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Non-Linear Modelling of Money Demand in Tunisia: Evidence from the STAR Model

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Abstract

Tunisia went through a turbulent 1980s and 1990s, characterized by the introduction of the IMF's Structural Adjustment Programs (SAPs) in 1986 and the modernization of the Stock Market Exchange. These changes and reforms in the monetary policy seek to control the supply of money and contribute to the achievement of price and financial stability. Over the period 1973–2013, this paper presents an empirical investigation into the stability of money demand using the Smooth Transition Autoregressive models (STAR) which is characterized by switching regimes through continuous transition functions. The instability of the money demand is explained by the fragility of the Tunisian economy to world shocks and by the implementation of the IMF's Structural Adjustment Programs.

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1. Introduction

The debate on the role of money demand function is not new. It was studies since 1956 by Milton Friedman in his seminal work: "the quantity Theory of Money: A Restatement". For Friedman, when the demand for money is stable then a change in money supply will automatically change the price level which in turn will affects the real value of national and economic activity in the short-run. Since Friedman's conclusion, numerous studies have developed the money demand function by adding new assumptions and hypotheses such as Miller–Orr (1966, 1968) Akerlof and Milbourne (1980), Sprenkle and Miller (1980), Laidler (1985), Lucas (1988), Hoffman and Rasche (1991), Miller (1991), Barr and Cuthbertson (1989), McCallum (1989) and Goodfriend (1992), McNown and Wallace (1992), Stock and Watson (1993), Ball (2001), etc. Therefore, analyzing money demand function has become an important task for central bankers since it could provide important information about portfolio allocations (Duca and VanHoose 2003) and it can also give a better understanding of monetary policy frameworks by helping controlling inflation and limiting high currency volatility.

Since 2000s, the question on money demand function has been receiving a specific attention by policymakers and academic researchers. Two reasons could explain the renewal interest. The first one is the recent advance in empirical researches and the birth of a new macro-econometrics theory which have reconsidered the earlier empirical models of the 80s and 90s. The second motivation is the change in monetary policy rules in the aftermath of the subprime crisis by most central banks in advanced and emerging economies alike under the so called the quantitative easing programs (QE, thereafter). The QE consists of implementing artificial measures by the central bank such as, cutting interest rate, buying assets and creating money by buying securities, such as government bonds, from banks. The purpose of these measures is to facilitate monetary policy transmission in a harsh period and to boost the banking sector and to keep the economy from falling into recession. Almost eight years later, these measurers have shown their effectiveness in some countries (UK, India and the US) while they failed to reestablish the dynamism of the financial sector in some other countries (Japan and EU). Therefore, the implementation of nonconventional policy could affect money supply and the transmission mechanism of the money policy.

Literature on money demand function and the determination of its stability is vast and opulent of interesting conclusions. These findings have been further supported by the number of new works that has been carried out in the recent years. In this research paper, we are interested to investigate the case of money demand function in Tunisia from 1973 till 2013. Hence, the aim of this paper is to develop the available literature by studying the Tunisian context by the mean of a new empirical investigation. Tunisia is an interesting case study for various reasons. First, during the selected period, the banking sector has witnessed the implementation of several structural reforms. Second, the government has progressively liberalized the banking sector in 1987 following the adoption of the structural adjustment programs (SAPs). Moreover, several other reforms were undertaken by the Tunisian government such as trade liberalization (1994), the adhesion to the European Union free trade agreement (1995) and the adhesion to the World Trade Organization (1994) (Hamdi 2013). Third, during this period, GDP in Tunisia was subject to multiple shocks: in 1988 following the liberalization process, then in 2001 following the terrorist attack in Djerba then in 2008 in the aftermath of the world financial crisis and in 2011 following to the social turmoil. Hence, Tunisia is currently experiencing a severe period of transition. Therefore, studying money demand function which takes into consideration data that cover all these events could provide some important results for policymakers.

Unlike the numerous studies that have used linear frameworks to test for the stability and determination of money demand function; in this paper we use a nonlinear modelling by the mean of the Smooth Transition Autoregressive models (STAR) (Teräsvirta and Anderson, 1992). The advantage of choosing this methodology is that it allows the business cycle indicator to switch between two distinct regimes smoothly rather than a sudden jump from one to the other. Therefore, STAR models provide further information on the dynamics of variables that display their value even during the transition period. The overall results reveal that the instability of the money demand is explained by the fragility of the Tunisian economy to world shocks and by the IMF's Structural Adjustment Program. This study is important for the Tunisia context since it could be used as a policy tool to stimulate the level of economic growth and help policy makers to achieve such goals.

The remainder of the paper is as organized as follows: section two presents the literature review. Section three introduces the STAR model and the main steps to estimate it. Section four provides the empirical results while section five concludes.

2. Recent Literature Review

Estimating money demand function was extensively explored by academicians during the past few decades. Researchers have focused their attention on the main determinants of money demand within different contexts. To achieve this goal researchers have used various techniques and methodologies such as linear and non-linear modelling, single equation and multivariate cointegration techniques and different proxies of broad money such as M0,M1, M2, M3 and even M5. Generally, money demand was firstly estimated as a function of real income, interest rate, the inflation rate and it can be described as follows:

$$\frac{M^d}{P} = f\left(\underset{(+)}{Y_P}, \underset{(-)}{r_s}\right)$$

Where $\frac{M^d}{P}$ represents real money proxied by M2, nominal money stocks M^d are deflated by the CPIs $(P_{i,t})$;

$(Y_{i,t})$ is the scale variable proxied by the country's income,

$(r_{i,t})$ is a domestic interest rate which represents the opportunity cost of holding money.

The expected signs of the variables show that $(Y_{i,t})$ acts positively and significantly on money demand while $(r_{i,t})$ exerts negative impact.

Recently some researchers have added other macroeconomic variables such as exchange rate, Libor, Tbill, financial and non-financial assets, and some other studies have used the different components of the GDP as a scale variable such as expenditures on investment goods and exports and final consumption expenditures (private and government sectors). The variables used depend of the selected country's macroeconomic condition. Some studies have been carried out using a single country case study while some other on group countries for developed and developing countries as well.

As an example of a research paper based on a single country study, we found the paper by Nell (1999) which studied the long-run money demand function for South Africa over the period 1965-1997 using a vector autoregressive system and the error correction modelling. The empirical finding provides evidence of a stable long-run demand for money function for M3 only. However, for the other monetary aggregates (M1 and M2), the results show parameter instability following financial reforms since 1980. For the same case study, Todani (2007) tests the stability of the long-run money demand using M3 as a monetary aggregate. By conducting a vector autoregression (VAR) and a cointegration analysis, the author found that despite the structural reforms that South Africa has known during the past years, the empirical results reveal evidence of a stable money demand function in the short run while in the long-run, the link between money and inflation is rather weak.

In India, Rao and Singh (2005) studied the determinants of the demand for money proxied by M1 using yearly data covering the period 1953 to 2002. The author found that the demand for money was stable during that period of the study. Another study by Sigh and Pandey (2009) for the India context aimed at investigating the stability of money demand during the period 1953-2007. Using the Hansen (1992) and Gregory Hansen (1996) co-integration approaches with structural break, the empirical findings reveal the presence of cointegration in demand for money, real GDP and nominal interest rate with structural break at 1965. The stability tests were conducted by the mean of the CUSUM and CUSUMSQ tests and they revealed that demand for money was unstable during the period of 1975-1998 but it is stable after few years of reform period. According to the authors, this instability is due to effect of reforms in the financial sector and the liberalization policies.

The paper by Bahmani-Oskooee and Wang (2007) aims at investigating the demand for money in China using quarterly data covering the period 1983Q1 to 2002Q4. The authors performed cointegration analysis and the stability test was verified by the mean of CUSUM and CUSUMSQ tests. They found that that while money demand in China proxied by M1 is stable; results with M2 reveals some instability. The authors conclude that M2 should not be a targeting instrument for monetary policy. In the same case study, Zuo and park (2011) have recently analyzed the stability of the money demand using quarterly data covering the period 1996 to 2009. By applying a time-varying cointegration approach, the authors showed the importance of the stock price as a new determinant of money demand.

For the USA, Rao and Kumar (2007 investigated the stability of money demand using yearly data covering the period 1960-2008. The econometric methodology employed in their paper is the Gregory and Hansen (1996) co-integration approach. Their results showed that there has been a structural change in 1998 and the constraint that income elasticity is unity could not be rejected by subsample estimates. The authors have also studied money demand function for the case of Fiji during the period 1970-2002 and using the same methodology. Their results suggest that a stable demand for *M1* persists in Fiji even in presence of structural breaks in the model.

Riyandi (2012) attempted to test the stability of money demand relations for the case Indonesia by analyzing the long run and the short run income and opportunity cost elasticity. Using fixed effects and unweighted average meta-analysis, the author showed that income and opportunity cost elasticity are consistent with theory of money demand.

Akcaolayan, and Dommez (2008) applied the Johansen multivariate cointegration analysis to investigate the behavior of broad money demand in in Turkey using monthly data covering the period 1990:M1 to2005:M12. The empirical results show evidence of a long-run relationship between the different monetary aggregates, real income, domestic interest rates, foreign interest rates, and the real effective exchange rate.

For a panel or group of countries, Bahmani-Oskooee and Rehman (2005) studied the stability of money demand (M1 and M2) for seven Asian countries including: Indonesia, Malaysia, Pakistan, the Philippines, Singapore, and Thailand. In the empirical study, they employed the cointegration procedures and the stability tests were done using CUSUM and CUSUMSQ techniques. The empirical finding reveal that despite real M1 or M2 monetary aggregates are cointegrated with their determinants, the estimated parameters are unstable. In the same context, Tang (2007) investigated the stability of money demand function of a panel of five Southeast Asian countries including: Malaysia, Philippines, Thailand, Indonesia and Singapore during the period 1960 to 2005.Unlike the other studies which have used GDP as a scale variable, the author has used three different scale variables including: final consumption expenditures (private and government sectors), expenditures on investment goods, and exports. By employing an ARDL modeling procedure, they found that the statistical significance of real income components suggests the bias of using single real income variable in money demand (M2 aggregate) specification of both short- and long-run. The stability tests were conducted using CUSUM and CUSUMSQ tests and they reveal that the estimated parameters are stable for the five Southeast Asian economies, except for Indonesia which is based on short-run specification.

For the African context, Fielding (1994) estimated a money demand function for four African countries including: Cameroon, Ivory Coast, Kenya and Nigeria. He concluded that the volatility of inflation and interest rates are the most important determinants of money demand in these countries. In the same context, Bahmani-Oskooee and Gelan (2009), studied the stability of money demand function for a panel of 21 African countries during the period 1971Q1-2004Q3. They found that in most African countries, including in Ghana, a stable cointegrating money demand relation can be established between broad money, income, inflation, and nominal exchange rate. The use of the CUSUM and CUSUMSQ tests to the residuals of error-correction models showed that in almost all 21 countries, M2 demand for money is stable. This could be justified integration of the error correction term when testing the stability in the long-run.

Singh and Kumar (2009) investigated the stability of the demand for narrow money for the case of the five Pacific Island Countries including: Fiji, Vanuatu, Samoa, Solomons and Papua New Guinea (PNG) during the period 1975-2007. The empirical studies employed the General to Specific (GETS) estimation by LSE-Hendry and Johansen's Maximum Likelihood (JML). they found that real income, nominal rate of interest and real narrow money, are cointegrated. The authors have used the CUSUM and CUSUMSQ techniques to check for the stability tests and they found that the money demand is stable in these pacific island countries.

A recent study by Kumar (2011), analyzed the consequences of financial reforms on the stability of money demand function of a panel of 20 twenty developing Asian and African countries. After incorporating the CUSUM and CUSUMSQ tests into cointegration analysis the author finds that the demand for money functions are temporally stable in all these countries. This result encourages central bankers to target money supply as a new monetary policy tool.

Dobnik (2012) conducted a panal error-correction model to study the long-run money demand function for 11 OECD countries during the period 1983Q1 to 2006Q4. His results suggest that while income acts positively on money demand function, interest rate impacts negatively as expected. The author concludes that the exchange rate is an important determinant of money demand, whereas the results for the stock prices are ambiguous. For the case of 15 Latin-American countries, Carrera (2012) studied the long-run money demand function by employing the Pedroni's (2002) Fully Modified Ordinary Least Square (FMOLS) to estimate the coefficients of the long-run money demand function. The author found evidence of a cointegrating money demand, an income elasticity of 0.94, and an interest-rate semi-elasticity of -0.01.

For the Gulf Cooperation Council (GCC hereafter) countries, four papers have been carried out using three different techniques and methodologies. The first paper is by Harb (2004) in which he employed Pedroni's heterogeneous panel cointegration tests to estimate money demand function in six GCC countries during the period 1979-2000. The authors found that interest rate for individual estimation has no effect of interest rate on money demand while it exerts a does for the group mean estimation. It was also shown that M1 as a proxy of broad money provide a better results that the use of M2. The second study was carried out by Lee *et al.* (2008) by employing Likelihood-based cointegration tests in heterogeneous panels. Their model includes the following variables: the real money balance, the real scale variable, the nominal interest rate, and the exchange rate and the time span covers the period 1979-2000. Their results show that the hypothesis of the quantity theory of money for the long-run elasticity of income equal to unity was rejected. The third study on the GCC context was done by Basher and Fachin (2012). The authors studied the long-run demand for broad money for the GCC countries by performing a Panel data analysis. Their dataset covers the period 1980-2009. The authors found a stable money demand function for all the six countries as well as for the panel. They also showed that the money supply is a significant determinant of inflation in both the short- and long-run. Finally the fourth paper is a recent study by Hamdi *et al.* (2015) who estimated the money demand function for the case of six Gulf Cooperation Council countries using quarterly data that cover the period 1980Q1-2011Q1. By applying panel cointegration tests, their empirical results reveal strong evidence of cointegration between the variables of the model for individual countries as well as for the panel. Moreover, the results support the existence of a stable money function in the long-run estimation. The Granger non-causality test due to Toda and Yamamoto (1995) procedure shows evidence of a bidirectional causal relationship between money demand and income for panel estimation. At an individual level, the results change from one country to another one.

3. Empirical study

3.1. Data an methodology

Fundamentally, to highlight the money demand in Tunisia is instable, we use the Smooth Transition Autoregressive models (STAR). We will estimate the following equation:

$$Md_t = \beta_0 (GDP_t)^{\beta_1} \exp(MR_t)^{\beta_2} \exp(NER_t)^{\beta_1} \exp(\varepsilon_t) \quad \forall \ \mathrm{t} = 1973 \rightarrow 2013 \tag{1}$$

$$Md_t = \beta_0 + \beta_1 GDP_t + \beta_2 MR_t + \beta_3 NER_t + \varepsilon_t \quad \forall \ \mathrm{t} = 1973 \rightarrow 2013 \tag{2}$$

Where:

Md denotes the natural logarithmic of money demand. In this study, we use two measures: *M1* which is the sum of currency in circulation and overnight deposits and *M2* which is the sum of *M1*, deposits with an agreed maturity of up to two years and deposits redeemable at notice of up to three months.
GDP is the natural logarithmic of the Real Gross Domestic Product.
MR is the Tunisian Rate of Interest.
NER is the natural logarithmic of the Nominal exchange rate.
β are the parameters to be estimated. ε is the error term.
Data is sourced from the Central Bank of Tunisia and the International Monetary Fund, international financial statistics.

To underline the cyclical phenomena of the money demand in Tunisia, we use the Smooth Transition Autoregressive models (STAR) because the changes in the monetary policy highlight the transition from one regime to the other. The STAR (p) is as follow:

$$Y_t = \left(\alpha_{10} + \sum_{j=1}^{P} \alpha_{1j} Y_{t-j} \right) + \left(\alpha_{20} + \sum_{j=1}^{P} \alpha_{2j} Y_{t-j} \right) F(Y_{t-d}) + \varepsilon_t \tag{3}$$

$$Y_t = \alpha_1' Z_t + \alpha_2' Z_t F(Y_{t-d}) + \varepsilon_t \tag{4}$$

Where: $\alpha_1' = (\alpha_{10}, \ldots\ldots, \alpha_{1P})$, $\alpha_2' = (\alpha_{20}, \ldots\ldots, \alpha_{2P})$ et $Z_t = (1, Y_{t-1}, \ldots\ldots Y_{t-p})'$

F (Y_{t-d}): is the transition variable bounded between 0 and 1. Teräsvirta and Anderson (1992) propose two transition functions (Logistic and Exponential):

Logistic: $F(Y_{t-d}) = \left(1 + e^{-\gamma(Y_{t-d} - c)}\right)^{-1}; \quad \forall \gamma \succ 0$ (5)

Exponential: $F(Y_{t-d}) = 1 - e^{-\gamma(Y_{t-d} - c)^2}; \quad \forall \gamma \succ 0$ (6)

$$F(Y_{t-d}) = \begin{cases} 0 & \text{Si } \mathrm{Y_{t-d}} \prec c \\ 1 & \text{Si } \mathrm{Y_{t-d}} \succ c \end{cases} \tag{7}$$

LSTAR (p) is as follow: $Y_t = \left(\alpha_{10} + \sum_{j=1}^{P} \alpha_{1j} Y_{t-j} \right) + \left(\alpha_{20} + \sum_{j=1}^{P} \alpha_{2j} Y_{t-j} \right) \left(1 + e^{-\gamma(Y_{t-d} - r)}\right)^{-1} + \varepsilon_t$ (8)

ESTAR (p) is as follow: $Y_t = \left(\alpha_{10} + \sum_{j=1}^{P} \alpha_{1j} Y_{t-j} \right) + \left(\alpha_{20} + \sum_{j=1}^{P} \alpha_{2j} Y_{t-j} \right) \left(1 - e^{-\gamma(Y_{t-d} - r)^2}\right) + \varepsilon_t$ (9)

The AR (p) model is a particular case of STAR (p) model if the null hypothesis of linearity is accepted. Luukkonen et al. (1988) propose the LM test to test H_0: AR model Vs H_1: STAR model. Teräsvirta (1994) proposes a test to determine the optimal lag length of the transition variable (d).

3.2. Results

We start the empirical analysis by testing for the presence of a unit root in data time series which has become a common starting point in applied macroeconomics. The presence or absence of unit roots helps to identify some features of the underlying data-generating process of a series. In the absence of unit root (stationary), the series fluctuates around a long-run mean constant and implies that the series has a finite variance, which does not depend on time. Results of Dickey-Fuller test are presented in table 1.

Table 1: Dickey-Fuller Test (1979-1981)

Variables	Md1	Md2	GDP	MR	NER
Lags	2	2	2	1	1
Model 1				0,172132	
Model 2	-1,531423		-0,153123		
Model 3		-1,2116312			-1,532174

Model 1: Model without constant and without trend, Model 2: Model with constant and without trend and Model 3: Model with constant and with trend.

The standard unit root test of Dickey-Fuller fail to reject the null hypothesis of a unit root for many economic time series.

Perron (1989) showed that failure to allow for an existing breaks leads to a bias that reduces the ability to reject a false unit root null hypothesis. Zivot and Andrews (1992) endogenous structural break test is a sequential test which uses the full sample and a different dummy variable for each possible break date. The break date is selected where the t-statistic from the ADF test of unit root is at a minimum (mostly negative). Consequently, a break date will be chosen where the evidence is least favorable for the unit root null. Results are presented in table 2.

Table 2: Test of Zivot and Andrews (1992)

	Md1	Md2	GDP	MR	NER
T-Statisticts	-3,198	-3,758	-3,217	-3,234	-2,982
λ	0,65	0,261	0,413	0,761	0,59
Break year	1989	1971	1978	1994	1986
Number of lags	3	3	3	3	3

The critical values for Zivot and Andrews test are -5.57,-5.30, -5.08 and -4.82 at 1 %, 2.5 %, 5 % and 10% levels of significance respectively.

The results of Zivot and Andrews (1992) indicate that the remaining five series are integrated at order one. This too has important implications. Knowing a break point is central to an accurate evaluation of any program intended to bring about structural changes; such as tax reforms, banking sector reforms etc.

The modelling of the money demand function in Tunisia by STAR models requires the determination of the optimal lag length of AR (p).

Table 3: Optimal lag length and estimation of AR (p)

T-Stat of lags	ΔMd1	ΔMd2	ΔGDP	ΔMR	ΔNER
Lag (1)	1,213	1,213	1,123	0,521	0.152
Lag (2)	0,132	1.131	1,421	0,621	0.521
Lag (3)	0,142	-0.132	0,553	-0,613	-0.142
Lag (4)	0.132	-0.342	-0,132	0,724	0.621
Lag (5)	0,113	0.421	-0,163	0,731	0.852
Lag (6)	-0,142	0.423	0,213	-0,123	0.421
Lag (7)	-0,112	0.612	0.229	-0,142	0.132
Lag (8)	0,433	0.131	0,754	0,512	0.421
AR (p)	AR (1)	AR (2)	AR (1)	AR (0)	AR (0)
Constante	0,21312*	0,2134*	0.143748*	0.13244*	0,4217*
φ_1	0,42132*	0,1321	0.443748*		
φ_2		0,1321**			
Variance of AR	0,00132	0,00132	0,00142	0,00002	0,001321

* and ** indicate statistical significance at the 1% and 5% levels.

We conclude that the first dependent variable Md1 has one lag (AR (1)) and the second dependent variable Md2 has 2 lags (AR (2)). Referring to the LM test, the null hypothesis that the model is linear is rejected at the 5% level for all variables.

Table 4: Linearity test

Statistics	ΔMd1	ΔGDP	ΔMd2
LM	3.421	2.4132	3,123
	(0.035)	(0.043)	(0.008)

After fixing the delay, Teräsvirta (1994) proposes a short sequence of ordinary Fisher test to decide between the exponential STAR model (ESTAR) and the logistic STAR (LSTAR) family of models. The ESTAR model implies symmetric adjustment towards equilibrium whereas in the LSTAR models the adjustment for deviations above and below the equilibrium level is asymmetric. The results are displayed in Table 5.

Table 5: Teräsvirta Test

ΔMd1	ΔGDP	ΔMd2
H_{01} :0,0423	H_{01} : 0,0145	H_{01} : 0,2964
H_{02} :0,1231	H_{02} : 0,0562	H_{02} : 0,0763
H_{03} :0,0853	H_{03}:0,96213	H_{03} : 0,1064

According to table 5, H_{01} has the smallest *p-value* suggesting that LSTAR model should be selected for Md1. However, H_{02} for GDP and Md2 have the smallest *p-values* showing that ESTAR model should be applied. The results of STAR models using the non-linear least squares (NLS) method are displayed in Table 6 presents.

Table 6: STAR Estimation Results

	ΔMd1	ΔGDP	ΔMd2
Parameters	**LSTAR**	**ESTAR**	**ESTAR**
α_{10}	0,1312	0,42312	0,13241
α_{11}	0.4213	0,43213	-0,6742
α_{12}			0,4213
α_{20}	0.1532	-0,1321	0,4213
α_{21}	0.1532	-0,4212	0,7654*
α_{22}			0,3421
γ	1.4251	0,6421	0,5642
c	0.0000	0,7421	0,0001*

** indicate statistical significance at the 1% level. c: the threshold .parameter γ the slope parameter*

We found that the shift between the two extreme regimes occurs around the location parameter c (the three location parameters seem to be far from their respective mean values). We also find, for all transition variables, a smooth transition and consequently the STAR is well adapted because the slopes of transition functions are low (the highest value is 1.4251). It means that conditionally to those variables, the relationship cannot be reduced to a limited number of regimes. This clearly illustrates the instability of the money demand in Tunisia influenced by the structural change at the national level. This result is explained by the adjustment plan in 1986 and the national economic situation.

4. Conclusion

Since the seventies, many structural reforms were introduced to the Tunisian financial sector and monetary policy has known many changes following the introduction of the IMF's Structural Adjustment Program (SAP) in 1986. These changes and reforms in the monetary policy seek to limit the supply of money to its demand facilitates the tasks of demand management and contributes to the achievement of price stability and highlight the transition from one regime to the other. Therefore, the main purpose of this paper is to test for the stability of money demand function in Tunisia during 1973-2013. In the empirical section we conducted a nonlinear modelling by the mean of the Smooth Transition Autoregressive models (STAR) (Teräsvirta and Anderson, 1992). Our results reveal that money demand function in Tunisia is instable and the instability is explained by the vulnerability of Tunisia economy to endogenous shocks. This study is important for Tunisia in the current period in which the country is experiencing political instability, continuous social tensions and many financial problems that could aggravate the situation. This study could also be useful to set the proper monetary policy that will in turn stimulate the level of economic growth and help policy makers to achieve such goals.

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