The Dynamics of Algeria's Natural Gas Exports to Europe: Evidence from ARDL Bounds Testing Approach with Breakpoints

Hicham Benamirouche, Oum Elkheir Moussi

Abstract—The purpose of the study is to examine the dynamics of Algeria's natural gas exports through the Autoregressive Distributed Lag (ARDL) bounds testing approach with break points. The analysis was carried out for the period from 1967 to 2015. Based on imperfect substitution specification, the ARDL approach reveals a long-run equilibrium relationship between Algeria's Natural gas exports and their determinant factors (Algeria's gas reserves, Domestic gas consumption, Europe's GDP per capita, relative prices, the European gas production and the market share of competitors). All the long-run elasticities estimated are statistically significant with a large impact of domestic factors, which constitute the supply constraints. In short term, the elasticities are statistically significant, and almost comparable to those of the long term. Furthermore, the speed of adjustment towards long-run equilibrium is less than one year because of the little flexibility of the long term export contracts. Two break points have been estimated when we employ the domestic gas consumption as a break variable; 1984 and 2010, which reflect the arbitration policy between the domestic gas market and gas exports.

Keywords—Natural gas exports, elasticity, ARDL bounds testing, break points, Algeria.

I. INTRODUCTION

ALGERIA is one of the main gas exporting countries. It is pioneering not only in the liquefied natural gas's export, which is the LNG Camel Plant in 1964, but also in the commissioning of the first transcontinental pipeline, Transmed in 1983, from the African continent to Europe. Taking advantage of the geographical proximity, the pipeline industry is the centerpiece of the natural gas policy's marketing.

In 1970, natural gas exports were destined only for the United Kingdom and France with respectively, 62% and 37% [1]. Since then, exports have been arbitrated on several countries including Italy, Spain, Portugal and Turkey.

Exports were peaked between 1999 and 2008 (52 billion of cubic meters (bcm) to almost 60 bcm [2]. Since then, gas exports have been marked by a downward trend. Moreover, in 2013, Algeria exports only 42.9 bcm, including 14.9 bcm of Liquefied Natural Gas [2]. This new situation remains far from the expectations of the Algerian authorities (85 bcm in 2015 to 100 bcm in 2020).

The decline of gas exports had an analytic explanation in

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the literature review. By and large, three elements could explain this decline. The first is the stagnation of gas production. Indeed, between 2005 and 2015, the marketed production was situated between 89 bcm and 79 bcm [2] (See Fig. 1). This volume could illustrate the end of plateau phase. In this context, we have to mention that the Mega-field Hassi R'Mel has delivered 55 bcm in 2013 instead 75 bcm delivered in 2008. Few authors had contributed in this subject; [3] had considered the gas peak dating of Algeria in 2011 and [4] noted the rapid depletion of gas reserves which results in a continuous decline of exports from 2022.
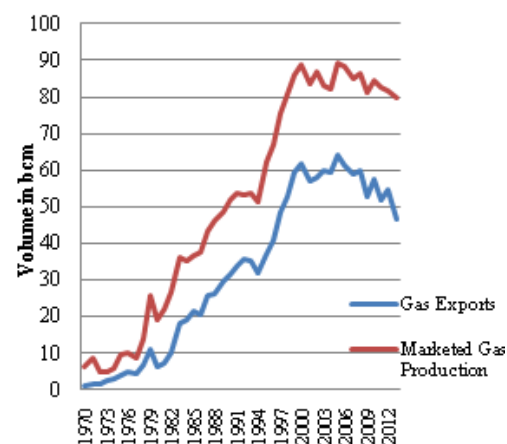

Fig. 1 Algeria's Gas Exports vs. Marketed Gas Production [2]

The second lies on the continued increase of the domestic gas consumption associated with the fact that the prices are fully regulated by the government [5]. This variable is considered as a forecast parameter to adjust the export volume [6]. Projections established by the commission for the regulation of electricity and gas [7] showed that the domestic gas consumption could be estimated to be between 45 bcm and 55 bcm in 2021 and 65 bcm to 70 bcm in 2030. Consequently, production profiles could not be able to honor export contracts in the long term (see Fig. 2). Reference [8] mentioned that [9] had warned that "a combination of subdued upstream gas development and growing domestic consumption has left the prospects of Algerian gas exports in a worse position than initially intended". Reference [5] alerted to the emergence of an "Egypt syndrome". Later, in 2016, [8] argued that "the supply and demand factors have been the main reasons for the dramatic decline in Algeria's gas
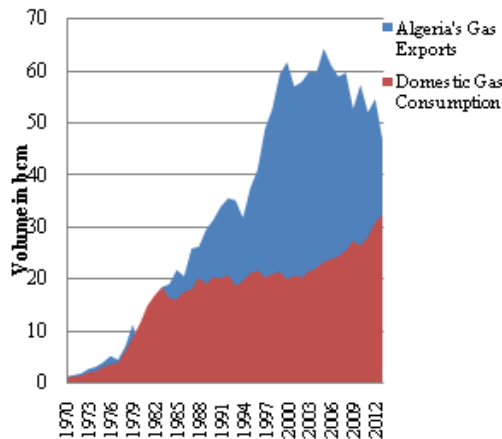
exports" during the last decade.

Fig. 2 Algeria's Gas Exports vs. Domestic Gas Consumption [2]

The third concerns the European natural gas market situation. This market absorbs more than 94% of Algeria's Natural gas exports. During the last decade, European market is characterized by a gas bubble, which may extend beyond 2017. This situation resulted from: (i) the accentuation of the competition due to the increase of suppliers' number and the volume offered (See Figs. 3 and 4), and (ii) the economic slowdown in Europe since the end of 2008, resulting in a fall of the energy demand, consequently, the size of the European natural gas market has shrunk by some 110 bcm [8]. In this context, other authors such [10], [6] analyze the difficulties in exporting appearing since the instauration of gas market liberalization. They discuss a different gas export strategy for the European market and the future of long term contracts, which are the main instrument of Algeria's gas export policy.
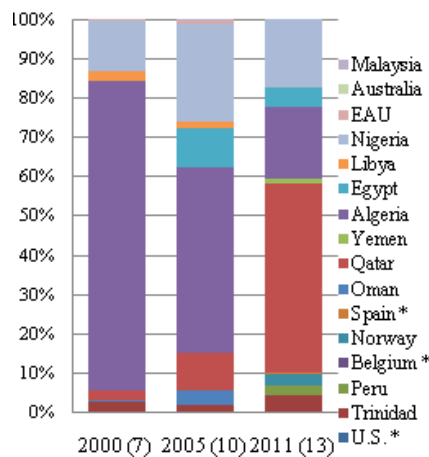

Fig. 3 LNG Europe market share [10]

Empirically, few studies have analyzed the evolution and the dynamic of Algeria's natural gas exports. Reference [11] provided an estimation of volumes exported between 67 bcm and 87 bcm in 2015, and 80 bcm to 106 bcm in 2020. These

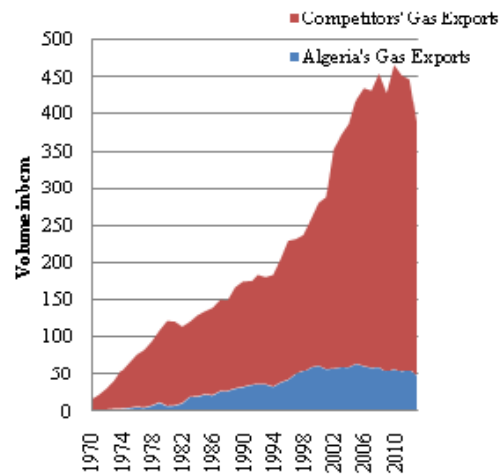results may be exaggerated compared to the achievements of the gas sector in recent years.

Fig. 4 Natural Gas Exports to Europe [10]

Based on the previous analysis and limited empirical studies on this subject, it is important to examine the dynamic of Algeria's Natural gas Exports to the European market to provide more empirical evidences about the effect of each factor mentioned above on gas exports, and, then, testing and concluding what are the main reasons for this dramatic decline of Algeria's gas exports. Thus, this paper investigates the relationship between Algeria's natural gas exports and their determinant factors, from 1967 to 2015, using the ARDL bounds testing approach of cointegration developed by [12], [13]. The results obtained in this study are dependent on the sample period, the variables used and the methodology employed.

The rest of the paper is organized as follows. Section II presents the theoretical setting. In Section III, we describe the methodology and data. Section IV reports the empirical results and discussion. The conclusion and policy implications are given in the final section.

II. THEORETICAL FRAMEWORK

Studies about international exchange modeling are mostly based on the demand behavior. The theoretical foundations of import and export equations are based on [14]. Armington introduced the hypothesis of differentiation of products in the theory of international trade, which makes it possible to estimate the degree of substitutability between domestic products and imported products.

Natural gas is an imperfectly substitutable product, which is produced in Europe and imported from Algeria and/or other countries. This implies that imports from Algeria are in competition with imports from other countries. It thus seems interesting to model the evolution of Algeria's gas exports to Europe on the basis of the imports' behavior, and subsequently to introduce a differentiation by origin to capture the share of imports from Algeria.

The standard formulation is a Constant Elasticity of Substitution (CES) specified by Armington. It assumes that the composite good (Q) consumed on the domestic market is a "CES" between imported products (M) and those produced locally (D).

The consumer chooses the combination of the quantities (M) and (D) which minimizes his total expenditure given P_M, P_D and the level of demand Q.

$$Q = \beta\left[\delta M^{-\theta} + (1-\delta)D^{-\theta}\right]^{\frac{-1}{\theta}} \quad (1)$$

We put:

$$\sigma = \frac{1}{1+\theta} \quad (2)$$

Then, (1) will be:

$$Q = \beta\left[\delta M^{\frac{\sigma-1}{\sigma}} + (1-\delta)D^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{1-\sigma}} \quad (3)$$

β: Constant of measure; δ: share parameter; σ: Elasticity of substitution.

The first order condition of minimization program is:

$$\frac{P_D}{P_M} = \left(\frac{1-\delta}{\delta}\right) * \left(\frac{D}{M}\right)^{-(\theta-1)} \Leftrightarrow \frac{M}{D} = \left(\frac{\delta}{1-\delta}\right)^{\sigma}\left(\frac{P_D}{P_M}\right)^{\sigma} \quad (4)$$

$$\text{With: } P_M = P_{WM}(1+t_M) * e \quad (5)$$

P_{WM}: International price of imports; t_M: Cumulative rate of imports' tax; e: Nominal exchange rate.

Taking the logarithm specification, (4) gives the interpretation of the parameter σ as an elasticity of substitution.

$$\ln\left(\frac{M}{D}\right) = \sigma \ln\left(\frac{\delta}{1-\delta}\right) + \sigma \ln\left(\frac{P_D}{P_M}\right) \quad (6)$$

with:

$$\sigma = d\log\left(\frac{M}{D}\right)/d\log\left(\frac{P_D}{P_M}\right) \quad (7)$$

The econometric formulation of (6) is:

$$\ln\left(\frac{M}{D}\right) = \beta_0 + \beta_1 \ln\left(\frac{P_D}{P_M}\right) + \varepsilon \quad (8)$$

where; ε is random error. Furthermore, the importer's GDP is considered as an additional variable that explains the sharing between the imported products and those produced locally. Then, (8) will be:

$$\ln(M) = \beta_0 + \beta_1 \ln\left(\frac{P_D}{P_M}\right) + \beta_2 \ln(GDP) + \beta_3 \ln(D) + \varepsilon \quad (9)$$

with D as the local production of Europe.

From the formulation obtained above, a second level of imports' differentiation by origin could be introduced. The imports' equation of the second level is given as follows:

$$\ln\left(\frac{M_A}{M_H}\right) = \beta_0 + \beta_1 \ln\left(\frac{P_{MH}}{P_{MA}}\right) + \beta_2 \ln(GDP) + \beta_3 \ln(D) + \varepsilon \quad (10)$$

with: M_A: Imports from Algeria; M_H: Imports from world expect Algeria.

Putting $X_A = M_A$, and $\frac{P_{MH}}{P_{MAl}} = P_e$, where; X_A are Algeria's exports to Europe. Then (10) will be:

$$\ln(X_A) = \beta_0 + \beta_1 \ln(P_e) + \beta_2 \ln(GDP) + \beta_3 \ln(D) + \beta_4 \ln(M_H) + \varepsilon \quad (11)$$

Furthermore, Algeria's gas production is intended primarily to satisfy the domestic market, only the remainder is intended to be exported. Therefore, it is appropriate to take account variables constituting supply constraints in this model: the gas production, which is a function of recoverable reserves [15] and the domestic gas consumption. Then, (11) will be:

$$\ln(X_A) = \beta_0 + \beta_1 \ln(RSV) + \beta_2 \ln(CSA) + \beta_3 \ln(DGDP) + \beta_4 \ln(Pe) + \beta_5 \ln(D) + \beta_6 \ln(M_H) + \varepsilon \quad (12)$$

where: RSV: Recoverable reserves of Algeria at the start of year; CSA: Domestic gas consumption of Algeria.

III. METHODOLOGY AND DATA

A. Analytical Framework

The empirical estimation is carried out for two objectives: (i) to understand how Algeria's gas exports and their determinant factors are linked in the long term and (ii to examine the short-run relationship. To achieve these objectives, we employ the ARDL bounds testing approach introduced by [12], and extended by [13]. This approach is based on the estimation of an Unrestricted Error Correction Model. It has several advantages over the conventional type of cointegration techniques. Here we mention the three most important of them: (i) the standard Wald or F-Statistics used in the bounds test have a non-standard distribution under the null hypothesis of no-cointegration relationship between the examined variables, irrespective whether the underlying variables are I(0), I(1) or fractionally integrated. (ii) It estimates the short- and long-run component of the model simultaneously, and then the short as well as long-run parameters of the model could be estimated simultaneously. (iii) It can be applied to a small sample size study [13]; therefore, conducting bounds testing will be appropriate for the present study.

Prior to implementing the model, it is imperative to use unit root tests to ensure if that the underlying data are non-stationary at level, but become stationary at the first difference. This is to ensure that the variables should not be stationary in order of I(2) because the computed F-Statistics provided by [13] are valid only when the variables are I(0) and/ or I(1).

Time series univariate properties were examined using two unit root tests that are the Augmented [16] (ADF) and the [17] (PP).

These two tests have a low power in the presence of

structural break. Reference [18] showed that in the presence of a structural break in time series, many perceived non-stationary series were in fact stationary. Reference [18] re-data examined data [19] and found that 11 of 14 important US macroeconomic variables were stationary when exogenous structural break is included. References [20] and [21] developed a break point unit root test when the structural break is selected endogenously. Following [18], [20], there are three types of break point; the first results from the change in the level of the time series (change in the intercept), the second results from the change in the growth's rate (change in trend), and the third is the result of both (change in the level and in the rate of growth). Reference [22] examined the accuracy of break point estimation using the endogenous break unit root tests of [20], [21]. They found that these tests tend to identify the break point incorrectly at one-period ($T_B - 1$) behind the true break point (T_B), where bias in estimating the persistence parameter and spurious rejections are the greatest. For the authors, the break point occurs when the t-statistic related to the unit root test is at its minimum value.

With a view to identifying a possible structural break for each variable included in this study, the break point unit root test has been used.

Once the time series properties of the variables are established, we perform the ARDL bounds testing approach in the presence of structural breaks. Then, we estimate (13) by ordinary least squares, in order to test for the existence of a long run relationship between the variables.

$$\Delta lnXA_t = \alpha_1 + \alpha_t T + \sum_{i=1}^{p} \beta_i \, \Delta lnXA_{t-i} + \sum_{j=0}^{q} \beta_j \, \Delta lnRSV_{t-j} + \sum_{k=0}^{r} \beta_k \, \Delta lnCSA_{t-k} + \sum_{l=0}^{s} \beta_l \, \Delta lnGDP_{t-l} + \sum_{m=0}^{u} \beta_m \, \Delta lnPe_{t-m} + \sum_{n=0}^{w} \beta_n \, \Delta lnD_{t-n} + \sum_{o=0}^{z} \beta_o \, \Delta lnMH_{t-o} + \alpha_{XA} lnXA_{t-1} + \alpha_{RSV} lnRSV_{t-1} + \alpha_{CSA} lnCSA_{t-1} + \alpha_{GDP} lnGDP_{t-1} + \alpha_{Pe} lnPe_{t-1} + \alpha_D lnD_{t-1} + \alpha_{MH} lnMH_{t-1} + Break_t + \varepsilon_t \quad (13)$$

where Δ is the difference operator, T is the time-trend and ε_t is the random errors.

Prior to testing whether there is a long-run relationship for the ARDL equation, it is essential to determinate the most appropriate lag length for the model. Given that we are constrained by the number of observations, a maximum lag length of four years is imposed on the ARDL equation. An appropriate lag selection is based on a criterion such as Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC).

Testing cointegration involves comparing the computed F-Statistic with the upper critical bound (UCB) and lower critical bound (LCB) as tabulated by [23] (critical bounds reformulated by Narayan are more appropriate for a small sample, 43 in our case). The null hypothesis of non cointegration $(H_0: \alpha_{XA} = \alpha_{RSV} = \alpha_{CSA} = \alpha_{GDP} = \alpha_{Pe} = \alpha_D = \alpha_{MH} = 0)$ is tested against the alternative hypothesis of cointegration $(H_1: \alpha_{XA} \neq 0, \alpha_{RSV} \neq 0, \alpha_{CSA} \neq 0, \alpha_{GDP} \neq 0, \alpha_{Pe} \neq 0, \alpha_D \neq 0, \alpha_{MH} \neq 0)$. If the calculated F-Statistic is above the upper critical value, the null hypothesis of no cointegration can be rejected irrespective of the orders of integration of the variables. If the calculated F-Statistic is below the LCB, the null hypothesis of no cointegration cannot be rejected. However, if the computed F-Statistic is between LCB and UCB, the result is inconclusive, [24] suggest, in some conditions, the error correction method is appropriate.

If there is evidence of long run relationships (cointegration) between the variables, (14) will be used to capture the long-run dynamic by ordinary least squares with breakpoints:

$$lnXA_t = \alpha_0 + \alpha_{RSV} lnRSV_t + \alpha_{CSA} lnCSA_t + \alpha_{GDP} lnGDP_t + \alpha_{Pe} lnPe_t + \alpha_D lnD_t + \alpha_{MH} lnMH_t + \varepsilon_t \quad (14)$$

Next, we estimate the error correction model for the short-run by using least squares method and AIC and SBC to select the order of the ARDL (p, q, r, s, u, w, z). This model will be written as follows:

$$\Delta lnXA_t = \alpha_1 + \alpha_t T + \sum_{i=1}^{p} \beta_i \, \Delta lnXA_{t-i} + \sum_{j=0}^{q} \beta_j \, \Delta lnRSV_{t-j} + \sum_{k=0}^{r} \beta_k \, \Delta lnCSA_{t-k} + \sum_{l=0}^{s} \beta_l \, \Delta lnGDP_{t-l} + \sum_{m=0}^{u} \beta_m \, \Delta lnPe_{t-m} + \sum_{n=0}^{w} \beta_n \, \Delta lnD_{t-n} + + \sum_{o=0}^{z} \beta_o \, \Delta lnMH_{t-o} + \Delta Break_t + \theta ECM_{t-1} + \varepsilon_t \quad (15)$$

The model validation is based on the absence of serial correlation, that we use LM Test, and testing the stability by applying the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests proposed by [25].

B. Data Sources

Annual time series data, which cover the period 1967-2015, have been used in this study. The data has been obtained from two sources: [2], [26].

Table I shows the main descriptive statistics of the variables used in this analysis: Algeria natural gas exports (*XA*), Algeria natural gas reserves (*RSV*), Algeria domestic gas Consumption (*CSA*), Europe gas Imports from world expect Algeria (*MH*) and, European gas production (*D*) are measured by Billion Cubic Meters (bcm), while the European Gross Domestic Product per Capita is measured by constant dollar-2013 and, Relative natural gas price (*Pe*). It should be noted that the data about Europe (*D* and *GDP*) concerns only the countries importing Algerian natural gas.

IV. EMPIRICAL RESULTS AND DISCUSSION

A. Time Series Properties of Data

In order to examine the integrating level of variables, we conducted the Augmented Dickey-Fuller (ADF) and the Phillip Perron (PP) tests. The results are reported in Table II.

The results indicate that three variables, which are the relative price (Pe), the European gas production (D) and the Europe gas imports from the world, are integrated at I(0), while the other variables are non stationary at levels, but stationary at their first differences. None of the variables is I(2), according to both tests.

We also employ the [27], [28] tests to identifying a possible structural break. Table III reports the results of the endogenous break point unit root test. The break years are selected when the t-statistic related to the ADF-test is at the minimum.

The results indicate that the most break years lie around the decade of the 1980s, marked, especially, by three main events: (i) the Algerian State-owned oil and gas company commissioned the Sonatrach Skikda LNG Plant and refinery (GL-1K Complex) and the government signed a 20-year agreement with France, (ii) the commissioning of the first transcontinental pipeline, Transmed in 1983, from Algeria to Spain and, (iii) a program of the massive electrification of the country based on the use of more natural gas in electricity generation in the early 1980s.

TABLE I
DESCRIPTIVE STATISTICS

	Description	Mean	Maximum	Minimum	Std. Dev.	Observations
LogXA	Algeria natural gas exports (bcm)	2.73	4.02	0.28	1.25	49
LogRSV	Algeria natural gas reserves (bcm)	8.28	8.42	7.99	0.12	49
LogCSA	Algeria domestic gas Consumption (bcm)	2.43	3.66	-0.36	1.16	49
LogGDP	European Gross Domestic Product per Capita (US$ constant)	12.34	13.22	10.42	0.79	49
LogPe	Relative natural gas price	0.63	3.53	-0.03	0.83	49
LogMH	Europe gas Imports from world expect Algeria (bcm)	4.16	5.55	-0.99	1.52	49
LogD	European natural gas production (bcm)	4.94	5.31	4.00	0.32	49

TABLE II
RESULTS OF UNIT ROOT TESTS

Unit root test	ADF Test t-stat	PP Test t-stat	Result
Variable at level			
logXA	1.01	1.15	Non-stationary
logRSV	0.48	0.39	Non-stationary
logCSA	0.46	0.96	Non-stationary
logGDP	1.30	0.99	Non-stationary
logPe	-1.94**	-1.81*	I(0)
logD	-3.93***	-4.62**	I(0)
logMH	-3.45**	-2.92**	I(0)
Variable at 1st Difference			
logXA	-4.96***	-5.00***	I(1)
logRSV	-9.69***	-9.59***	I(1)
logCSA	-3.42***	-3.47***	I(1)
logGDP	-4.12***	-9.38***	I(1)

***, ** and * indicate 1%, 5% and 10% level of significance, respectively. I(0) denotes the variable is stationary at the level, while I(1) denotes the variable is stationary after the first difference.

These results lead to conclude that our model is mixed; the bounds testing cointegration procedure may use to test the presence of long-run equilibrium relationship.

TABLE III
ENDOGENOUS BREAK POINT UNIT ROOT TESTS

Variable	Break date	ADF-test t-stat	Result
logXA	1980	-5.31***	I(0) with break point
logRSV	1994	-7.86***	I(0) with break point
logCSA	1983	2.88	Non stationary
logGDP	2011	-5.16***	I(0) with break point
logPe	1982	-6.19***	I(0) with break point
logD	2004	-6.86***	I(0) with break point
logMH	1987	-5.11***	I(0) with break point

***, ** and * indicate 1%, 5% and 10% level of significance, respectively. I(0) denotes the variable is stationary at the level

1. Cointegration Test

As the variables are stationary at I(0) or at I(1), the ARDL model is employed to examine if the variables are cointegrated. The ARDL bounds test for the cointegration based on (13) is sensitive to lag length, so we use the Akaike Information Criterion and the Hannan-Quinn Information Criterion to determine the optimal lag length. The results are reported in Table IV.

The result shows that four is the optimal lag length, basing on AIC and HQ criterion. Once the optimal lag length is selected, we test for the existence of long-run relationship.

TABLE IV
LAG LENGTH SELECTION

	AIC	HQ	Intercept and Trend
ARDL (4)	-2,38	-1.91	Intercept
ARDL (3)	-2.08	-1.71	--
ARDL (2)	-1,30	-1.12	Intercept
ARDL (1)	-1.21	-1.05	Intercept

Table V reports the partial F-statistic to test the null hypothesis of long-run relationship among the variables with the asymptotic critical value reformulated by [23].

TABLE V
RESULTS OF BOUNDS TEST APPROACH TO COINTEGRATION

Test Statistic	Value	k
F-statistic	5.04	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	1.99	2.94
5%	2.27	3.28
2.5%	2.55	3.61
1%	2.88	3.99

As shown in Table V, the F-statistic exceeds the upper critical bound at all significance level. We can conclude the existence of the long-run relationship among Algeria's natural gas exports and their determinants.

B. Long-Run Relationship Estimating

As explained in Section III.*A*, for the long-run relationship, we use the Least Square to estimate (14). However, the variables of our model present a structural breakpoint. For that, it is more convenient to estimate this relationship with structural change. Based on [29], [30], we estimate a structural change model. The suggested procedure consists on testing for the existence of structural change (1 break, 2 breaks… etc.). If structural change exists, we determine the number of break using sequential procedure and model selection criterion (Modified BIC).

In Algeria's case, the gas production is intended primarily

to satisfy the domestic market; only the remainder is intended to be exported. Consequently, we can propose a partial structural change model, in which some coefficients are different in each regime. In this case, the domestic gas consumption could be considered, also, as a breaking variable. Table VI reports the results of the preferred model.

The results show two break points occurring in 1984 and 2010, and three sub-samples with the domestic gas consumption as an additional breaking variable.

In the first and the second sub-sample, the domestic gas consumption has a positive effect on gas exports, but only significant during the first period 1967-1983, in which a 1% increase in domestic gas consumption implies 0.65% increase in natural gas exports. This could be explained by the abundance of gas supply to satisfy both domestic consumption and exports, but the priority was accorded to the domestic market during this period, which is marked by a low investment in exports capacity.

The first break year (1984) reflects the change in natural gas exports since the commissioning of the first transcontinental pipeline in 1983, and then the priority was accorded to exports. During the second period (1984-2009), natural gas exports were developed independently of the domestic market. This was further confirmed since the adoption of the hydrocarbon law of 1986 and 1991; large investments in upstream and exports capacity were implemented to produce and export more quantities, in order to generate more foreign exchange earnings. The third sub-sample is quite small, in which the domestic gas consumption has a negative and significant effect on natural gas exports; a 1% increase in domestic consumption leads to 0.76% decrease in natural gas exports. This is due, in part, to the decline (or stagnation at best) of natural gas production during this period. In fact, since 2010, with the production decline, exports have been contracting more rapidly than domestic consumption has been expanding. This may also be due to other factors.

The results show that gas reserves have a strong positive and significant effect on natural gas exports. The implemented investments in the upstream in the end of 1980s have allowed to a significant increase in natural gas reserves; from 3200 bcm in 1987 to 4500 bcm from 1999. This has led to a significant increase in both production (from 41.2 bcm in 1987 to 88.2 bcm in 2005) and exports (from 24 bcm to 65 bcm in the same period).

It is also found that the variables reflecting the competitiveness (relative prices and competitors' gas exports) have a negative effect on Algeria's gas exports. A 1% increase in the two variables, leads to 0.15% and 0.19% decrease in natural gas exports, respectively.

The fall in EU gas demand since 2008 could extend beyond the short and medium term. Reference [8] indicated that,

"in addition to the impact of the recession and subsequent economic restructuring, the fall in demand has been driven by gains in efficiency use and, in the power sector, by a significant deployment of lower-(variable) cost renewable and, in part, the use of imported cheap coal displaced by shale gas in the US".

TABLE VI
ARDL LONG-RUN RESULTS

Dependent Variable: LXA
Method: Least Squares with Breaks
Sample: 1967 2015
Breaks: 1984, 2010
Allow heterogeneous error distributions across breaks

Variable	Coefficient	Std.Error	Prob
1967 - 1983 -- 17 obs			
LCSA	0.65	0.10	0.0000
C	-16.35	1.63	0.0000
1984 - 2009 -- 26 obs			
LCSA	0.37	0.25	0.1449
C	-14.79	1.19	0.0000
2010 - 2015 -- 6 obs			
LCSA	-0.76	0.25	0.0050
C	-10.72	1.84	0.0000
Non-Breaking Variables			
LRSV	1.41	0.19	0.0000
LGDP	0.38	0.11	0.0013
LPe	-0.15	0.05	0.0099
LD	0.29	0.13	0.0381
LMH	-0.19	0.06	0.0031
R-squared	0.99	F-statistic	502.15
Adjusted R-squared	0.99	Prob(F-statistic)	0.0000
S.E. of regression	0.12	Akaike info criterion	-1.17
Sum squared residuals	0.56	Schwarz criterion	-0.75
Log likelihood	39.87	Durbin-Watson stat	1.96

In this context, the effect of competition becomes very high. In fact, Algeria through Sonatrach has had to compete with traditional suppliers in the EU market, the majority of which are, the pipeline exporters and the LNG exporters, especially Qatar and recently the US. With the stagnation of domestic production and the continuous increase in domestic consumption, Algeria has lost more than 30 bcm in a total gas export since 2005 and it will be more difficult to defend its market. Reference [8] justified the losses by terminations or suspensions of contracts, including the Distrigaz Belgium contract, US LNG contracts and many small Italian contracts – both LNG and pipeline. The author adds also the curtailments of the Engie LNG contract and most recently of the Eni contract through the Transmed. The huge competition in this market has started to affect the gas pricing. The majority of suppliers have agreed to some degree of flexibility in their pricing while focusing on maintaining volumes. Some contracts have been converted or adjusted to hub price. Consequently, the gas price will be more elastic to demand.

C. Short-Run Relationship Estimating

On the basis of (15), the ordinary least squares method was employed to obtain the estimated parameters of the short-run relationship. The results are reported in Table VII. Column 2, column 3 and column 4 in Table VII show the estimated parameters, the standard deviation value and, the probability of significance, respectively. Akaike and Schwartz criterion (AIC and SIC) are used to select the optimum number of lags in the ARDL model. The Breusch Godfrey test (LM test) indicates that the null hypothesis of the presence of serial correlation in the residuals is rejected at 5%. The estimated error correction coefficient ECM (-1) is negative and significant at 1%. Its value indicates that any deviation from the long-run equilibrium between variables is corrected about

114% for each period, and it takes less than one year (about 10 months and 15 days) to restore the long-run equilibrium level. The results confirm the high significant effect of gas reserves on gas exports. However, this effect is only positive on the first and second lag period. Furthermore, the domestic gas consumption has a strong negative and significant effect on gas exports in all lag period. Regarding the priority accorded to satisfy the domestic market, this variable becomes as an annual adjustment variable that negatively affect gas exports, especially during the last decade. In fact, based on the stagnation of the gas production at 82 bcm (with some fluctuations) between 2004 and 2015, the domestic gas consumption has grown at 5.2% by year; from 22.6 bcm to 39 bcm, while gas exports has declined from 60 bcm to 43 bcm in the same period.

The economic activity in Europe (Gross Domestic Product) affects positively the evolution of Algeria's gas exports, but the coefficient of the second and third lag is negative but not significant at 5%. The effect of GDP in the short term could be clearly seen during the global financial crisis of 2008-2009, that caused a fall in European gas demand, which is followed by a drop in a total gas exports to Europe, where Algeria's gas exports were contracted from 56 bcm in 2008 to 50 bcm in 2009.

The effect of the relative price and competitors' gas exports is positive and significant only in the third and fourth lag for price and in the second and third lag for competitors' exports. Given that the Algerian gas is mainly exported under a long-term contract, this positive effect could be explained by the Algeria's efforts to maintain its market share, taking advantage from a lower transportation cost compared to the other competitors, and to Europe's growing dependence on foreign supply. European gas production has a negative impact on Algeria's gas exports in the short term. Any re-adjustment in European gas production or if the decline of gas production in Europe is lower than the fall in European gas demand, this allows European countries to determine the quantities imported at a minimum in long-term contracts or buying less gas in the spot market.

Finally, to check the stability of coefficients, we employ the CUSUM and CUSUM Squares tests, which are reported in Fig. 5. If the plots of the CUSUM and CUSUMQ statistics stay within the critical bounds of 5% level of significance, the null hypothesis of all coefficients are stable cannot be rejected. Fig. 5 shows that CUSUM and CUSUMQ statistics are well within 5% critical bounds implying that short-run and long-run coefficients in the ARDL-ECM are stable.

D. Further Discussion

Based on the estimation results in Sections IV.C and IV.D, it appears that the variables constitute the supply constraints, which are the reserves volume (reflecting the performance of Algeria's gas industry) and domestic gas consumption (reflecting domestic gas market evolution), have the strongest effect on country's gas exports, that confirms the analyses of some authors like [8], [9].

TABLE VII
SHORT-RUN RELATIONSHIP TEST RESULTS

Short run relationship estimating Dependent variable D(LXA) Selected Model: ARDL(1, 4, 4, 3, 4, 3, 4) Sample: 1967 2015			
Variable	Coefficient	Std. Error	Prob.
D(LRSV)	1.38	0.20	0.0000
D(LRSV(-1))	0.47	0.21	0.0449
D(LRSV(-2))	-0.98	0.22	0.0008
D(LRSV(-3))	-1.52	0.34	0.0005
D(LCSA)	-0.96	0.15	0.0000
D(LCSA(-1))	-2.68	0.41	0.0000
D(LCSA(-2))	-2.47	0.36	0.0000
D(LCSA(-3))	-0.59	0.21	0.0141
D(LGDP)	0.37	0.07	0.0001
D(LGDP(-1))	-0.13	0.06	0.0611
D(LGDP(-2))	-0.11	0.05	0.0617
D(LPE)	0.03	0.02	0.2824
D(LPE(-1))	-0.03	0.02	0.2628
D(LPE(-2))	0.15	0.02	0.0001
D(LPE(-3))	0.15	0.03	0.0003
D(LD)	0.09	0.17	0.5933
D(LD(-1))	-0.81	0.24	0.0050
D(LD(-2))	-0.39	0.17	0.0367
D(LMH)	-0.08	0.06	0.1902
D(LMH(-1))	0.38	0.06	0.0000
D(LMH(-2))	0.29	0.06	0.0005
D(LMH(-3))	0.05	0.03	0.1374
D(BREAK)	-0.42	0.06	0.0000
CointEq(-1)	-1.14	0.13	0.0000
R-squared	0.99	ARCH Test	1.33
Adjusted R-squared	0.99	Prob ARCH	0.27
F-statistic	394.09	Akaike info criterion	-2.38
Prob(F-statistic)	0.0000	Schwarz criterion	-1.13
LM Test	2.54	Hannan-Quinn criterion	-1.91
Prob LM-Test	0.10		

In fact, the natural gas reserves' volume is strictly related to technico-economic conditions that ensure only the recovery of about 30% of reserves in Algeria. In 2013, the natural gas reserves increased by 320 bcm, and extracted and marketed volumes were approximately 80 bcm. These volumes represent an additional four years of production, but the current technico-economic conditions ensure only the recovery of 110 bcm, which cannot allow to extract more gas taking into account that 50% of this gas must be re-injected to stabilize pressure of field, especially the old one like Hassi R'Mel. Thus, the level of gas reserves has a strong positive effect on the marketed gas production and constitutes, then, an important supply constraint. Furthermore, the rapid growth of the domestic gas consumption, especially during the last decade, is coincided with the production decline (stagnation at best). Gas consumption in Algeria is driven mainly by two sectors; the power generation sector, in which natural gas is used at 97% in the electricity generation, and the public distribution sector because of the rapid housing stock's expansion. Since, satisfying this large gas public demand becomes the first priority, only the remained could be exported. Then, the evolution of the domestic gas

consumption has a strong negative effect on gas exports.

The effect of GDP's European destination countries on gas exports is the third strongest one. This variable reflects the demand behavior. Regarding its insufficient (or continued decline) gas production, European countries become more dependent to the foreign gas supply. Algeria is considered as one of the main foreign suppliers. The historical increasing gas demand in Europe allowed Algeria to increase subsequently its natural gas sales taking profit of the geographical proximity and its high exports capacity (about 87 bcm in 2014). In fact, the economic activity has had a positive effect on gas exports. However, after an export peak year in 2006 with 60 bcm, Algeria's gas exports start to decline. This decline has accelerated aftermath the global financial crisis.

Since 2008, gas demand declined considerably. Reference [8] argued that the EU gas market has shrunk by 22% losing about 110 bcm (60% of them in power generation sector) and the fall in European gas demand has been larger than the fall in gas production. In addition, Algeria has competed for a long time traditional suppliers (where the majority were a pipeline exporters), but the reforms articulated by the European Commission aimed at liberalizing and integrating national markets into one single market have allowed to multiply the number of suppliers (from seven in 2000 to 13 in 2011), which are mainly LNG suppliers. Thus, the competition becomes harder and affects more negatively Algeria's natural gas exports.
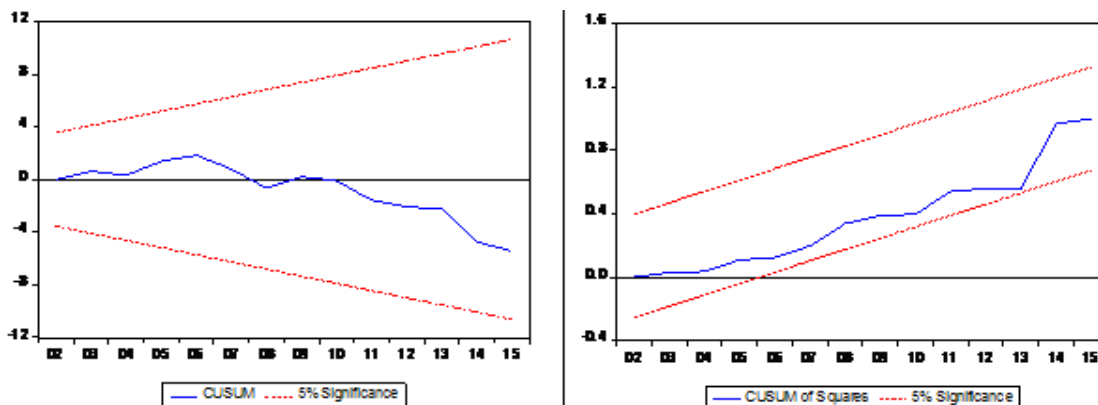

Fig. 5 CUSUM and CUSUMSQ Statistics

V. CONCLUSION

Beside its importance in Algeria's energy balance, a part of gas production is destined for export, thus participating in about 30% in the state rent available for socio-economic development.

Algeria is one of Europe's main natural gas suppliers, mainly via pipelines. After a long period of exports' increase to this market (which absorbs 94% of annual exports), a continued decline has been registered in gas exports during the last decade.

This paper examines the dynamic of Algeria's gas exports to Europe through the relationship between gas exports and their determinant factors (demand variables and supply constraints), basing on the imperfect substitute specification and using the ARDL bounds testing model extended to introduce break points, for the period 1967-2015.

The results suggest there is evidence on the long-run and short-run relationship between the variables. The results show that the Algerian gas reserves and European GDP per capita have a positive and significant effect on gas exports in both the long and short term; while, domestic gas consumption in Algeria has a negative effect in the short term, and which also appears negative from 2010 in long-run relationship taking into account two breaking dates; 1984 and 2010. In addition, the significant estimated coefficients of competitiveness (relative prices and competitors' exports) are negative in the

long term.

All these results could be considered adequate with the economic theory and suggests that the use of the imperfect substitution specification with supply constraints may well reflect the natural gas import/export behavior. Furthermore, the supply constraints (Algeria's gas reserves and domestic gas consumption) have the strongest effect on gas exports in both the long and short term, which let them to be considered as the main factors influencing any evolution of Algeria's gas exports.

Expect the positive effect of GDP; terms of competitiveness had a low impact on gas exports. This was explained by the fact that the majority of Algerian gas is exported to Europe under long-term contracts during long period marked by gas demand's increase and a continued fall in European gas production, which allowed all suppliers to adjust the exported volume within the interval defined in this type of contract.

Based on the recent evolutions of all these explanatory factors, it appears that Algeria's gas exports face serious challenges. On the domestic factors side, natural gas reserves have been drastically revised downward; from 4500 bcm to 2700 bcm, according to the ministry council in the end of 2015, where the renewal rate not exceed 40%. The domestic market becomes the major growing component, with 5.2% by year during the last decade, with projections (established by the CREG) of 54 bcm in 2023 and about 65 bcm in 2030. In

the same time, the gas production has stagnated at the best, and could fall below 70 bcm in 2030.

On the foreign factors side, like mentioned above, [8] argued that the European gas market has shrunk by 11% after the recession and subsequent economic restructuring. This fall in demand has been driven by gains in efficiency use, by significant deployment of lower cost renewable and by the use of cheap imported coal displaced by shale gas in the US. The restructuration and liberalization of the European gas market has led to a multiplication of gas suppliers. Terms and duration of the long-term contracts, which become untenable for buyers, are revised largely to give them more flexibility.

Given all these recent evolutions and based on the estimated elasticities in this study, the future trend of Algeria's gas exports could be not optimistic. At best, few quantities of Algeria's gas will probably be exported.

This empirical analysis could provide policymakers a better understanding of Algeria's natural gas exports' dynamic and suggests some recommendations. In fact, to ensure the renewal of reserves, this requires intensifying investment in upstream gas. It needs to create an attractive atmosphere for absorbing foreign investment and develop shared fields. Therefore, amendments in the new hydrocarbon law are required to revitalize the sector. It is probably important to be pragmatic with the rule (49/51%), which may not attract investment in upstream gas for medium and small fields. In parallel, a fiscal easing seems necessary because the taxation of super-profits is not adequate with the current situation, marked by low prices and intense competition.

It is also important to implement an ambitious energy efficiency program taking into account the thermal insulation, high-performance lighting, high-performance public lighting and solar water-heaters, together with a rational pricing policy, which must gradually reduce energy demand growth, particularly in the power generation sector and public distribution sector.

The rapid decrease in renewable energies' production costs, particularly in the photovoltaic option, in the medium term, constitutes an advantage for the effective installation of 22 GW by 2030 (reported in National Program of Renewable Energies). This could allow gaining and saving more than 10 bcm of natural gas in the power generation sector, which could be destined for export.

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