since 2013. The share of private investment in the manufacturing sector and the construction sector has declined from about 70 percent to less than 30 percent since 2016. The shares of private and public investment have remained stable in the transportation sector, the information and communications sector, and the trade sector, with public investment dominating the transportation sector and private investment mainly dominating the other two sectors. Private investment plays a major role in the tourism sector, except for uncertainty periods such as political instability in 2013 and the Covid-19 pandemic, when public investment contributed to this sector. Although the contribution of public investment in the real estate sector was almost nonexistent before 2014, it has controlled over 30 percent of this sector since then. Although the educational sector and health services sector are mainly dominated by public investment, private investment plays a non-trivial role in these sectors.

In sum, an analysis of gross private investment and gross public investment reveals that the share of the private sector has been declining in the Egyptian economy. Banks are becoming more inclined to extend credit to the public sector. Analysis of the relative contributions of private and public investment at the sectoral levels reveals further insights into the role of the public and private sectors in the economy. That is, there are some sectors that are mainly dominated by public investment, such as crude oil, transportation, health, and education, while other sectors are dominated by private investment, such as trade and tourism. More importantly, the share of public investment in some sectors, such as construction, real estate, oil refining, and agriculture, has been increasing.

Table 3 shows the correlation matrix of included variables in model one. Gross public investment is strongly and positively associated with GDP with a correlation coefficient of 0.73. Gross public investment is positively associated with the lending rate with a significant correlation coefficient of 0.27. Additionally, it is positively associated with the ratio of credit that is extended to the public sector with correlation coefficient of about 0.5. These two correlation coefficients suggest that government spending on public investment is financed via borrowing which, in turn, drives up the lending rate. A correlation between the ratio of public

investment to total investment and ratio of private investment to total investment at the sectoral level (model two) is omitted since by definition it is equal to -1.

Table (3): Correlation matrix of gross investment

	private investment	public investment	Credit to public sector	Lending rate	ln (GDP)
private investment	1				
public investment	0.08 (0.51)	1			
Credit to public sector	0.03 (0.81)	0.49 (0.00)	1		
Lending rate	0.24 (0.05)	0.27 (0.03)	0.21 (0.09)	1	
ln (GDP)	0.16 (0.19)	0.73 (0.00)	0.87 (0.00)	0.08 (0.54)	1

Note: p-value in parentheses.

5. Econometric Model

5.1 Model One: gross investment analysis

To estimate Model One (equation 1), this paper uses the bounds test approach to establish cointegration which was proposed by Pesaran et al. (2001). The bounds test can be applied when using ARDL models whether they are I(0), I(1), or mutually cointegrated.

The first step in establishing cointegration is to estimate the unrestricted error correction form of the gross private investment function (equation 1) using OLS as follows. The unrestricted error correction form of the gross private investment function is given as

$$\Delta \ln privI_t = C_0 + \sum_{j=1}^{p} \gamma_{1j} \Delta \ln privI_{t-j} + \sum_{j=1}^{q1} \gamma_{2j} \Delta \ln publI_{t-j} + \sum_{j=1}^{q2} \gamma_{3j} \Delta credit_{t-j} + \sum_{j=1}^{q3} \gamma_{4j} \Delta r_{t-j} + \quad (3)$$

$$\sum_{j=1}^{q4} \gamma_{5j}\, \Delta \ln y_{t-j} + \beta_1 \ln privI_{t-j} + \beta_2 \ln pubI_t + \beta_3 \mathrm{credit}_t + \beta_4 \mathrm{r}_t + \beta_5 \ln y_t + \epsilon_t$$

where Δ is the first difference operator, $\gamma_{1j}, \gamma_{2j}, \ldots, \gamma_{5j}$ are the coefficients of short-run dynamics of the underlying corresponding variables, with lag length $p, q1, q2, \ldots, q4$ respectively, $\beta_1, \beta_2, \ldots, \beta_5$ are the coefficients of the long-run relationship of the variables in the cointegrating set, and ϵ_t is a white-noise error term.

The second step in establishing cointegration is to ensure that the errors of the unrestricted error-correction form (equation 3) are white noise. Serial correlation in the error term will invalidate the bounds test, while heteroskedastic errors will lead to inefficient estimation. To test for the presence of serial correlation and heteroskedasticity, the Breusch-Godfrey test and the Breusch-Pagan-Godfrey test are used, respectively.

Once the white-noise assumption of the error term is satisfied, the bounds test can be applied. This test is a standard Wald test used to test the null hypothesis of no cointegration, i.e., H_0: $\beta_1 = \beta_2 = \cdots = \beta_9 = 0$, against the alternative that at least one of them is not. The computed F-statistic is then compared to two critical values corresponding to cases of all variables being purely I(0) or purely I(1). The null hypothesis of no cointegration is rejected if the test statistic is above the upper critical value, while it cannot be rejected if the test statistic is below the lower critical value. If the test statistic falls between the lower- and upper-critical values, then the bounds test is inconclusive.

Once cointegration has been established, the long-run equilibrium private investment function can be estimated. The long-run equilibrium private gross investment relationship is given as

$$\ln privI_t = C_0 + \beta_1 \ln pubI_t + \beta_2 \mathrm{credit}_t + \beta_3 \mathrm{r}_t + \beta_4 \ln y_t + \mu_t \qquad (4)$$

where μ_t is an error term. To capture short-run dynamics, the restricted error correction model (ECM) is then derived. The ECM for gross private investment is given as

$$\Delta \ln privI_t = C_0 + \sum_{j=1}^{p} \gamma_{1j} \Delta \ln privI_{t-j} + \sum_{j=1}^{q1} \gamma_{2j} \Delta \ln pubI_{t-j} + \sum_{j=1}^{q2} \gamma_{3j} \Delta \text{credit}_{t-j} + \sum_{j=1}^{q3} \gamma_{4j} \Delta r_{t-j} + \sum_{j=1}^{q4} \gamma_{5j} \Delta \ln y_{t-j} + \psi EC_{t-1} + \mu_t \quad (5)$$

where ψ captures the speed of adjustment to long-run equilibrium, following a shock to the system.

5.2 Model Two: sectoral-level analysis

The estimation of Model Two (equation 2) will follow a very similar procedure to that of Model One given in the previous subsection. The unrestricted error correction form of the sectoral-level private investment function is given as

$$\Delta \ln privI_{k,t} = C_{0,k} + \sum_{j=1}^{p} \gamma_{1j,k} \Delta \ln privI_{k,t-j} + \sum_{j=1}^{q1} \gamma_{2j,k} \Delta \ln pubI_{k,t-j} + \sum_{j=1}^{q2} \gamma_{3j,k} \Delta credit_{t-j} + \sum_{j=1}^{q3} \gamma_{4j,k} \Delta r_{t-j} + \sum_{j=1}^{q4} \gamma_{5j,k} \Delta \ln y_{t-j} + \beta_{1,k} \ln privI_{k,t-j} + \beta_{2,k} \ln pubI_{k,t} + \beta_{3,k} \text{credit}_t + \beta_{4,k} r_t + \beta_{5,k} \ln y_t + \epsilon_{k,t} \quad (6)$$

where Δ is the first difference operator, $\gamma_{1j,k}, \gamma_{2j,k}, \dots, \gamma_{5j,k}$ are the coefficients of short-run dynamics of the underlying corresponding variables for the economic sector $k = 1, \dots, 14$, with lag length $p, q1, q2, \dots, q4$, respectively, where different sectors are not necessary having the same lag length. $\beta_{1,k}, \beta_{2,k}, \dots, \beta_{5,k}$ are the coefficients of the long-run relationship of the variables in the cointegrating set for the economic sector k. $\epsilon_{k,t}$ is a white-noise error term.

The long-run equilibrium relationship of private investment for each economic sector k is given as

$$\ln privI_{t,k} = C_0 + \beta_{1,k} \ln pubI_{t,k} + \beta_{2,k} \text{credit}_t + \beta_{3,k} r_t + \beta_{4,k} \ln y_t + \mu_{t,k} \quad (7)$$

where $\mu_{t,k}$ is an error term. The ECM for sectoral-level private investment is given as

$$\Delta \ln privI_{t,k} = C_{0,k} + \sum_{j=1}^{p} \gamma_{1j,k} \Delta \ln privI_{t-j,k} + \sum_{j=1}^{q1} \gamma_{2j,k} \Delta \ln pubI_{t-j} + \sum_{j=1}^{q2} \gamma_{3j,k} \Delta \text{credit}_{t-j} + \sum_{j=1}^{q3} \gamma_{4j,k} \Delta r_{t-j} + \sum_{j=1}^{q4} \gamma_{5j,k} \Delta \ln y_{t-j} + \psi_k EC_{t-1} + \mu_{t,k} \quad (8)$$

where ψ_k captures the speed of adjustment to the long-run equilibrium of sector k, following a shock to the system.

6. Discussion

This section presents the results for Model One and Model Two.

6.1 Model One: gross investment analysis

To apply the bounds test, none of the included series should be integrated of order two or higher. This paper tests for stationarity using the Augmented Dickey-Fuller (1981) unit-root test. If the null hypothesis of the existence of a unit root is rejected, no further testing is conducted. However, if the null hypothesis cannot be rejected, the test is repeated on the first difference of the series. Table 4 reports the estimates of the Augmented Dickey-Fuller test. The estimates show that the included series are a mix of I(0) and I(1), and, more importantly, none of the included series is integrated of order two.

Table (4): Results of the Augmented Dickey-Fuller unit-root test

		Level		1st difference	
		ADF	**specification**	**ADF**	**specification**
Gross private investment		-6.42***	C		
Gross public investment		-1.61	T	-9.55***	None
Credit to public sector ratio		-0.28	None	-6.31***	None
Lending rate		-3.44*	C		
ln (GDP)		-2.45	C, T	-4.05**	C
Public Investment in:					
	Agri.	-2.09	C, T	-12.35***	None
	Crude	-6.14***	C		
	Gas	-4.13***	C		
	Oil Ref.	-7.91***	C, T		

Continue…..

		Level		1st difference	
		ADF	specification	ADF	specification
	Manuf.	-2.93	C	-8.16***	None
	Constr.	-2.22	C, T	-11.83***	None
	Trans.	-4.58***	C, T		
	Comm.	-1.88	None	-8.84***	None
	Trade	-3.75**	C		
	Tourism	-7.28***	C, T		
	R. State	-5.24***	C, T		
	Educ.	-5.79***	C, T		
	Health	-5.49***	C		
	Others	-2.06	C	-10.38***	None
Private Investment in:					
	Agri.	-2.90*	C	-10.26***	None
	Crude	-3.82**	C, T		
	Gas	-7.26***	C		
	Oil Ref.	-3.48**	C, T		
	Constr.	-2.79	C	-12.76***	None
	Trans.	-5.72***	C		
	Comm.	-4.01**	C		
	Trade	-5.86***	C		
	Tourism	-3.67**	C		
	R. State	-6.86***	C		
	Educ.	-2.68	C	-13.03***	None
	Health	-2.19	C	-8.53***	None
	Others	-6.30***	C, T		

Notes: *, **, and * indicate that the estimated coefficient is statistically significant at the 1%, 5%, and 10%, respectively. C and T designate the statistical significance of the included constant and\or trend, respectively. "None" indicates that neither constant nor trend are statistically significant. Source: author's calculations.**

Using the Akaike Information Criterion (AIC), the order of lags (p, q1, q2, q3, q4) to be included in the ARDL regression is (6, 5, 5, 4, 0). Both the LM test statistic of the Breusch-Godfrey test of no serial correlation, 1.19, and the F statistic of the Breusch-Pagan-Godfrey test, 1.41, of homoskedasticity in the error term of equation 3 are insignificant, suggesting that there is no evidence of serial correlation or heteroskedasticity, respectively. The F-statistic of the bounds test is 5.07, which is greater than the upper bound critical value of 3.09 at a 1% level of significance. Therefore, I conclude that there exists a long-run co-integration relationship between gross private investment and the included explanatory variables: gross public investment, credit to public sector ratio, lending interest rate, and GDP.

Table 5 reports the estimated long-run coefficients for the gross investment function in Egypt over the period 2004Q3 to 2022Q4.[(1)] The coefficient of log gross public investment is -0.66 and is significant, i.e., a 10% increase in gross public investment will reduce gross private investment by 6.6%. Therefore, there is evidence of a crowding-out effect of gross public investment on private investment in Egypt. A 1% increase in the ratio of credit extended to the public sector will reduce gross private investment by 2.86%, i.e., evidence in favor of the lazy-banking hypothesis. There is evidence that gross private investment is procyclical with an elasticity of 2.27 with respect to output. Contrary to prior expectations, gross private investment is positively related to lending interest rate, though the magnitude of its response is trivial. The error correction (EC) coefficient measures the speed of adjustment of long-run gross private investment if disturbed by changes in one of its explanatory variables. The estimated EC coefficient, -1.27, is negative and statistically significant, indicating that the system is convergent, yet, it has an oscillatory adjustment process.

[(1)] The results of short-term dynamics are omitted for brevity, but they are available upon request.

Table (5): Results for the long-run relationship of Model One

Dependent: ln (reserves)	**Long-run form coefficients**
ln (public)	**-0.66*** (-3.56)**
credit	**-2.86*** (-4.29)**
lending rate	**0.07*** (6.59)**
ln (GDP)	**2.27*** (3.74)**
Constant	**-12.07* (-1.91)**
$\boldsymbol{EC}\ (-1)$	-1.27*** **(-5.8)**
$\boldsymbol{R^2}$	**0.60**
Durbin-Watson Statistic	**1.97**
Serial correlation[1]	**1.19**
Heteroskedasticity[2]	**1.41**
F-statistics[3]	**5.07*** **
Jarque-Bera	**1.19**
No. Observations	**68**
ARDL	**(6,5,5,4,0)**

Notes: t-statistics are in parentheses. Newey and West (1987) standard errors are used. *, **, and * indicate that the estimated coefficient is statistically significant at the 1%, 5%, and 10%, respectively. [1] The LM test statistic of the Breusch-Godfrey test of no serial correlation. [2] The F-statistic of the Breusch-Pagan-Godfrey test of homoskedasticity. [3] The F-statistic of the bounds test. Source: author's calculations.**

To test the stability of the estimated long-run relations, Appendix 3 shows the Brown et al. (1975) CUSUM and CUSUMSQ tests. Since the plots of the CUSUM and CUSUMSQ do not cross the two 5% significance level critical lines, it can be concluded that the coefficients of the long-run gross private investment regression are stable. The adjusted $\boldsymbol{R^2}$ for the estimated ARDL regression is 0.60 suggesting an acceptable fit of the estimated model. Moreover, since the Durbin-Watson statistic is 1.97 which is greater than the adjusted $\boldsymbol{R^2}$, a case of spurious regression can be ruled out (Granger & Newbold, 1974). Additionally, Appendix 4

depicts the observed versus fitted values for gross private investment, along with the residuals, indicating that the estimated model fits the data very well.

6.2 Model Two: sectoral-level investment analysis

Unit-root tests for public and private investment in fourteen economic sectors are reported in Table 4. The included series are a mix of I(0) and I(1). The order of lags to be included in each ARDL regression is reported in Table 6 along with diagnostic tests for serial correlation and homoskedasticity. Except for the oil refining sector, no serial correlation is present in the remaining 13 equations. Although the error term in some equations suffers from heteroskedasticity, this will not affect the validity of the bounds test. The F statistics of bounds tests are also reported in Table 6. There is evidence for cointegrating relationships in nine out of the fourteen economic sectors included in the analysis. The error-correction term is negative and significant which also supports the convergence towards the long-run relationship if a shock occurs. The adjusted $\boldsymbol{R^2}$ and Durbin-Watson statistics are also reported in Table 6. Appendices 5 and 6 show the CUSUM and CUSUM2 tests, respectively, for the fourteen estimated equations. Appendix 7 depicts observed versus fitted values for private investment in each economic sector. The next subsections discuss the long-run estimates of the fourteen economic sectors which are reported in Table 6.[(2)]

[(2)] The estimates of Model Two short-run dynamics are not reported for brevity but are available upon request.

Table (6): Results for the long-run relationship of Model Two

		ln (Private Investment in sector X_i)													
		Agri.	Crude	Gas	Oil Ref.	Manuf.	Constr.	Trans.	Comm.	Trade	Tourism	R. State	Educ.	Health	Others
ln (Public Investment in sector X_i)	δ	0.59***													
	Crude		-1.04												
	Gas			0.59***											
	Oil Ref.				0.33										
	Manuf.					0.53**									
	Constr.						0.69***								
	Trans.							-0.13							
	Comm.								-0.63***						
	Trade									-1.13*					
	Tourism										-0.95				
	R. State											0.18**			
	Educ.												-2.37		
	Health													6.09	
	Others														-1.15
Control	Credit	1.71*	1.58	-0.73*	-8.58	5.81**	-1.67	-1.59	-9.57***	-2.73**	-13.57**	-1.57	4.87	-18.72	-0.57
	r	-0.09***	-0.88	-0.02	-0.02	-0.09**	-0.38***	0.01	0.12***	0.02	0.25*	0.03	0.13	-0.48	-0.01
	ln (y)	-1.17	3.18	0.57	0.30	-4.27**	2.43**	0.56	4.99***	3.67***	1.83	-0.46	-8.13	30.34	1.06
	Const.	19.71**	-28.44	2.71	-12.71***	62.04***	-26.99**	2.57	-53.1***	-34.96**	-8.14	15.57	138.61	-450	-5.85
Diagnosis	Bounds[1]	6.58***	2.5	8.13***	6.84***	9.17***	7.49***	7.16***	5.22***	5.08***	4.79	9.38***	4.46***	4.52	12.92***
	LM[2]	0.08	0.83	0.14	6.4***	1.41	1.32	0.47	1.18	2.16	0.36	0.3	1.26	1.59	1.05
	Hetero.[3]	1.91*	0.84	1.08	10.96***	1.57	0.49	2.4**	0.91	0.88	2.68***	0.61	1.68	1.26	1.19
	Adj. R^2	0.70	0.96	0.77	0.92	0.66	0.94	0.39	0.64	0.90	0.44	0.37	0.94	0.82	0.41
	DW[4]	1.92	2.29	2.11	2.54	2.32	2.25	1.95	1.74	2.10	1.89	1.93	2.29	2.25	2.06
	EC (-1)	-0.85***	-0.12***	-2.98	-0.57***	-0.67***	-1.41***	-0.86***	-0.67***	-1.91***	-0.84***	-0.99***	-0.43***	0.07	-0.88***
	ARDL[5]	4,2,1,1,5	7,8,8,8,8	8,6,6,4,2	1,0,0,0,6,0	1,1,1,1,4	8,8,8,7,8	1,0,2,1,4	1,4,6,1,0	8,8,8,7,8	2,4,0,0,0	1,5,1,1,0	7,8,8,7,8	7,2,7,7,7	1,0,1,0,4

Notes: t-statistics are in parentheses. Newey and West (1987) standard errors are used. ***, **, and * indicate that the estimated coefficient is statistically significant at the 1%, 5%, and 10%, respectively. [1] The F-statistic of the bounds test. [2] The LM test statistic of the Breusch-Godfrey test of no serial correlation. [3] The F-statistic of the Breusch-Pagan-Godfrey test of homoskedasticity. [4] Durbin Watson Statistics. Source: author's calculations.

6.2.1 Agriculture

There is evidence of a crowding-in effect of public investment on private investment in the agricultural sector with a significant elasticity of 0.59. Extending credit to the public sector appears to improve and encourage private investment in the agricultural sector. As expected, private investment in the agricultural sector is negatively related to the lending interest rate. The effect of output on private investment in the agricultural sector is insignificant. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the agricultural sector and public investment in the agricultural sector along with the other control variables. The error-correction term is negative, significant and less than 1 in absolute value,

indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs. No evidence of serial correlation is present in the error term of the estimated equation.

6.2.2 Crude Oil

No evidence of a long-run relationship between private and public investment in the crude oil sector. Additionally, private investment in the crude oil sector does not depend on credit extended to the public sector, interest rate, or output. Although somewhat unanticipated, these findings may be attributed to the fact that investing in the crude oil sector has a special nature which requires substantial overhead costs that are not to be sensitive to changes in interest rates or credit ratio.

6.2.3 Natural Gas

There is evidence of a crowding-in effect of public investment on private investment in the natural gas sector with a significant elasticity of 0.59. However, private investment in the natural gas sector is negatively related to extending credit to the public sector with an elasticity of -0.73. Private investment in this sector is statistically unrelated to lending rate and output. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the natural gas sector and public investment in the natural gas sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation.

6.2.4. Oil Refining

Although there is evidence of a long-run relationship between private and public investment as well as other control variables in the oil refining sector, public investment had no significant impact on private investment in this sector. A dummy variable, not reported in Table 6, was included in the regression to capture the structural break in private investment in this sector in 2013Q2. Additionally, private investment in the oil refining sector does not depend on credit extended to the public sector, interest rate, or output. This is consistent with the previous findings in the crude oil sector, suggesting again that investing in oil-related sectors has a special nature which requires substantial overhead costs.

6.2.5 Manufacturing

This is evidence of a crowding-in effect of public investment on private investment in the manufacturing sector with a significant elasticity of 0.53. Moreover, extending credit to the public sector appears to encourage private investment in this sector. As expected, private investment in this sector is negatively related to the lending rate. Surprisingly, there is evidence that private investment in the manufacturing sector is countercyclical. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the manufacturing sector and public investment in the manufacturing sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is less than 1, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs.

6.2.6 Construction and Building

This is evidence of a crowding-in effect of public investment on private investment in the construction sector with a significant elasticity of 0.69. A 1% increase in the lending rate decreases private investment in the construction sector by 0.38%. Private investment in the construction sector is procyclical with a significant elasticity of 2.43. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the construction and building sector and public investment in the construction and building sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is between 1 and 2, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs although with an oscillatory pattern.

6.2.7 Transportation and Storage

The bounds test and error-correction term provide evidence of a long-run relationship between private investment in the transportation sector and other variables included in the model, though none of the explanatory variables are significant. This suggests that investment in the transportation sector requires substantial overhead costs that may not be justifiable by a lower lending rate or a lower credit ratio to the public sector.

6.2.8 Information and Communications

This is evidence of a crowding-out effect of public investment on private investment in the information and communications sector with a significant elasticity of -0.63. A 1% increase in the lending rate decreases private investment in the information and communications sector by 9.57%. There is evidence in favor of the lazy-banking hypothesis in this sector with a significant elasticity of private investment with respect to ratio of credit to the public sector of -9.57. Private investment in the information and communications sector is procyclical with a significant elasticity of 4.99. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the information and communications sector and public investment in the information and communications sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is less than 1, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs.

6.2.9 Trade

This is evidence of a crowding-out effect of public investment on private investment in the trade sector with a significant elasticity of -1.13. A 1% increase in the lending rate decreases private investment in the trade sector by 2.73%. Extending credit to the public sector discourages private investment in the trade sector with an elasticity of -2.73. Private investment in the trade sector is procyclical with a significant elasticity of 3.62. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the trade sector and public investment in the trade sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is between 1 and 2, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs although with an oscillatory pattern.

6.2.10 Tourism

There is no evidence of a crowding-in or a crowding-out effect of public investment in tourism on private investment, though there is evidence in favor of the lazy-banking hypothesis in this sector – where the estimated coefficient of credit is negative and significant. There is evidence that the tourism sector is acyclical, indicating that private investment in the tourism sector depends

on factors other than output such as safety. There is no evidence of a long-run relationship between private and public investment in the tourism sector.

6.2.11 Real Estate

There is evidence of a crowding-in effect of public investment on private investment in the real estate sector with a significant elasticity of 0.18. Surprisingly, private investment in the real estate sector is statistically unrelated to output, interest rates, and credit to the public sector ratio. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the real estate sector and public investment in the real estate sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is less than 1, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs.

6.2.12 Educational Services

The bounds test and error-correction term provide evidence of a long-run relationship between private investment in the educational services sector and other variables included in the model, though none of the explanatory variables are significant. These results are not surprising given the high costs of establishing a new educational facility. The F-statistic of the bounds test is highly significant, suggesting an existence of a long-run cointegrating relationship between private investment in the educational services sector and public investment in the educational services sector along with the other control variables. No evidence of serial correlation is present in the error term of the estimated equation. The error-correction term is negative, significant and its absolute value is less than 1, indicating a convergence behavior toward the long-run cointegrating relationship if a shock occurs.

6.2.13 Health Services

No evidence of a long-run relationship between private and public investment in the health services sector. Additionally, the F-statistic of the bounds test is insignificant, suggesting that public and private investments in the health services sector are not related.

6.2.14 Others

The bounds test and error-correction term provide evidence of a long-run relationship between private investment in the others economic activities sector and other variables included in the model, though none of the explanatory variables are significant.

7. Conclusion

This paper investigates whether public investment crowds in or crowds out private investment in Egypt. It does so both at the gross investment level and at the sectoral level of investment. In an attempt to answer this question, the paper also examines the elasticity of private investment with respect to output and interest rate and revisits the lazy-banking hypothesis.

The research design of this paper is as follows: the paper first presents the evolution of relative contributions of public and private investments in each economic sector. Then, using quarterly data spanning from 2004Q3 to 2022Q4, the paper estimates two models. First, an ARDL model is used to regress gross private investment on gross public investment, the ratio of credit to the public sector, the lending rate, and GDP. Second, fourteen ARDL models are used to regress private investment in each economic sector on public investment in that sector, in addition to other control variables.

The findings of this paper are as follows: There is evidence that gross public investment crowds out gross private investment with an elasticity of -0.66, i.e., each 10% increase in gross public investment in Egypt reduces gross private investment by 6.6%. Additionally, a 1% increase in extending credit to the public sector reduces private investment by 2.86%. In addition, as output grows by 1%, gross private investment increases by 2.27%.

Sectoral level analysis reveals further insights about the interactions between private and public investment in Egypt. Specifically, there is evidence that public investment crowds in private investment in the agricultural, natural gas, manufacturing, construction, and real estate sectors. Conversely, there is evidence that public investment crowds out private investment in the information and communications, and trade sectors. Regarding the effect of lending interest rates on private investment, there is evidence that the agricultural, manufacturing, and construction sectors are negatively related to lending rates. Additionally, the construction, information and communications, and trade sectors are

procyclical, yet, surprisingly, there is evidence that the manufacturing sector is countercyclical. Moreover, the natural gas, information and communications, trade, and tourism sectors are negatively related to the credit ratio extended to the public sector, suggesting that private investment in these sectors is mainly financed via borrowing.

This paper recommends policymakers to decrease public investment in the information and communications and trade sectors, where public investment crowds out private investment, and increase public investment in the agricultural, natural gas, manufacturing, construction, and real estate sectors, where public investment crowds in private investment. However, while this paper recommends increasing public investment in sectors where public investment crowds in private investment, it also recommends that policymakers rely less on borrowing, since extending credit to the public sector reduces private investment. With regards to monetary policy, policymakers should be mindful of carrying out a tight monetary policy, since private investment in sectors such as agriculture, manufacturing, and construction is sensitive to lending interest rates. Finally, during economic downturns, policymakers should provide stimulus packages to private investors in the construction, information and communications, and trade sectors, as these sectors are sensitive to fluctuations in output.

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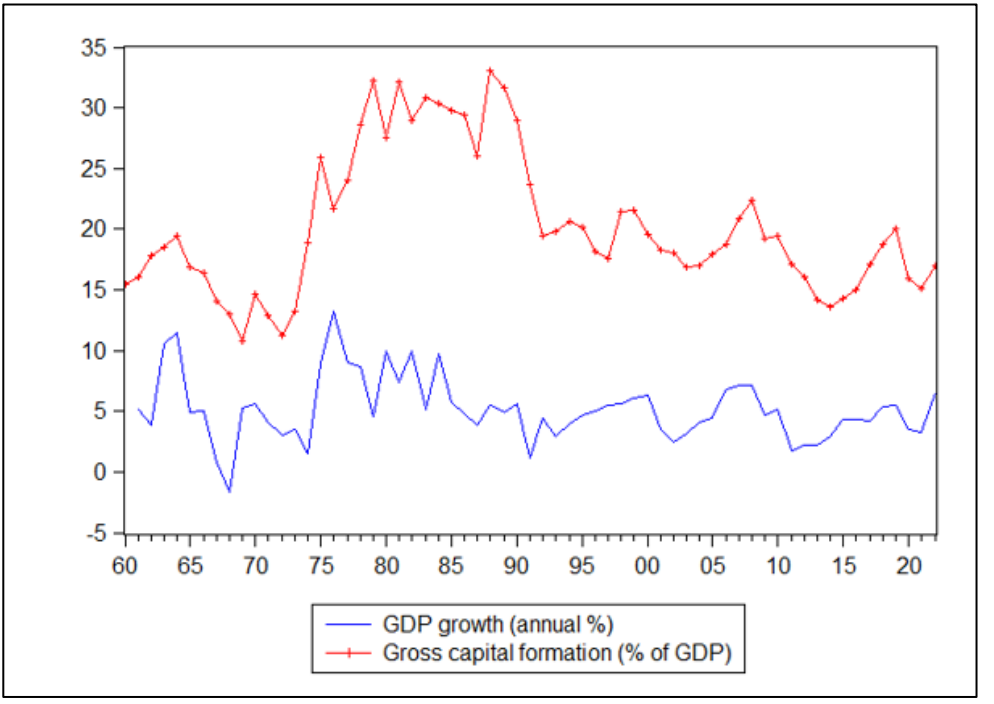
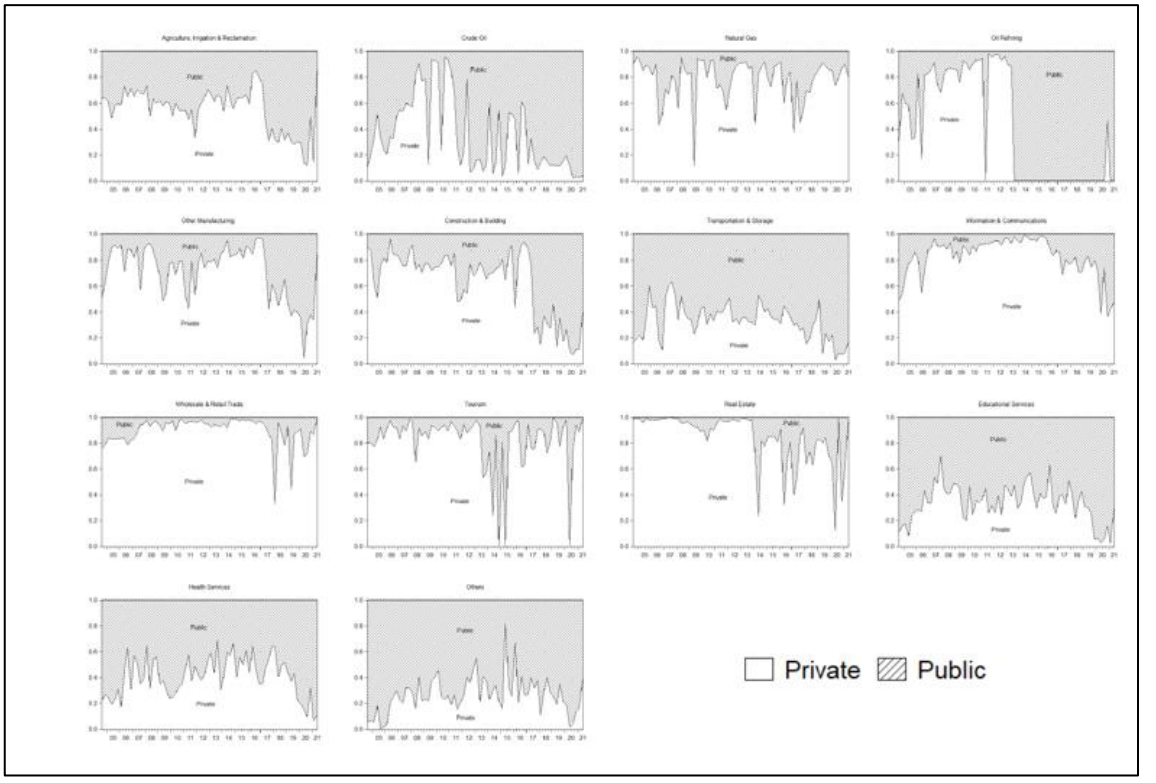
Appendix

Appendix (1): GDP growth rate and gross capital formation in Egypt. The correlation coefficient between the two series is 0.43



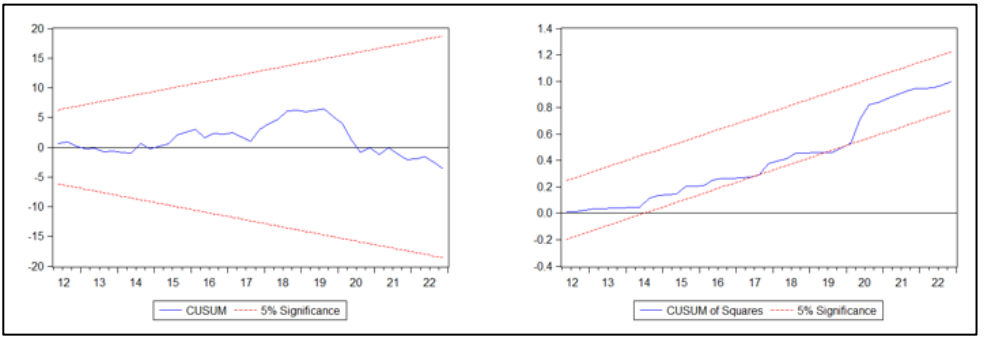
Source: prepared by the author.

Appendix (2): Historical evolution of private and public investment contributions in different economic sectors



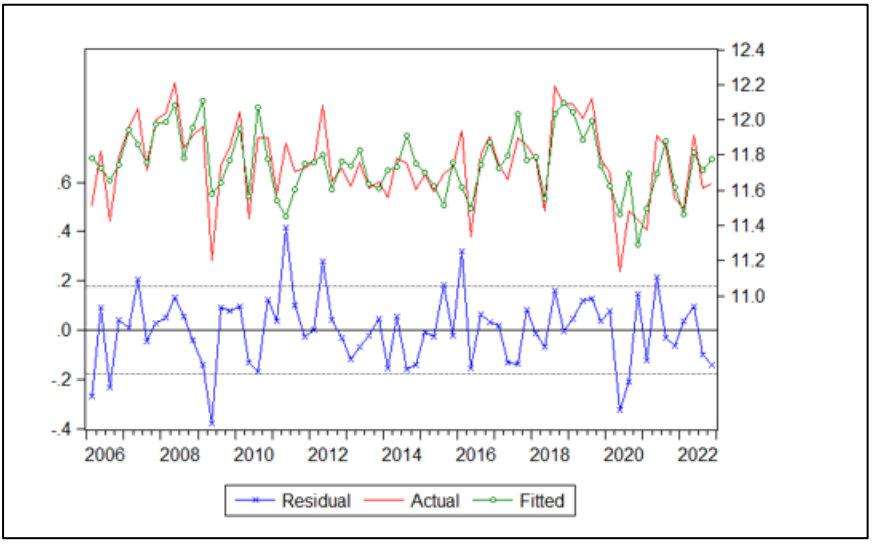
Source: author's calculations.

Appendix (3): Plots of CUSUM and CUSUMSQ statistics for Model One



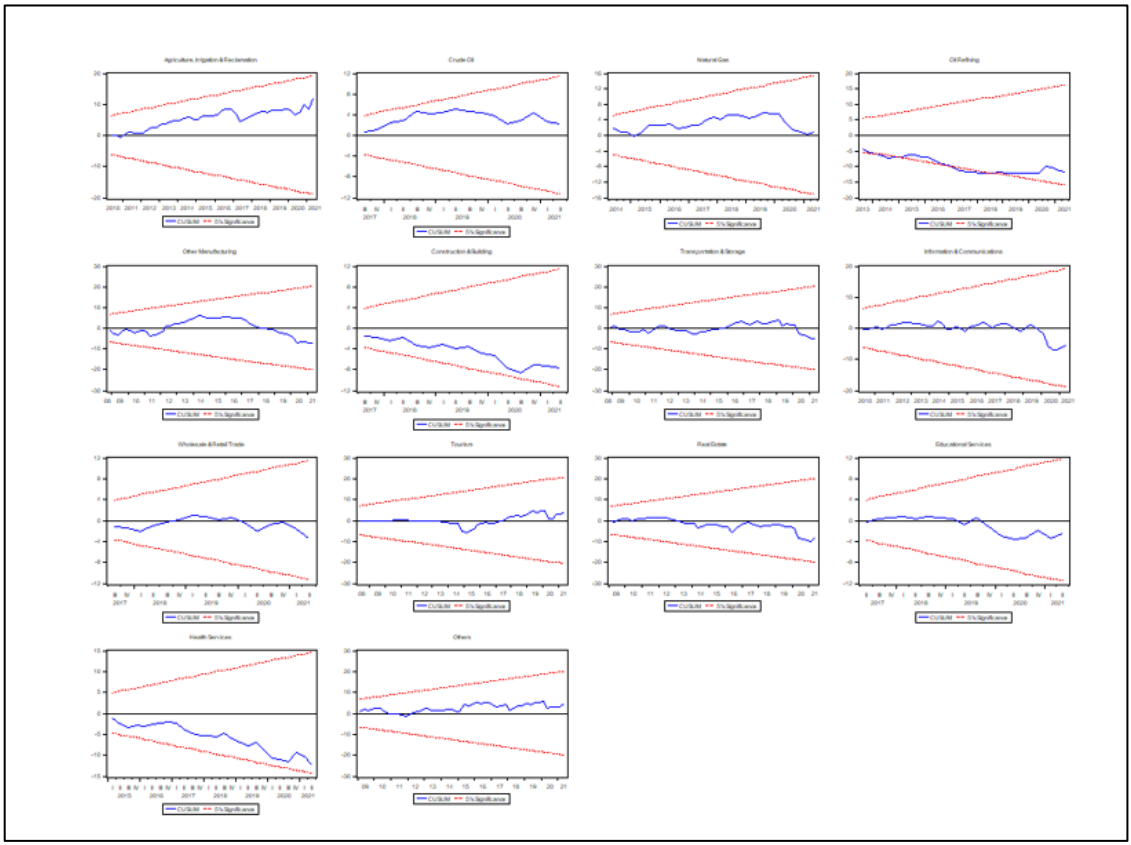
Source: author's calculations.

Appendix (4): Actual vs fitted foreign reserves, along with residuals for Model One



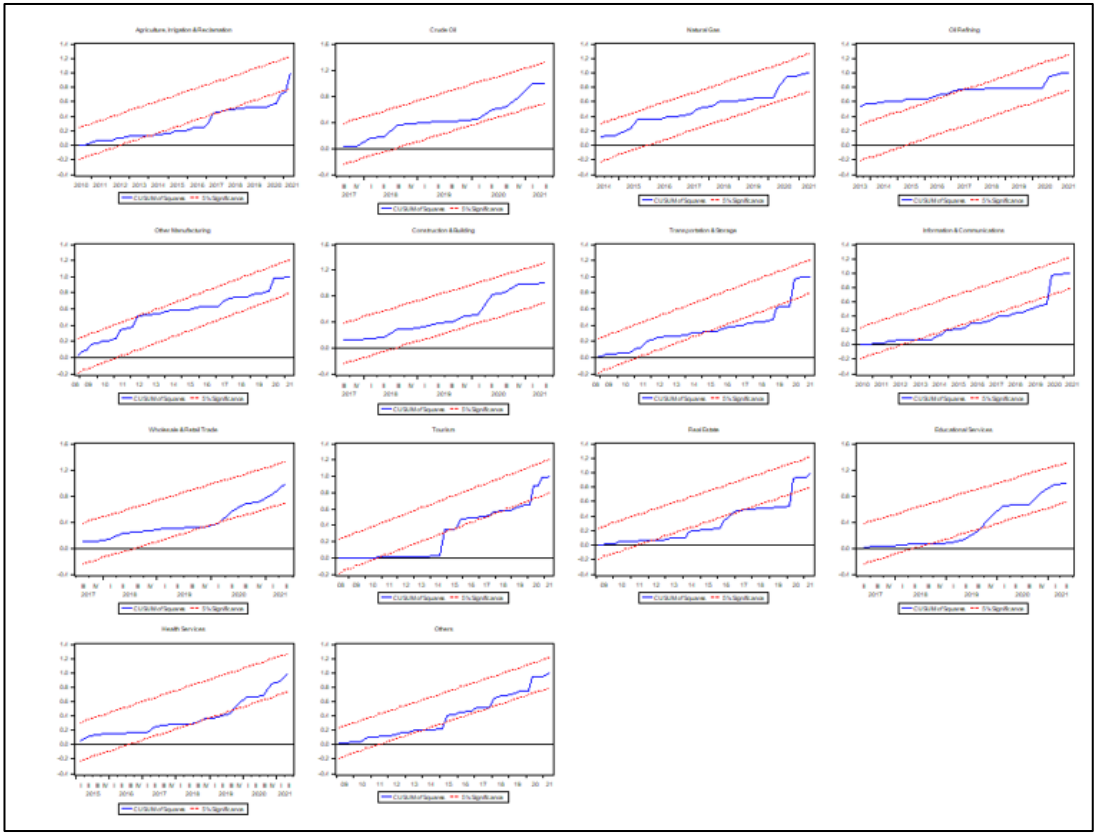
Source: author's calculations.

Appendix (5): Plots of CUSUM statistics for Model Two



Source: author's calculations.

Appendix (6): Plots CUSUMSQ statistics for Model Two



Source: author's calculations.

Appendix (7): Actual vs fitted foreign reserves, along with residuals for Model Two

Source: author's calculations.