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Causality Between Inflation, Economic Growth and Unemployment in North African Countries

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Abstract

This paper investigates the relationship between unemployment rate, economic growth and inflation rate in North African countries between 1965 and 2016, using the vector error-correction model. We examine the causal relationship between economic growth, inflation and unemployment rate. In order to test the Granger causality, we applied the unit root test (Dickey–Fuller test and Phillips–Perron) and Johansen co-integration test. Our empirical results show a unidirectional causality running from inflation to economic growth, from economic growth to unemployment and from inflation to unemployment. Hence, we offer some economic implications that emerge from this study.

Keywords: economic growth, inflation, unemployment, vector error-correction model.

JEL codes: J6, O11, O47, O55.

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1. Introduction

The countries of North Africa (Algeria, Egypt, Morocco and Tunisia) were marked by the political transition triggered by the Arab Spring. However, regional tensions, combined with a difficult external environment, still affect the economies of these countries. Economic growth has slowed down, unemployment has risen and inflation has increased mainly in Egypt and Tunisia.

The instability of economic growth in these countries was more pronounced in 2011, the majority of countries were marked by low or even negative growth rates (Tunisia -1.9%). However, Egypt boasted large economy and relatively strong growth, recorded a large share of GDP growth in the region in 2015 and 2016 (*Cf.* Figure 1). Since 2015, the countries (Algeria, Egypt, Morocco and Tunisia) have experienced a sustained weakening of their currencies, thus causing inflationary spirals. Indeed, efforts to restore macroeconomic stability were accompanied by an increase in the inflation rate in 2016, especially in Tunisia and Egypt, inflation rates were 5.5% and 6.2%respectively. Inflation was low and stable in Algeria and Morocco -0.9% and 2.2%, respectively (*Cf.* Figure 2).

Figure 1: GDP growth annual (%)

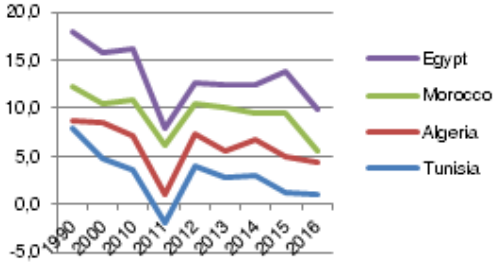


Figure 2: Inflation rate (%)

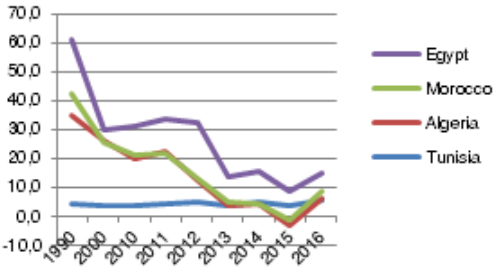
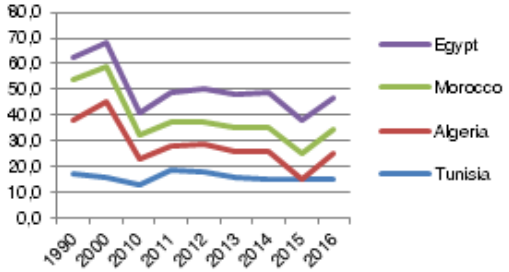


Figure 3: Unemployment rate (%)



Source: ***World*** *Bank (2017)*

The Revolutions and social unrest worsened the labor market situation and led to a sharp rise in unemployment in 2011, particularly in Egypt and Tunisia (*Cf*. Figure 3). Although unemployment began to fall again in the years following the revolution, it remained higher than in other countries around the world. Overall, the structural reforms that took place in these countries after the Arab Spring did not generate the expected GDP results to combat inflation and unemployment.

In fact, the relationship between economic growth, inflation and unemployment is an interesting topic for debate in the economic literature. Inflation played a very important role in economic growth (Fischer, 1983; Barro, 1995; Gylfason et Herbertsson, 2001; Burdekin et al., 2004; Gillman et al., 2004; Gillman and Kejak, 2005; Kremer et al., 2013). This relationship suggests that economic growth and inflation may have mixed links. Similarly, unemployment played a crucial role in economic growth (Lee, 2000; Viren, 2001; Harris and Silverstone, 2001; Sogner and Stiassny, 2002). The well-known Okun's law (1962) has become a popular tool for studying the relationship between economic growth and unemployment in different countries. The link between inflation and unemployment has been considered as one of the basic principles of economics. This relationship was first considered by Phillips (1958) who asserted an inverse relationship between these two variables. Thus, the Phillips curve was confirmed by Solow (1970) and Gordon (1971) but criticized by Friedman (1968) and Lucas (1976) who suggested that in the long run there is no compromise between inflation and unemployment. Unemployment and inflation are considered two of the main factors to measure the degree of development in any country, especially developed countries. That has become one of the essential areas of research in economic theory.

Therefore this paper fills the gap in the literature with new empirical evidence. In fact, we examined the causality between economic growth, inflation and unemployment in the long and short term in Tunisia, Algeria, Morocco, and Egypt. In addition, neither this sample of countries nor this period have been investigated by other researchers in the literature. Compared to previous studies, the present study uses a technique that has not yet been used in this context, such as the vector error-correction model which allows

additional channels of causality over the period 1965–2016.

The rest of this paper is structured as follows. Section 2 presents the literature review. Section 3 discusses the method used for the empirical analysis and presents the database. Section 4 reports and discusses the empirical results. Finally, the last section discusses policy implications of the findings and concludes the paper.

2. Literature Review

Several existing works used panel data modeling techniques to study the links between economic growth, inflation, and unemployment. Thus, this paper reviews the literature under three subsections, *i.e.* (a) inflation and economic growth; (b) economic growth and unemployment; and (c) inflation and unemployment. The literature has revealed general interest in the relationship between inflation, economic growth and unemployment. In this section, we review the most important works in this literature.

Inflation and Economic growth

The relationship between inflation and economic growth has extensively been investigated in the economic literature. The results of the studies concerning this relationship are mitigated. Some report that inflation is a constraint to growth and that it negatively influences economic growth and inflation influences economic growth as at a specific threshold (Fischer, 1983; Barro, 1995; Gylfason et Herbertsson, 2001; Burdekin et al., 2004; Gillman et al., 2004; Gillman and Kejak, 2005; Kremer et al., 2013). Others indicate that inflation favors growth (Mallik and Chowdhury, 2001; Rapach, 2003, Benhabib and Spiegel, 2009). However, some studies showed that inflation has no impact on economic growth (Wai, 1959; Dorrance, 1966; Sidrauski, 1967).

Fisher (1993) was the first author to identify a non-linear relationship where low inflation rates have a positive impact on growth but as inflation increases it becomes negative. Later, Bruno and Easterly (1998) confirmed the conclusion of a negative effect of high inflation rates but doubt the positive effect low inflation has on improving growth. Based on Philips curve conception, high inflation affects the growth rate by creating a low unemployment rate. Bruno and Easterly (1998) found that the negative relation between inflation and economic growth is only observed when inflation rates are high. Also, they showed that there is no conclusive evidence of the relationship between inflation and economic growth when inflation rates are very low. Gillman and Kejak (2005) used a model that combines a mixture of physics and human capital in the production of goods and a mixture of means of exchange (money and credit) in the purchase of goods. They showed that when inflation increases, the cost of exchanging goods also increases. This increase creates a substitution effect by shifting consumption to leisure and thus leads to a negative effect of inflation on economic growth. Mohseni and Jouzaryan (2016) examined the role of inflation on economic growth in Iran over the period from 1996 to 2012 using the Autoregressive Distributed Delay (ARDL) model and argued that inflation affects significantly and negatively economic growth in the long term. Using time series data about four Latin American countries between 1970 and 2007, Bittencourt (2012) found that inflation had a negative effect on growth in the region.

Some authors (Sarel, 1996; Ghosh and Phillips, 1998; Gylfason and Herbertsson, 2001; Khan and Senhadji, 2001; Kremer et al., 2013; Tung and Thanh, 2015; Aydın et al., 2016) confirmed the above negative relationship between inflation and growth

once inflation reaches particular threshold. Ghosh and Phillips (1998) used a panel regression and found a positive correlation between inflation and economic growth for very low inflation rates. The inflation-growth relationship is significantly negative and this negative relationship is convex when inflation rates are high. Recently, Aydın et al., (2016) explored the link between inflation and economic growth in five Turkish republics and found that there is a non-linear relationship between inflation and growth rate. The threshold for the influence of inflation on economic growth is 7.97% and an inflation rate above this threshold is harmful to growth while an inflation rate below this threshold has a positive impact on economic growth. These results showed that a high inflation rate will have a considerable influence on economic growth. They recommended sustainable growth that plays a crucial role in increasing the effectiveness of the monetary policies implemented and ensuring stability. Gylfason and Herbertsson (2001) studied the existence of a threshold effect in the relationship between inflation and growth in 170 countries between 1960 and 1992 and determined that an inflation rate on an annual basis of 10 to 20% affected negatively economic growth.

Based on the annual data about the Pakistani economy over the period 1973-2000, Mubarik (2005) found that an inflation rate above 9% threshold has a negative influence on growth. Moreover, Kremer et al., (2013) examined the influence of the inflation threshold on long-term economic growth from data gathered over the period 1950-2004 for 124 industrialized and non-industrialized countries. They found that the inflation threshold would be 2% for industrialized countries and 17% for non-industrialized countries. Hence, they concluded that if an inflation rate above the threshold had a negative influence on economic growth, an inflation rate below the threshold had an insignificant influence on it. These results supported the idea that inflation contributes to growth in developing countries. Using a dynamic threshold model and examining the same relationship for 32 Asian countries over the period 1980 and 2009, Vinayagathasan (2013) showed that an inflation rate higher than 5.43% has a negative influence on economic growth and an inflation rate below this threshold has no influence. Tung and Thanh (2015) used a sample of data in a transition economy (Vietnam) over the period between 1986 and 2013 and showed that an inflation rate above 7% has a negative influence on economic growth. Baharumshah et al., (2016) studied the relationship between inflation, inflation uncertainty, and economic growth in a group of 94 emerging and developing economies using the system generalized method of moments (SGMM) and revealed that inflation does not affect growth only in non-crisis countries, while inflationary uncertainty favors growth. Furthermore, Barro (2013) examined the relationship between inflation and economic growth across a large sample of countries and found that the level of inflation (even at low rates) has a negative and significant impact on growth. It should be mentioned that Barro (2013) goes to great lengths to argue that inflation (even at low levels) can distort economic progress because of its distorting effect on relative prices and thus on the efficiency of market allocations. In addition, Gillman et al., (2004) studied a wide range of OECD and APEC countries during the period 1961-1997. The negative effect of inflation was found to be globally significant for both OECD and APEC countries. López-Villavicencio and Mignon (2011) examined the effects of inflation on growth in a large sample of countries, including industrialized and emerging economies, using a new modeling technique called PSTR model. The

key characteristic of this modeling technique is that the threshold level of inflation is determined endogenously. They found that inflation has a non-linear impact on economic growth. There is a threshold beyond which inflation has a negative effect on growth and below which it stimulates growth for advanced economies. Eggoh and Khan (2014) provided new evidence for the non-linearity of the inflation-growth relationship by applying dynamic PSTR and GMM models to a broad dataset for 102 developed and developing countries. They showed that the inflation-growth relationship is non-linear, and their threshold estimates decrease with income level. Thus, inflation indexing and inflation tolerance are higher in developing economies than in developed economies. These results are consistent with those of López-Villavicencio and Mignon (2011) for a relatively small dataset of 44 countries.

Unemployment and economic growth

The relationship between unemployment and economic growth has attracted the interest of several economists (Lee, 2000; Viren, 2001; Harris and Silverstone, 2001; Sogner and Stiassny, 2002). This empirical research validated this relationship. In his study of the United States, Okun (1962) showed an inverse relationship between the unemployment rate and the potential output, according to labor market participation, hours of work, and labor market participation and the evolution of productivity. In fact, Okun (1962) showed that the theoretical basis of these studied relationships is based on the fact that the increase in the labor force must produce more goods and services. Moreover, he found that the unemployment rate declined during the years when the real growth rate was high, while the unemployment rate increased in the years when the real growth rate remained low or even negative.Moosa (1997) tested the validity of Ohun's law for the United States and found that North America has the highest coefficient and Japan has the lowest, which can be explained by differences in rigidities in the labor market. Later, Moosa (2008) retested this relationship for other countries (four Arab countries: Algeria, Egypt, Morocco and Tunisia) and proved that the growth of production does not translate into employment gains for these four countries, which means that the Okun coefficient is statistically insignificant. Using Okun's law and four types of models (difference model, dynamic model, ECM and VAR estimation approach) on quarterly Macedonia data covering the period 2000-2012, Sadiku et al., (2015) found that not all models provide strong evidence and do not confirm an inverse relationship between the unemployment rate and economic growth, as Okun's law suggested. Villaverde and Maza (2009) analyzed Okun's law for the Spanish regions over the period 1980-2004. They showed an inverse relationship between unemployment and economic growth for most regions and for the country as a whole. Thus, they concluded a regional disparity in productivity which explains the variation of the coefficients.

Seeking to explore the relationship between long-term economic growth and unemployment in Nigeria over the period 1980-2013, Michael et al., (2016) used the co-integration test, the Vector Error Correction Model (VECM) technique and the Granger causality test. He showed that unemployment and economic growth variables have a close relationship, unemployment has a negative and significant impact on GDP and a unidirectional relationship between UNEMP and GDP, with causality ranging from economic growth to unemployment. Similarly, Tiryaki and Ozkan (2011) used quarterly data from Turkey covering the period 1998-2010 and found that there is one-way causality ranging from the GDP gap to unemployment.

However, Dritsakis and Stamatiou (2016) used the approach of (ARDL) and ECMARDL model on annual data for Greece over the period 1995-2015. They showed that there is a unidirectional causal relationship between unemployment and economic growth with the direction from unemployment to economic growth.

Using micro econometric evidence and fixed-effect regression methods for the United Kingdom, Zagler (2006) showed a significant and negative relationship between unemployment and economic growth. Moreover, using Nigerian data over the period from 2000 to 2008, Oye and Inuwa (2011) showed that unemployment has a significant effect (over 65%) on the realization of Nigerian GDP, an inverse relationship between unemployment and GDP and any increase in unemployment leads to a decrease in GDP and vice versa.

Inflation and unemployment

According to Phillips (1958), the relationship between unemployment and the rate of change in wages in UK 1861-1957 is magnified by an explicit link between unemployment and inflation: when the unemployment rate was high, inflation was low and vice versa. Samuelson and Solow (1960) supported the Phillips hypothesis in their study for USA. Moreover, Keynesian theory assumes that governments could tolerate a reasonably high rate of inflation, which would lead to lower unemployment. The Phillips curve has been confirmed by Solow (1970) and Gordon (1971) who assumed a negative tradeoff between unemployment and inflation in the United States, using both pre-1970 and post-1970 data. Along the same line, Karanassou and Sala (2010) suggested that the movements in output and unemployment depend on currency fluctuations. Islam et al., (2003) found a weak long-term co-integration relationship between unemployment and inflation for the United States over the period from 1950 to 1999. Soon after, Islam et al., (2011) applied ARDL and DOLS approaches to co-integration and noted the existence of both long-term and short-term Phillips curve for northern Cyprus. However, Friedman (1968) criticized the concept of the Phillips curve and suggested that in the long run there is no trade-off between inflation and unemployment. Besides, Lucas (1976) opposed the existence of the Phillips curve, suggesting that unless policy makers do not create a situation where high inflation is associated with low unemployment, this could be a relationship of compromise between unemployment and inflation. On the one hand, employees predict that inflation and an increase in wages would be possible. On the other hand, there would be a high unemployment rate and a high inflation rate known as the Lucas Criticism. For instance, Alogoskoufis and Smith (1991) supported Lucas's critique by testing this relationship on empirical data for the United States and Great Britain. Furuoka (2007) empirically examined the relationship between the inflation rate and the unemployment rate for Malaysia and concluded the existence of a long-term interrelation, a trade-off and also causality between these two variables. That said, this validates the existence of the Phillips curve in the case of Malaysia.

Dritsaki and Dritsaki (2012) used annual data from Greece over the period 1980 – 2010 to examine the relation between inflation and unemployment. They found that there is a long-term interrelation and causality between inflation and unemployment. Thus, the shocks of the inflation rate lead to a reduction in the unemployment index for the first years, followed by a slight increase in the remaining years under consideration.

Recently, Bhattarai (2016) suggested that inflation and unemployment reduce the well-being of individuals and should be as

low as possible in any economy. He used cointegration and Granger causality tests and a panel VAR model over the period from 1990 to 2014 for OECD countries to show that there is a long-term interrelation between these two variables. He also concluded coherence between the Okun curves and the Phillips curve relations. We summarize the results of previous studies in Table 1.

Table 1. *Summary table of the main previous findings*

Author (s)	Countries	Econometric techniques	Main results
Fisher (1993)	53 countries	Cross-sectional and panel regressions	Growth is negatively associated with inflation.
Bruno and Easterly (1998)	31 countries	Cross-country regressions	There is a strong and robust interdependence between high inflation and growth, a negative effect of inflation and growth for inflation rates higher than 40 percent.
Gillman et al., (2004)	OECD and APEC member countries	A monetary model of endogenous growth	A negative inflation-growth effect, and one that is stronger at lower levels of inflation.
Mohseni and Jouzaryan (2016)	Iran	Autoregressive Distributed Delay (ARDL) model	A significant and negative effect of inflation and unemployment on economic growth in the long term.
Bittencourt (2012)	Four Latin American countries	Time series	Inflation has a detrimental effect on growth in the region.
Ghosh and Phillips (1998)	IMF member countries	Panel regression	A significant negative connection between inflation and growth.
Aydın et al., (2016)	Five Turkish republics	Dynamic panel data analysis based on threshold	A nonlinear interdependence between inflation and growth rate; an inflation rate above 7.97% threshold has a negative influence on economic growth while an inflation rate below this threshold has a positive influence on economic growth.
Gylfason and Herbertsson (2001)	170 countries	Random effect panel model	Inflation and growth are statistically significant and robust.
Mubarik (2005)	Pakistani	Granger Causality test, Threshold Model Estimation	Causality flow from inflation to GDP and not vice versa (uni-directed), the inflation below the estimated level of 9% is conducive for economic growth.
Kremer et al., (2013)	124 industrialized and non-industrialized countries	Dynamic panel threshold model	For industrialized countries: inflation targets of about 2% set by many central banks. For non-industrialized countries: inflation rates exceeding 17% are associated with lower economic growth.
Vinayagathasan (2013)	32 Asian countries	Dynamic panel threshold growth regression	A nonlinear relationship between inflation and economic growth, inflation hurts growth when it exceeds 5.43% but has no effect below this level
Tung and Thanh (2015)	Vietnam	OLS,2-SLSand Generalized Method of Moments (GMM)	The inflation threshold is about 7% which means inflation will be detrimental to economic growth if inflation rate exceeds 7 %.
Baharumshah et al., (2016)	94 emerging and developing economies	System Generalized Method of Moments (SGMM)	Only in non-inflation crisis countries does inflation harm growth, while inflation uncertainty promotes growth.
Barro (2013)	100 countries	Simple regression	The effects from an increase in average inflation by 10 percentage points per year are a reduction of the growth rate of real per capita GDP by 0.2percentage points per year and a decrease in the ratio of investment to GDP by 0.4percentage points.
López-Villavicencio and Mignon (2011)	industrialized and emerging economies	PSTR model	Inflation has a non-linear impact on economic growth.
Eggoh and Khan (2014)	102 developed and developing countries.	Dynamic PSTR and GMM models	The inflation-growth relationship is non-linear, and their threshold estimates decrease with income level

Moosa (1997)	United States G7 countries	Structural time-series approach	North America has the highest coefficient and Japan has the lowest, which can be explained by differences in rigidities in the labor market.
Moosa (2008)	Arab countries	A parsimonious regression model	The growth of production does not translate into employment gains for these four countries.
Sadiku et al., (2015)	Macedonia	Difference model, dynamic model, ECM and VAR estimation approach	All models provide strong evidence and do not confirm an inverse relationship between the unemployment rate and economic growth, as Okun's law suggested.
Villaverde and Maza (2009)	Spanish regions	First-difference model	An inverse relationship between unemployment and economic growth for most regions and for the country as a whole.
Michael et al., (2016)	Nigeria	Co-integration test, the Vector Error Correction Model (VECM) technique and the Granger causality test	Unemployment has a negative and significant impact on GDP, a unidirectional relationship between UNEMP and GDP, with causality ranging from economic growth to unemployment.
Tiryaki and Ozkan (2011)	Turkey	Vector Error Correction Model (VECM) technique and the Granger causality test	One-way causality ranging from the GDP gap to unemployment.
Dritsakis and Stamatiou (2016)	Greece	(ARDL) and ECM-ARDL model	A unidirectional causal relationship between unemployment and economic growth with the direction of unemployment to economic growth.
Zagler (2006)	United Kingdom	Fixed-effect regression methods	A significant and negative relationship between unemployment and economic growth
Islam et al., (2003)	United States	Cointegration test	Weak long-term cointegratin relationship between unemployment and inflation.
Islam et al., (2011)	Regions of Cyprus	ARDL and DOLS approaches to cointegration	The existence of both long-term and short-term Phillips curve for northern Cyprus.
Furuoka (2007)	Malaysia	Vector Error Correction Model (VECM)	The existence of a long-term relationship, a trade-off and also a causal relationship between the unemployment rate and the rate of inflation,the existence of the Phillips curve in the case of Malaysia.
Dritsaki and Dritsaki (2012)	Greece	Cointegration, Granger Causality	A long-term and causal relationship between inflation and unemployment.
Bhattarai (2016)	OECD countries	Cointegration and Granger causality tests and a panel VAR model	Along-term relationships between unemployment and inflation rate.

3. Data and Methodology

Data sources

The analysis used in this paper covers annual panel data from 1965 to 2016 that should be sufficient to determine the relationship between economic growth, inflation and unemployment in our sample of countries. Selected variables included GDP (measured in constant US $), the inflation rate measured by the GDP deflator (annual %), the unemployment rate measured by the number of unemployed aged (15-64) years as percentage of the labor force. We used additional control variables: investment, measured as the ratio of gross fixed capital formation to GDP; population growth, to control for population dynamics; trade openness, measured as the ratio of imports plus exports to GDP; the foreign direct investment, net inflows (% of GDP). The data for these variables are collected from World Development Indicators. Finally, the final consumption expenditure is taken to control the size of government which is collected from the Worldwide Governance Indicators. The descriptive statistics and the correlation matrix of these variables for Tunisia are presented in Table 2 and 3.

Table 2. *Descriptive statistics of variables*

	Y	INF	UNE	GFCF	POP	FDI	EXP	OPE
Mean	10.67917	7.701790	13.75061	11.00506	2.031570	0.778504	16.32014	60.33852
Median	10.68071	5.691545	13.58000	8.817271	2.135134	0.144445	16.54671	57.26474
Maximum	11.41633	53.7886	31.84000	77.87327	3.122386	9.424248	28.22164	114.3548
Minimum	9.704137	-11.1879	1.530000	-31.58649	0.760981	-0.129555	10.28571	30.02141
Std. Dev	0.396474	8.240989	6.054275	13.27494	0.587789	1.311354	3.268371	18.53119
Skewness	-0.315083	2.095941	0.626145	0.478099	-0.261713	2.764331	0.139169	0.541046
Kurtosis	2.472135	10.36289	3.837375	5.463473	2.143806	14.02018	3.715711	2.644104
Jarque-Bera	5.856519	6131551	13.90008	53.24549	8.727778	1114.744	1.277713	11.24572
Probability	0.053490	0.000000	0.000095	0.000000	0.21729	0.000000	0.527896	0.003614
Observations	208	205*	147*	183*	208	176*	208	208

Note: Y gross domestic product, INF inflation , UNE unemployment rate, GCF Gross Capital Formation, POP population growth, FDI foreign direct investment, EXP General government final consumption expenditure, OPE trade openness.
** according to the availability of data.*

Table 3. *Pairwise correlation of the variables*

	Variable	1	2	3	4	5	6	7	8
1	**Y**	1							
2	**INF**	0.1087	1						
3	**UNE**	-0.2198*	0.1719*	1					
4	**GFCF**	-0.3976*	-0.2162*	0.2042*	1				
5	**POP**	-0.1691*	0.3064*	-0.0791	-0.1146	1			
6	**FDI**	-0.4172*	-0.1682*	0.1498	0.5489*	-0.2949 *	1		
7	**EXP**	-0.3288*	-0.2326*	-0.2054*	0.0622	-0.0039	0.0959	1	
8	**OPE**	-0.1263*	-0.0314	-0.0001	0.4451*	-0.4363*	0.5383*	0.0650	1

Methodology

The adopted methodology is a three-step approach: unit root tests, Johannsen cointegration tests, Granger causality tests as part of an error-correction vector model. To examine the three links between economic growth, inflation and unemployment, the following model can be specified as follows;

$$LY_t = \alpha + \beta_1 IN_t + \beta_2 UN + \beta_3 GFCF + \beta_4 POP + \beta_5 FDI + \beta_6 EXP + \beta_7 OPE + \mu_t$$

Where LY, INF, UN, GFCF, POP, FDI, EXP and OPE represent the natural logarithms of gross domestic product, inflation, unemployment, gross fixed capital formation, population growth, the foreign direct investment, the final consumption expenditure and trade openness, respectively.

4. Results and interpretation

Panel unit root tests

Before testing cointegration, it is necessary to ensure the stationarity of the variables studied by carrying out unit root tests for the detection of deterministic or stochastic trends. Augmented Dickey-Fuller (ADF) and Phillips and Peron test are applied to ensure stationarity of the variables.

Table 4. *Results of Unit root tests with ADF and PP test in logarithm form (with trend and intercept).*

	Phillips and Peron		ADF		Order of integration
	T.statistics	Prob.	T.statistics	Prob.	
Level					
GDP	-0.509	0.151	-0. 509	0.231	I(1)
INF	0.151	0.800	-0.607	0.118	I(1)
UNE	-0.910	0.404	-0.330	0.180	I(1)
POP	-1.011	0.111	-1.802	0.101	I(1)
OPENESS	1.100	0.207	1.177	0.405	I(1)
EXP	0.958	0.333	0.955	0.557	I(1)
FDI	-0.080	0.988	-1.011	0.131	I(1)
1st Difference					
GDP	-3.2744	0.0022***	-3.2744	0.0023***	I(1)
INF	-6.6523	0.0000***	-6.6523	0.0000***	I(1)
UNE	-5.7019	0.0001***	-5.7019	0.0001***	I(1)
POP	1.9433	0.0305**	2.7620	0.0000***	I(1)
OPENESS	-3.4102	0.0402**	-3.1878	0.0409**	I(1)
EXP	-1.9433	0.0709*	-3.2149	0.0999*	I(1)
FDI	-4.9906	0.0011***	-4.9906	0.0011***	I(1)

The lag length for augmented Dickey–Fuller (ADF) test is decided based on Schwarz information criteria (SIC) and for Phillips–Perron (PP) test is decided based on maximum band.
**p≤0.01; **p≤0.05 and ***p≤ 0.1 (significance).*

Table 4 shows the results of the unit root test for the variables used in the study for their levels and first differences. The hypothesis of the presence of a unit root detected by ADF and PP is accepted since the t-statistic is superior to the critical value, which then indicates that the seven series are non-stationary in level. In contrast, the stationarity in difference first verifies that t-statistic is less than the critical value of both the tests, from which the series are integrated of order 1 (I (1)).

Johansen Cointegration Test

The choice of the number of delays to be introduced is conditioned by the short-term part of the VECM. Then the number of delays must be decided before the rank test (Johansen Cointegration Test). Thus, we use the Wald test, which is based on the traditional criteria of AIC and Schwartz, and we draw the number of delays. In our series we found two delays. To estimate the cointegration space and to test its rank, the VECM is estimated by Johansen's maximum likelihood method. This test indicates the number of cointegration relationships.

Table 5. *Results of Johansen co-integration test*

Unrestricted Cointegration Rank Test (Trace and Max Eigen value)				
Hypothesized No. of CE(s)	**Fisher statistic Trace test**	**Prob**	**Fisher statistic Max-Eigen value**	**Prob**
None*	**197.5**	**0.000000**	**52.21**	**0.000000**
At most 1*	137.6	0.000000	99.83	0.000000
At most 2*	88.91	0.000000	49.88	0.000000
At most 3*	46.49	0.000000	29.19	0.000000
At most 4*	21.85	0.0013	13.78	0.032200
At most 5*	11.93	0.0636	11.49	0.074500
At most 6*	5.116	0.000000	4.445	0.000008
At most 7*	8.242	0.000032	6.401	0.000032

**Indicates the number of co-integrating relationships*

The results of the co-integration tests for the relevant variables are shown in Table 3. The null hypothesis of non-cointegration for (r = 0, r = 1, r = 2, r = 3, r = 4, r = 5, r = 6 and r = 7) is rejected at the 1% significance level. This allows us to conclude a causal relationship between variables and its move together in the long run so the error-correction model can be retained.

Estimation of VECM

To identify the direction of the causal relationship, the Granger causality test is performed in the vector error correction model (VECM). The VECM can distinguish and detect the relation in both long and short term between the variables and can identify the causality sources. The VECM representation is as follows:

$$\Delta LY_t = \alpha_1 + \sum_{i=1}^{P} \beta_{11i}\, \Delta LY_{t-i} + \sum_{i=12i}^{P} \beta_1\, \Delta LIN_{t-i} + \sum_{i=1}^{P} \beta_{13i}\, \Delta LUN_{t-i} + \gamma ECT_{t-i} + \varepsilon_{1t}$$

$$\Delta LIN_t = \alpha_2 + \sum_{i=21i}^{P} \beta_2\, \Delta LY_{t-i} + \sum_{i=1}^{P} \beta_{22i}\, \Delta LIN_{t-i} + \sum_{i=1}^{P} \beta_{23i}\, \Delta LUN_{t-i} + \gamma ECT_{t-i} + \varepsilon_{2t}$$

$$\Delta LUN_t = \alpha_3 + \sum_{i=31i}^{P} \beta_3\, \Delta LY_{t-i} + \sum_{i=1}^{P} \beta_{32i}\, \Delta LINF_{t-i} + \sum_{i=1}^{P} \beta_{33i}\, \Delta LUN_{t-i} + \gamma ECT_{t-i} + \varepsilon_{3t}$$

Where LY, LINF and LUN represent the natural logarithms of gross domestic product, inflation and unemployment, respectively, indicates first differences, ECT refer to the error correction terms whose coefficients measure speeds of adjustment and are derived from the long-run cointegrating relationships, are intercepts, and p is the lag lengths.

Table 6. *Granger Causality Results based on VECM*

Dependent variable	Short-term					Long-term	Joint test				
							Strong causality				
	ΔLY	ΔLIN	ΔLUN	ΔLPOP	ΔLOPE	ECM	ΔLY, ECM	ΔLIN, ECM	ΔLUN, ECM	ΔLPOP, ECM	ΔLOPE, ECM
Δ LY	-	-0.065 (0.040)**	-0.123 (0.066)*	0.089 (0.065)*	0.546 (0.044)**	- 0.3412 (0.001)***	-	- 0.412 (0.035)**	- 1.780 (0.082)*	0.2032 (0.053)*	0.555 (0.032)**
ΔLIN	-0.698 (0.233)	-	-0.567 (0.880)	1.780 (0.182)	0.099 (0.071)*	0.1221 (0.090)*	- 1.780 (0.182)	-	-0.335 (0.070)*	1.1454 (0.9500)	0.160 (0.051)*
ΔLUN	-0.184 (0.966)	-0.400 (0.078)*	-	0.053 (0.045)**	-0.036 (0.088)*	0.3009 (0.097)*	-0.578 (0.446)	-1.001 (0.088)*	-	0.102 (0.032)**	-0.210 (0.001)***
ΔLPOP	0.056 (0.234)	0.116 (0.733)	0.342 (0.040)**	-	0.1613 (0.688)	0.09 (0.018)***	0.0035 (0.953)	0.1929 (0.660)	1.404 (0.870)	-	0.100 (0.101)
ΔLOPE	0.254 (0.123)	0.5330 (0.465)	-0.654 (0.332)	0.0331 (0.855)	-	0.279 (0.059)*	0.3297 (0.565)	0.5484 (0.459)	1.002 (0.606)	-0.800 (0.434)	-

t- statistic are in the parentheses, (***),(**) and (*) indicate 1%, 5% and 10% level of significance, respectively.

Both the short-term and long-term causality are shown in Table 4.The long-run causality can be analyzed by the coefficient of the lagged error correction model. On the other hand, the Fisher test (joint test) was also used to test the strong causality, where the variables are overloading the short-term adjustment to restore long-term equilibrium. In the short term, the result shows evidence of unidirectional causal flow from inflation to economic growth. Our results seem to be consistent with the finding of Bittencourt (2012) for Latin American countries, Kremer et al., (2013) for industrialized and non-

industrialized countries, Tung and Thanh (2015) for Vietnam and Ramzi and Wiem (2016) for 25 countries. This result implies that high inflation can hurt economic growth in Tunisia, whereas a variation in economic growth is without effect on inflation. The challenge here is to perform the economic growth without increasing inflation rate. In the long term, there is bidirectional causality between the inflation and the economic growth. In addition, there is long term Granger causality between inflation and economic growth. Our results seem to be contradicting those of (Andres and Hernando, 1997; Nguyen and Wang, 2010; López-Villavicencio and Mignon, 2011; Eggah and Khan, 2014; Aydin et al., 2016). In fact, there is a unidirectional relationship ranging from economic growth to unemployment rate both in the short and long term. This result seems to be in accordance with those of (Tiryaki and Ozkan, 2011; Michael et al., 2016). The mutual causality between these two variables is negative and significant at 10% level. This result implies that unemployment rate has a negative effect on the economic growth. Moreover, there is a unidirectional relationship from inflation to unemployment in the short and long term. The inflation rate influences negatively and significantly the unemployment rate at 5% level. These results validate the existence of the Phillips curve and corroborate those of the monetarist who suggest that, in the long term, the unemployment rate has no depends on the rate of inflation. These results are also in accordance with those of Furuoka (2007), Dritsaki and Dritsaki (2012) and Bhattarai (2018). These authors support the idea that the long-run equilibrium unemployment rate is said to be natural or even structural, *i.e.*, it is not due to cyclical causes. The implication of this finding indicates that the inflation rate leads to a reduction in the unemployment rate. In addition, for control variables, there is a unidirectional relationship flow from population to economic growth and from population to unemployment in the short and long-term. Indeed, population movements may be a problem for developing countries as more people will use more limited resources, leading to a reduction in the country's long-term potential growth. Our results seem to be in conformity with those of (Solow, 1956; Banerjee, 2012; Huang and Xie, 2013;Yao et al., 2013; Linden, 2017), while there are other studies that show that high population growth promotes a high rate of GDP growth (Piketty, 2014; Tumwebaze and Ijjo, 2015; Buccio, 2015).On the other hand, the population has a positive effect on unemployment. This result implies that an increase of the population constitutes a brake for the government to ensure full employment for citizens. Moreover, there is a unidirectional relationship flow from trade openness to growth and from trade openness to unemployment and from trade openness to inflation. In fact, the trade openness promotes economic growth *i.e.,* maintaining trade and reducing trade barriers, governments are improving the state of the country's economy. Thus, trade openness has a negative and significant effect on the unemployment implying that globalization can reduce the effect of long-term unemployment. These results are consistent with those of (Davis, 1998; Egger and Kreickemeier, 2009; Helpman and Itskhoki, 2010).

Finally, trade openness has a positive effect on inflation rate. This implies that the influence of monetary policies on the international markets is very high and the degree of influence leads to swings in consumption demands for domestic goods. However, this relationship can offer new opportunities for developing countries, such as better access to developed economies, technology exchanges that improve

productivity and improve living standards. Our results are consistent with those of (Tauci et al., 2009; Samimi and Ghaderi, 2012; Thomas, 2012; Kurihara, 2013) but do not confirm those of Romer theory.

Conclusions and recommendations

This paper examined the relation of causality between economic growth, inflation and unemployment for (Algeria, Egypt, Morocco and Tunisia) over the period 1965–2016 by using the recently developed panel data unit root tests, Johansen co-integration techniques, and Granger causality test. This study leads to different results. The results of the unit root test showed that all the variables are non-stationary and should be integrated in order (1). In addition, economic growth, inflation and unemployment are co-integrated. Firstly, in the short term there is evidence of unidirectional causal flow from inflation to economic growth. In the long term, inflation and economic growth are mutually causal so there is a feedback between these variables. This feedback implies that the two variables can reinforce each other. Such results provide policymakers with a better understanding of the link between economic growth and inflation. A control policy should be adopted in these countries in order to fight or temper inflation and accordingly boost economic growth. This would provide policymakers awareness of how to ensure economic growth without driving up inflation.

Secondly, there is unidirectional relationship ranging from economic growth to unemployment rate both in the short and long term. This finding implies that there is no feedback between these two variables. Hence, unemployment can reduce economic growth, yet economic growth does not lower unemployment. Indeed, governments should counteract unemployment by pursuing and implementing effective active employment policies to rectify the dysfunction of the labor market. Moreover, it is imperative to achieve sustainable economic growth, while improving the instruments of macroeconomic policy in order to stimulate economic growth, which in turn should control unemployment. Finally, there is a unidirectional relationship from inflation to unemployment both in the short and long term. This relationship therefore recommends that the governments of these countries should create opportunities for job openings in order to absorb the abundant population of the unemployed labor force in the country. Yet the challenge remains to guarantee a low unemployment rate without increasing the inflation rate.

References

Alogoskoufis, G. S., & Smith, R. (1991). The Phillips curve, the persistence of inflation, and the Lucas critique: Evidence from exchange-rate regimes. *The American Economic Review*, 1254-1275.

Andrés, J., & Hernando, I. (1999). Does inflation harm economic growth? Evidence from the OECD. In *The costs and benefits of price stability* (pp. 315-348). University of Chicago Press.

Aydın, C., Esen, Ö., & Bayrak, M. (2016). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Turkish Republics in Transition Process. *Procedia-Social and Behavioral Sciences*, *229*, 196-205.

Baharumshah, A. Z., Slesman, L., & Wohar, M. E. (2016). Inflation, inflation uncertainty, and economic growth in emerging and developing countries: Panel data evidence. *Economic Systems*, *40*(4), 638-657.

Bakari S & Mabrouki M & Elmakki A, (2018). The Impact of Domestic Investment in the Industrial Sector on Economic Growth with Partial Openness: Evidence from Tunisia, *Economics Bulletin*, 38(1), pp. 111-128.

Banerjee, R. (2012). Population growth and endogenous technological change: Australian economic growth in the long run. Economic Record, 88, 214-228.

Barro, R. J. (1995). *Inflation and economic growth* (No. w5326). National bureau of economic research.

Barro, R. J. (2013). Inflation and economic growth. *Annals of Economics & Finance*, *14*(1).

Benhabib, J., & Spiegel, M. M. (2009). Moderate inflation and the deflation–depression link. *Journal of Money, Credit and Banking*, *41*(4), 787-798.

Bhattarai, K. (2016). Unemployment–inflation trade-offs in OECD countries. *Economic Modelling*, *58*, 93-103.

Bittencourt, M. (2012). Inflation and economic growth in Latin America: Some panel time-series evidence. *Economic Modelling*, *29*(2), 333-340.

Bruno, M., & Easterly, W. (1998). Inflation crises and long-run growth. *Journal of Monetary Economics*, *41*(1), 3-26.

Bucci, A. (2015). Product proliferation, population, and economic growth. *Journal of Human Capital*, 9, 170-197.

Burdekin, R. C., Denzau, A. T., Keil, M. W., Sitthiyot, T., & Willett, T. D. (2004). When does inflation hurt economic growth? Different nonlinearities for different economies. *Journal of Macroeconomics*, *26*(3), 519-532.

Davis, D. R. (1998). Does European unemployment prop up American wages? National labor markets and global trade. *American Economic Review*, 478-494.

Dorrance, G. S. (1966). Inflation and growth: the statistical evidence. *Staff Papers*, *13*(1), 82-102.

Dritsaki, C., & Dritsaki, M. (2012). Inflation, Unemployment and the NAIRU in Greece. *Procedia Economics and Finance*, *1*, 118-127.

Dritsakis, N., & Stamatiou, P. (2016). Trade openness and economic growth: A panel cointegration and causality analysis for the Newest EU countries. *Romanian Economic Journal*, *18*(59), 45-60.

Egger, H., & Kreickemeier, U. (2009). Firm heterogeneity and the labor market effects of trade liberalization. *International Economic Review*, *50*(1), 187-216.

Eggoh, J. C., & Khan, M. (2014). On the nonlinear relationship between inflation and economic growth. *Research in Economics*, *68*(2), 133-143.

Fischer, S. (1983). Inflation and growth.

Friedman, M. (1968). *Dollars and deficits: inflation, monetary policy and the balance of payments* (No. 332.4/F91d).

Furuoka, F. (2007). Does the "Phillips curve" really exist? New empirical evidence from Malaysia. *Economics Bulletin*, *5*(16), 1-14.

Ghosh, A., & Phillips, S. (1998). Warning: Inflation may be harmful to your growth. *Staff Papers*, *45*(4), 672-710.

Gillman, M., & Kejak, M. (2005). Contrasting models of the effect of inflation on growth. *Journal of Economic Surveys*, *19*(1), 113-136.

Gillman, M., Harris, M. N., & Mátyás, L. (2004). Inflation and growth: Explaining a negative effect. *Empirical economics*, *29*(1), 149-167.

Gordon, R. J. (1971). Steady anticipated inflation: Mirage or oasis?. *Brookings Papers on Economic Activity*, *1971*(2), 499-510.

Gylfason, T., & Herbertsson, T. T. (2001). Does inflation matter for growth?. *Japan and the world economy*, *13*(4), 405-428.

Gylfason, T., & Herbertsson, T. T. (2001). Does inflation matter for growth? *Japan and the world economy*, *13*(4), 405-428.

Harris, R., & Silverstone, B. (2001). Testing for asymmetry in Okun's law: A cross-country comparison. *Economics Bulletin*, *5*(2), 1-13.

Helpman, E., & Itskhoki, O. (2010). Labour market rigidities, trade and unemployment. *The Review of Economic Studies*, *77*(3), 1100-1137.

Huang, T., Xie, Z. (2013). Population and economic growth: A simultaneous equation perspective. *Applied Economics*, 45, 3820-3826.

Islam, F., Hassan, K., Mustafa, M., & Rahman, M. (2003). The empirics of US Phillips Curve: A revisit. *American Business Review*, 21(1), 107.

Islam, F., Shahbaz, M., & Shabbir, M. (2011). Phillips curve in a small open economy: A time series exploration of North Cyprus.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, 12(2-3), 231-254.

Karanassou, M., & Sala, H. (2010). The US inflation–unemployment trade-off revisited: New evidence for policy-making. *Journal of Policy Modeling*, *32*(6), 758-777.

Khan, M. S., & Ssnhadji, A. S. (2001). Threshold effects in the relationship between inflation and growth. *IMF Staff papers*, 48(1), 1-21.

Kremer, S., Bick, A., & Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, *44*(2), 861-878.

Kurihara, Y. (2013). International trade openness and inflation in Asia. *Research in World Economy*, 4(1), 70.

Lee, J. (2000). The robustness of Okun's law: Evidence from OECD countries. *Journal of macroeconomics*, 22(2), 331-356.

Linden, E. (2017, June). Remember the population bomb? It's still ticking. *TheNew York Times*: Sunday Review, 4

López-Villavicencio, A., & Mignon, V. (2011). On the impact of inflation on output growth: Does the level of inflation matter?. *Journal of Macroeconomics*, *33*(3), 455-464.

Lucas, R. E. (1976). Some International Evidence on output-inflation tradeoffs. *The American Economic Review*, *66*(5), 985-985.

Mallik, G., & Chowdhury, A. (2001). Inflation and economic growth: evidence from four south Asian countries. *Asia-Pacific Development Journal*, *8*(1), 123-135.

Michael, E A., Emeka, A., Emmanuel, E N. (2016). The Relationship between Unemployment and Economic Growth in Nigeria: Granger Causality Approach. *Research Journal of Finance and Accounting,* Vol.7, No.24.

Mohseni, M., & Jouzaryan, F. (2016). Examining the Effects of Inflation and Unemployment on Economic Growth in Iran (1996-2012). *Procedia Economics and Finance*, *36*, 381-389.

Moosa, I. (2008). Economic growth and unemployment in Arab countries: Is Okun's law valid? *Journal of Development and Economic Policies*, *10*(2), 7-24.

Moosa, I. A. (1997). On the costs of inflation and unemployment. *Journal of Post Keynesian Economics*, *19*(4), 651-666.

Mubarik, Y. A. (2005). Inflation and growth: An estimate of the threshold level of inflation in Pakistan. *State Bank of Pakistan Research Bulletin*, *1*(1), 35-44.

Nguyen, T. T. B., & Wang, K. M. (2010). Causality between housing returns, inflation and economic growth with endogenous breaks. *Journal of Chinese Economic and Business Studies*, *8*(1), 95-115.

Okun, A. M. (1963). *Potential GNP: its measurement and significance* (pp. 98-103). Yale University, Cowles Foundation for Research in Economics.

Oye, N. D., & Inuwa, I. (2011). Unemployment in Nigeria: implication on the gross domestic product (gdp) over the years. Muhammad Shakil Ahmad et. al. *Int. J. Eco. Res*, *2*(1), 66-71.

Phillips, A. W. (1958). The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861–1957. *Economica*, *25*(100), 283-299.

Piketty, T. (2014). Capital in the twenty-first century. Cambridge, MA: Belknap Press of Harvard University Press.

Ramzi, T., & Wiem, J. (2016). Causality Nexus between Economic Growth, Inflation and Innovation. *Journal of the Knowledge Economy*, 1-24.

Rapach, D. E. (2003). International evidence on the long-run impact of inflation. *Journal of Money, Credit, and Banking*, *35*(1), 23-48.

Sadiku, M., Ibraimi, A., & Sadiku, L. (2015). Econometric Estimation of the Relationship between Unemployment Rate and Economic Growth of FYR of Macedonia. *Procedia Economics and Finance*, *19*, 69-81.

Samimi, A. J., Ghaderi, S., Hosseinzadeh, R., & Nademi, Y. (2012). Openness and inflation: New empirical panel data evidence. *Economics Letters*, *117*(3), 573-577.

Samuelson, P. A., & Solow, R. M. (1960). Analytical aspects of anti-inflation policy. *The American Economic Review*, *50*(2), 177-194.

Sarel, M. (1996). Nonlinear effects of inflation on economic growth. *Staff Papers*, *43*(1), 199-215.

Sidrauski, M. (1967). Inflation and economic growth. *Journal of political economy*, *75*(6), 796-810.

Sögner, L., & Stiassny, A. (2002). An analysis on the structural stability of Okun's law - a cross-country study. *Applied Economics*, *34*(14), 1775-1787.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, 65-94.

Solow, R. M. (1970). Growth theory. An exposition. In *Growth theory. An exposition.*. Oxford: Clarendon Press.

Tauci, H. M., Esener, S. Ç., & Darici, B. (2009). The effects of openness on inflation: panel data estimates from selected developing countries. *Investment Management and Financial Innovations*, *6*(4), 28-34.

Thomas, C. (2012). Trade Openness And Inflation: Panel Data Evidence For The Caribbean. *The International Business & Economics Research Journal (Online)*, *11*(5), 507

Tiryaki, A., & Özkan, H. N. (2011). Economic activity and unemployment dynamics in Turkey. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *6*(2).

Tumwebaze, H. K., Ijjo, A. T. (2015). Regional economic integration and economic growth in the COMESA region, 1980-2010. *African Development Review*, 27, 67-77.

Tung, L. T., & Thanh, P. T. (2015). Threshold in the relationship between inflation and economic growth: Empirical evidence in Vietnam. *Asian Social Science*, *11*(10), 105.

Villaverde, J., & Maza, A. (2009). The robustness of Okun's law in Spain, 1980–2004: Regional evidence. *Journal of Policy Modeling*, *31*(2), 289-297.

Vinayagathasan, T. (2013). Inflation and economic growth: A dynamic panel threshold analysis for Asian economies. *Journal of Asian Economics*, *26*, 31-41.

Virén, M. (2001). The Okun curve is non-linear. *Economics letters*, *70*(2), 253-257.

Wai, U. T. (1959). The relation between inflation and economic development: a statistical inductive study. *Staff Papers*, *7*(2), 302-317.

Yao, W., Kinugasa, T., Hamori, S. (2013). An empirical analysis of the relationship between economic development and population growth in China. *Applied Economics*, 45, 4651-4661.

Zaglar, M. (2006), Does Economic Growth Exhibit a Different Impact on Job Creation and Job Destruction?. *Scottish Journal of Political Economy*, 53, 672-683.