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# Is Economic Growth Really Jobless? Empirical Evidence from North Africa

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**Abstract** North African countries recorded the highest youth unemployment rate in the World during the latest years. The main causes for that situation continue to be at the forefront of the debate among economists, sociologists and policymakers. This paper contributes to the existing literature by estimating the Okun's law for four North African economies over the period 1991–2013. It examines the reaction of unemployment rate to output for different groups of the labor force as determined by age-group and gender. In addition to the basic linear specification, we present estimates of the Okun's coefficients by taking into account the potential presence of structural breaks, threshold and asymmetry. The empirical investigation highlights the presence of mixed findings regarding the significance, magnitude and stability of coefficients for the different groups of the labor force and countries. Policy implications are correspondingly drawn.

**Keywords** Economic growth · Unemployment · Okun's law · North Africa

**JEL Classification** E24 · E32 · J01

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## Introduction

The relationship between output and unemployment has been largely documented in the economic literature. Such a relationship has been captured by means of the so called Okun's law, which suggests the presence of an inverse statistical association between the two variables. According to the original work of Okun (1962), one percentage point more in the unemployment rate has been associated with about three percent fall in real GNP during the postwar period in USA. Since then, the output–unemployment link has received a huge attention from both economists and policymakers and continues to be in the center of the scholars' interest, especially in the aftermath of the latest economic and financial crisis.

Although the inverse relationship between output and unemployment has been frequently confirmed, recent empirical studies have often reached mixed results regarding the robustness and stability of the Okun's law. First, some researchers have focused on the Okun's law by extending the analysis beyond the aggregate macroeconomic variables. The diverse reaction of unemployment associated with some groups of the labor force to fluctuations in the business cycle has prompted a fresh discussion framework on the relationship between output and unemployment (Razzu and Singleton 2013; Zanin 2014). The disaggregation of unemployment might offer a clearer picture on the degree of vulnerability of some specific groups, such as youth, to economic fluctuations. Second, a large body of the literature has been based on a linear framework by implicitly assuming the presence of a symmetric impact (Christopoulos 2004; Gabrisch and Buscher 2006). However, recent empirical investigations suggest that the Okun's law may exhibit nonlinear and asymmetric behaviors (Silvapulle et al. 2004; Huang and Chang 2005; Koutroulis et al. 2016). This has been especially motivated by the sharp fluctuations of business cycles experienced by many countries around the World and resulting in recession and expansion periods. Third, some other studies shed lights on the relevance of Okun's law at a regional level and conclude that the magnitude of the Okun's coefficient is subject to important spatial heterogeneities (Pereira 2014; Binet and Facchini 2013).

The present study contributes to the existing literature by estimating the relationship between gross domestic product and unemployment in four North African countries, namely Algeria, Egypt, Morocco and Tunisia. By doing so, it discriminates itself from previous studies in several directions. To start, this is the first study investigating the validity of Okun's law in the North African region, since most of previous studies focused on developed and some Asian and Latin American countries. In fact, North African countries have witnessed many economic and financial reforms during the last decades, such as the adoption of structural adjustment programs and the conclusion of many bilateral and multilateral free trade agreements. Despite all efforts, their economies have been trapped in a vicious development cycle and have been unable to reach economic growth that allows creating enough jobs. The situation is particularly critical in countries that experienced heavy political turmoil known as the *Arab Spring*. As it is well known, despite the *Arab Spring* led to important political changes, its deep reasons have not been political, but rather

social and economic. Among others, the significant regional disparities, the endemic corruption and the high unemployment rates pushed people to manifest against the existing political regimes. In addition to these political and economic changes, North African countries have faced important social challenges, materialized especially by the exponential growth of youth population and the demographic pressure. According to the Global Employment Trends for Youth 2015 published by the International Labour Organization (2015), North African countries recorded the highest youth unemployment rate in the World, reaching 30.5% in 2014. Understanding the relationship between the economic activity and unemployment in these countries might help policymakers to design suitable labor market policies. Second, this paper investigates the validity of the Okun's law for different categories of the labor force as determined by age-group (youth, adult) and gender (male, female). This analysis is mainly motivated by the potential existence of labor market disparities and will allow identifying group-specific reactions. Moreover, it is possible that the Okun's law may be confirmed for some groups of the population, while this may not be the case for the whole population. Third, this paper aims not only to estimate the Okun's coefficient, but also to check its stability and robustness. Regarding this point, we employ two versions of the linear Okun's law (first difference model and gap model) and account for potential nonlinearities, threshold and asymmetries in the unemployment–output relationship.

The rest of the paper is structured as follows. "Brief Review of the Related Literature" section reviews the recent empirical literature documenting the Okun's law. In "Key Characteristics of Labor Markets in North Africa" section, we outline the key characteristics of labor markets in North African countries. "Empirical Issues" section describes the empirical methodology and data. The empirical results are wrapped in "Empirical Findings" section, while "Concluding Remarks and Policy Implications" section draws concluding remarks and policy implications.

## Brief Review of the Related Literature

A review of the literature suggests that prior studies generally give support to the initial version of the Okun's law, i.e., the presence of an inverse relationship between output and unemployment. However, some studies have not been conclusive regarding the magnitude and stability of coefficients (Huang 2003; Adanu 2005). For example, Zanin (2014) finds a negative relationship between economic growth and unemployment rate in selected Organization for Economic Co-operation and Development (hereafter OECD) countries, but highlights the presence of spatial differences regarding the coefficients' magnitude. Harris and Silverstone (2001) reach similar conclusions when checking the validity of Okun's law for Japan, Western Germany, Canada, Australia, the USA, and the UK. Focusing on 16 OECD countries, Lee (2000) concludes that the magnitude of coefficients in absolute value largely differs across countries and ranges between 0.57 for Italy and 6.55 for Japan. This puzzle in empirical results may be particularly explained by the choice of samples and empirical methodologies.

It is worthy to mention that the pioneer empirical studies assessed the Okun's law by assuming linearity in the relationship between unemployment and output. However, this assumption is not convincing in the presence of structural change, threshold and asymmetry in the abovementioned relationship (Cuaresma 2003; Huang and Chang 2005; Chinn et al. 2014; Shin et al. 2014). Using data relative to G7 economies, Moosa (1997) checks the stability of the Okun's coefficients using the Chow breakpoint test and concludes the presence of structural breaks after 1973. In the same vein, Lee (2000) investigates the robustness of the Okun's coefficient in 16 OECD countries and confirms the instability of the Okun's coefficients resulting from the presence of structural breaks occurring in the 1970s. Sögner and Stiassny (2002) conclude that the stability of the Okun's coefficients is not verified for all considered OECD countries. Huang (2003) employs the Bai and Perron (1998, 2003) test to check the existence of multiple structural breaks in the relationship between cyclical unemployment and cyclical output in USA and Canada. Results confirm the existence of structural breaks characterizing the relationship in the two countries, regardless of the used filtering technique.[1] Using US quarterly data, Cuaresma (2003) estimates the nonlinear threshold regression of the Okun's model. Strong evidence in support of the threshold specification has been advanced. Fouquau (2008) also investigates the Okun's law in 20 OECD countries using the threshold panel data models. The author reveals that the relationship is nonlinear and the impact of cyclical output on cyclical unemployment depends on the level of unemployment. Malley and Molana (2008) suggest that an economy may move between "high-effort" and "low-effort" states, which means that the temporal relationship between output and unemployment may be nonlinear.

In addition, an increasing number of studies claim that the output–unemployment relationship presents an asymmetric behavior. For example, Cuaresma (2003) finds evidence of an asymmetric effect of growth on unemployment. Results reveal that the response of unemployment to GDP is clearer in recession periods than in expansion periods. Shin et al. (2014) implement the nonlinear Autoregressive Distributed Lag (hereafter ARDL) approach to investigate the existence of potential asymmetries in the relationship between output and unemployment in the USA, Canada and Japan. In a recent work, Palombi et al. (2017) examine the Okun's law by applying the hidden cointegration test for a panel of 128 UK regions. It has been shown that output expansion (output contraction) causes unemployment decrease (unemployment increase). Moreover, the authors confirm the existence of an asymmetric behavior as the impact of GDP expansion on unemployment is smaller in absolute value than the impact of GDP contraction.

Furthermore, recent empirical studies estimate the Okun's coefficients by using disaggregated data by region. Freeman (2000) considers regional unemployment data in the USA and finds an Okun's coefficient ranging in absolute value between 1.84 and 3.57. With reference to Europe, Villaverde and Maza (2009) and Binet and Facchini (2013) examine the Okun's coefficients by region in Spain and France,

[1] The author employs four filtering methods, namely the quadratic trend, the Hodrick–Prescott, the Band-Pass and the structural time series model.

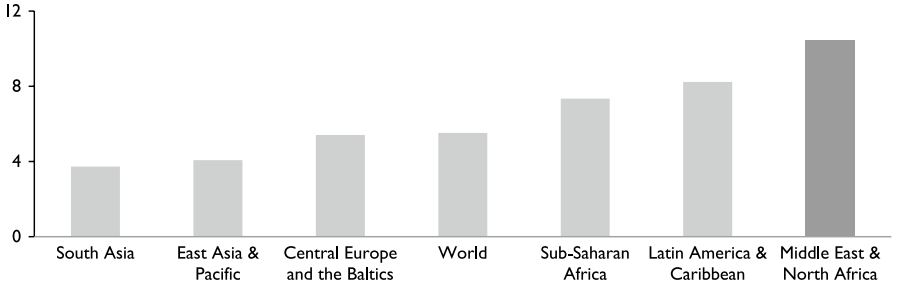


**Fig. 1** Unemployment rate by region in 2017. *Source*: The authors, based on data from the ILOSTAT database

respectively. Findings suggest that coefficients vary across region in both countries. The Okun's law has been also examined by disaggregating unemployment according to age and gender. For instance, Hutengs and Stadtmann (2013, 2014) estimate the Okun's coefficient for a sample of European countries by distinguishing between the unemployment rate of youngest cohort and oldest cohort. Estimation results reveal that the magnitude of the output effect was relatively higher for young people than for old people. Banerji et al. (2015) investigate the causes of youth and adult unemployment in 22 European countries. It has been concluded that GDP downturn explains around 50% of youth unemployment and 60% of adult unemployment. Moreover, when the various expenditure components of GDP are considered,[2] findings suggest that youth and adult unemployment rates are more sensitive to consumption expenditures and less sensitive to export expenditures. Alternatively, Razzu and Singleton (2013) investigate the relationship between unemployment rate and output gap for both male and female in the UK. The authors conclude that the business cycle is not gender neutral since the male unemployment and female unemployment differently react to economic fluctuations. In the same way, Zanin (2014) examines the impact of business cycle on unemployment associated with male and female age cohorts over the period 1998–2012 in 33 OCDE countries. The author suggests that the young population, mainly the young male, tends to be most exposed to business cycle fluctuations.

## Key Characteristics of Labor Markets in North Africa

### Unemployment Trend in North Africa

According to the World Employment and Social Outlook—Trends 2018, the total number of unemployed people around the World is expected to exceed 192 million (International Labour Organization 2018). The global unemployment rate is expected to fall slightly from 5.6% in 2017 to 5.5% in 2018. However, as Fig. 1

[2] The three components are: consumption growth, investment growth and export growth.

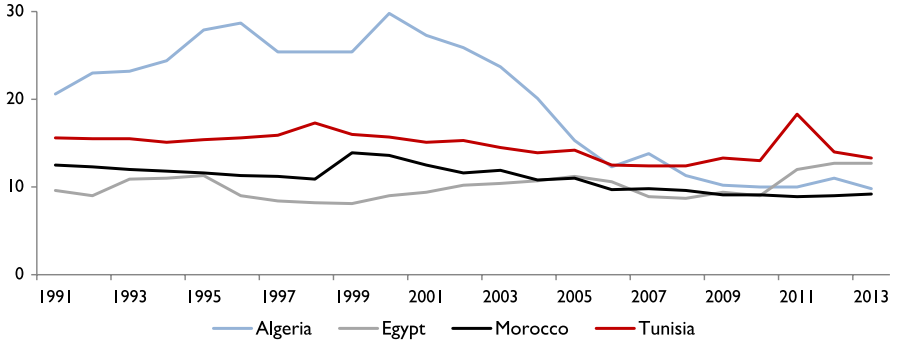


**Fig. 2** The overall unemployment rate in selected North African countries. *Source*: The authors, based on data from the Key Indicators of the Labour Market database

shows, some important disparities across regions with reference to unemployment levels have to be highlighted.

Perhaps the most important thing to note is that the highest unemployment rate is observed in the Middle East and North African (hereafter MENA) region. While the global unemployment rate reached 5.6% in 2017, the one recorded in the MENA region was almost twice (10.64%) and exceeded the one observed in some low income countries (7.6% in Sub-Saharan Africa).

In fact, despite the relatively good economic performance during the 2000s, North African countries have been confronted to serious social problems. The main concern of policymakers in these countries has been decidedly related to the situation of labor markets. In fact, the increasing demographic pressure and the high level of the unemployment rate are the major challenges and common features characterizing those countries. Figure 2 shows the evolution of the aggregate unemployment rate in Algeria, Egypt, Morocco and Tunisia between 1991 and 2013.

Two main sub-periods may be observed. Until mid-2000, Algeria recorded the highest unemployment rate among the four studied economies. It reached 30% in 2000 and then started to decrease significantly. During the same period, Egypt, Morocco and Tunisia experienced relatively stable unemployment rates ranging between 8 and 18%. The second sub-period is characterized by a steady decline of the Algerian unemployment rate reaching 9.8% in 2013. The situation in Tunisia and Egypt has been rather deteriorated especially starting from 2011, the year at which the social and political turmoil started. These two countries recorded the highest unemployment rates in 2013.

Despite its ability to draw the situation of the labor market, the aggregate unemployment rate could cloud considerable disparities in the evolution of unemployment associated with various categories of the labor force as determined for instance by age (youth, adult) and gender (male, female). In fact, stylized facts occurring in the four countries during the last decades show a growing share of youth in total population, causing a high pressure on the labor markets. This situation has been exacerbated by the inability of these countries to create sufficient and decent jobs for

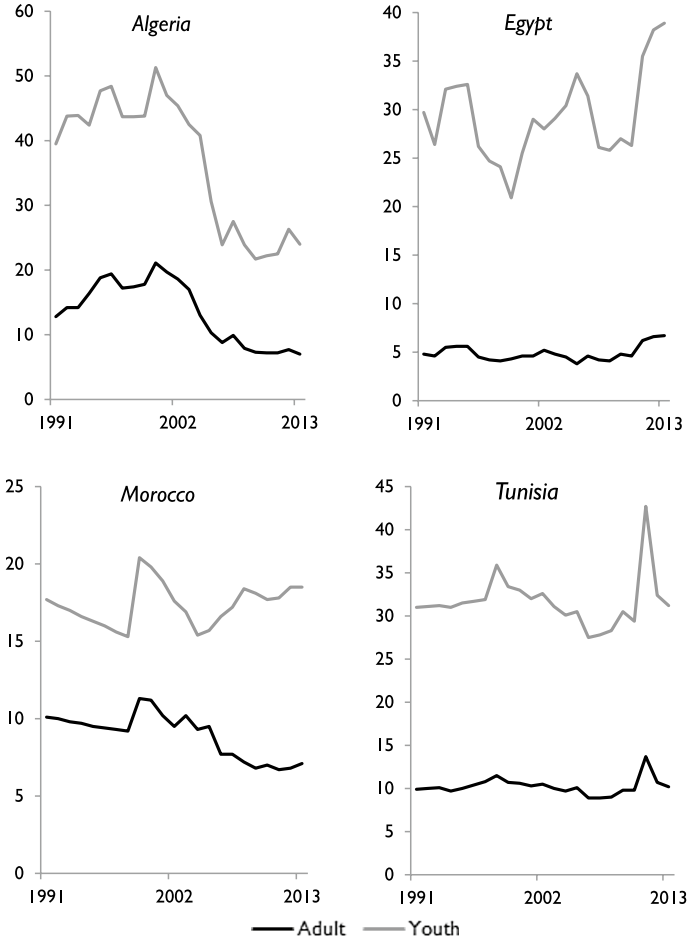


**Fig. 3** Unemployment rate by age-group in selected North African countries. *Source*: The authors, based on data from the Key Indicators of the Labour Market database

this category, even during the upturn periods of the economy. In Fig. 3, we plot the youth and adult unemployment rates in the four countries.

A first look suggests that the youth unemployment rate is higher than the adult unemployment rate in all countries. However, some disparities between them may be observed. The youth unemployment rate in Tunisia reached 31.2% in 2013, which is three times higher than the unemployment rate associated with adult. Despite the adult and youth unemployment rates almost have the same pattern during the whole period in Algeria, the youth-to-adult unemployment rate ratio is still high. In Egypt, the situation is worse since adults faced a jobless rate of 6.6% in 2013, whereas the unemployment rate of young people is about 38.9%, meaning that the youth unemployment rate is six times higher than in the case of adult. While the youth and adult unemployment rates in Morocco have the same trend at early stage, the

adult unemployment rate declines starting from 2005, while the one associated with youth grows to reach 18.5% in 2013. Overall, Fig. 3 highlights the sharp disparities between youth and adult to join the labor market. This statement is in line with the International Labour organization's report stating that the youth unemployment rate in North African countries is the highest in the World (Global Employment Trends for Youth 2015). In fact, the global youth unemployment rate reached 13.1% in 2013, while the average youth unemployment rate in the four studied countries was about 28.15% during the same year.

Another feature of the North African countries is that females are more in risk than males in labor markets. They are susceptible to be unemployed over twice than males, despite the fact that they have a participation rate three times less in the labor market (International Labour Organization 2013). Globally, the female labor force participation has witnessed an increase in this region during last years. This can be explained by the equal opportunity in access to education and employment, which has added pressure on the supply side of labor markets (Subrahmanyam and Castel 2014).

Figure 4 clearly shows that the female unemployment rate is higher that the male unemployment rate in the considered countries. However, we note the existence of a considerable variation between countries. In Algeria and Egypt, the female-to-male unemployment rate ratios are high, reaching about 2 and 4 during the whole period, respectively. Tunisia exhibited a slightly higher unemployment rate for female during the period 1991–2013. Finally, we observe the existence of equal unemployment rates among males and females in Morocco. In some cases, the male unemployment rates exceeded the one of females (for instance, in 1999, female unemployment rate was 13.3%, while male recorded an unemployment rate of 14.1%).

### Labor Market Policies in North Africa

Labor market regulations play a vital role in the functioning of labor markets and exert a noteworthy impact on employment, earnings and productivity (Betcherman 2014). The international experience shows a marked disparity between countries regarding the adoption of labor market regulations. Compared to other developing countries, labor market regulations in North African countries are relatively rigid (Achy 2010; Gatti et al. 2014). This may be confirmed through Fig. 5 reporting the rigidity of employment index in the World, the MENA region and some developing countries. It is worth noting that the index is a composite indicator based on three measures, namely a difficulty of hiring index, a difficulty of firing index and a rigidity of hours index.[3]

As Fig. 5 shows, the level of employment rigidity in the Middle East and North Africa countries (24.4) is almost close to the one recorded at the global level (27.4), suggesting that employment regulations are relatively flexible in the region. This is essentially due to the flexibility of employment regulations in the Middle East.

[3] The index ranges from 0 to 100, where higher values indicate more rigid regulations.

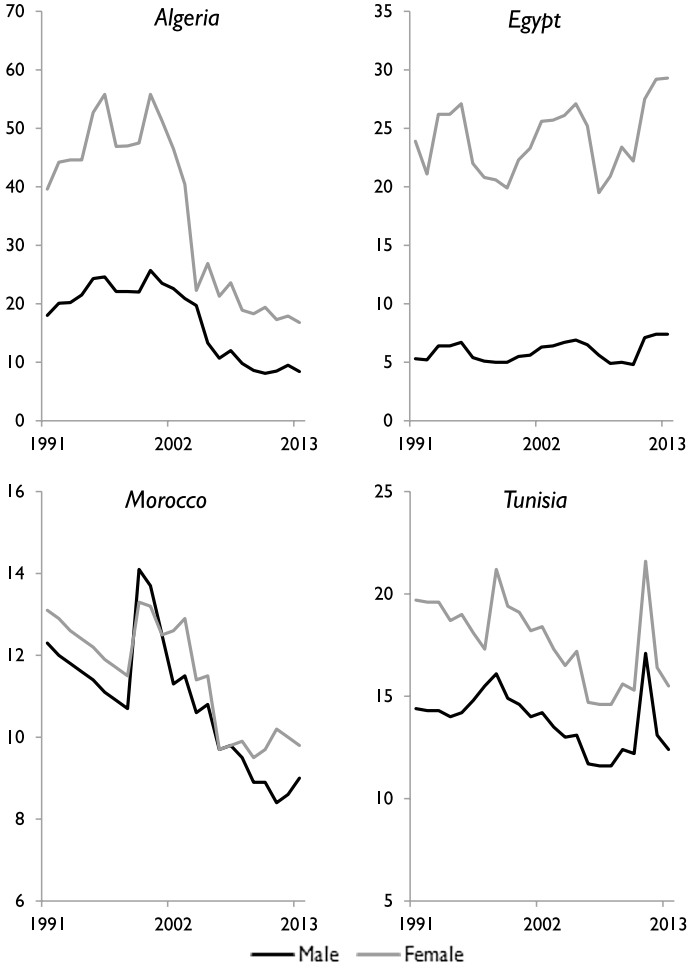


**Fig. 4** Unemployment rate by gender in selected North African countries. *Source*: The authors, based on data from the Key Indicators of the Labour Market database

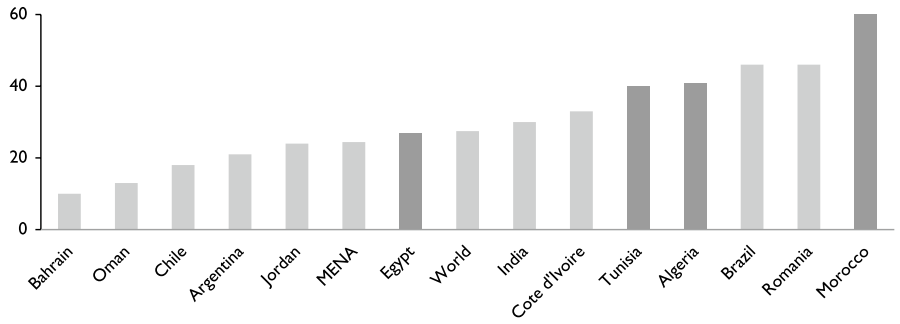


**Fig. 5** The rigidity of employment index in 2009. *Source*: The authors, based on data from the Doing Business database

This may be observed from the same figure, since Bahrain, Oman and Jordan have scores below the MENA and World levels. In addition, the Gulf Cooperation Council (GCC) countries have the lowest difficulty of redundancy index (4), while the MENA non-GCC (essentially North Africa) countries have the highest index in the World (43.3). Firing regulations in the North African region are quite strict, and firing costs are high (Angel-Urdinola and Kuddo 2010; Gatti et al. 2014). Regarding the four studies countries, it is clear that Morocco has rigid labor regulations and is among the top ten rigid labor regulations in the World in 2009. The labor market regulations are specifically rigid in hiring and firing processes. The difficulty of hiring workers has been particularly highlighted by Aita (2008). Of course, only workers in formal sectors benefit from these regulations. Those in the informal sectors suffer from low protection and no job security. Algeria and Tunisia have more flexible labor regulations than Morocco and are ranked 39 and 48, respectively. In Tunisia, labor market regulations in firing workers are high but regulations to hire them are more flexible. For instance, fixed-term contracts have become the most used tool to hire workers, provided that its duration does not exceed 4 years. On the other hand, when a worker is laid off from the firm, the process is lengthy and expensive (Zouari 2014). According to Angel-Urdinola et al. (2015), annual redundancies touch less than 1% of the workforce in Tunisia, compared with more than 10% in the average OECD country. There have been two revisions of the labor code. Revisions conducted in 1994 dealt essentially with the economic dismissal measures and serious offense for which the employer could dismiss a worker, which became more easier but still too expensive for employers. The second wave of reforms have been realized in 1996 and aimed to facilitate the recruitment procedures by introducing the determined duration contracts (Ben-Salha 2013). In Algeria, some flexibility has been introduced in labor market regulations during last decades, which became more flexible in terms of labor contracts. For instance, about 79.5% of wage workers in the private sector are employed on a temporary basis in 2011, while the public sector particularly offer permanent wage jobs (Musette 2014). Finally, Egypt has the most flexible labor market regulations in the sample according to the rigidity of employment index and is ranked before some developed countries, such as Spain, France and Greece. The introduction of the new labor law in 2004 provided increased flexibility for the private sector in the hiring/firing processes (Wahba and Assaad 2017). For example, fixed-term contracts are not prohibited for permanent tasks. In addition, there is no maximum length of fixed-term contracts. However, the severance pay for redundancy dismissal reaches 54.2 salary weeks (World Bank 2017).

The four studied countries have also implemented regulations for minimum wage setting. Minimum wages are periodically revised by governments. While Morocco and Tunisia have signed and ratified ILO's Collective Bargaining Convention, Egypt created in 2003 the National Council for Wages mandated to set a minimum wage and revise it every 3 years (Barsoum et al. 2017). In Tunisia, the minimum wage is subject to regular revisions by the government after negotiations with trade unions. In Algeria, the minimum wage was set up in the 1990s and covered all economic sectors. Wages depend on negotiations between trade unions and employers. Trade union density rate is weak in micro-enterprises, representing about 95% of small

and medium enterprises (Musette 2014). To sum up, even if some differences exist, labor legislations in the studied countries have underwent some reforms to ensure more flexibility, such as the adoption of fixed-term contracts, part-time contracts and ease of the hiring process. However, compared to other developing countries, labor market regulations are still relatively rigid, particularly the firing process. This situation has induced a prevalence of informal employment,[4] since firms are more and more incited to exert a share of their activities informally and conduct informal arrangements with employees (Achy 2010) by creating jobs without legal contracts or adequate social protections. Labor market policies in North African economies have produced a dual labor market, characterized by the presence of significant differences between the formal and informal sectors. In fact, only 30% of workers in Morocco, 46% in Tunisia and 50% in Egypt have employment contracts (Subrahmanyam and Castel 2014). According to International Labour Organization (2013), 41.4% of non-agricultural employment has been realized in the informal sector in 2012. The informality rate among wage earners in Tunisia reached 44.5% in 2011, and particularly touched the labor force with primary education or less (Angel-Urdinola et al. 2015). A recently published report states that about 51% of the workforce operates within the informal economy in Morocco and that 2.4 million workers were operating in the non-agricultural informal sector in 2013 (Danish Trade Union Council for International Development and Cooperation 2018). Finally, estimates of the International Labour Organization (2002) suggest that the informal employment in Algeria and Egypt reached 43% and 55% between 1994 and 2000, respectively.[5]

Alongside Labor Codes reform, North African countries have implemented several measures to ease the integration of job seekers into the labor market. Among others, these measures include the implementation of a set of active labor market policies (hereafter ALMPs). ALMPs dated back to the 1980s in Morocco and Tunisia and the mid-1990s in Algeria (Achy 2010). As mentioned by Barsoum et al. (2017), Tunisia, Morocco and Algeria have increased their allocated expenditures for ALMPs during last decades. While publicly available data regarding expenditures on ALMPs are scarce in North African countries, the available statistics suggest, for example, that 0.8% of gross domestic product was allocated to boost employment in Tunisia via ALMPs between 1997 and 2006 (Haouas et al. 2012). These expenditures reached 1.5% in 2002, but only 5.3% of the working population has been concerned by these policies (Redjeb and Ghobentini 2005). The World Bank (2004) points out that the Tunisian experience in implementing ALMPs has been the most exhaustive in the region. According to Millennium Development Goal Fund (2009), ALMPs expenditures in Tunisia focused on micro-credits (42%) wage subsidy programs (37%), public works (10%), employment services (5%) and vocational training (4%). In Algeria and Morocco, the expenditures on ALMPs have been

[4] Informal employment includes self-employment in informal enterprises, generally small and not registered, and paid employment that is not formally declared, without legal contracts or social protections (Danish Trade Union Council for International Development and Cooperation 2018).

[5] See Fig. 6 in the "Appendix."

also important and reached 0.6 and 0.7% of gross domestic product, respectively (Dyer 2005). In Egypt, spending on public works reached 0.3% of gross domestic product in 1995 (Auer et al. 2008). Compared to other developing and developed countries, these expenditures are relatively high and are comparable to the OECD average expenditures (0.6%). According to Angel-Urdinola et al. (2013), in some MENA countries like Tunisia and Morocco, ALMPs are being mainly implemented through the public sector, while in Egypt the private sector plays a crucial role in deploying those policies. It is important to note that training is the most frequent program offered by the private sector in the MENA region. Although the public sector offers more diversified programs, the vocational training and retraining programs remain the most popular instruments. Other ALMPs deployed in the region include counseling, intermediation, job-search assistance, wage subsidies, support to self-employment and entrepreneurship. Finally, it is worth mentioning that Algeria and Egypt have also implemented some passive labor market policies, essentially unemployment insurance systems (Angel-Urdinola et al. 2013).

## Empirical Issues

### Data Description

This paper employs data associated with four North African countries (Algeria, Egypt, Morocco and Tunisia) to check the relationship between real GDP and unemployment rate. Data on real GDP are extracted from the World Development Indicators database of the World Bank, while total unemployment rate and unemployment rates among youth, adult, male and female come from the Key Indicators of the Labour Market database produced by the ILO Department of Statistics. The empirical study was conducted using annual time series between 1991 and 2013.

### Empirical Strategy

The initial work of Okun (1962) proposed two versions to estimate the impact of economic growth on unemployment rate, namely the difference version and the gap version (Knotek 2007). The first version focuses on the impact of output growth on movements of unemployment, which means that the two variables should be taken in first difference. The difference model is expressed as the following linear regression model:

$$e_t = \alpha_1 + \alpha_2 x_t + \epsilon_t \tag{1}$$

where $x_t = \Delta y_t$ is the output growth, while $e_t = \Delta u_t$ represents the change in unemployment rates. $\alpha_2$ is the Okun's coefficient to be estimated. Finally, $\epsilon_t$ is the error term. Intuitively, the coefficient $\alpha_2$ should be negative, as a growing economy leads to a decline of unemployment rates.

The gap version rather considers the relationship between cyclical components of the two variables. Thus, the relationship between cyclical unemployment and the gap

between potential output and actual output is checked. The gap version model takes the following form:

$$g_{ut} = \alpha_1 + \alpha_2 g_{yt} + \tau_t \quad (2)$$

where $g_{ut} = u_t - u_t^*$ and $g_{yt} = y_t - y_t^*$. The cyclical unemployment rate (unemployment gap) $g_u$ is obtained by extracting the natural unemployment rate $u^*$ from the observed unemployment rate $u$. Likewise, the cyclical level of output (output gap) $g_y$ is derived from the actual output $y$ and the potential level of the output $y^*$. However, this version of the Okun's law needs information about the potential output $y^*$ and the natural unemployment rate $u^*$, which are not observable. To this end, we follow many previous studies by smoothing the actual output $y$ and the observed unemployment rate $u$ using the Hodrick–Prescott filter (Hodrick and Prescott 1997). After filtering data, the ordinary least squares technique (OLS) is used to estimate the Okun's coefficients. The robustness of empirical findings is checked by taking into account the presence of structural breaks, threshold and asymmetry.

In the current study, we use the gap version of the Okun's law in our baseline estimates, while the difference version is employed to check the robustness of our findings. These aforementioned models have been largely employed to test the validity of the Okun's law by generally using aggregate unemployment rate. However, considering the unemployment rate associated with different categories of the labor force seems to be of great importance. In fact, the decomposition of unemployment according to the age cohort (youth and adult) and the gender (female and male) may show complex and different responses of unemployment to the economic cycle (Razzu and Singleton 2013; Boďa and Považanová 2015; Marconi et al. 2016; Dixon et al. 2016). Therefore, the current paper takes this issue in consideration when checking the validity of the Okun's law in North African economies.

## Empirical Findings

Before estimating the Okun's coefficients, we start by checking the stationary properties of variables. As mentioned by Durech et al. (2014), the cyclical components of unemployment and output should be stationary. Such an issue is of great importance since the use of the ordinary least squares to estimate the relationship between non-stationary time series may result in specious conclusions. In Table 7 (reported in the Appendix), we present results of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) non-parametric unit root test applied to output gap, aggregate unemployment gap and unemployment gap associated with youth, adult, male and female. It is clear that we cannot reject the null hypothesis of stationarity at least at 10%, which suggests that the use of the Hodrick–Prescott filter allows us to detrend the data and obtain stationary variables.

### The Gap Version Estimates

Table 1 gives the OLS estimates of the unemployment–output relationship using the gap version of the Okun's law.

**Table 1** Baseline linear model estimation results—gap version

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| Algeria | −1.865** (0.876) | −1.129 (0.909) | −2.451*** (0.871) | −1.548 (0.958) | −2.858** (1.198) |
| Egypt | −4.276*** (0.536) | −4.532*** (0.644) | −2.126* (1.098) | −5.422*** (0.648) | −3.925*** (0.570) |
| Morocco | −0.653 (0.572) | −0.461 (0.571) | −0.667 (0.578) | −0.675 (0.622) | −0.531 (0.434) |
| Tunisia | −1.815 (1.137) | −1.730 (1.152) | −1.720 (1.149) | −1.753 (1.154) | −1.811 (1.159) |

Robust standard errors are in parentheses. ***, ** and * are significant coefficients at 1, 5 and 10 percent levels, respectively

One may note that findings are mixed since they differ across countries and groups. In Egypt, a negative and significant relationship between total unemployment and the output is found, suggesting the validity of the Okun's law. A rise of cyclical output by 1% induces a fall of total cyclical unemployment by 4.2%. When focusing on the relationship between output and unemployment rates by age cohorts, findings confirm the existence of a significant inverse relationship for both youth and adult. However, the magnitude of coefficients is higher for youth than for adult. While the Okun's law is confirmed for the two categories, youth seems to be more exposed to the business cycle. These results corroborate those found in many prior studies, such as Hutengs and Stadtmann (2014) for the case of Scandinavian countries and Zanin (2014) for the case of OECD countries. Finally, we check the impact of output on unemployment by gender and conclude in this context that the reaction of male unemployment is higher than the one associated with female. In Morocco and Tunisia, things seem to be totally different. In fact, even though coefficients are negative, they are not statistically significant. In these two countries, the relatively good economic performance recorded during the 2000s seems to not be able to reduce the total unemployment and particularly the unemployment among youth, adult, male and female. Lastly, the table shows that the relationship between output gap and unemployment gap varies across groups in Algeria. While the expected sign is confirmed in all cases, coefficients are only statistically significant when considering the overall unemployment, adult unemployment and female unemployment. Youth population is found to be less exposed to economic growth, given the existence of many labor market barriers for first-job seekers, especially new graduates. The same statements are also observed for male, where the coefficient is not statistically significant. This divergence in results across groups and countries when examining the validity of the Okun's law represents a strong argument toward the necessity of decomposing the overall unemployment according to age and gender. Working only on the overall unemployment rate may results in flawed conclusions.

**Table 2** Linear model estimation results—difference version

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| Algeria | −1.100 (0.914) | −0.478 (0.979) | −1.529 (1.010) | −1.312 (1.203) | −0.266 (1.335) |
| Egypt | −4.337*** (1.370) | −4.589*** (1.580) | −2.490 (1.874) | −5.397*** (1.657) | −4.094** (1.632) |
| Morocco | −0.407 (0.275) | −0.194 (0.280) | −0.408 (0.314) | −0.408 (0.294) | −0.309 (0.228) |
| Tunisia | −2.818 (1.649) | −2.915 (1.768) | −2.619 (1.625) | −2.622 (1.684) | −3.129* (1.608) |

See the footer of Table 1

## The Difference Version Estimates

In order to check the robustness of our baseline results, we present in this subsection findings using the difference version. This version has been initially used by Okun (1962) and also widely employed in the related empirical literature (see for instance Economou and Psarianos (2016) and Melguizo (2017)). It simply links the annual change of unemployment rate to the annual change in real output.

Results summarized in Table 2 partially confirm those found using the gap version. In fact, the inverse relationship between total unemployment and output is confirmed in Egypt. As in the gap version, the highest Okun's coefficients are found for young cohorts and male. In addition, the law is not validated for adult since the coefficient is not statistically significant. It is useful to note that the coefficient associated with adult is weakly significant (only at 10%) when we employed the gap version. In Morocco and Tunisia, coefficients are negative but not statistically significant, confirming the absence of linkages between unemployment and output in these two countries. Finally, for Algeria, result of the difference version of the Okun's law shows that output exerts negative effects on total unemployment and unemployment associated with all groups. However, contrary to the gap version, all coefficients are not statistically significant. To summarize, estimations based on the difference version do not almost bring new conclusions on the validity of the Okun's law and highlight the need for more in-depth analysis.

In the previous sub-sections, the analysis has been performed under the hypothesis that the relationship between output and unemployment is linear and symmetric. These features have to be carefully considered before concluding and presenting policy implications.

## Controlling for Structural Breaks

The aim of this subsection is to shed light on an important empirical issue, namely the existence of structural breaks in the output–unemployment trade-off. In fact, the relationship may be subject to significant structural breaks which may hide the validity of the Okun's law or appear an insignificant relationship. It is also crucial to check the temporal stability of the relationship during the period, since many

**Table 3** Results of the Bai and Perron breakpoint test

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| Algeria | 4.262 | 5.329 | 4.171 | 4.570 | 3.579 |
| Egypt | 32.869*** | 14.019*** | 50.947*** | 176.826*** | 10.336* |
| Morocco | 43.945*** | 12.806** | 37.523*** | 33.954*** | 27.447*** |
| Tunisia | 14.574** | 11.327* | 14.268** | 12.717** | 14.677** |
| Critical values | 1% | 15.37 | | | |
| | 5% | 11.47 | | | |
| | 10% | 9.81 | | | |

***, ** and * denote the significance of the breakpoint at 1, 5 and 10 percent levels, respectively

internal and external shocks may occur. Such an issue has been highlighted in many related studies (see for instance Sögner (2001) and Kitov and Kitov (2012)). To deal with this concern, we start by applying the Bai and Perron (1998, 2003) test on results obtained using our baseline estimates obtained using the gap version. The advantage of this test is that it endogenously determines the date of breakpoints.

Econometrically, Eq. 2 will be extended to allow for structural breaks in the model parameters. The standard linear regression with $m$ breaks ($m+1$ regimes) is written as follows:

$$y_t = x_t'\beta + z_t'\delta_j + \tau_t \tag{3}$$

For regime $j = 1, 2, 3, \ldots, m+1$, there are two groups of explanatory variables in Eq. 3: The $x(p * 1)$ vector where the corresponding coefficient $\beta$ do not vary across regimes and the $z(q * 1)$ vector where the coefficient $\delta_j$ is regime dependant. $\tau_t$ is the disturbance term. When $p = 0$, we obtain a pure structural change model where all parameters are subject to changes. In order to obtain the structural change Okun's regression, we rewrite $y_t = g_{ut}$, $z_t = \left(1, g_{yt}\right)'$ and $\delta_j = (\alpha_{1,j}, \alpha_{2,j})'$. As a result, Eq. 3 can be rewritten as,

$$g_{ut} = z_t'\delta_j + \tau_t \tag{4}$$

Based on T observations on $g_{ut}$ and $g_{yt}$, our purpose is to estimate the unknown parameters $\alpha_{2,j}$ for $j=1, 2,\ldots, m+1$, together with the break points.

The aim of considering the existence of breakpoints is to see whether the different relationships between output and unemployment in the studied countries are subject to significant structural breaks. It is important to note that the number of potential breakpoints is limited to one given the relatively short time period.

As can be seen in Table 3, findings confirm the presence of structural breaks in Egypt, Morocco and Tunisia, while in Algeria, no breakpoints have been detected. These results suggest that the estimated Okun's coefficients are not stable over time in the first three countries. The next step is to estimate the relationship between output gap and unemployment gap by accounting for the determined breakpoint. The

**Table 4** Breakpoint model estimation results

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| Egypt | −11.480*** (1.563) | −12.770*** (2.319) | −11.816*** (0.888) | −5.943*** (0.572) | −10.117*** (2.115) |
| | −3.872*** (0.483) | −3.846*** (0.622) | −1.614 (1.120) | 0.440* (0.252) | −3.408*** (0.536) |
| Morocco | 0.212 (0.283) | 0.281 (0.336) | 0.246 (0.248) | 0.253 (0.321) | 0.165 (0.217) |
| | −3.924*** (0.562) | −3.271*** (0.959) | −4.118*** (0.697) | −4.187*** (0.692) | −3.163*** (0.715) |
| Tunisia | 0.679 (0.568) | 0.363 (0.487) | 0.546 (0.570) | 0.414 (0.612) | 1.022 (0.616) |
| | −3.279** (1.567) | −3.488 (2.442) | −3.485* (2.039) | −3.560 (2.347) | −3.461** (1.593) |

See the footer of Table 1

estimation is therefore done for two sub-periods, before and after the breakpoint date. Given the results of Table 3, Algeria is excluded from the analysis at this stage.

As shown in Table 4, even when we take into account the presence of structural breaks in the relationship between unemployment and output, the Okun's law remains valid in Egypt. Despite the higher response of unemployment to output in the first sub-period, coefficients are almost statistically significant in the two sub-periods, which confirm the presence of a stable inverse relationship over time. Finally, it is important to note that the reaction of unemployment to cyclical output is more pronounced for youth than adult and for female than male. Turning to Morocco and Tunisia, the estimation with breakpoints brings new findings. In the two countries, the negative impact of output gap on unemployment gap may be observed in the second sub-period. In Morocco, coefficients are statistically significant at 1 percent level for all groups, while in Tunisia, the significance is only observed for overall unemployment, adult unemployment and female unemployment. It seems that youth and male unemployment are unresponsive to output in the country. These findings suggest that the insignificance of coefficients in Morocco and Tunisia (Table 1) is not due to the absence of an inverse relationship between output gap and unemployment gap in these two countries, but to the instability of the relationship over time. Once we consider the potential existence of structural breaks, the Okun's law has been validated, which represents a strong argument toward the importance of such an analysis. In the case of Egypt, the inverse relationship between output and unemployment seems to be strong and stable over time.

### Controlling for Threshold

In what follows, we turn our attention to the possible existence of a threshold level in the relationship between output gap and unemployment gap. Such an issue has been previously documented in the previous studies on the subject [to cite a few, Fouquau (2008) and Herzog (2013)]. We will empirically test whether the impact of output on unemployment depends on an endogenously determined unemployment threshold level. For that reason, we adopt here a threshold model of the original Okun's model presented in Eq. 2. The corresponding model is defined as follows:

$$g_{ut} = \begin{cases} \alpha_{1,1} + \alpha_{2,1} g_{yt} + \tau_t, & if\ g_{ut} \leq \gamma \\ \alpha_{1,2} + \alpha_{2,2} g_{yt} + \tau_t, & if\ g_{ut} > \gamma \end{cases} \tag{5}$$

where $\gamma$ is the threshold level endogenously determined using the Bai and Perron (2003) test. It is clear that the Okun's coefficient $\alpha_{2,i}, (i = 1, 2)$ depends on the level of cyclical unemployment $g_{ut}$. In periods of low cyclical unemployment rate, i.e., $g_{ut} \leq \gamma$, the relationship between cyclical unemployment and GDP is measured by $\alpha_{2,1}$, whereas $\alpha_{2,2}$ measures the contribution of increases in output to unemployment reduction when unemployment rate is high ($g_{ut} > \gamma$). Different values of the Okun's coefficients in the two regimes might indicate the existence of a threshold relationship effect of output on unemployment. Results are displayed in Table 5. It is worth to mention that the threshold level may vary according to the country and the group.

**Table 5** Threshold model estimation results

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| Algeria | −0.959* (0.539) | −0.371 (0.618) | −1.178** (0.525) | −0.893 (0.587) | −1.283 (0.887) |
| | −0.641 (0.853) | 0.467 (0.695) | −0.040 (1.023) | 0.867 (0.630) | −2.138 (1.769) |
| Egypt | −1.913** (0.773) | −1.927** (0.767) | −0.267 (1.246) | −4.982*** (0.820) | −0.045 (1.145) |
| | −1.907** (0.851) | −1.273 (0.870) | 2.495 (2.148) | −0.067 (0.559) | −1.691** (0.762) |
| Morocco | −0.362 (0.299) | −0.367 (0.352) | −0.391 (0.288) | −0.349 (0.324) | −0.362 (0.274) |
| | −1.124*** (0.353) | −1.463*** (0.414) | −1.259*** (0.199) | −1.451*** (0.374) | −0.545** (0.208) |
| Tunisia | −0.903* (0.539) | −0.798 (0.524) | −0.691 (0.604) | −0.700 (0.324) | −1.126* (0.601) |
| | −3.859 (2.755) | −7.296*** (0.305) | −9.295*** (1.181) | −9.087*** (0.854) | −6.738*** (0.073) |

See the footer of Table 1

Our analysis is performed for two levels of unemployment gap, namely low and high.

We start our interpretation of results by focusing on Morocco and Tunisia, given that they present some similarities. It is clear that coefficients are only statistically significant when unemployment exceeds a given threshold. Such findings strongly confirm the existence of an inverse relationship between output gap and unemployment gap for high levels of unemployment in these two countries. In Egypt, estimates reveal that overall unemployment negatively reacts to output for whatever level of unemployment rate. Moreover, the coefficients are very close. When considering unemployment by age cohorts and gender, results are mixed. While youth and male are more sensitive to the business cycle when the associated unemployment rates are low, unemployment among female is only affected by output when the unemployment rate exceeds a given threshold level. These findings prove that the decreasing impact of output on youth unemployment and male unemployment becomes neutral as their levels grow. Table 5 partially confirms previous results associated with adult, since coefficients are not statistically significant. Therefore, the impact of output on adult unemployment is weak. What can be retained for the case of Egypt is that the inverse relationships are verified for low and high levels of unemployment rate. These findings relatively confirm the insensitivity of results to the threshold. Finally, Algeria stands out again since no solid conclusion on the validity of the Okun's law has been revealed when considering the existence of threshold in the relationship. Coefficients are weakly significant for only total unemployment and adult unemployment when the unemployment rate is below the threshold level. When comparing the Okun's coefficients among countries, Tunisia records the highest levels for all groups. This suggests that unemployment in Tunisia is more affected by business cycle changes than are their North African peers.

**Table 6** Asymmetric model estimation results

| Country | Total | Age | | Gender | |
|---|---|---|---|---|---|
| | | Youth | Adult | Male | Female |
| *Panel A: Positive changes in GDP (expansion)* | | | | | |
| Algeria | −1.760 (1.077) | −0.978 (1.121) | −2.385** (1.083) | −1.346 (1.189) | −2.818* (1.504) |
| Egypt | −4.289*** (0.631) | −4.609*** (0.786) | −2.100* (1.134) | −5.390*** (0.733) | −3.986*** (0.648) |
| Morocco | −1.006 (0.649) | −0.824 (0.643) | −0.993 (0.671) | −1.061 (0.702) | −0.811 (0.505) |
| Tunisia | −1.824* (0.980) | −1.744* (0.956) | −1.734* (1.019) | −1.750* (1.011) | −1.843* (0.976) |
| *Panel B: Negative changes in GDP (recession)* | | | | | |
| Algeria | −1.498 (1.025) | −0.728 (1.069) | −2.255** (1.036) | −1.105 (1.181) | −2.695* (1.374) |
| Egypt | −4.229*** (0.607) | −4.491*** (0.678) | −2.041* (1.194) | −5.371*** (0.728) | −3.894*** (0.660) |
| Morocco | −1.119* (0.653) | −0.920 (0.658) | −1.106 (0.665) | −1.189 (0.713) | −0.890* (0.494) |
| Tunisia | −1.824 (1.278) | −1.738 (1.307) | −1.731 (1.284) | −1.768 (1.291) | −1.808 (1.312) |

See the footer of Table 1

## Controlling for Asymmetry

In the previous analysis, we implicitly assume that the reaction of cyclical unemployment to cyclical output is symmetric. This means that the impact of a rise or a decline of output on unemployment is identical. This assumption may not hold true in some cases since unemployment may differently respond to a rise or a decline of output. Recent studies on the subject conclude that the reaction of unemployment rate to the economic upturns can be different from its response to the economic downturns, which means that the Okun's law might be asymmetric (Marinkov and Geldenhuys 2007; Jardin and Stephan 2012; Cevik et al. 2013; Shin et al. 2014). To deal with this issue, we estimate in the current sub-section the impact of positive and negative components of cyclical output on cyclical unemployment. To do that, we follow Shin et al. (2014) by introducing in Eq. 2 the two components of the output gap variable, namely the cumulative positive sum $g_{yt}^{+}$ and the cumulative negative sum $g_{yt}^{-}$. The two cumulative sums are defined as follows:

$$g_{yt}^{+} = \sum_{j=1}^{t} \Delta g_{yj}^{+} = \sum_{j=1}^{t} \max\left(\Delta g_{yj}, 0\right) \tag{6}$$

$$g_{yt}^{-} = \sum_{j=1}^{t} \Delta g_{yj}^{-} = \sum_{j=1}^{t} \min\left(\Delta g_{yj}, 0\right) \tag{7}$$

Therefore, the gap version of Okun's law can be written as:

$$g_{u,t} = \alpha_1 + \alpha_2^{+} g_{yt}^{+} + \alpha_2^{-} g_{yt}^{-} + \tau_t \tag{8}$$

where $\alpha_2^+$ and $\alpha_2^-$ are the Okun's coefficients associated with expansion and recession periods, respectively. Table 6 reports the estimation results of the impact of output gap on unemployment gap in both expansion periods (Panel A) and recession periods (Panel B).

The table brings out many interesting findings. In Egypt and Algeria, it is shown that the cyclical upturns and downturns have symmetric impact on unemployment. In Egypt, all coefficients are negative and statistically significant in both expansion and recession periods. Moreover, it is clear that the magnitude of the Okun's coefficient is almost the same in the two states of the economy, confirming that unemployment rates have the same reaction to output in expansion and recession periods. Finally, the highest reaction to expansion and recession of output gap is observed for youth and male, corroborating our previous results. While the relationship is also symmetric in Algeria, it is clear that only unemployment associated with adult and female reacts to the business cycle. Such findings are in line with those presented in Table 1. Contrary to Egypt and Algeria, the impact of output on unemployment seems to be asymmetric in Tunisia and Morocco. In Tunisia, the table suggests that unemployment is only affected by output when the economy is in the expansion state, i.e., higher cyclical output is associated with lower cyclical unemployment rate. Many issues may explain such findings. In fact, during the last decades, Tunisian authorities have implemented many ALMPs to boost employment. As mentioned previously, the ALMPs implemented in Tunisia have been the most exhaustive in the region (World Bank 2004). It is evident that the expenditure on implementing ALMPs primarily depends on the state of the economy and increases in expansion periods. A final remark drawn from the table is that the output gap negatively affects unemployment rates associated with all groups in expansion periods. In Morocco, estimates reveal that the relationship between output gap and unemployment gap is also asymmetric. However, contrary to Tunisia, we find that the overall cyclical unemployment responds to cyclical downturns but not to cyclical upturns. When considering unemployment by groups, the table shows that unemployment among female rises when the output falls, whereas youth, adult and male are unresponsive to the economic downward.

## Concluding Remarks and Policy Implications

The relationship between the economic activity and unemployment has received a growing interest during the last decades. This paper contributes to the existing debate by focusing on a sample of North African developing countries that have been usually ignored in previous studies, namely Algeria, Egypt, Morocco and Tunisia. In addition, it discriminates itself by investigating the validity of the Okun's law for different categories of the labor force as determined by age-group (youth, adult) and gender (male, female). Such an analysis may be useful since it allows estimating the age cohort and gender-specific Okun's coefficients. Finally, when checking the impact of economic growth on unemployment, our study takes into account the potential presence of three main characteristics of macroeconomic relationships, namely structural change, threshold and asymmetry.

Using annual data ranging between 1991 and 2013, the empirical investigation reveals some heterogeneity among the four studied countries regarding the significance, magnitude and stability of the Okun's coefficients. In Egypt, findings suggest that output and unemployment are negatively related and that the relationship has been stable against structural breaks that occurred during the studied period. Furthermore, it has been shown that the inverse relationship between cyclical output and cyclical unemployment holds true in expansion and recession periods, confirming the absence of asymmetry in the Okun's law. Finally, we reveal that youth and male have the highest Okun's coefficients in absolute terms. Studying the aforementioned relationship in the Algerian economy, we conclude that only unemployment associated with adult and female weakly responds to output. As in Egypt, the relationship is found to be symmetric with approximately close Okun's coefficients in expansion and recession periods. Turning to Morocco and Tunisia, the analysis shows some similarities. The relationship between cyclical output and cyclical unemployment turns to be significant only when we account for structural breaks, which implies that it has been unstable over time. Generally, the Okun's law is found to be valid starting from the 2000s, a period during which many economic reforms have been implemented in these two countries. The analysis also reveals that the reaction of unemployment to output is observed during periods of high unemployment rates. Finally, while there are overwhelming evidences in support of asymmetry in the two countries, they have different behaviors with respect to cyclical downturns and cyclical upturns. In fact, our findings suggest that the inverse relationship between output and unemployment is observed during recession periods in Morocco and expansion periods in Tunisia.

Results of this paper may offer recommendations for the design of economic policies and the conduct of future empirical studies. Regarding the first issue, since findings show that the response of youth unemployment to output is weak in the studied countries (except Egypt), it is imperative to make more efforts to help young people, especially university graduates, to join the labor market. To do so, the reform of the educational system imposes itself more than ever in order to reduce the mismatch between the schooling skills and the required skills. In fact, high levels of educated unemployed people are due to the failure of education systems to provide them with skills required by the private sector (Angel-Urdinola et al. 2015). As mentioned by the World Bank (2013), more than one-third of employers in the MENA region consider skill shortages as a major constraint to business development and is the highest share among developing regions in the World. In addition, the Arab World Competitiveness Report 2011–2012 confirms this idea since inadequate education is considered as the fourth-most-constraining issue to economic growth (WEF and OECD 2011). Education systems in the studied countries are still preparing students for jobs in the public sector, rather than providing them with skills needed by the private sector (Subrahmanyam and Castel 2014). The inadequacy between schooling skills and required skills pushes first-time educated job seekers in many cases to integrate the informal sector to avoid unemployment. To reduce the informal employment, policymakers have to establish some reforms, such as lowering taxes and simplifying tax administration, liberalizing labor regulations, improving the business climate and removing bureaucratic barriers (World Bank 2011). The upgrade of professional qualifications, the training and retraining programs and the support of entrepreneurship are other essential instruments that may facilitate the integration of youth into

the labor market. Furthermore, the active labor market policies should be really active, in the sense that they should be addressed to people who need them. According to Subrahmanyam (2011), the deployed programs have benefitted only a small share of unemployed youth and have not been efficient in reducing youth unemployment. For instance, vocational training schemes and self-employment programs are relatively low cost and did not guarantee job security. Despite wage subsidy programs are costly to implement, the created jobs rarely last beyond the subsidy period (Subrahmanyam 2011). Before implementing reforms regarding policies, it is important for policymakers in North African countries to conduct impact evaluation of ALMPs to assess the degree of their effectiveness and improve the design of programs. Another important point is related to the quality of created jobs. In fact, even if the Okun's law is generally validated in our sample, it is crucial to focus on the quality of created jobs. First, it is no longer sufficient to create jobs, but it is rather important to create decent jobs that guarantee a permanent and secure incomes. Second, there is an urgent need for skilled jobs able to absorb the growing number of university graduates in North African countries. Regarding this point, policymakers should conceive and build new economic models aiming the creation of wealth using the abundant qualified human capital.

The last recommendation is methodological. In fact, the empirical investigation highlights the necessity of considering unemployment associated with specific groups of the population when checking the output–unemployment relationship. Furthermore, researchers should pay special attention to specific econometric issues such as nonlinearity, threshold and asymmetry. Ignoring these econometric features when estimating the Okun's law may lead to inappropriate, if not incorrect results.

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## Appendix

See Fig. 6 and Table 7.

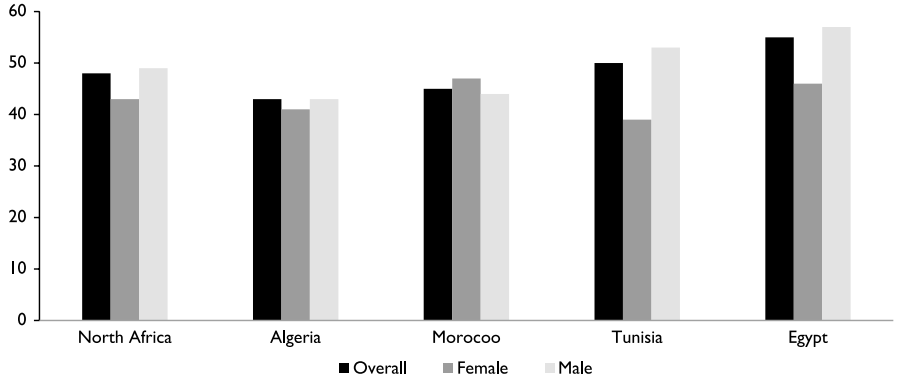


**Fig. 6** Informal employment in the non-agricultural sector in North Africa, 1994–2000. *Source*: The authors, based on data from International Labour Organization (2002)

**Table 7** Results of KPSS unit root test

| Variable | Algeria | Egypt | Morocco | Tunisia |
|---|---|---|---|---|
| Gross domestic product | 0.100*** | 0.053*** | 0.050*** | 0.061*** |
| Gross domestic product (expansion) | 0.126** | 0.108 ** | 0.168 * | 0.058 ** |
| Gross domestic product (recession) | 0.110** | 0.086 ** | 0.166* | 0.073 ** |
| Total unemployment rate | 0.099*** | 0.050*** | 0.072*** | 0.073*** |
| Youth unemployment rate | 0.089*** | 0.051*** | 0.053*** | 0.076*** |
| Adult unemployment rate | 0.100*** | 0.065*** | 0.082*** | 0.073*** |
| Male unemployment rate | 0.097*** | 0.050*** | 0.073*** | 0.075*** |
| Female unemployment rate | 0.092*** | 0.050*** | 0.072*** | 0.068*** |
| Critical values 1% | 0.216 | | | |
| 5% | 0.146 | | | |
| 10% | 0.119 | | | |

The test has been performed on the cyclical component of variables obtained using the Hodrick–Prescott filter. ***, ** and * denote significance at 1, 5 and 10 percent levels, respectively

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