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Smooth transition regression model relating inflation to economic growth in Tunisia

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Abstract

Since its independence, Tunisia has embarked on monetary and financial sector reforms aimed at boosting economic growth. However, these reforms have not been effective due to inflation pressures in this country. Thus, this paper examines the nature of the relationship between financial development and economic growth between 1965 and 2019, using the non-linear logistic smooth transition regression model and considering inflation as a threshold financial development. The results show the existence of a non-linear abrupt relationship with an inflation threshold equal to 3.63%. Specifically, when inflation is below 3.63%, all variables, including inflation, have a significant and positive impact on economic growth. However, when inflation exceeds the estimated threshold, inflation has a significant and negative impact with an elasticity equal to −0.365. To effectively manage inflation, the Tunisian authorities are encouraged to set and embrace specific inflation targets as a goal. This approach aims to mitigate inflationary pressures and foster a favourable environment for financial development in Tunisia, thereby promoting economic growth. Hence, it becomes imperative to implement such measures that alleviate inflationary pressures and drive economic growth through the facilitation of development finance by the banking sector.

Keywords: Inflation, Economic growth, Smooth transition regression

JEL Classification: C24, E31, E44, O11

1 Introduction

In Tunisia, banks perform an essential function in which they provide more than 90% of financial intermediation and the number of universal banks is relatively high (24 banks), given the size of the country. However, these banks have low profitability and companies are still struggling to access bank financing. As a result, banks retain in their portfolios assets of companies with a low probability of survival, which hinders the reallocation of resources to more productive companies. Between 2010 and 2016, the share of non-performing loans in total loans increased from 12% to 15.4% and even reached 20% in public banks. This is perhaps justified by the weaknesses of bankruptcy procedures, which allow inefficient companies to avoid paying their debts but continue to do business, instead of forcing them to restructure or exit the market, have aggravated the problem (OECD 2018).

Therefore, important steps have been taken to establish a modern banking system, subject to strong supervision and effective competition through the restructuring of state-owned banks, establish a risk-based supervisory system, and set up a risk management system. All these reforms, along with the implementation of the new bankruptcy law in 2016, will help banks take active steps to get rid of their non-performing loans (IMF 2016; OECD 2018).

The banking system remains well-capitalized, but several banks are not meeting regulatory liquidity requirements. The system wide capital adequacy ratio remained stable at 11.7% in December 2018. In addition, nonperforming loans (NPLs) decreased to 13.4% of total loans in December 2018 from 14.2% in September as public banks made progress in reducing their NPL portfolios. On the other hand, the ratio of liquid assets to total assets system wide decreased to 4.5% at the end of 2018, from 5.7% at the end of 2017, and the ratio of liquid assets to short-term liabilities to 75.2%, from 91.7%. As of March 2019, five banks did not meet the minimum liquidity coverage ratio (LCR), which was increased to 100% in January (IMF 2019).

In particular, from 2011 to 2017, the domestic credit provided by banks to the private sector has been steadily increasing, representing, on average, 63% of Tunisia's Gross Domestic Product (GDP), and reaching as high as 69% of GDP in 2017. Despite such a crucial role played by banks to channel funds to the economy, the government did not cease from calling on banks to improve their efficiency (Jelassi and Dalhoumi 2021).

Tunisia's economic performance is weakening due to various internal and external shocks and the short-term forecast of the macroeconomic management of the Tunisian economy during the period 2011–2018 resulted in the decline average economic growth from 4.6% over the period 2001–2010 to 1.5% over the period 2011–2019 and the deterioration of macroeconomic fundamentals (Nabi 2021).

Economic activity in Tunisia has evolved in the recent years under the double effect of an unfavourable international economic situation and a national environment marked by political and security hazards. Consequently, the weakness of production and export activities was compounded by the worsening of macroeconomic imbalances, notably those linked to the increase in prices and the inflation rate (Ghandri et al. 2021).

A well-functioning financial system is considered one of the main foundations for sustainable economic development (Demirgüç-Kunt 2006). Nevertheless, the relationship between financial development and economic growth has not yet reached a consensus and still represents the most debated issue for several authors. Thus, there are two approaches who describe the relationship between them. Proponents of the first believe that financial development is essential for economic growth (Schumpeter 1912; Goldsmith 1969; McKinnon 1973; Levine 1997) and that finance affects growth by influencing savings, investment and technological innovation (Demirgüç-Kunt 2006). In contrast, advocates of the second approach believe that finance is not the main source of growth (Romer 1986). According to Lucas (1988), the relationship between financial development and economic growth has been overestimated in the literature (Christopoulos and Tsionas 2004).

Recent empirical studies have agreed that financial sector development has a positive impact on economic growth (King and Levine 1993a, 1993b; Beck et al. 2000; Khan and Senhadji 2000; Zhang et al. 2012; Uddin et al. 2013; Samargandi et al. 2014;

Ben Jedidia et al. 2014; Pradhan et al. 2016; Muhammad et al. 2016). However, some authors found that this relationship is negative (Singh 1997; Andersen and Tarp 2003; Narayan and Narayan 2013; Ayadi et al. 2015; Ductor and Grechyna 2015).

Empirical studies have witnessed an explosion in research interest in Finance–Growth relationship with non-linear models. Rousseau and Wachtel (2002), for instance, established an annual inflation threshold of a rate between 13% and 25%, depending on the measure of financial depth chosen, beyond which the positive correlation between finance and growth will disappear. Likewise, Lee and Wong (2005) used a threshold regression model to study whether there was an inflation threshold in Taiwan and Japan between the first quarter of 1965 and the fourth quarter of 2002, and they proved the existence of an inflation threshold that can affect the relationship equal to 7.25% for Taiwan and for Japan at 9.66%. Furthermore, using threshold regression, Njindan and Odhiambo (2017) showed the inflationary threshold range for Ghana between 1964 and 2011 is 10.73–29.83%, whereas for Nigeria, the inflationary threshold range is 10.07–19.25% between 1961 and 2011.

With regard to Tunisia, the non-linear relationship has been examined by several studies. First, in their study, Boujelbène and Helali (2017a) found strong evidence for the existence of a threshold effect between inflation and growth. In addition, Boujelbène and Helali (2017b) examined the threshold effect on the relationship between during the period between January 1993 and November 2012 and proved that inflation promotes economic growth when the threshold is below 3.48% and generates a negative and significant effect above this threshold.

From 1956, the year of independence, until the 1980s, commercial banks, development banks, postal savings banks and insurance companies constituted the majority of the financial sector in Tunisia, while the role and activity of stock markets were limited (Jbili 1997). During this period, this financial system was based on selective credit allocation, regulated interest rates and bonuses for certain priority or strategic sectors, such as agriculture, export activities, SMEs and the energy saving sector (Bahlous and Nabli 2000).

Tunisian banks were under strict control, but the management of fixed interest rates at artificially low levels led to negative and unstable savings results, and sector-specific intermediary financing at favorable rates was unable to generate sufficient savings mobilization to fuel the loans distributed. As a result, real interest rates for creditors remained negative, a manifestation of "financial repression" until 1986, and bank financing, largely based on money creation, and caused an average inflation rate of about 10% during the period 1980–1986. Thus, the financial sector was characterized by rigidities, controls and inefficiencies (Ben Jedidia et al. 2014).

Thus, to remedy the crisis, Tunisia adopted financial liberalization reforms that developed the financial system especially in the late 1980s after the 1986 crisis and in the 1990s through the implementation of the Structural Adjustment Program (SAP) with the abolition of the price control policy, the restriction of public expenditure, financial reforms and innovations aimed at liberalizing the banking sector and the establishment of the stock market in 1994. Despite these reforms, the banking sector remains the most dominant sector in Tunisia and this represents an imbalance for the financial system in Tunisia.

As a result of these reforms, the years 1986–1995 were characterized by low inflation, falling from 8.2% to 4%, while the per capita GDP growth rate grew from −4.5% to 0.38. However, the inflation rate remains at a level comparable to that observed in its European economic partners, recording a remarkable decline from 6.3% in 1995 to 3.1% in 2007. Since 2008, the inflation rate has experienced a remarkable increase reaching 7.5% in 2018, while the GDP per capita growth rate evolves from 5.21% in 2007 to −1.68% in 2011 and 2.5% in 2018 (Helali et al. 2021).

Then, since the January 2011 revolution, the fragile economic situation and high inflation rates led to a weak mobilization of deposits and several Tunisian banks found themselves in a situation of insufficient liquidity and increasing dependence on direct refinancing by the Central Bank of Tunisia (IMF National Report 2015; Helali and Kalai 2015; Helali et al. 2021; Helali 2022) which prompted the CBT to decrease its nominal rate by 100 basis points, from 4.5% to 3.5% with the reduction of the required reserve ratio of commercial banks from 12% to 2% and giving 2.6 billion dollars to commercial banks to boost liquidity (Matta et al. 2019). The aim was to reduce the financial burden on companies, especially those affected by the effects of the political crisis, and to increase the liquidity of financial intermediation.

Following the terrorist attacks in "Bardo" and "Sousse" in 2015, a steady expansion of the CBT's balance sheet was initiated following the acceleration of demand for liquidity and foreign exchange which was met by a substantial increase in the central bank's refinancing operations. This balance sheet expansion stimulated broad money growth and ultimately inflation, which peaked in June 2018 at a rate of 7.7% (End et al. 2020).

In April 2017, the CBT made its first nominal rate increase, but its increasing liquidity injections continued the objective of easing credit supply. Indeed, the negative real interest rates, the increasing volume of refinancing and the collateral policy have helped meet the demand for money by economic agents and especially the demand for liquidity and foreign exchange fuelled by depreciation expectations. In 2018, a clear shift in the BCT's monetary and macroprudential policies emerged, and the nominal rate was gradually raised from 5% at the beginning of 2018 to 7.75% in February 2019, dampening credit demand. In addition, macroprudential policy was tightened at the end of 2018 and limited credit supply (End et al. 2020).

The importance of inflation in mediating the impact of financial development on economic growth is gaining traction in the literature (Ehigiamusoe et al. 2019; Ehigiamusoe and Samsurijan 2021). This is because, while improved financial sector may drive Economic Growth, higher levels of inflation weaken potency of the financial sector in efficiently mobilizing resources by lowering agents' purchasing power and savings (Ehigiamusoe et al. 2020). However, English (1999) argues that increase in inflation leads to higher interest rate on deposits, while purchasing power is weakened thereby causing households to shift from purchasing of goods and services to saving with the banks. This stimulates capital accumulation for the financial institutions making more credit available to meet the needs of the deficit unit (Ehigiamusoe et al. 2020).

Financial development in Tunisia is characterized by a dominance of banks and has an effect that influences the Tunisian economy. However, despite its efforts to deepen its financial sector, Tunisia has not achieved the expected level of economic development due to the problem of inflation. Thus, the main contribution of this article is to

investigate whether the Financial Development-Economic Growth link varies according to the evolution of the inflation rate in Tunisia. This country has implemented financial liberalization policies and at the same time experienced episodes of high inflation. This study seeks to determine the extent to which inflation is responsible for Tunisia's failure to achieve the expected level of economic development, despite its financial development efforts. Indeed, we study how variations in inflation can affect the relationship between financial development and economic growth. Moreover, the relationship between financial development and economic growth in the Tunisian case is still limited and previous ones have studied this relationship through linear models and found a positive relationship between them (Ghali 1999; Boulila and Trabelsi 2004; Ben Jedidia et al. 2014) and only Helali et al. (2021) studied this relationship through a Threshold Regression (TR) model.

To examine the impact of inflation on the connection between financial development and economic growth, the non-linear Smooth Transition Regression (STR) model will be utilized for our analysis. This model enables us to analyse the relationship by dividing it into two distinct regimes. In addition, this study provides a review of recent theoretical and empirical contributions to the literature of the relationship between finance and economic growth. Similarly, this study will contribute to the literature by introducing time series data that capture recent liberalization and control policies of the Tunisian financial sector during periods of low and high inflation. In addition, it attempts to answer the following question: in what perspectives the asymmetric effect of the inflation level can contribute to the progress of the relationship between financial development and economic Growth in Tunisia?

Consequently, the aim of this article is to analyse the non-linearity relationship between financial development (measured by inflation rate) and economic growth (measured by GDP growth) using the non-linear STR model of Teräsvirta and Anderson (1992) and Teräsvirta (1994), and an important annual time series ($T=55$) data from 1965 to 2019. Smooth transition regression (STR) model is a type of nonlinear regression model that allows for the relationship between the dependent and independent variables to change smoothly over time in contrast to traditional linear regression models which assume that the relationship between the variables is constant.

Therefore, the subsequent sections of this article are structured as follows: Sect. 2 provides a literature review that elucidates the non-linear relationship between inflation and growth. Section 3 outlines the methodology employed for estimating the STR model. In Sect. 4, the obtained results from this model are presented and discussed. Finally, the last section encompasses the conclusions and policy implications.

2 Literature review and hypothesis development

A prosperous economy depends on the development of its financial sector, through the creation and expansion of institutions, instruments, and markets that support massive investments and growth to reduce poverty. Indeed, through financial development, it is possible to obtain better information about possible profitable investments and to promote optimal capital allocation. In other words, financial institutions reduce the costs of acquiring information and ensure efficient execution of contracts and transactions. In addition, better access to finance promotes the productivity of the dynamic system by

stimulating structural change through innovation and welfare gains for the economy as a whole.

The concept of financial development is generally defined as strengthening the quality of five key financial functions: (1) collecting and processing information on potential investments and allocating capital based on these assessments; (2) monitoring individuals and firms and exercising corporate governance after capital allocation; (3) facilitating exchange, diversification, and risk management; (4) mobilizing and pooling savings; and (5) facilitating trade in goods, services, and financial instruments (Čihák et al. 2013). Similarly, a financial system development can be defined as the development of the size, efficiency, and stability of financial markets along with increased access to financial markets that can have multiple benefits on the economy (Guru and Yadav 2019).

In theory, classical economic thought considers economic development as a succession of innovations, where the interactions between innovations in the financial and real sectors represent the driving force for rapid economic growth. According to Schumpeter (1912), the banking system plays an important role in economic growth by supporting innovation and creativity and thus enhancing future growth through the identification and financing of productive investments. Therefore, the banking system facilitates wealth creation, trade and capital formation (Ahmed 2006).

For their part, Keynes (1936) and Robinson (1952) argues that where enterprise leads, finance simply follows, meaning that it is economic development that generates demand for financial services, not the other way around. Thus, when incomes increase at a sufficient rate, the demand for financial assets, moreover, increases at an appropriate rate (Gurley and Shaw 1955).

In contrast to these authors, Patrick (1966) contends that the development of a well-functioning financial sector can promote economic growth. Thus, the creation of financial markets and their services well in advance of their demand will push the non-financial (real) sector on a growth path through the transfer of scarce resources from surplus to deficit spending units based on the highest rates of return on investment. In addition, Patrick (1966) offers a variant view which is that is the demand-following. This argument assert that an expanding economy will culminate into a high demand for the services of the financial sector, and thus a developed financial sector is a corollary of the demands of the growing real sector of the economy (Adu et al. 2013).

Contrarily to Schumpeter (1912) which claimed that exists a financial development when it exists a sequence of innovations in the financial system, Hicks (1969) had opined that financial development can influence economic growth via capital accumulation and argued that the main ingredient of industrialization is capital market liquidity instead of technological innovations. According to him, liquidity transformation diverts savings into capital market in the form of purchasing financial assets, such as stocks and demand deposits, where capital market further converts it into the long-term capital investment and hence, industrialization takes place, which stimulates economic growth. This indicates that finance leads to economic growth and hence supports the supply-side hypothesis.

In the beginning of 70's, Mckinnon (1973) and Shaw (1973) examined the effects of government intervention on the development of the financial system. Their main proposition is that government restrictions on the banking system, such as interest

rate ceilings, high reserve requirements, and direct credit programs, have negative effects on the development of the financial sector and, consequently, reduce economic growth (Ghali 1999).

These authors claimed that financial liberalization policies would increase savings which consequently spurs investment and induces economic growth. They argued that higher interest rates brought about by liberalization leads to a more efficient allocation of resources, higher level of investment and economic growth. The focus of liberalization has been to replace the severely constrained "command and control" system with a relatively liberalized regime with prices reflecting economic costs, along with a greater reliance on the private sector as the engine of growth (Bhaduri 2005).

The endogenous growth literature reached similar conclusions and that by explicitly modelling the services provided by financial intermediaries, such as risk-sharing and liquidity provision. This literature suggests that financial intermediation has a positive effect on steady-state growth (Greenwood and Jovanovic 1990; Bencivenga and Smith 1991) and that government intervention in the financial system has a negative effect on the growth rate (King and Levine 1993b).

However, Lucas (1988) and Stern (1989) suggest that there is no relationship between financial system development and economic growth. According to Lucas (1988), finance is an "overstressed" determinant of economic growth. Therefore, any strategies aimed at promoting financial system development would be a waste of resources, as it diverts attention from more relevant policies, such as labor and productivity improvement programs, implementation of pro-investment tax reforms, encouragement of exports; amongst others (Puatwoe and Piabuo 2017).

Literature widely shows that financial development, through appropriate financial systems, facilitates capital accumulation and increases the availability of credit while generating growth. According to Levine (1997), capital accumulation and technological innovation are the elements that link financial development and growth. The distribution of credit through the financial system provides a channel between the financial and real sectors that can be used to finance working capital needs and fixed capital investments. The first channel is used to increase output, while the second improves productivity in the real sector (Das and Guha-Khasnobis 2008).

This implies that higher capital accumulation drives investment and savings, which in turn enhances the size and intensity of economic activities when real growth occurs (Nyasha and Odhiambo 2017). Furthermore, a well-developed and technologically solid financial system enables efficient mobilization and allocation of capital, reduces information asymmetry and transaction costs, minimizes risk, and provides funds for private investment while driving growth (Solow 1960; Bencivenga and Smith 1991). Thus, financial development has a consequential influence on economic growth, and the level of influence depends on the efficiency of the development of the underlying financial system.

The debate on the non-linearity of the relationship between financial development and economic growth has been important since the beginning of 2000s and many authors analyse this relationship by certain economic factors like inflation. For instance, Rousseau and Wachtel (2002) established an annual inflation threshold of a

rate between 13% and 25%, depending on the measure of the financial depth chosen, beyond which the positive correlation between finance and growth will disappear.

Likewise, Lee and Wong (2005) used a threshold regression model to study whether there was a threshold inflation effect between them in Taiwan and Japan between the first quarter of 1965 and the fourth quarter of 2002. They showed that there is an inflation threshold that can affect the relationship between them estimated for Taiwan at 7.25% and for Japan at 9.66%. They explained this threshold by the costly flow of information on investment projects which has caused high volatility of returns on investment and consequently impedes economic growth.

In the same vein, Huang et al. (2010), using Levine et al. (2000), investigated whether the Finance–Growth relationship was actually affected by a threshold level of inflation between 7.31% and 7.69%, and whether the impact becomes positive if inflation is below this threshold but becomes negative or insignificant when it exceeds this threshold.

Furthermore, Mehrara et al. (2012), who used nonlinear regressions and the Logistic Smooth Transition model, found strong evidence that the Finance–Growth relationship varies with the rate of inflation in Iran. In addition, they claim that the threshold of the inflation rate parameter is 10.4% and that when the Iranian economy is characterized by a low-rate inflation regime, the effect of financial development on economic growth has been constructive and positive but turns negative at a high inflation rate regime.

In the African context, Raheem and Oyinlola (2015) tested the nonlinear relationship between inflation and growth through financial development in Nigeria, Ghana and Ivory Coast during the period 1970–2010 using TR model. They found that the threshold value of inflation which could ensure a positive association in the Finance–Growth link is between 5% and 10% per year for Ghana, and 15% per year for Ivory Coast and Nigeria. However, above these thresholds, the inflation rate would have adverse effects on the process of economic growth through the activities of financial markets.

Similarly, Njindan and Odhiambo (2017) empirically evaluated the role of inflationary threshold effects on the Finance–Growth relationship for Ghana between 1964 and 2011 and Nigeria between 1961 and 2011 using threshold regression. The authors showed the inflationary threshold range for Ghana is 10.73–29.83%, and for Nigeria, the inflationary threshold range is 10.07–19.25%. They, furthermore, found that financial development had positive and significant effect on economic growth during low and moderate inflationary regimes and insignificant effect on growth during high inflationary regimes, for both countries.

In addition, Ibrahim et al. (2022) examine the effect of inflation in mediating the link between financial development and economic growth based on panel data from 36 sub-Saharan African countries over the period 1996–2016 using Hansen (2000) approach. Their findings show that the inflation thresholds at which the impact of financial development on economic growth switches sign are 7.65% and 6.76%. In particular, financial development stimulates economic growth when inflation rates are low. However, above the estimated thresholds, the impact becomes insignificant, indicating that higher inflation does not support the effect of financial development on growth.

Using a three-regime threshold autoregressive distributed lags (TARDL) model, Shahbaz et al. (2022) examines the asymmetric effect of financial development on economic growth in top 10 financially developed countries between 1971 and 2016. Through

their empirical analysis, the researchers uncover evidence of threshold asymmetric cointegration among the variables. Specifically, in the upper regime, financial development positively impacts economic growth in Singapore but negatively affects economic growth in Finland. In the middle regime, financial development contributes to economic growth in Australia and Singapore. However, in the lower regime, financial development impedes economic growth in the US, Malaysia, and Singapore.

Very recently, Bandura (2022) employs a non-dynamic threshold approach to investigate the influence of inflation on the relationship between finance and economic growth in 23 Sub-Saharan African countries. The study utilizes a data set spanning the years 1982 to 2016, averaged over 5-year periods. The findings reveal a notable inflation threshold of 31%, beyond which the impact of financial development on economic growth transitions from positive to negative. In addition, when financial development is measured by private credit from deposit money banks and other financial institutions as a percentage of GDP, a lower inflation threshold of 13% is identified. Interestingly, beyond this threshold, financial development exhibits an even more pronounced positive effect on economic growth. The author maintains the stance that the inverse relationship between financial development and growth only emerges at significantly higher inflation levels, surpassing 31%. Conversely, below this threshold, a robust positive relationship between finance and growth is observed.

In the case of Asian countries, Tung et al. (2015) investigated the threshold effect of the relationship between inflation and growth in their study for Vietnam as an economy in transition covering the period 1986 to 2013 and using three econometric methods (OLS, 2SLS, GMM). They observed that if the inflation rate is above 7%, the negative impact on economic growth becomes apparent.

Moreover, Dinh (2015) used panel smooth transition regression (PSTR) model for five Asian countries from 1980 to 2011 to test Inflation-Growth nonlinearity. Their results revealed an inflation threshold equal to 7.84%. Furthermore, when the inflation rate is below this threshold, there is a statistically significant positive correlation between them, and when it is below this threshold, and inflation began to hump economic growth.

As well, Aydin et al. (2016) estimated the inflation impact on economic growth for Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan and Turkmenistan during the transition period through dynamic analysis of threshold-based panel data. Their results show that there is a non-linear relationship between them with an inflation threshold equal to 7.97%. In addition, if the inflation rates are above the estimated threshold, there is a negative effect on economic growth and the impact will be positive if this variable is below the estimated threshold.

In Tunisia's case, Boujelbène and Helali (2017a) analysed the non-linear effect of inflationary effects in Tunisia during the period between January 1994 and June 2011 using Threshold Regression approach. Their empirical results present strong evidence for the existence of a threshold effect. This clearly shows the possibility of a non-stationary and non-linear monthly inflation rate in Tunisia in this period. In addition, the Perron (1997) test proves the existence of a unit root, and the unit root test Threshold Regression can be considered significant.

In addition, Boujelbène and Helali (2017b) examined the threshold effect in the relationship between inflation and economic growth in Tunisia during the period

between January 1993 and November 2012. The empirical results of the threshold regression model show that inflation promotes economic growth when the threshold is below 3.48% and generates a negative and significant correlation between them above this threshold.

In a recent study, Ben Jedidia et al. (2019) studied the non-linear effect of trade openness on economic growth in Tunisia over the period from the first quarter of 1975 to the fourth quarter of 2015. Empirical results show that as long as the change in trade openness does not exceed the threshold, there is a statistically significant negative relationship between increasing trade openness and increasing consumer price inflation (CPI).

To illustrate the theoretical tripartite nexus among inflation, financial development and Economic Growth, Hung (2003) developed a theoretical model that allows the existence of informational imperfections in the financial sector due to adverse selection and expensive state financial intermediation costs and show the existence of multiple equilibria characterizing (i) low inflation and (ii) high inflation. More specifically, financial development spurs economic growth when inflation is low and for countries with relatively high inflation, Financial Development raises the equilibrium rate of inflation, which lowers Economic Growth.

Moreover, the foregoing theoretical studies underscore the significance of inflation in shaping the effect of Financial Development on Economic Growth. Indeed, high inflation largely distorts efficient resource allocation, including the delay in the execution of investment projects and lengthening contract periods (Huang et al. 2010).

Measuring financial development using the inflation rate and economic growth using GDP growth is a reasonable approach, as inflation rate is often used as a proxy for financial development, and GDP growth is a widely accepted indicator of economic growth. Specifically, the study considers the possibility of unbridled inflation impeding the efficient functions of financial system and changing how improved Financial Development spurs Economic Growth.

In a recent study, Helali et al. (2021) used a threshold regression model to test the nonlinear relationship between economic growth and financial development in Tunisia from the first month of 1982 to the twelfth month of 2018, and used inflation as the threshold variable. Their findings show strong evidence for the threshold effect equal to 4.89%, which altered the impact of financial deepening on Tunisia's economic growth. If the inflation rate is less than 4.89%, financial depth will stimulate economic growth. However, this effect decreases as the inflation rate increases.

When analysing the data, it is important to keep in mind that a non-linear relationship between financial development and economic growth may indicate that there are certain thresholds or tipping points at which changes in financial development have a greater impact on economic growth. This can have important implications for policymakers and investors, as it suggests that small changes in financial development may have little effect on economic growth until a certain threshold is reached.

For all these reasons, we try to test the following hypothesis in this article (*H1*): the relationship between inflation and economic growth is mixed in Tunisia. We suggest that there may not be a clear linear relationship between these two variables in Tunisia. This is consistent with the idea that there may be non-linearity or thresholds in the relationship, as discussed earlier.

Testing this hypothesis using the non-linear STR model can help provide more nuanced insights into the relationship between inflation and economic growth in Tunisia. In addition, if the hypothesis is supported by the data, it may suggest that policymakers and investors should consider a more nuanced approach to managing inflation and promoting economic growth in Tunisia.

3 Empirical methodology

3.1 Model and data

The aim of this article is to estimate the non-linear effect of inflation on the Finance–Growth relationship in Tunisia using the Smooth Transition Regression (STR) model by annual time series data from 1965 to 2019. In the literature, the variable that can be used to measure the effect of macroeconomic variables on the economic activity of a country is the GDP growth rate (GDPG). Based on this reasoning, this variable will be incorporated as the dependent variable in our model. Smooth transition regression (STR) models have several advantages over competing structural break and nonlinear models. First, this model allows the application of linearity tests and modelling the process of regime switching without requiring a prior non-linear functional form. Second, STR models are theoretically more appealing over simple threshold and Markov regime switching models, which impose an abrupt change in the coefficients. Third, it provides a good framework to study possible non-linearity in the interrelationship between the inflation rate and output, since it allows an economic intuition for the nonlinear dynamic identifying why and when inflation sensitivity changes toward output fluctuations (Kobbi and Gabsi 2017).

Then, to quantify the correlation between economic growth and financial development, drawing upon the works of Boujelbène and Helali (2017b), Ben Jedidia et al. (2019), and Helali et al. (2021), we adopt the following specification:

$$\mathrm{GDPG}_t = \beta_0 + \beta_1 \mathrm{ACT}_t + \beta_2 \mathrm{INV}_t + \beta_3 \mathrm{INF}_t + \beta_4 \mathrm{Credit}_t + \beta_5 \mathrm{Trade}_t + \varepsilon_t \quad (1)$$

where GDPG represents GDP growth rate, ACT represents the activity rate which measures the entire working population in relation to the size of the working-age population, INV represents the gross fixed capital formation as a percentage of GDP, INF describes the inflation rate which reflects the degree of uncertainty of an economy, Credit represents the credit ratio of the monetary sector to the private sector as a percentage of GDP, Trade represents the trade openness ratio measured by the sum of imports and exports divided by GDP, and ε_t is a random variable assumed as in the usual fashion to be serially uncorrelated with zero mean and constant variance. The parameters of the model measure the sensitivity of the variables to the economic growth. We summarize all these variables in Table 1.

3.2 Non-linear model specification

Before using the STR model to estimate Eq. 1, it is mandatory to know the threshold parameter value in the series. Then, if the threshold is known, the STR model estimate is easy to obtain and can be estimated by the ordinary least squares (OLS) method. On the other hand, if the threshold is unknown, other parameters must be used for the estimation.

Table 1 Variables definition

Variables	Definition	Source
GDPG	Gross Domestic Product Growth (Annual %)	WDI
ACT	The proportion of the population ages 15 and older that is economically active	WDI
INV	Gross fixed capital formation (% of GDP)	WDI
INF	Inflation rate (% of Consumer Price Index)	WDI
Credit	Monetary sector credit to the private sector (% of GDP)	WDI
Trade	Sum of exports and imports of goods and services (% of GDP)	WDI

Indeed, Chan and Tong (1986) generalized the abrupt transition threshold models by allowing the transition between regimes to be smooth and evolve STR processes. These models describe outer regimes between which the transition is assumed to be smooth and a continuum of intermediate states between these regimes. The main contribution of these processes compared to linear models is that they do not restrict the dynamics of these regimes. The statistical properties of the STR processes have been essentially studied by Teräsvirta and Anderson (1992) and Teräsvirta (1994).

Therefore, the estimation of the STR models is done with a transition function $G(q_t, \gamma, c)$, and therefore, Eq. 1 is formulated as follows:

$$y_t = \beta_1' z_t + \beta_1' z_t G(q_t, y, c) + \varepsilon_t \text{ which } \varepsilon_t \to N\left(0, \sigma^2\right) \tag{2}$$

where $z_t = (w_t\prime, x_t\prime)$ is an $((m+1)\times 1)$ vector of explanatory variables with $w_t\prime = \left(1, y_{t-1}, ..., y_{t-p}\right)$ and $x_t\prime = (x_{1t}, ..., x_{kt})$.

In fact, the transition function $G(q_t, \gamma, c)$ is assumed to be either a logistic one and can be written as follows:

$$G(q_t, \gamma, c) = (1 + \exp(-\gamma(q_t - c))^{-1} \text{ which } \gamma > 0. \tag{3}$$

Alternatively, it can be written as an exponential function as follows:

$$G(q_t, \gamma, c) = (1 - \exp\left(-\gamma(q_t - c)^2\right) \text{ which } \gamma > 0 \tag{4}$$

where γ describes the degree of smoothing in the change of the value of the logistic function and c represents the value of the threshold variable.

The STR model can be seen as a regime change model which describes two regimes, associated with the extreme values of the transition function, $G(q_t, \gamma, c) = 0$ and $G(q_t, \gamma, c) = 1$ or the smooth transition from one regime to another.

In that context, Teräsvirta (1994) suggested approximating the logistic function (Eq. 3) in (Eq. 2) by a third-order Taylor expansion around the null hypothesis $\gamma = 0$. Assuming that the transition variable q_t is an element in z_t and let $z_t = \left(1, \widetilde{z}_t\prime\right)\prime$, where $\widetilde{z}_t\prime$ is an $(m \times 1)$. Therefore, Taylor approximation yields the following auxiliary regression:

$$y_t = \alpha_0' z_t + \sum_{k=1}^{3} \alpha_j' \widetilde{z}_t' q_t^k + \varepsilon_t^* \tag{5}$$

where $\varepsilon_t^* = \varepsilon_t + R_3(\gamma, c, q_t)\beta_1{}'z_t$, with $R_3(\gamma, c, q_t)$ the residual of Taylor expansion, and the null hypothesis of linearity is noted by $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = 0$, where α_1, α_2 and α_3 are the three order coefficients of the Taylor expansion vector $\alpha_j{}'$ in Eq. 5.

The F-versions of the Lagrange Multiplier (LM) statistic are employed in this context, and they follow an approximate F-distribution with degrees of freedom of $3m$ and $T - 4m - 1$ under the null hypothesis (H_0). When the null hypothesis of linearity is rejected, it indicates that a linear relationship does not adequately capture the data. In such cases, it becomes necessary to determine the appropriate functional form, whether it should be logistic or exponential. Teräsvirta (1994) outlines a method for selecting the suitable transition function by testing a series of nested null hypotheses in the following manner:

$$\begin{cases} H_{04}{:}\alpha_3 = 0 \\ H_{03}{:}\alpha_2 = 0/\alpha_3 = 0 \\ H_{02}{:}\alpha_1 = 0/\alpha_2 = \alpha_3 = 0 \end{cases} \tag{6}$$

The decision rule is as follows: if the test results in the most significant rejection of the null hypothesis H_{03} (i.e., the smallest p value), then the choice is to select the exponential form. Conversely, if the test does not yield the strongest rejection of H_{03}, the preference is given to the logistic specification.

The following steps will then be covered in this article. In the beginning, the key components of this model, such as the GDP growth rate and inflation, will be statistically and graphically analysed as well as the interpretation of the unit root test of Perron (1997) and the Cointegration test of Gregory and Hansen (1996). The linearity test of the model will then be used. There is at least one threshold in the model if the probability is less than 5%, so the relationship between inflation and economic growth is non-linear. Therefore, the STR model's results can be used and examined. Finally, diagnostic tests will be used, such as no remaining non-linearity, constancy of parameters, the heteroscedasticity, serial correlation and normality as well as the representation and the analysis of the model's transition function.

4 Estimates and interpretation of empirical results

4.1 Variable description

We begin our empirical analysis, with the descriptive and the graphic analysis of variables. With reference to Table 2 and Fig. 1, the evolution of GDPG represents a series of fluctuations from 1965 to 2019, with a large peak recorded in 1972 and a large trough recorded in 2011 which is linked to the outbreak of the revolution. This variable has an average value of 4.423 with a median and a standard deviation equal to 4.237 and 3.330, respectively. The minimum and the maximum of this variable are −1.917 and 17.742, respectively.

According to Fig. 2, the evolution of the inflation rate is characterized by a series of fluctuations during the period between 1965 and 1975 and then follows an upward trend from 1975 to 1982. After 1982, this series follows a downward trend until 2006 and then returns to an upward trend. This variable has an overall mean of 5.497 with a standard deviation of 3.058 and a median of 6.003. The set of 55 observations ranges from 1.041 to 15.467.

Table 2 Descriptive statistics of variables

Designations	GDPG	ACT	INV	INF	Credit	Trade
Mean	4.423	47.034	24.235	5.497	48.458	79.790
Median	4.237	48.231	23.671	6.003	49.578	85.341
Maximum	17.742	51.750	34.031	15.467	68.595	114.358
Minimum	− 1.917	33.200	17.690	1.041	28.706	31.786
Standard error	3.330	4.063	3.871	3.058	10.235	21.237
Skewness statistic	1.054	− 1.946	0.671	1.394	− 0.038	− 0.798
Kurtosis statistic	3.630	3.723	− 0.201	2.326	− 0.688	0.005
Jarque–Bera (JB) statistic	40.404	66.524	4.223	30.225	1.100	5.847
JB probability	0.000	0.000	0.121	0.000	0.576	0.053
Ljung–Box (LB) statistic (lags $p = 12$)	14.888	118.593	103.119	54.458	384.435	386.543
LB probability	0.247	0.000	0.000	0.000	0.000	0.000

LB refers to Ljung–Box (1978), where p represents the number of delays chosen for the Ljung–Box test. JB refers to Jarque–Bera (1980) normality test. "p" represents the number of lags in the Ljung–Box test

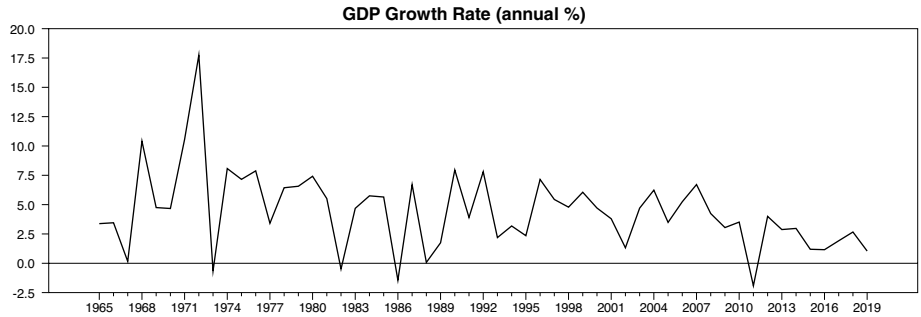

Fig. 1 Evolution of the GDP growth rate 1965–2019

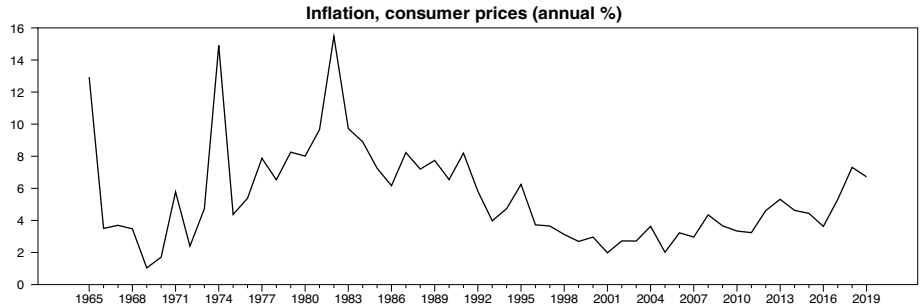

Fig. 2 Evolution of the inflation rate 1965–2019

Then, we examine the stationarity of variables by applying the Perron (1997) unit root test with breaks. The results presented in Table 3 show that all the variables are stationary with breaks in first difference, and therefore, we consider them as integrated of the first order 1 ($I[1]$). This is due to the presence of some significant ruptures, such as the oil shocks of 1973 and 1979, the debt crisis of 1982 and the crisis of 1986, the political transition of 1987, the attacks of 11 September 2001, the Subprime crisis in 2007 and even the Tunisian revolution of 2011. These shocks negatively influenced growth with

Table 3 Unit-root test results

Models	GDPG	ACT	INV	INF	Credit	Trade
Panel A: at level						
A						
Break date	1981	2005	1979	1986	1979	1977
t-Statistic	− 8.318***	− 5.181*	− 5.900**	− 5.036*	− 3.980	− 4.611
B						
Break date	1981	1996	1979	2016	2002	1977
t-Statistic	− 8.376***	− 5.654**	− 6.099**	− 3.535	− 4.138	− 4.623
C						
Break date	2008	2006	1977	2016	1981	1974
t-Statistic	− 2.740	− 3.548	− 4.050	− 3.462	− 3.468	− 3.947
Decision	NS	NS	NS	NS	NS	NS
Panel B: at first difference						
A						
Break date	1971	2004	1981	1975	1985	1980
t-Statistic	− 10.151***	− 7.891***	− 6.021***	− 8.829***	− 7.143***	− 7.185***
B						
Break date	1981	2004	1981	1994	2007	1987
t-Statistic	− 8.881***	− 7.185***	− 6.139**	− 8.647***	− 7.334***	− 7.087***
C						
Break date	1972	1997	1974	1970	2018	1991
t-Statistic	− 8.576***	− 5.484***	− 5.422**	− 9.157***	− 7.281***	− 4.714*
Decision	S	S	S	S	S	S

The critical values at 1%, 5% and 10%, respectively, for model A are (− 5.92), (− 5.23) and (− 4.92), for model B (− 6.32), (− 5.59) and (− 5.29) for the C model (− 5.45), (− 4.83) and (− 4.48)

NS not stationary, *S* stationary

*, ** and *** represent the significance at 10%, 5% and 1%

Table 4 Cointegration test results

Models	Model 2: level change	Model 3: level change with trend	Model 4: regime change
ADF* *t*-statistic	− 9.770	− 10.092	− 10.427
Lag	1	1	1
Date of break	2009	1974	1974

Critical values at 5%: level change model: ADF* *t*-statistic (− 5.56); Level change model with trend: ADF* *t*-statistic (− 5.83); Regime change model: ADF* *t*-statistic (− 6.41)

the recording of negative rates or low positive growth rates (− 0.65% in 1973, − 0.49% in 1982, − 1.44% in 1986, 0.072% in 1988, 1.32% in 2002 and − 1.92% in 2011) with a high inflation rate (14.9% in 1974, 8.25% in 1979, 15.47% in 1982, 6.16% in 1986, 8.25% in 1987, 4.34% in 2008, 4.61% and 5.31% in 2012 and 2013).

4.2 Non-linear estimation and interpretation

After we proved the stationarity of variables at first difference, it is necessary to apply the Gregory and Hansen (1996) cointegration test with breaks to verify the existence of a long-run cointegration relationship between variables. The results presented in Table 4 show that there is at least one long-term cointegration relationship in the

Table 5 Linearity test results

F tests	*F1*	*F2*	*F3*	*F4*	Decision
p values	5.977e−03	6.644e−03	7.755e−03	9.797e−03	LSTR

Table 6 Estimation of inflation threshold values on GDP Growth with LSTR model

Order	Optimal threshold value $\hat{c}$	Transition parameters $\hat{\gamma}$	SSR	AIC	SIC
$m=1$	3.632	41.348	895.545	0.330	0.381

presence of a significant structural break in 1974 and 2009 for each variable in our model related, respectively, to petroleum shock and Subprime crisis which affects negatively the economic activity in Tunisia and raises inflation rates during these two crisis. Therefore, we must take the variables in first difference as suggested by Caner and Hansen (2001). Thus, we consider all variables in terms of growth as follows:

$$\text{Growth\_}y_t = y_t - y_{t-1},$$

where y is the GDPG, ACT, INV, INF, Credit, Trade.

The next step is to test whether or not there is a non-linear relationship between inflation and growth over the study period. Indeed, the linearity test results of Teräsvirta (1994), presented in Table 5, shows the existence of a non-linearity between inflation and growth, where all Fisher probabilities are less than 5%, and therefore, we reject the null hypothesis of linearity. Therefore, we conclude that there is only one threshold in the model. This implies that the relationship between inflation growth and economic growth is non-linear in Tunisia and follow a logistic smooth transition regression (LSTR). Based on this finding, we move on to estimating the inflation threshold value "$\widehat{c}$" and the transition parameter "$\widehat{\gamma}$" by the LSTR model.

So, as observed in Table 6, the values which minimize sum squared residual (SSR), Akaike information criterion (AIC) and Schwarz information criterion (SIC) are reached at the threshold value of inflation which is equal to $\hat{c}=3.632\%$ and that the transition parameter is equal to $\hat{\gamma}=41.348$ which is assumed very large.

Based on the empirical study with the LSTR model, the results, presented in Table 7, show that when inflation is less than 3.63%, all variables have a positive and significant impact on economic growth, and that the increase of ACT, INV, INF, Credit and Trade variables by 1% increases the GDP growth rate by 0.116%, 0.156%, 0.405%, 0.932% and 0.015%, respectively. However, when inflation exceeds the estimated threshold 3.63%, it has a negative and significant impact with an elasticity equal to −0.365 and the other variables ACT, INV, Credit and Trade have a positive and significant impact by elasticities with respect to GDPG equal to 0.871, 0.213, 0.197 and 0.030, respectively. These results reveal the strengthening and clarity of the nonlinearity of the relationship between economic growth and financial development

Table 7 LSTR estimation

Variables	Regime 1: INFLATION ≤ 3.63%		Regime 2: INFLATION > 3.63%	
	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Constant	− 9.717	− 1.674	7.179	1.161
Growth_ACT	0.116	2.438**	0.871	2.495**
Growth_INV	0.156	2.193**	0.213	2.191**
Growth_INF	0.405	1.894*	− 0.365	− 2.691***
Growth_Credit	0.932	1.949*	0.197	2.343**
Growth_Trade	0.015	2.056**	0.030	3.103***
R^2	0.647			
Estimated residual standard deviation	4.668			

***, ** and * represents significance at 1%, 5% and 10%, respectively

Table 8 Diagnostic tests

No remaining non-linearity test				
Transition variable	**F1**	**F2**	**F3**	**F4**
Inflation	0.227	0.340	0.645	0.983
Constancy parameter test				
Transition function hypothesis	***F* test**			***p* value**
H_1	0.631			0.797
H_2	0.520			0.923
Heteroscedasticity, serial correlation and normality tests				
Tests	**Chi-square value**			***p* value**
ARCH LM-test	6.422			0.600
LM-test	0.933			0.501
JB test	14.723			0.000

LM test is the Lagrange Multiplier test for the Breusch–Godfrey serial correlation. ARCH LM-test is the autoregressive conditional heteroscedasticity test. JB test refers to Jarque–Bera normality test

due to the destabilization caused by inflation on the contribution of the financial sector through its main functions to economic growth.

According to the results displayed in Table 8, the tests on the estimated residuals show the absence of the heteroscedasticity and serial autocorrelation problems, the stability of the parameters and the non-normality of the residual. In addition, the non-linearity test, where the various probabilities are greater than 5%, shows the absence of non-linearity in the final model.

Explaining these results, the marginal effect of financial development on economic growth is positive in low level of inflation but negative at high level of inflation. Hence, inflation negatively moderates the impact of finance on growth (Ehigiamusoe et al. 2019). A higher rate of inflation leads to decrease the real value of long-term returns through imposing cost representing in losses that reducing the real value of

cash balances. Furthermore, the real value of bank's individuals' deposits and projects as well as the monetary reserves of the banking system will be reduced because of high inflation and hence reduces financial depth (Khan 2002).

Higher inflation leads to a limitation on the signing of long-term financial contracts, less enthusiasm on the part of intermediary financial institutions to provide long-term financing for physical capital formation, and reduced incentives for lenders and borrowers to sign long-term contracts involving cash balances. In addition, rising inflation increases the cost of maintaining liquid cash balances, which forces individuals and projects to transfer their money into real products and thus reduces the ratio of money supply to GDP, which is a major determinant of banking sector performance (Batayneh et al. 2021).

This implies that high inflation rates are harmful to financial development, while low inflation rates are not. Some empirical studies have reported the detrimental effect of inflation rate on financial development (Huang, et al. 2010; Bittencourt 2011; Ehigiamusoe et al. 2020). Moreover, this study shows that inflation rate has an adverse moderating effect on GDP and that a high inflation rate has both direct and moderating detrimental effects on financial development.

In addition, high, persistent and uncertainty in inflation rate hinders financial development because of its adverse effects on long-term financial contracts and financial intermediaries which distorts effective resource allocation, provides incentives to delay investment projects, and increases unemployment via changes in optimal contract length and the degree of indexation (Huang et al. 2010).

Inflation could affect the link between finance and growth through two ways. First, it could negatively affect the ability of the financial system to accumulate capital, and thus to invest. In particular, when the rate of inflation is sufficiently high, the ability of financial intermediaries to raise capital may decline, and thus the positive effect of financial development on capital accumulation may be reduced and hence growth diminished. Second, higher inflation rates could affect the productivity of capital investments financed by the financial system. Intuitively, in high-inflation environments, even if the level of financing provided for capital investment is not affected, a high rate of inflation may decrease the productivity of accumulated capital, which will negatively influence the link between investment and economic growth (Sargolzaei and Bahrololoum 2019).

As the estimated value of the smoothing parameter is large ($\widehat{\gamma} = 41.348$). We conclude that the transition from the first to the second regime is abrupt, which is confirmed by Fig. 3, describes the estimated transition function of the LSTR model for

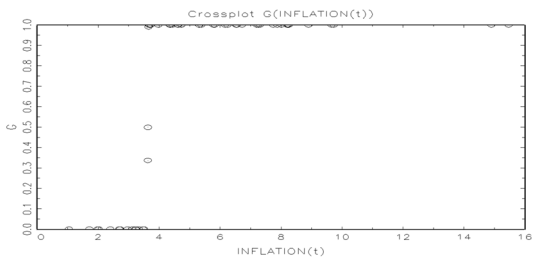

Fig. 3 Estimated transition function of the STR model for inflation

the threshold variable inflation from the weak regime to high one. Based on these results, inflation explains the non-linearity of the relationship between growth and finance. Therefore, our results support the idea of a non-linear relationship between financial development, inflation and economic growth. This evidence is consistent with previous studies such as those by Njindan and Odhiambo (2017), Ben jedidia et al. (2014, 2019) and Helali et al. (2021).

In fact, a low inflation below 3.63% can help register economic growth rates, make the economic activity of the country very attractive toward efficient investments, allow these investments to be allocated to improve the activity of the banking sector in Tunisia, and allow the country to be more open to international trade. However, if inflation exceeds 3.63%, it can have a detrimental effect on the Tunisian economy by leading to a weak contribution of financial activity in Tunisia to economic growth.

The non-linear LSTR estimation shows that credit variable is less contributory to economic growth than linear model, which can be attributed to the excess of money creation and credits demand, besides the fact that these credits are not intended for efficient investments and production that can increase the country's wealth or GDP Growth.

In addition, Azariadis and Smith (1996) asserted that if inflation is very low, frictions in the credit market can be non-binding and that it neither distorts the flow of information nor interferes with the allocation of re—sources and especially economic growth. However, if inflation exceeds a certain threshold, the frictions in the credit market become binding due to the decline in performance, the intensification of credit rationing, and therefore, it hampers the effect of financial development on economic development.

Furthermore, Boyd et al. (2001) found that the rate of inflation interfered with the ability of the financial sector to allocate resources in an efficient manner which causes negative performance of financial markets and consequently the long-term activities of the real sector. Therefore, if the inflation rate increases, the financial sector cannot accomplish the development process as high inflation decreases profits, reduces the incentive to save and ultimately will result in the withdrawal of savings from the financial sector (Hadian and Izadi 2014).

The effect of financial development under inflationary conditions negatively affects the real rate of return on all assets that exacerbate credit market frictions, leading to credit rationing and higher rates of inflation. As a result, the financial sector lends less, the allocation of resources become less efficient, and then the activity of financial intermediaries will decline due to the negative consequences of inflation on investment and on total factor productivity that can reduce economic growth (Farahani et al. 2021).

Furthermore, trade openness has a positive effect but is weaker in the STR model. This effect reinforces the fact that Tunisia's export is an engine of economic development but is insufficient for competitiveness compared to other countries. Rodriguez and Rodrik (1999), Rodrik (2001) and Stiglitz (2004) think that prescribing trade openness as a key to the success of contemporary economies, and especially in developing countries, is a utopia, because most developing countries have not adapted structures that are able to cope with the industries of developed countries and, therefore, cannot benefit from trade openness. In addition, Romer (1987) focuses on the effects of specialization and says that

it is difficult to identify the sources of productivity gains to the extent that the producer cannot appropriate this downstream gain from the diversity of inputs available.

By the early 90s, Tunisia started to implement an economic openness policy that helped it integrate the global economy which was accompanied by a growth of foreign trade. However, since the end of 1990s, the Tunisian exports have declined despite the incentives offered by the state. In this context, Tunisia began to wonders about the reasons for its foreign trade failure such poor Tunisian export performance, negative trade balance, interest from establishing competitiveness poles, etc. (Zayani and Helali 2017).

Taking into account its complete entry in the free trade area of industrial products with Europe in the 1 January 2008 after bringing a successful conclusion of the transition period of 12 years of tariff dismantling, Tunisian exports and imports achieved an evolution of 8.7% and 8.9%, respectively. The 2009 was a particularly difficult year because of the severe subprime crisis impact. However, the Tunisian economy tried to resist through a continuous reformist momentum and timely targeted measures and, mainly, thanks to a highly satisfactory agricultural season (Zayani and Helali 2017).

Since the revolution of 14th January 2011, the Tunisian economy went through a very difficult situation in 2011 during and after 14 January revolution, the repercussions of the war in Libya and the slowdown in the EU demand. This situation deeply affected the economic activity, particularly in the mining, phosphate and derivatives, energy, transport and tourism engendering a negative growth of 23% (BCT 2011).

In the same way, the inflation rate has increased outstandingly and Tunisia's trade openness has, nevertheless, declined due to internal factors such the increase of strikes and sitins, the decline of investment, the reign of insecurity and the high economic uncertainty. Furthermore, the Tunisian dinar was depreciated by 51.93% during the period from January 2012 to January 2018 with respect to the Euro, which stimulated the inflationary process (Ben Jedidia et al. 2019).

The results of the LSTR model show that ACT and INV variables affect positively economic growth in Tunisia. In fact, human capital can enhance economic development through technological progress whose impact economic development through educational facilities (Diebolt and Hippe 2022). Moreover, human capital is observed as a fundamental source of economic growth which enhances the total productivity level and potential earnings of the labour force such skills, qualifications, ability to create new products, and experience of labour. Furthermore, it can stimulate economic growth by specialization and labour division, improvement in basic education, vocational training, encouragement to self-employment, and creating business opportunities (Intisar et al. 2020).

In addition, domestic investment plays a crucial role in fostering economic growth. Increased investments in productive sectors have a positive influence on growth, creating a mutually reinforcing relationship between growth opportunities and domestic investment. Consequently, by prioritizing investments in education, healthcare, and other social services, the government promotes the development of human capital. This, in turn, leads to a skilled and educated workforce, which serves as a fundamental driver of economic growth by enhancing productive capacity.

5 Conclusion and policy implications

This paper examines the nature of the relationship between financial development and economic growth using a non-linear logistic STR approach and considering inflation as a threshold variable. Based on this model, we found strong evidence for the existence of a non-linear relationship between economic growth and financial development with an inflation threshold equal to 3.63%.

In Tunisia, forecasts of future inflation dynamics do not exist given the non-existence of a performing forecasting model and the financial system is not sufficiently developed and stable as it is levelled by a banking sector characterized by competition relatively limited and fragile, and suffers from high graded debt and the Tunisian stock market is very illiquid (Ghandri et al. 2021).

As a solution to combat the effects of inflation on Finance–Growth, the question of inflation targeting must be raised to decrease these effects by improving the authorities' communication policy and by setting achievable goals to increase their credibility, so that economic agents have confidence in the financial system and consequently economic growth improves. The monetary policy, therefore, is advised to take into account such a range and avoid excessive inflation. Thus, these authorities should focus on the inflation level as a guideline for monetary policies. This means that inflation should be considered when policies to promote financial development are established aiming to boost economic growth (Helali et al. 2021).

In addition, the BCT should conducts a very restrictive monetary policy by limiting the massive creation of central bank money and by encouraging private savings. Such savings ensure private investment at the expense of public investment to avoid the crowding out effect and consequently the real economy and the risk of financial instability decrease (Mgadmi et al. 2021).

In this same idea logic, credits must be allocated to more productive firms and the government should utilize the resources optimally and need to shift resources from consumption to investment expenditure. Furthermore, the central bank should impose rules for strict credit standards to avoid too much liquidity (Wen et al. 2022).

Another solution can promote Tunisian economy which is Fintech Industry, this technology could have the potential to reduce costs by maximizing economies of scale and increasing the speed and security of transactions. These technological developments can facilitate financial operations and avoid risks, such as money laundering, tax evasion, fraud, etc. Indeed, since January 2020, Tunisia has adopted the Fintech industry thanks to the support and management mechanisms that have been brought up to date with Fintech and ensure the birth of a sector at an embryonic age. However, given the age of the foreign exchange law, Tunisia must modify this law and update it, so that this country can benefit from this service (Zone 2021).

Moreover, the country must address the obstacles related to competition and the weakness of its application will be essential to help the Tunisian economy to emerge from the crisis and find a sustainable trajectory to benefit households by creating more jobs and better purchasing power. In addition, the state attempted to provide economic support to the population, including through public salaries, consumer subsidies, transfers to public enterprises, and cash transfers. This unlocks the potential of the economy

and accelerates recovery while creating more jobs and improving access for households and businesses to better quality goods and services at lower cost (World Bank 2021).

Because Tunisia has only been opened to the European market which is currently insufficient, opening to other markets such as the African market is necessary to improve trade openness and, therefore, economic growth. In fact, Tunisia's accession to COMESA in June 2019, the date of entry into force of the agreement, will allow it to benefit from total exemption from all customs duties and other charges and taxes having equivalent effect, subject to subject to the principle of reciprocity. This agreement covers, among other things, all industrial products imported from member countries of the COMESA free trade area, with the exception of imports from certain countries (Eritrea, Ethiopia, Eswatini, the Democratic Republic of Congo and Uganda) (ITCEQ 2022).

As well, Tunisia has joined actually the Guided Agreement initiative which is part of the African Union's efforts to initiate meaningful trade within the African Continental Free Trade Area. These trade agreements can open up other opportunities for Tunisia to export national products, because it is more competitive than several African countries and makes it possible to rebound the industrial sector and encourage it to create more jobs and promote economic growth.

In order for Tunisia to escape the middle-income trap, it shall move toward a Knowledge-Based Economy based on human capital accumulation rather than physical capital accumulation. Such a transition will be difficult with the existing financial system, as the Knowledge-Based models are exposed to more severe credit constraints from the banking system. Indeed, the innovative enterprises and particularly the start-ups do not have the physical collateral that enables them to access the traditional bank financing. Therefore, it is important to develop the equity-finance component of the financial system. Such a component is more willing to finance R&D activities and technological start-ups. This can be done by developing the stock markets' role in financing the private sector and promoting entrepreneurship. It can be done by favouring the emergence of new channels for raising funds like crowdfunding (Nabi 2019).

Our findings rely on estimating the effect of financial development measured by inflation on economic growth in Tunisia. Therefore, to enhance the findings of our study, we suggest exploring potential research avenues that can help mitigate the limitations and further develop the current investigation. Some future research could extend, first, by examining the impact of financial development on industrial development in Tunisia. Second, we can analysis this nonlinear relationship using institutional indicators. Third, we can extend our research by studying the effect of financial development on economic growth in UMA or MENA regions.

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Author contributions
All authors participated in the methodology and the writing of the different sections of the article. Professor Kamel HELALI carried out the empirical part on the basis of the available data.

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Availability of data and materials

The study estimates are based on annual data covering a 55-year sample (1965–2019) for Tunisia. The study aimed at presenting the estimated model and the relative variables knowing that they were collected from the databases of the World Development Indicators (WDI), the Tunisian National Institute of Statistics (INS), and the Central Bank of Tunisia (BCT). We use Winrats 9.0 and JMulTi 4.23 softwares to run different programs. The data are available on request from the corresponding author.

Declarations

Competing interests

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process. We are responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. Authors are responsible for correctness of the statements provided in the manuscript.

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