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Inflation, financial intermediation and growth: the case of Egypt

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There is now a consensus in the theoretical and the empirical literature that a nonlinear relationship exists between the rate of inflation and the rate of economic growth. Using a threshold regression technique, this paper re-examines this relationship and the critical role that financial intermediation plays in it. Data to examine our hypothesis are from Egypt. We find that inflation contributes positively to economic growth until it reaches a threshold rate of about 12%, after which it becomes detrimental to growth. We then show that such a nonlinear relation is connected to whether or not financial deepening has crossed a certain threshold level. Given these thresholds, a coordination of policies (especially monetary) and financial reform is needed to achieve success in economic growth.

Keywords: inflation; economic growth; financial intermediation; Egypt; threshold regression

JEL Classifications: E31; E44; O16

1. Introduction

The main objective of macroeconomic policy is to achieve high income growth in combination with low inflation. A key natural question is then: what exactly is the relationship between inflation and growth, and – more importantly – what drives that relationship? Attempts at answering these questions have been the subject of considerable investigation in both theory and empirics. One theoretical proposition that has received much attention focuses on the key role of financial development. In this view, which we shall present later, inflation contributes positively to economic growth at low levels of financial development and negatively at high levels of financial development. Yet evidence – at least in the majority of studies – suggests that inflation itself exhibits an inverted U effect on growth whereby an increase in inflation is associated with higher growth rates when the inflation rate is low and with lower growth rates when the inflation rate is already high. Are there any underlying linkages between these two effects, i.e., the effect of inflation on growth and the role of financial development in the impact of inflation on growth? (In a related way, is there a relationship between inflation and financial development?)

These questions have not been satisfactorily answered. Specifically, while empirical tests of the relation between inflation and economic growth have been generally successful in establishing the nonlinear pattern described above (albeit with some methodological

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shortcomings that we will address in this paper), the nexus of inflation and financial development has not been adequately or rigorously tested as we shall see. This paper addresses these issues. To do so, it adopts Hansen's threshold estimation technique (Hansen, 2000) for examining the inflation-financial development-growth hypothesis. While the Hansen method is a subset of other switching models, especially those in the broad class of Markov Switching models, it offers several advantages over those models, hence the reasons for its increased popularity. First, one essential limitation of the Markov Switching models is their exogenous choice of the number of time regimes. Second, the challenge of dealing with a nuisance parameter in Markov Switching models is that the asymptotic distributions are nonstandard. This is what led Hansen (1996) to develop a simulation method to approximate these asymptotic distributions and apply them to threshold models. In Hansen (2000) this method is further perfected to allow for hypothesis testing (see also Garcia, 1998, for a discussion of some of these points).

Once the paper establishes the threshold estimates, it goes further by applying a Probit regression to examine the association, if any, between a threshold inflation rate and a threshold level of financial development. The paper takes time series data for Egypt from 1981 to 2009. This is for at least two reasons. First, using a time-series approach avoids complications of fixed country and unobserved heterogeneity effects associated with panel data. Naturally, issues of data stationarity and unit root need to be addressed. Second, the choice of Egypt is so as to compare our results with an earlier study of Egypt in which no threshold level of inflation was found for the 1981–2006 period (Abou-Ali & Kheir-El-Din, 2009). Although our methodology goes further and examines other relationships beyond what Abou-Ali and Kheir-El-Din consider, our finding nonetheless confirms the existence of a threshold level of inflation that contrasts with theirs. Beyond finding a threshold inflation rate, this is the first study in a time series context to formally and rigorously establish the existence of (a) a threshold level of financial depth, and (b) an association between the threshold level of inflation and the threshold level of financial depth.2

In the following, Section 2 presents a brief overview of both theoretical and empirical literature examining the nature of the relationship between inflation, finance and growth. Section 3 examines the determinants of economic growth in Egypt. Section 4 presents the econometric model and investigates the threshold effect in the relation between inflation and growth. Section 5 searches for a threshold level of financial development beyond which inflation significantly reduces growth. This section also establishes a linkage between the two threshold effects. Section 6 provides some policy implications and concludes.

2. Inflation, finance and growth: theoretical and empirical evidence

This section provides a background of the theory and empirical evidence governing the nonlinear relation between inflation and economic growth, the relation between inflation and financial depth,3 and finally the relation between financial development and economic growth. This will then provide the basis for our empirical analysis in Section 3. The principal focus of the paper is to ask whether financial development plays a role in the relation between inflation and economic growth. It is worth noting the distinction between this question and one studied by Rousseau and Yilmazkuday (2009) as well as Eggoh (2012) within a similar triangular framework. Those studies examine the role of inflation in the relation between finance and growth. Moreover, while Eggoh (2012)
also uses as threshold method, that study is done in a panel context whereas we apply the threshold method in a time series context. It is also worth drawing a distinction between this paper and a paper by Pradhan (2011) which, as in our case, is a time series study (in this case of India). While Pradhan also focuses on the triangular nexus of finance-inflation-growth, it takes on a more common cointegration/error-correction approach. In doing so, it naturally assumes a linear structure that does not permit examination of possible nonlinearities that our use of Hansen threshold method permits. We will now consider each leg of this triangular relationship in terms of the corresponding literature.

2.1. Inflation and growth: theory and empirics

It is helpful to start this subsection with a quote from Friedman (1973): ‘Historically, all possible combinations have occurred: inflation with and without development, no inflation with and without development’. This illustrates that the relationship between inflation and growth has never been exactly clear, exhibiting great variance across countries or over time. The nature of the relationship between inflation and economic growth dates back to the debate between structuralists and monetarists. On one hand, structuralists believed that inflation contributes positively to economic growth (Felix, 1961; Sidrauski 1967; Tobin, 1965) based on the contention that inflation induces savings. On the other hand, monetarists consider inflation as detrimental to growth (Fischer, 1983; Jung & Marshall, 1986; Vogel, 1974) as it impedes efficient resource allocation by obscuring the signaling role of relative price changes and creating uncertainty about future earnings, thus causing distortions in investment decisions, a misallocation of resources and subsequently less growth. Besides the role of savings and investments, supply and demand shocks have played a role in the thinking about inflation and growth. In this thinking, if demand shocks dominate, the relationship is thought to be positive as a result of movements along the aggregate supply curve, while if supply shocks dominate it is thought to be negative as one moves along the aggregate demand curve (Abou-Ali & Kheir-El-Din, 2009).

Empirically, Fischer (1993) was among the first to identify a nonlinear relationship between inflation and economic growth. Following Fischer’s seminal paper, a number of empirical studies have tried to formally identify threshold effects in this relation, where, at low rates of inflation, the relationship is positive or non-existent, but at higher rates it becomes negative. Sarel (1996) specifically tested for the existence of a structural break in the relationship between inflation and growth and found such evidence at an annual inflation rate of about 8%. Sarel further argued that ignoring the existence of this threshold substantially biases one’s estimate of the effect of inflation on growth. Using a larger sample than in Sarel’s study, Ghosh and Phillips (1998) find a much lower threshold effect at an annual inflation rate of about 2.5%. For transitional economies, Christoffersen and Doyle (1998) estimate the threshold level at about 13%. Ghosh (2000) provides a brief summary of empirical work on this issue up to that date.

Against this background, Hansen’s (2000) seminal paper provides a new impetus, but one that has been applied to the question of inflation and growth only scantily. Hansen formally developed a proper threshold regression technique for the estimation and inference, based on a bootstrapping and sample splitting approach. Following Hansen’s seminal methodology, only a few studies have revisited the nonlinear relationship between inflation and economic growth. Khan and Senhadji (2001) were the first to apply Hansen’s methodology for a cross-sectional dataset of developing countries covering the
period 1960 to 1998. They estimated a threshold level of inflation of 11% above which inflation significantly impacts growth. Their main finding is that inflation below this threshold level has no significant effect on growth while inflation rates above the threshold have a significant, negative and robust effect on economic growth. However, more recently, and specifically for the case of Egypt, which is the focus of our study, Abou-Ali and Kheir-El-Din (2009) applied an earlier version of Hansen’s threshold methodology based on Hansen (1996) and used annual data for the period 1982 through 2006, but found no significant threshold level of inflation beyond which inflation would be harmful to growth, a result that contrasts with our study here; but more on that later.

2.2. Inflation and financial depth: theory and empirics

If the majority, if not all, of the findings seem to support the existence of a threshold inflation level associated with a non-linear relationship between inflation and economic growth, the next logical question to ask is how, that is by what mechanism, does inflation affect growth and in particular, what gives rise to the threshold effect in this relationship? One answer comes from Azariadis and Smith (1996) and Khan, Senhadji, and Smith (2001) who argue that the real effects of inflation follow from the consequences of inflation for financial development, or financial deepening. These papers provide us with a framework to better understand a possible threshold effect that might exist in the inflation-finance relation. Consider an economy with initially low financial depth as indicated by a low lending-to-GDP ratio. In such an economy, where agents are likely to hold large sums of cash, an increase in the inflation rate induces agents to substitute away from cash into investment in physical and/or human capital, following a Mundell-Tobin effect (see Tobin, 1965). As investment spending increases, real activity is stimulated.

Now consider the opposite case, i.e., an economy with ‘high’ financial depth as indicated by high loans-to-GDP ratio. In such an economy, savings deposited in banks are initially high. An increase in the inflation rate will then act as a tax on real balances, reducing real rates of return. In turn, this would reduce financial intermediaries’ incentive to lend, raising the cost of borrowing as the supply of funds for investments in physical and/or human capital is reduced. Eventually this will lead to a lower rate of economic growth. While it is well known that inflation may increase future price uncertainty and thus retard investments (cf. Sahin, 2013, for the case of Turkey) it would stand to reason that such uncertainty may be more limited when inflation is low than when it is high. Thus, the overall net positive effect of low inflation on investments may still hold, whereas in the case of high inflation the two effects reinforce each other. Ultimately, empirics will have to settle the question.

What is the evidence on the role of inflation in bank lending and credit? Boyd, Levine, and Smith (2000) reported a negative correlation between inflation and bank lending to private sector in a cross-country sample. Khan, Senhadji, and Smith (2001) and Khan (2002) provide empirical results that support a nonlinear relation between inflation and financial depth, explaining their findings through the effect of credit rationing on financial development. Specifically, the authors argue that in a model that generates a Mundell-Tobin effect, absent any credit rationing, an increase in the inflation rate causes agents to substitute away from cash and into investment. This leads to a positive effect on real activity and growth rates. However, in the presence of credit frictions, these authors argue that higher inflation may lead to less extension of bank credit and therefore to lower investment and slower growth.
2.3. Financial depth and growth: theory and empirics

The theoretical foundation of the relationship between financial depth and economic growth can be traced back to the work of Shaw (1973). Shaw’s argument is basically that government regulations in the banking system such as interest rate ceilings, and reserve requirement ratios, affect financial development and can ultimately affect growth. More recently, Levine (2004, p. 5) argues that financial intermediaries are essential in offsetting credit market imperfections and frictions. Specifically, financial intermediaries offset these frictions through improvements in the provision of ex-ante information about potential investments, monitoring of investments and corporate control, diversification and management of risk, as well as mobilization of savings. In sum, financial depth facilitates the allocation of resources over space and time, influencing savings and investment decisions and hence economic growth.

A comprehensive review of the empirical work on the relationship between financial development and growth is given by Levine (1997, 2004). King and Levine (1993) in a cross-sectional study of 80 countries for the 1960–1989 period show that financial development has predictive power for future growth and they interpret this finding as evidence of a causal relationship that runs from financial development to growth. Khan and Senhadji (2000) acknowledge that financial development has a positive impact on economic growth, but they present evidence that the size of the effect may vary with different measures of financial development, different estimation methods, data frequency, and the functional form of the relationship.5

2.4. Is there a link?

Andres, Hernando, and Lopez-Salido (1999, p. 2) pointed out that ‘these strands of the empirical literature have lived separate lives’. In another paper, Khan (2002) uses the above arguments to suggest that the nonlinear relation between inflation and growth results from the threshold role of financial deepening. Repeating Khan and Senhadji’s (2001) threshold estimation approach, cited earlier – this time as applied to inflation and financial deepening – Khan (2002) then shows a threshold inflation rate of 3–6% in its effect on financial deepening. Combining these results, Khan (2002) as well as Khan, Senhadji, and Smith (2001) then conclude that financial markets are an important channel through which inflation can nonlinearly affect economic growth. However, despite their important contribution in presenting a first attempt at documenting such a link, both papers have a key shortcoming in that a proper inference is hard to establish in a framework where two separate threshold regressions are estimated, as in these papers.

This paper builds on these efforts and rectifies their shortcomings. First we establish a nonlinear relation between inflation and economic growth. Next, we establish that there exists a threshold inflation effect below which inflation contributes to growth and above which it detracts from growth. We then establish the existence of a threshold level of financial depth in the inflation-growth nexus. Finally, we are able to link the financial depth threshold to the inflation threshold by empirically examining the linkage between performance of the economy above and below the inflation threshold to the performance of the economy above and below the threshold value of financial depth. Thus, we are able to show that the nonlinear relationship between inflation and economic growth is driven by, and depends on, the level of financial development in a country.
3. Determinants of economic growth in Egypt

3.1. A first look at the data

Our data cover a sample period from 1981 through 2009 for Egypt. This is somewhat longer than the period used in Abou-Ali and Kheir-El-Din (2009), but the focus on the same country, Egypt, allows easier comparison of the results. The data source is the World Development Indicators (WDI) online database. We now examine our main variables of interest, namely the growth rate of real GDP, the inflation rate, and financial depth. The GDP growth rate, according to WDI, is defined as the annual percentage growth rate of GDP at market prices based on constant local currency. The inflation rate is measured by the annual percentage change in the consumer price index. Financial depth is defined as credit to the private sector as a percentage of GDP. Summary descriptive statistics for these variables are provided in Table 1.

Figure 1 is a scatter plot of the relationship between real GDP growth and the inflation rate in Egypt over the period of study. We can see that the relationship is slightly positive for low levels of inflation, but becomes negative for higher rates of inflation. Fitting a line according to the LOWESS smoothing method clearly shows a nonlinear relationship between both variables (see Cleveland, 1979; Cleveland & Devlin, 1988).

Interestingly, although this extends the data in Abou-Ali and Kheir-El-Din’s paper, in fact it has the exact same minimum and maximum values for both variables as in their paper (Abou-Ali & Kheir-El-Din, 2009, p. 63) (although average and standard deviation have slightly changed). Inflation rates over the whole period clearly show sharp fluctuations around an average annual rate of 11.4% with a fairly large standard deviation of 6.38%. GDP growth, on the other hand, does not show similar volatility. Altogether, however, although Figure 1 provides an overall picture of the relationship between inflation and growth, it does not tell us whether there are other variables that may influence or even give rise to the observed relationship. We examine this issue in depth presently.

3.2. Baseline growth regressions

The standard cross-section growth regression now includes RHS variables such as initial per capita income, education, financial development, trade openness, fiscal policy, exchange rate, and population growth among others (see Barro, 1991; Easterly, 2005, p. 1037). The recommendation that countries pursue good policies in these dimensions was labeled as the ‘Washington Consensus’ by Williamson (1990). The basic regression is as follows:

\[ GDP_{growth_t} = c + \beta_1 \text{inflation}_t + \sum_{i=2}^{K} \beta_i X_{it} + \epsilon_t \]  

(1)

Table 1. Description of inflation and GDP growth (1981–2009).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation rate</td>
<td>11.486</td>
<td>6.384</td>
<td>2.270</td>
<td>23.864</td>
</tr>
<tr>
<td>GDP growth rate</td>
<td>4.873</td>
<td>1.862</td>
<td>1.079</td>
<td>9.907</td>
</tr>
<tr>
<td>Financial Depth</td>
<td>42.437</td>
<td>12.461</td>
<td>26.194</td>
<td>62.103</td>
</tr>
</tbody>
</table>
where $X_i (i = 2, \ldots, K)$ stands for all other regressors. Following Singh and Kalirajan (2003) we then systematically vary the other variables to test the robustness of the inflation coefficient.

3.2.1. Choice of variables

To make the comparison easier we adopt Abou-Ali and Kheir-El-Din’s choice of regressors and consider the following explanatory variables: government consumption expenditures ($GOV$), gross fixed capital formation ($GFCF$), credit to the private sector ($CRPRV$) as a measure of financial development, $^7$ trade of goods and services ($TRADE$) as a measure of openness, all defined as a percentage of GDP. We also include the nominal exchange rate ($EXCH$)$^8$ and the population growth rate ($POP$). All the above variables are represented in log forms.

3.2.2. Stationarity

Before we run any regressions, we need to examine the Stationarity of the data. $^9$ The Augmented Dickey Fuller (ADF) and Elliott, Rothenberg and Stock (ERP) unit root tests were used to establish the stationarity of all the time series variables. It has been argued in the literature that one should use a test proposed by Elliott, Rothenberg and Stock (1996) for maximum power against very persistent alternatives. The results are summarized in Table 2.

All the test results significantly reject the null of non-stationarity for all the variables, with the exception of the population growth rate ($POP$). ($POP$) was found to be I(1), so we drop it from our list of RHS, as it is difficult to interpret the effect of changes in first-differenced population growth rates on the dependent variable. We are now ready to run the regressions.

3.2.3. Estimation results

As a preliminary regression, we estimate equation (1) above by OLS using different RHS variables. Our objective here is to examine the significance, and more importantly the sign of the inflation coefficient. As a first step before we embark on threshold estimation we investigate the possibility of a nonlinear relationship between inflation and growth by

![Image of Figure 1. Inflation and GDP growth rates in Egypt.](link)
simply including both a linear inflation rate \((\text{inflation})\) and a quadratic term \((\text{inflation})^2\) among our set of explanatory variables. As discussed above, theory stipulates that at low levels of inflation the relationship is positive or non-existent, but at higher levels it becomes negative. Therefore, we would expect a positive (perhaps insignificant) coefficient on the \(\text{inflation}\) variable, and a negative significant coefficient on the \((\text{inflation})^2\) variable. We express all the variables in log form to smooth the data, and to enable us to think of the coefficients in terms of elasticities. Our regression equation will now take the following form:

\[
\log(GDP_{growtht}) = c + \beta_1 \log(\text{inflation}_t) + \beta_2 \log(\text{inflation}_t)^2 + \sum_{i=3}^{K} \beta_i \log(X_{it}) + \epsilon_t
\]  

We examine three different specifications of the growth equation (2) above. Model (1) regresses \((GDP_{growth})\) on \((\text{inflation})\), \((\text{inflation})^2\) and a set of basic explanatory variables; namely \((GFCF)\), \((CRPRV)\), and \((TRADE)\). This specification is the most basic as it captures measures of capital accumulation, financial development, and trade openness. Model 2 adds \((GOV)\), and model 3 adds \((EXCH)\).\(^{10}\) Results are reported in Table 3 using Newey-West HAC standard errors and covariance.

Reported results show that the adjusted \(R^2\) varies between 0.31 and 0.45.\(^{11}\) Moreover, we also report the BIC (Schwarz Criterion) model selection criteria. When comparing two or more models with the same dependent variable, the model with the lowest value of BIC is preferred.\(^{12}\) The F-statistic of overall significance of the model is, in all cases, significant at the 5% level. We can also notice that the coefficients on the explanatory variables, in all three models, show the expected signs, and are statistically significant in most cases.

Results show that the estimated \((\text{inflation})\) coefficient is positive and significant, and the \((\text{inflation})^2\) coefficient is negative and significant, supporting our hypothesis of a nonlinear relationship between inflation and GDP growth rate in all three models. The estimated coefficients are fairly robust, as their magnitudes do not change with the addition of more explanatory variables.

A few other comments are in order. Government consumption expenditures \((GOV)\) in models 2 and 3 appear to be negatively correlated with GDP growth. Abou-Ali and Kheir-El-Din (2009) argue that government expenditures in Egypt during the period of study were mainly directed towards paying the salaries of civil service employees and subsidizing basic commodities, which are not productivity enhancing; hence the negative \((GOV)\) coefficient. In fact, Kheir-El-Din and Moursi (2007) report a significant inverse

The negative and significant \((EXCH)\) coefficient in model 3 implies that a 1% increase (depreciation) in the exchange rate would lead to an almost 1% decrease in GDP growth. In a recent study examining the effect of devaluation on output in Egypt, El-Ramly and Abdel-Haleim (2008) find a similar result. They find that the effect of devaluation on output can have a contractionary effect that lasts for as long as four years before the expected positive effect starts to materialize. They further report that exchange rate variations explain as much as 45–68% of the changes in the rate of growth of output in Egypt during the period 1982–2004. Our results here indicate an elasticity of almost one in the relationship between \((EXCH)\) and \((GDP growth)\).

The estimated coefficients for financial development \((CRPRV)\), trade openness \((TRADE)\), and capital accumulation \((GFCF)\) all show the expected signs and are mostly significantly different from zero.

Finally we note that in the following sections, we choose model 3 (in terms of the included regressors), as it reports the highest adjusted \(R^2\), and lowest BIC. Furthermore, it is the model with greatest number of coefficients different from zero.

4. Finding a threshold level of inflation

Results from the previous section showed a significant nonlinear relationship between inflation and the GDP growth rate. However, they neither tell us the point where the relation switches, nor whether there is a possible sample split. We now try to more rigorously test for a certain threshold level of inflation below which inflation has a positive effect on growth, and above which it has an adverse effect on economic growth.

<table>
<thead>
<tr>
<th>Table 3. Estimates of the GDP growth equation.</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: (\log(GDP growth))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanatory Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-9.837***</td>
<td>-10.466***</td>
<td>-8.687***</td>
</tr>
<tr>
<td>(\log(inflation))</td>
<td>2.008**</td>
<td>2.215**</td>
<td>2.068**</td>
</tr>
<tr>
<td>(\log(inflation)^2)</td>
<td>-0.506**</td>
<td>-0.549**</td>
<td>-0.509**</td>
</tr>
<tr>
<td>(\log(GFCF))</td>
<td>1.630***</td>
<td>2.207***</td>
<td>0.692</td>
</tr>
<tr>
<td>(\log(CRPRV))</td>
<td>0.902**</td>
<td>1.146***</td>
<td>2.301***</td>
</tr>
<tr>
<td>(\log(TRADE))</td>
<td>0.312</td>
<td>0.311</td>
<td>1.718***</td>
</tr>
<tr>
<td>(\log(GOV))</td>
<td>-</td>
<td>-0.9107</td>
<td>-3.298***</td>
</tr>
<tr>
<td>(\log(EXCH))</td>
<td>-</td>
<td>-</td>
<td>-0.938***</td>
</tr>
<tr>
<td>F-test</td>
<td>3.617**</td>
<td>3.488**</td>
<td>4.28***</td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.318</td>
<td>0.348</td>
<td>0.45</td>
</tr>
<tr>
<td>BIC</td>
<td>1.29</td>
<td>1.32</td>
<td>1.22</td>
</tr>
<tr>
<td>Number of observations</td>
<td>29</td>
<td>29</td>
<td>29</td>
</tr>
</tbody>
</table>

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%. Estimation uses Newey-West HAC standard errors and covariance.
4.1. Methodology

As discussed, while some evidence suggested a threshold effect in the relationship between inflation and economic growth, application of Hansen (1996) to the case of Egypt failed to reject the null of no threshold even though it did find such a threshold (Abou-Ali & Kheir-El-Din, 2009). Thus, our first task in this paper is to re-examine this evidence using Hansen (2000) instead. Unlike Hansen (1996), Hansen (2000) provides the framework that allows for hypothesis testing. It does so because it is able to produce an empirical distribution of the dummy threshold variable based on bootstrapping and simulation.

Specifically, the relationship between inflation and growth can be described with the following sample-split or threshold regression model:

\[ y_t = \hat{\theta}_1 x_t + e_t \quad q_t \leq \gamma \]  \hspace{1cm} (3)

\[ y_t = \hat{\theta}_2 x_t + e_t \quad q_t > \gamma \]  \hspace{1cm} (4)

where \( y \) measures the GDP growth rate at time \( t \), \( x \) is a set of explanatory variables including inflation, and \( e_t \) is the regression error. The variable \( q \) (which can be an element of \( x \)) is the threshold variable that splits the sample into two regimes, a low inflation and a high inflation regime. The aim is to derive an asymptotic approximation to the distribution of the least squares estimate \( \hat{\gamma} \) of the threshold parameter \( \gamma \), so that we can split the sample into two regimes and separately estimate a regression for each one.

Following Hansen we re-write equations (3) and (4) above as a single equation:

\[ y_t = \theta' x_t + \delta' d_t(\gamma) + e_t \]  \hspace{1cm} (5)

where \( \theta = \theta_2 - \theta_1 \), \( \delta = \theta_1 - \theta_2 \), \( x_t(\gamma) = x_t d_t(\gamma) \), and the dummy variable \( d_t(\gamma) = \{ q_t \leq \gamma \} \). This method allows both endogenizing the search for a threshold as well as testing the statistical significance of the threshold. Expressing the model in matrix notation, define \( n \times 1 \) vectors \( Y \) and \( e \), and the \( n \times m \) matrices \( X \) and \( X' \). Then, we can re-write equation (5) as:

\[ Y = X \theta + X' \delta_n + e \]  \hspace{1cm} (6)

where the regression parameters are \( (\theta, \delta_n, \gamma) \) and the natural estimator is OLS, or MLE when \( e_t \) is iid \( N \sim (0, \sigma^2) \). Hansen (2000) then shows that the threshold estimate \( \hat{\gamma} \) is the one that minimizes the following concentrated sum of squared error function, \( S_n(\gamma) \):

\[ S_n(\gamma) = S_n(\hat{\theta}(\gamma), \hat{\delta}(\gamma), \gamma) = Y'Y - Y'X'Y X X' Y \]  \hspace{1cm} (7)

Specifically, the threshold value can be uniquely defined as:

\[ \hat{\gamma} = \arg \min S_n(\gamma) \]  \hspace{1cm} (8)

Here \( \gamma \in \Gamma_n \) where, \( \Gamma_n \cap \{ q_1, \ldots, q_t \} \).

Once a value for the threshold variable is estimated, we can test for its significance. The null hypothesis is no threshold: \( H_0 : \theta_1 = \theta_2 \). Under the null hypothesis, however, the threshold level of inflation, \( \hat{\gamma} \), will not be identified, so classical tests such as the t-test or
Wald-tests are not applicable (Hansen, 2000). Hence, Hansen suggested a bootstrap method to derive the asymptotic distribution of the following likelihood ratio test using the following test statistic:

\[ LR = \frac{(S_0 - S_1)/\hat{\sigma}^2}{\chi^2_9} \]  

where \( S_0 \) is the residual sum of squares (RSS) under the null \( H_0 \), \( S_1 \) is the RSS under the alternative \( H_1 \), and \( \hat{\sigma}^2 \) is the residual variance under \( H_1 \). Hansen (2000) provides the asymptotic critical values for this statistic.

4.2. Estimation results of the threshold level of inflation

We are now ready to test the existence of a threshold level of inflation. We estimate equation (5) above, using model (3) regressors, and employing time series data for Egypt during the period 1981–2009. Estimation was performed in GAUSS after modifying a code adapted from Hansen (2000). Results are reported in Figure 2, and Table 4.13

Using the \( p \)-values from Hansen (2000), the null hypothesis of no threshold effect is rejected at the 10% significance level. This suggests that there is indeed a sample split based on a threshold level of inflation (see Figure 2, left panel).

Furthermore, Figure 2 (right panel) graphs the normalized likelihood ratio sequence \( LR(\gamma) \) as a function of the inflation threshold. The LS estimate of the threshold level of inflation is the value that minimizes this graph. This occurs at \( \hat{\gamma} = 12.1 \). The 95% critical value of 7.35 (from Hansen, 2000, p. 582) is plotted as the dotted line, so we can read off the asymptotic 95% confidence interval \( \Gamma^* = [12.106 – 15.742] \) from the graph from where \( LR(\gamma) \) crosses the dotted line. These results present evidence for a two-regime specification. We now look at both regimes in detail.

Results in Table 4 re-confirm the nonlinear relationship between inflation and economic growth in Egypt. As previously discussed, theory stipulates that at low levels of
inflation the relationship is positive or non-existent, but at higher levels inflation becomes harmful to growth. Our task here was to empirically estimate this threshold. Results show a positive and significant coefficient on the inflation variable in the low inflation regime, and a negative significant coefficient in the high inflation regime, confirming theory. Other coefficients all show the expected signs.

One should also compare these results with existing studies. As previously mentioned, Sarel (1996) reported a structural break in the relation between inflation and growth at an annual inflation rate of 8%. Christoffersen and Doyle (1998) estimated the threshold level at 13% for transition economies, and Khan and Senhadji (2001) estimated a threshold level of inflation of 11% for developing countries. More relevant to us, Abou-Ali and Kheir-El-Din (2009) reported a threshold inflation level of 16% for Egypt during the 1982–2006 period, although they could not reject the null of no threshold. Our results are, therefore, closely related to previous literature. One possible cause that may drive the difference between our results and theirs may be their reliance on the point estimates used by Hansen in his 1996 article, whereas we have used an updated Hansen methodology which, by developing an empirical distribution of $\hat{\gamma}$, allows for hypothesis testing that Hansen (1996) does not. Another possible cause may be the slightly different (longer) time series that we have used.

In addition, Figure 3 below follows Abou-Ali and Kheir-El-Din (2009) and examines whether there is a structural break in the data or not. In order to do so, we use the cumulative sum (CUSUM) of recursive residuals and their squares (CUSUM2) structural stability tests of Brown, Durbin, and Evans (1975). Results of CUSUM2 confirm the existence of a threshold level of inflation, as it crosses the 95% confidence band (see Figure 3, right panel).

In sum, results indicate that inflation can be detrimental to growth in Egypt starting at 12%. This result, although important in itself, leaves us wondering why such a relation exists. We tackle this issue in the following section.

### Table 4. Threshold estimates of inflation and GDP growth.

<table>
<thead>
<tr>
<th>Regime</th>
<th>Low inflation regime</th>
<th>High inflation regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: log(GDP growth)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanatory variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>$-3.902^{**}$</td>
<td>$-13.342^{***}$</td>
</tr>
<tr>
<td>log(inflation)</td>
<td>$0.489^{**}$</td>
<td>$-2.696^{**}$</td>
</tr>
<tr>
<td>log(GFCF)</td>
<td>$1.282$</td>
<td>$-1.175$</td>
</tr>
<tr>
<td>log(CRPRV)</td>
<td>$2.540^{***}$</td>
<td>$4.057^{**}$</td>
</tr>
<tr>
<td>log(TRADE)</td>
<td>$1.196^{**}$</td>
<td>$3.13^{*}$</td>
</tr>
<tr>
<td>log(GOV)</td>
<td>$-3.74^{***}$</td>
<td>$-5.378$</td>
</tr>
<tr>
<td>log(EXCH)</td>
<td>$-0.786^{**}$</td>
<td>$-1.924$</td>
</tr>
<tr>
<td>Threshold level of Inflation</td>
<td>12.107</td>
<td></td>
</tr>
<tr>
<td>CI (95%)</td>
<td>[12.106, 15.742]</td>
<td></td>
</tr>
<tr>
<td>LR test for no threshold</td>
<td>12.55*</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.083</td>
<td></td>
</tr>
<tr>
<td>Heteroskedasticity test ($p$-value)</td>
<td>0.623</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.692</td>
<td>0.883</td>
</tr>
<tr>
<td>Number of observations</td>
<td>17</td>
<td>12</td>
</tr>
</tbody>
</table>


*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%
5. Explaining the threshold level of inflation

We now turn to a more interesting question. Why is it that there exists a nonlinear relation between inflation and growth in Egypt? What is driving such a relationship? Theoretical analysis has provided various channels through which inflation may positively or negatively affect growth. In this section, we test the hypothesis that the reason behind such a result is that there exists a threshold level of financial development beyond which inflation negatively affects economic growth.

5.1. Estimation results of the threshold level of financial development

Section 2 provided a theoretical framework where inflation’s effect on growth may depend on the level of financial development in a country. To test such a hypothesis, we use Hansen’s (2000) methodology again, but this time we choose financial development as the threshold variable. The aim is to split the sample into two regimes depending on the level of financial depth, and then investigate the inflation coefficient in both regimes.

Specifically, we re-write equation (5) as follows:

$$y_t = \theta' x_t + \delta' x_t(\gamma) + e_t$$

where, as before, $x_t(\gamma) = x_t d_t(\gamma)$, and the dummy variable $d_t(\gamma) = \{q_t \leq \gamma\}$. Now, $q$ is our threshold financial depth variable that is used to split the sample into two regimes, and the least squares estimate $\gamma$ of the threshold parameter $\gamma$ minimizes the concentrated sum of square error function $S_n(\gamma)$ presented by equation (7). Again, we use the bootstrap method to derive the asymptotic distribution of the LR test presented by equation (9).

The results of estimating equation (10) using model (3) regressors, are reported in Figure 4, and Table 5.14

The results suggest that there is a sample split based on a threshold level of financial depth ($CRPRV$) (see Figure 4, left panel). Looking at Figure 4, right panel, the LS estimate of the threshold level of ($CRPRV$) is 33.9. Again, the 95% critical value of 7.35 (from Hansen 2000, p. 582) is plotted as the dotted line, so we can read off the asymptotic 95%
confidence interval $\Gamma^* = [32.15 \text{ – } 34.28]$ from the graph from where $LR(\gamma)$ crosses the dotted line. These results present evidence for a two-regime specification based on a sample split of financial development. We now look at both regimes in detail.

Results reported in Table 5 show an insignificant coefficient on the (inflation) variable in the low financial depth regime, and a negative significant coefficient in the high financial depth regime. Other coefficients all show the expected signs. This finding reconciles with theory, and provides an answer to the question about the factor that drives the nonlinear relationship between inflation and economic growth in Egypt. The following subsection explores this issue further.

Table 5. Threshold estimate of financial depth in the impact of inflation on growth.

<table>
<thead>
<tr>
<th>Regime</th>
<th>Low CRPRV regime</th>
<th>Dependent variable: log(GDP growth)</th>
<th>High CRPRV regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanatory variables</td>
<td>Constant</td>
<td>$-16.225$</td>
<td>$-4.039^{**}$</td>
</tr>
<tr>
<td></td>
<td>log(inflation)</td>
<td>$-0.670$</td>
<td>$-0.312^{***}$</td>
</tr>
<tr>
<td></td>
<td>log(GFCF)</td>
<td>$-3.639$</td>
<td>0.971</td>
</tr>
<tr>
<td></td>
<td>log(TRADE)</td>
<td>$-1.683$</td>
<td>1.966^{***}</td>
</tr>
<tr>
<td></td>
<td>log(GOV)</td>
<td>$-3.299$</td>
<td>$-1.672^{***}$</td>
</tr>
<tr>
<td></td>
<td>log(EXCH)</td>
<td>$-2.428$</td>
<td>$-0.363^*$</td>
</tr>
<tr>
<td>Threshold level of financial depth</td>
<td>33.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI (95%)</td>
<td>[32.15 – 34.28]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR test for no threshold</td>
<td>12.31^{**}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteroskedasticity test (p-value)</td>
<td>0.348</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.668</td>
<td></td>
<td>0.724</td>
</tr>
<tr>
<td>Number of observations</td>
<td>10</td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>


*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%
5.2. Further evidence from a Probit model: are the two thresholds related?

Our results so far indirectly suggest that incremental increases in inflation during periods of time with low financial depth positively contribute to growth, while incremental increases in inflation during high financial depth periods negatively affect economic growth in Egypt.\(^{15}\)

To examine this issue directly we propose the following Probit estimation.

\[
\text{infdummy} = c + \beta_1 \text{CRPRVdummy} + \sum_{i=2}^{K} \beta_i \log(X_{it}) + \epsilon_t \tag{11}
\]

where \((\text{infdummy})\) is a dummy variable that takes the value of one if that year’s inflation rate is above the estimated threshold rate of inflation, and zero otherwise. Similarly, \((\text{CRPRVdummy})\) takes the value of one when the level of financial development is above its estimated threshold level, and zero otherwise. Lastly, \(X_{it}\) is the list of \(k\) explanatory variables that we have used in the previous sections. Results are reported in Table 6. In this table, we also report the results from a logit model using the same specification. As we see from this table, results are very similar to the probit model. On deciding which model to choose, we follow Cameron and Trivedi (2010), and suggest the probit model as the preferable model since it has the higher log pseudolikelihood ratio.

Results show that the \((\text{CRPRVdummy})\) coefficient is positive and statistically significant at the 5% significance level, as expected. This reinforces our earlier claim that there exists a level of financial development that is driving the nonlinear relationship between inflation and economic growth in Egypt.

In conclusion, results from the above sections can now provide a link between the theoretical and empirical literature examining the relations between inflation and growth, inflation and financial depth, and finally financial depth and growth in a single threshold regression.

6. Conclusion and policy implications

Theoretical and empirical literature suggests a nonlinear relationship between inflation and economic growth. Specifically, there is a certain threshold level of inflation below

<table>
<thead>
<tr>
<th>Model</th>
<th>Probit</th>
<th>Logit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: infdummy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanatory variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>11.631</td>
<td>19.021</td>
</tr>
<tr>
<td>CRPRVdummy</td>
<td>2.075**</td>
<td>3.459*</td>
</tr>
<tr>
<td>log(TRADE)</td>
<td>4.061*</td>
<td>6.738*</td>
</tr>
<tr>
<td>log(GOV)</td>
<td>−28.315**</td>
<td>−46.352**</td>
</tr>
<tr>
<td>log(EXCH)</td>
<td>−4.797***</td>
<td>−7.934***</td>
</tr>
<tr>
<td>log(GFCF)</td>
<td>14.599*</td>
<td>23.793</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>−7.9925214</td>
<td>−8.0971793</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>0.599</td>
<td>0.594</td>
</tr>
</tbody>
</table>

*** Significant at the 1% significance level, ** Significant at 5%, * Significant at 10%

$S$: Inflation and financial depth dummy variables are indicator variables of whether or not inflation and financial depth are below or above their respective threshold levels (equaling 1 if above and 0 if below).
which the relation is positive or non-existent, but beyond which inflation significantly harms economic growth. Our objective in this study was to investigate the possible cause of such a relationship as well as to estimate such a threshold for the case of Egyptian data during the period 1981–2009.

Our empirical results indicate that there is indeed a non-linear relationship between inflation and economic growth in Egypt. Specifically, inflation contributes positively to growth until it hits a threshold of 12%, after which it can be detrimental to growth. This threshold falls within the range estimated in other empirical studies covering different country groups over different time periods. We then took the analysis one step further, and asked what is driving such a relationship. Specifically, we showed that a threshold level of domestic credit to the private sector as a percentage of GDP (defined as financial depth) of 33.9% is what creates this sample split leading to the different effects of inflation on growth. This result has narrowed the gap between the three strands of literature; namely the relations between inflation and growth, inflation and financial depth, and finally financial development and growth.

What does this imply then in terms of policymaking? We can think of both monetary and fiscal policies. For one, we could argue that the Central Bank of Egypt (CBE) should target a level of inflation that does not exceed the estimated threshold limit. Abou-Ali and Kheir-El-Din (2009) recommended that Egypt’s inflation target should be kept in line with the inflation rates prevailing in its major trading partners to avoid loss of competitiveness. The CBE should also complement such policy with other tools that help improve on financial intermediation. Improving on the CBE’s Financial Sector Reform Program (FSRP) is crucial in this context. The FSRP, originally launched in 2004, has significantly contributed to the efficiency of Egypt’s financial system with measures such as the privatization and restructuring of large public banks, and the establishment of the private sector credit bureau. Despite the significance of these measures, there is still room for improvement. The IMF’s most recent report on the Egyptian economy (IMF, 2010) has identified a number of such programs including clearing non-performing loans, the resolution of public sector entity debt and further modernizing prudential oversight. The same report has commended the introduction of new legislations and the establishment of the Egyptian Financial Supervisory Authority with the aim of regulating the growing non-bank financial markets and instruments. These financial sector reforms would further facilitate bank credit intermediation, expand investment projects, and ultimately contribute to the process of economic growth in Egypt.

Besides improving financial intermediation, which is implied by our analysis, others have argued that inflation in Egypt may not be considered an entirely monetary phenomenon but have some roots in the fiscal policy world (Abou-Ali and Kheir-El-Din, 2009). For example, effective coordination of both monetary and fiscal policies is thought to be essential in this regard. Our own results do show that government expenditures negatively affect economic growth. It would be inaccurate, of course, to argue that fiscal policymakers should necessarily decrease their spending, but at least they need to re-consider the composition of such expenditure and identify channels of expenditure that are growth or productivity enhancing. Fiscal consolidation measures that would boost revenues and limit expenditures such as rationalizing the consumption of subsidized petroleum products, and revising income and sales tax legislations are encouraged. Furthermore, initiatives such as the Public Private Partnership program aiming to attract private funds for investment in large infrastructure projects should be
designed in such a way as to avoid falling into debt, thus enhancing the soundness of the financial markets.

With respect to technical extensions, a possible future area of research would be to use Hansen and Seo’s (2002) technique to estimate threshold regressions in the context of a co-integration framework for the present inquiry for the case of Egypt.

Acknowledgements
We thank two anonymous referees and the editor for extremely helpful comments. The views expressed in this paper are those of the authors and do not necessarily represent those of the IMF or IMF policy.

Notes
1. A possible future area of research would be to use Hansen and Seo’s (2002) technique to estimate a threshold regression in the context of a co-integration framework for Egypt. This belongs to a separate line of inquiry that we have not pursued in this paper.
2. We are aware of one study in a panel context that considers a different question, namely the role of inflation in the relation between finance and growth (Eggoh, 2012) but we are not aware of any threshold time series methods in this context regardless of which variable is the catalyst and which is causal.
3. The terms financial depth and financial development will be used interchangeably in this study, following Levine (1997, 2004).
4. This earlier version of Hansen’s work does not develop distribution for the threshold parameter. As a result, it is more appropriate for point estimates than for hypothesis testing.
5. If we move from level of financial development to growth of finance with a focus on developed countries we find that researchers are more agnostic: a stimulating recent analysis by Cecchetti and Kharroui (2012) finds that too much growth of finance retards economic growth by drawing resources and talent away from other sectors, a sort of Dutch disease. However, it is found that moderate growth of finance is good for economic growth.
7. The empirical literature largely agrees on using domestic credit to the private sector as a share of GDP (CRPRV) as the indicator of financial development/financial depth (see Khan and Senhadji, 2000, p. 8; Levine, 2004, p. 56).
8. We tried the same regressions with real instead of nominal exchange rates and found a threshold rate of inflation very close to the thresholds found in this paper (11% using real exchange rate instead of 12% using nominal exchange rate, as we shall see below). Those results are available from the authors. However, here we chose to report the results with nominal exchange rates in order to allow for a closer comparison with other papers on Egypt, namely Abou Ali and Kheir El Din (2009) who also used nominal exchange rates.
9. If a variable has a unit root (is non-stationary), then the OLS estimates will be biased downward.
10. Abou-Ali and Kheir-El-Din (2009, p. 69) consider similar specifications to the models presented here, but they do not include the \((INF)^2\) variable. Therefore, results are not directly comparable.
11. We chose to report the adjusted \(R^2\) rather than \(R^2\) because the former penalizes the addition of more explanatory variables.
12. We report BIC since it penalizes larger models more heavily than AIC.
13. Threshold estimates of (inflation) have also been conducted using models 1 and 2. Results (not reported) show quite similar results. Coefficient signs, magnitudes and significance are mostly the same.
14. Threshold estimates of (CRPRV) have also been conducted using models 1 and 2. Results (not reported) show quite similar results. Coefficient signs, magnitudes and significance are mostly the same.
15. Low and high financial depth in this context refer to levels of financial depth that are below and above the estimated threshold level, respectively.

References
Hansen, B. E. (1996). Inference when a nuisance parameter is not identified under the null hypothesis. Econometrica, 64(2), 413–430.


