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Trade Performance and Potential of North African Countries: An Application of a Stochastic Frontier Gravity Model

Lota D. Tamini
Houssem Eddine Chebbi
Abdessalem Abbassi

About the Authors

Lota D. Tamini is an Associate professor, Laval University, Department of Agricultural Economics and Consumer Science and Center for Research on the Economics of the Environment, Agri-food, Transports and Energy (CREATE). Corresponding author: Pavillon Paul-Comtois, 2425, Rue de l'Agriculture, local 4412, Québec (QC), G1V 0A6, Canada. Email: lota.tamini@eac.ulaval.ca.

Houssem Eddine Chebbi is an Associate professor, Higher School of Economic and Commercial Sciences (ESSEC de Tunis), MACMA, University of Tunis, Tunisia and Economic Research Forum (ERF).

Abdessalem Abbassi is an Assistant professor, Faculty of Economics and Management of Nabeul, ENVIE, University of Carthage, Tunisia and CREATE, Laval University.

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Abstract

The objective of this paper is to analyze trade potential versus actual realized trade among North African trading partners. Following the literature on production economics, we built a stochastic frontier gravity model. The underlying assumption is that all deviations from trade potential is not due to white noise but may also be due to inefficiencies. Time-variant country-specific trade efficiency estimates are obtained and analyzed. Our results indicate that Mauritania, as a country both of destination and of origin, is where the region's trading relationship is the least efficient. Tunisia, followed by Morocco, faces the fewest behind- and beyond-the-border effects. Our analysis of market integration and trade efficiency at the disaggregated level indicates that trade efficiency scores exhibit high variability between categories of products. Moreover, North African market integration is worst when considering the goods from "Textiles; Footwear & Headgear" category. Our estimates indicate that trade efficiency for agricultural products is relatively low, indicating the existence of significant behind- and beyond-the-border inefficiencies. Our estimates also underline the importance of improving domestic policies to encourage entrepreneurial development and business facilities.

Résumé

L'objectif de cet article est d'analyser le potentiel commercial et celui réalisé entre les partenaires commerciaux de l'Afrique du Nord. Suivant la littérature sur l'économie de la production, nous construisons un modèle de gravité avec frontière stochastique. L'hypothèse sous-jacente est que tout écart par rapport à un potentiel commercial n'est pas dû au bruit blanc, mais peut également être expliqué par de l'inefficacité. Les estimations de l'efficacité commerciale de chaque pays et qui varient dans le temps sont obtenues et analysées. Nos résultats indiquent que la Mauritanie, en tant que pays à la fois de destination et d'origine, est l'endroit où les relations commerciales sont les moins efficaces. À contrario la Tunisie, suivie du Maroc sont ceux ayant les scores d'efficience les plus élevés. Notre analyse de l'intégration du marché et de l'efficacité commerciale au niveau désagrégé indique que les scores d'efficacité commerciale présentent une grande variabilité entre les catégories de produits. Par ailleurs, l'efficacité commerciale pour les produits agricoles est relativement faible, ce qui indique l'existence d'inefficacité au-delà et à l'intérieur des frontières. Nos estimations soulignent l'importance de l'amélioration des politiques nationales pour encourager le développement du commerce entre pays de l'Afrique du Nord.

1. Introduction

The North Africa region (Mauritania, Morocco, Algeria, Tunisia, Libya, and Egypt) represents about one-third of Africa's total GDP and a market of nearly 172 million people. This region is viewed as a large regional trade market; however, intra-regional trade among North African countries is among the lowest in the world (AfDB, 2012), even though these countries are involved in a variety of bilateral and regional trade agreements.

In fact, all but Egypt are founders of the Arab Maghreb Union (AMU), which was established in 1989 by the Treaty of Marrakech.[1] In addition, the North African countries are members of the Greater Arab Free Trade Area (GAFTA), also known as the Pan-Arab Free Trade Area (PAFTA), with the exception of Mauritania, which is in the process of joining the organization. The Arab League decided to create the GAFTA in 1997 to facilitate and develop trade among League members through a gradual elimination of trade barriers[2]. In March 2001, the League decided to speed up the liberalization process, and on January 1, 2005, the elimination of most tariffs among GAFTA members was enforced. In addition, within this context of Pan-Arab integration, three North African countries (Egypt, Morocco, and Tunisia) founded the Agadir Agreement, signed in 2004, to establish a free trade area and enjoy the expected benefits of the Pan-Euro-Mediterranean cumulation of origin system (Rouis and Kounetsron, 2010).

These various trade agreements have not yet achieved all of their objectives, however, and recent events may have worsened the pattern of low intra-regional trade. First, political and security tensions, including the threat of terrorism, have affected trade relationships and imposed tighter border controls. In particular, the Morocco-Algeria border has been closed since 1994, and Mauritania, Morocco, Algeria, Tunisia, and Egypt have all implemented the 1992 United Nations embargo on Libya. Second, in 2007–2008, food and financial crises affected world trade (i.e., the so-called trade collapse) and may also have influenced intra-regional trade.[3] Finally, North African countries have been affected by the Arab revolution of 2011 when the region saw a disruption of economic activity, a decline in investments, a sharp decrease in foreign direct investment inflows,[4] and a reduction of tourism receipts.

Several studies have analyzed the impact of free trade agreements (FTAs) on trade in the Middle East and North Africa (MENA) region. Söderling (2005) analyzes export performance in the MENA using a gravity model.[5] The gravity approach is also used by Ekanayake and Ledgerwood (2009) and Parra, Martinez-

[1] See at http://www.maghrebarabe.org/en/. Accessed April 06, 2016.
[2] Eighteen of the twenty-two Arab League states signed the GAFTA agreement.
[3] As reported by the World Bank and European Union (2010), the North African countries (Morocco, Algeria, Tunisia, and Egypt) have experienced a 10.6 percent drop in remittances in 2009 as a result of the global financial crisis.
[4] See UNCTAD statistics at http://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics.aspx. Accessed October 22, 2015.
[5] In its basic form, the standard gravity equation explains bilateral trade as a function of the economic size of two countries and the distance between them.

Zarzoso and Suárez-Burguet (2016), among. Overall, the results of these studies show that FTAs have increased trade, with a higher impact seen for (i) south-south FTAs and (ii) industrial products.[6]

A two-stage approach is common when analyzing trade potential within the gravity model framework (Gros and Gonciarz, 1996; Nilsson, 2000; De Benedictis and Vicarelli, 2005; Papazoglou et al., 2006). In the first stage, the gravity model of trade is estimated and in the second stage, the model's parameters are used to project predicted trade flows. These predicted flows can be compared with realized trade, the difference between the two representing the gains that have to be made in order to achieve full trade potential.[7] However, this assumption also implies that all of the deviation between observed and predicted trade is an indication of the spread between actual and potential trade. This is unlikely when studying the market potential between North African countries. In this region, there are measurement errors of trade induced, e.g. by informal transboundary trade (see Carrère and Grigoriou, 2014; Rijkers, Baghdadi and Raballand, 2015).[8] In addition, far from being erratically driven, the gap between predicted trade and reported trade can be partially explained by several economic variables. For example, trade is found to occur across heterogeneous firms (Melitz, 2003) and can be inefficient in using those firms' inputs.[9] For these reasons, we argue that using the two-stage approach described below could lead to false results when analyzing trade potential between North African countries.

The objective of this paper is to analyze trade performance among North African trading partners. Accordingly, we use a gravity model that draws heavily on Anderson and van Wincoop (2003) and that reflects recent applications (e.g. Anderson and Yotov, 2010; Fally, 2015). Following the literature on production economics (Aigner et al., 1977), a stochastic trade frontier representing the maximum possible level of bilateral trade could be construed using a gravity model (Bhattacharya and Das, 2014; Ravishankar and Stack, 2014). Time-variant country-specific trade efficiency estimates can be obtained. The trade efficiency term is conditioned by the country of destination and the country of origin variables, as well as some variables characterizing the bilateral relationship. If two countries achieve high levels of integration, they will operate on the trade frontier and will realize their maximum trade potential. Failing that, deviations of observed trade levels from the trade frontier indicate inefficient levels of trade, which imply scope for further integration between markets. The underlying assumption is that not all deviations from observed

[6] This result is also found by Montalbano and Nenci (2014), who use matching econometrics to estimate the impact of FTA because of its potential endogeneity.

[7] Using a gravity approach, UNECA (2013) finds that the intra-regional trade potential is far from being achieved and the observed flows represent only 46% of the predictions. It is also clear from this study that Tunisia and Mauritania, with completion rates above 100% are far beyond projections. The Arab Maghreb Union sub-region averages 56% of the predicted level, but with a shade size for Libya that would achieve in this area 97% of its trade potential. According to this study, the main growth opportunities for intra-regional trade would be thus focused on the trade opportunities offered by Algerian and Moroccan markets (UNECA, 2013).

[8] Carrère and Grigoriou (2014) show that potential incentive for misreporting are e.g. average tariffs and taxations and corruption.

[9] The heterogeneous firms model assertion has been integrated in the international trade literature since the seminal papers of Melitz (2003), Chaney (2008), Helpman, Melitz and Rubinstein (2008) and Melitz and Ottaviano (2008), which united recent work on heterogeneous firms in the determination of bilateral trade flows.

trade is due to white noise; inefficiencies in trade could also be a factor since trade occurs at the firm level. This assertion has been integrated in the gravity literature since the seminal papers of Melitz (2003), Chaney (2008), Helpman, Melitz and Rubinstein (2008), and Melitz and Ottaviano (2008), which united recent work on heterogeneous firms in the determination of bilateral trade flows.

Our work is innovative in several ways. First, we provide estimates of trade efficiency scores as well as seller and buyer incidence for each North African country. This enables us to examine the capability of each country to benefit from regional market integration. Second, we provide empirical results on the impact of some policy variables on trade efficiency and present key policy recommendations to increase market integration. Third, we analyze market integration and trade efficiency at the disaggregated level to provide some explanations for current levels of market integration and trade efficiency based on North African countries' patterns of trade.

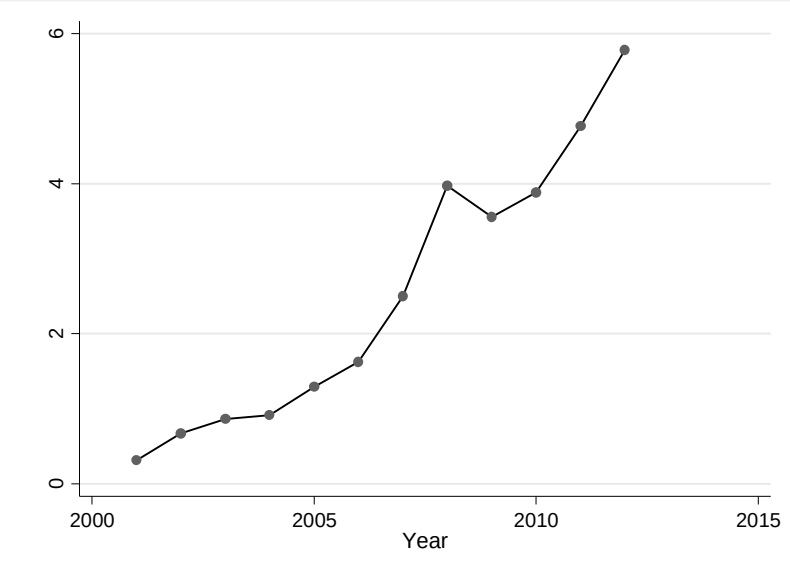
Our analysis of the evolution of North African countries' trade potential suggests that inefficiencies have decreased over time, especially for Morocco and Tunisia, the two most integrated countries in the region. Tunisia faces the fewest behind- and beyond-the-border effects. In contrast, Algeria is far from trading at full potential, especially with its first round neighboring countries. It is also important to note that Mauritania, as both a country of destination and of origin, is where the trading relationship is the least efficient; our results confirm that Mauritania's "natural" trading partners are not North African countries.

The rest of the paper is organized as follows. Section 2 is devoted to an overview of North Africa's market integration and intra-regional trade. Section 3 presents the analytical framework and describes the data. Section 4 is devoted to the results, and section 5 concludes.

2. A Brief Overview of Intra-regional Trade

The evolution of the total value of North Africa's imports is represented in Figure 1. While modest, it shows steady growth in trade and, like other regions in the world, negative impact from the economic crisis of 2008-2009.

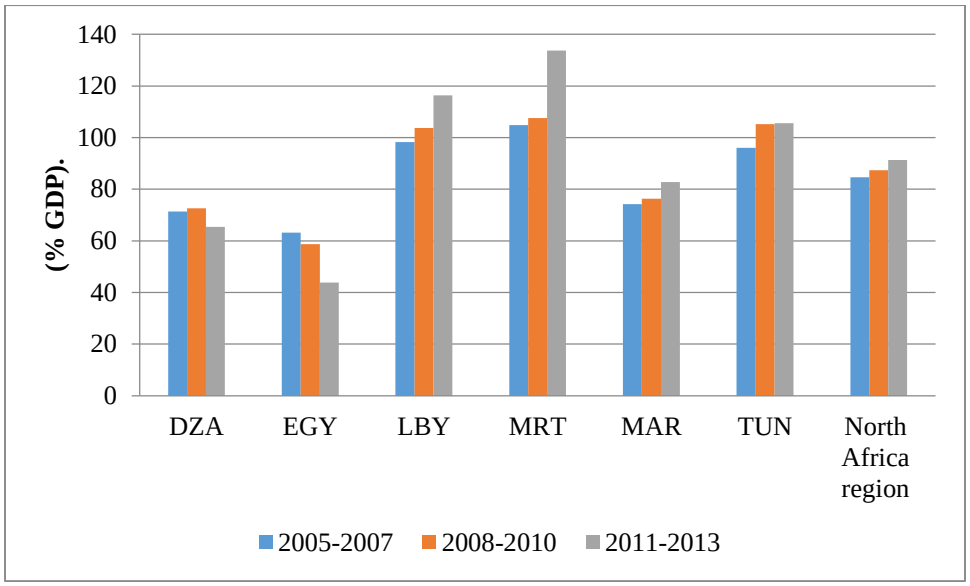
Figure 1. Total value of imports (in millions of U.S. dollars) from trading partners in North Africa



Source: Author's calculations based on UN Comtrade data.

Total trade (import + export) accounted for more than 90 percent of GDP in the North Africa region from 2011-2013 (Figure 2). Mauritania, Libya, and Tunisia are the most open North African economies, with average trade volumes exceeding GDP during 2008–2013. However, for Egypt and Algeria, trade levels decreased significantly between 2005-2007 and 2011-2013.

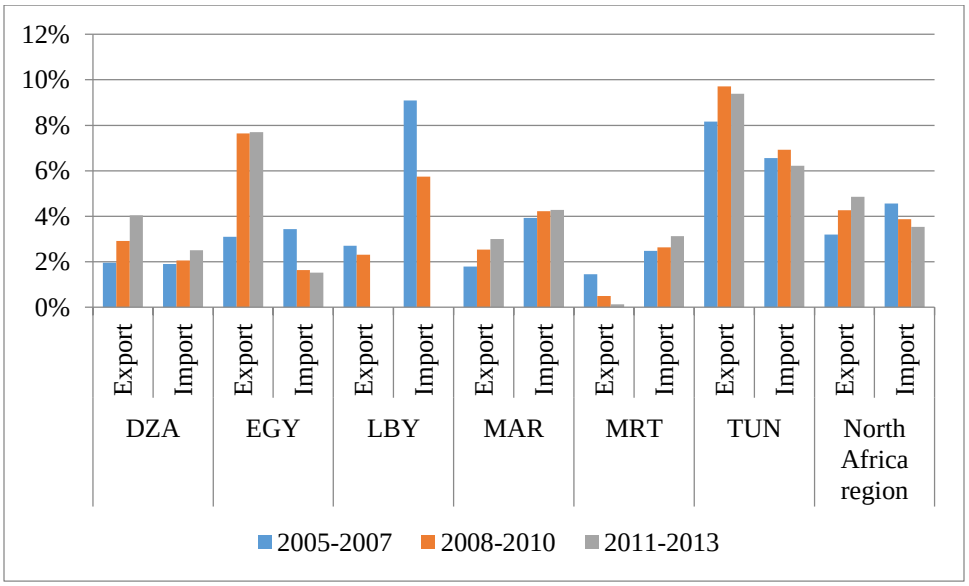
Figure 2. Total trade in North Africa region (% GDP)



Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia.
Source: Author's calculations based on UN Comtrade data.

On average, the total exports of North African countries to their trading partners in the same region represented less than 5 percent of the region's total exports during 2011–2013 (Figure 3). For Algeria and Egypt, exports to other parts of the region increased significantly between 2005-2007 and 2011-2013 (representing 4 and 8 percent of the total exports, respectively, for the last period). The economic crisis of 2008-2009 seems to have had an impact on the evolution of imports from North Africa; imports of North African products from other countries in the region continuously decreased and represented less than 4 percent of total import during 2011–2013.

Figure 3. Share of intra-North African trade (in total trade)



Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia.
Source: Author's calculations based on UN Comtrade data.

For Algeria, Egypt, and Tunisia, the shares of exports to the rest of the North Africa region are higher than the share of imports, while imports of Morocco and Libya are higher than those countries' exports to the region. Despite the visible consequences of the 2011 revolution on Tunisian trade, that country remains the most integrated in the North Africa region.

3. Analytical Framework and Data

3.1 Intensity of Trade

Following Anderson and Yotov (2010) and Fally (2015), we estimate the structural gravity equation as:

$$M_{ij} = \frac{Y_i}{\Pi_i^{-\theta}} D_{ij}^{-\theta} \frac{E_j}{P_j^{-\theta}} \qquad (1)$$

In equation (1), M_{ij} represents the value of trade, $P_j^{-\theta}$ and $\Pi_i^{-\theta}$ are respectively inward and outward multilateral resistance indexes, Y_i refers to total output in country *i*, E_j refers to total expenditure in country *j*, D_{ij} captures trade costs from *i* to *j*, and the parameter θ reflects the elasticity of trade flows to trade costs. The log-linearization of equation (1) defines what Head and Mayer (2014) call the generalized gravity equation:

$$\log\left(\frac{M_{ij}}{Y_i E_j}\right) = \Gamma_j + \Gamma_i - \ln\left(D_{ij}^{-\theta}\right) \qquad (2)$$

where $\Gamma_j \equiv \ln\left(P_j^{-\theta}\right)$ and $\Gamma_i \equiv \ln\left(\Pi_i^{-\theta}\right)$ are exporter and importer fixed effects, respectively. As indicated by Olivero and Yotov (2012), in estimating a size-adjusted gravity model we deal, at least partially, with expenditure and production endogeneity as well as with the important issue of heteroscedasticity.[10] Also, by bringing output and expenditure shares on the left-hand side in our estimations, we impose unitary estimates of the coefficients of these variables, as suggested by gravity model theory (Anderson and van Wincoop, 2003).

3.2 Trade Costs

The trade costs include the distance summarized by d_{ij} with $d_{ij} = d_{ji}$ and the effect of some factual factors of trade preference:

$$D_{ij}^{-\theta} = \exp\left(\begin{array}{l} \vartheta_1 \ln d_{ij} + \vartheta_2 Contiguity\_DZA + \vartheta_3 MAR\_DZA \\ + \vartheta_4 MAR\_EU\_d + \vartheta_5 MAR\_EU\_o + \sum_{y=2002}^{2012} \lambda_y Year \end{array}\right) \qquad (3)$$

where the variable $Contiguity\_DZA$ is a binary variable taking the value of 1 if the trading partner is contiguous with Algeria and 0 otherwise. The variable captures the fact that Algeria is contiguous with the other studied countries except for Egypt. We have no expectations about the sign of this variable. The potential positive value of contiguity could be counterbalanced by the fact that the Algerian economy is highly dominated by the energy sector. The variable MAR_DZA takes the value of 1 if the trading partners are Algeria and Morocco, without any consideration for the country of origin or country of destination. We expect this variable to have a negative value because of the "tense" political relationship between these two countries. The indicator variables of year are included to control for the potential impact of economic crises

[10] Santos Silva and Tenreyro (2006) show that heteroscedasticity renders the log-linearized version of gravity estimates inconsistent.

on the value of trade, and the years 2011 and 2012 control for the impact of the region's political change and the popular uprisings in Tunisia and Egypt. We expect the food and economic crises (2007, 2008, and 2009) and the wave of political change (2011 and 2012) to have significant negative impact. Finally, the variables $MAR\_EU\_o(d)$ take the value of 1 after the year 2007 for Morocco as a country of origin (destination) and capture the advanced status of Morocco with the European Union.[11]

3.3 Efficiency of Trade

Following Ravishankar and Stack (2014) and Bhattacharya and Das (2014), we use a stochastic frontier analysis applied to a gravity model. The underlying hypothesis is that we can define a trade frontier whereby 'inefficient' refers to the degree to which trade falls short of the frontier. Figure A1 in the Appendix provides a representation of trade potential under stochastic trade frontier representation. The inefficiency effect shows the progress required to achieve market integration. The stochastic trade frontier representation is achieved by specifying the error term of the gravity model to be estimated as follows:

$$h(e_{ij}) = \exp(v_{ij} - u_{ij}) \qquad (4)$$

Given equation (4), the error term is an additive error with a symmetric noise component, v_f with zero mean and a half-normal distribution component u_f. Following Kumbhakar and Tsionas (2005) and Kumbhakar, Tsionas and Sipliläneen (2009), we assume that v and u are not only mutually independent but are also independent of the explanatory variables. We also assume that $e_{ij} \sim N_{ij(n-1)}\left(0_{ij(n-1)}, \Sigma \otimes I_{ij}\right)$ where Σ is a $(n-1)\times(n-1)$ covariance matrix, $v_{ij} \sim N(0, s_v^2)$ and $u_{ij} \sim N^{+}\left(z_{ij}'d, s_u^2\right)$ (i.e., u follows a half-normal distribution). The vector z represents a set of variables that condition differences in trade inefficiency and use the following decomposition scheme:

$$u_{ij} = \lambda_0 + \lambda_1 time + \lambda_2 Sim_{ij} + \sum_{i=1}^{5} \lambda_{3,i} C_j^o + \sum_{i=1}^{5} \lambda_{4,i} C_i^d + \lambda_5 2008 + \lambda_6 2011 + \lambda_7 2012 \qquad (5)$$

In equation (5), the variable *time* (from 2002 to 2012) captures progress in market integration over time and is expected to have a positive impact on trade efficiency; Sim represents economic similarity between the trading partners and is calculated as Egger (2000):

[11] See at http://ec.europa.eu/trade/policy/countries-and-regions/countries/morocco/ . Accessed March 12, 2016.

$$Sim = \ln\left(1+\left|\left(\frac{GDP\_PC_i}{GDP\_PC_i+GDP\_PC_j}\right)^2-\left(\frac{GDP\_PC_j}{GDP\_PC_i+GDP\_PC_j}\right)^2\right|\right) \quad (6)$$

where GDP_PC is the GDP per capita. According to the Heckscher-Ohlin model, the variable Sim is expected to have a positive impact on trade efficiency since a larger difference in the per capita incomes of two countries results in stronger specialization and more trade.[12] The years 2008, 2011 and 2012 are indicator variables of crises; we expect to see a negative impact stemming from political crises. Finally, $C_i^d\left(C_j^o\right)$ are indicator variables of country of destination (origin). They are introduced in order to capture potential differences between countries' trade efficiencies.

3.4 Estimation Strategy

Given the above distributional assumptions, and following Battese and Corra (1977), the likelihood function of the model is:

$$\ln L = -\frac{F(n-1)}{2}\ln(2p)-\frac{F}{2}\ln(s^2)-\frac{F}{2}\ln|\Sigma|+\sum_{ij=1}^{F}\ln\Phi\left(-\frac{e_f}{s}\sqrt{\frac{g}{1-g}}\right)-\frac{1}{2}\sum_{ij=1}^{N}\left[e_{ij}\Sigma^{-1}e_{ij}+e_{ij}^2s^{-2}\right] \quad (7)$$

where $e_{ij}\equiv u_{ij}-v_{ij}$, $\Phi(\cdot)$ is the cumulative distribution function of a standard normal random variable, $s^2\equiv s_v^2+s_u^2$ and $g\equiv s_u^2/s^2\in[0,1]$. If $g=0$, then all deviations from the frontier are due to noise, while $g=1$ means that all deviations are due to trade inefficiency. The model is estimated with a constrained maximum likelihood estimator.

As Baldwin and Taglioni (2006) and many others demonstrate, to properly identify the elasticity of a trade policy in a gravity panel setting, one needs to control for time-varying importers' and exporters' fixed effects. This is because multilateral resistances should not be time-invariant. However, in the present study and because of collinearity issues, we introduce 4-year time-varying importers' and exporters' fixed effects. Moreover, Baier and Bergstrand (2007) suggest that the best way to account for endogeneity, which is due to omitted variable bias (and other endogeneity issues), is to use time -invariant pair-fixed effects (see also Martínez-Zarzoso, Felicitas and Horsewood, 2009; Raimondi, Scoppola and Olper, 2012). Accordingly, our estimating equation includes (by clustering) a time-invariant country-pair effect, Υ_{ij}, with $\Upsilon_{ij}\neq\Upsilon_{ji}$. We estimate using a two-step procedure as suggested by Heckman (1979) to correct for zero trade flows. The

[12] Adding differences in first and second moments of income distributions to an augmented gravity model, Eppinger and Felbermayr (2015) revisit the effect of similarity in income distributions on bilateral trade flows and present new robust empirical regularity: while differences in average incomes between two countries increase trade, differences in income dispersion reduce it. Their result sheds new light on the Linder hypothesis and stresses the importance of demand-based theories of international trade.

first step involves a probit model while in the second step, the inverse mills ratio (IMR) is introduced in the gravity model as an additional explanatory variable.

3.5 Data Sources and Description

Our empirical analysis covers five North African countries (Algeria, Egypt, Mauritania, Morocco, and Tunisia). Libya is excluded because of a lack of data. Trade volumes for the period 2001-2012 were obtained from the UN Comtrade database[13]. We consider data for global trade and for nine product categories constructed using the Harmonized System (HS) 2-digit level data.

Transport cost proxies are important variables in gravity models. Previous studies have found that trade elasticities with respect to transport costs and other transaction cost variables are sensitive to the method used to proxy transport cost (Head and Mayer, 2002). Some authors have designed more intricate measures that take into consideration the dispersion of economic activity within a region. Head and Mayer (2002) suggest the following indicator:

$$d_{ij} = \sum_{g \in i} \left(\sum_{h \in j} \varpi_h d_{gh} \right) \varpi_g \qquad (8)$$

where d_{gh} is the distance between the two sub-regions $g \in i$ and $h \in j$ and ϖ_g and ϖ_h represent the economic activity share of the corresponding sub-region. The Centre d'Études Prospectives et d'Informations Internationales (CEPII) uses the above formula to create a dataset.[14] Data on competiveness, GDP, population, and trade openness come from the World Development Indicators[15], while data on industrial production are from UNIDO.[16] Table 1 presents summary statistics concerning the data used.

[13] Data on trade were collected using the World Integrated Trade Solution (WITS) software developed by the World Bank, in close collaboration and consultation with various International Organizations including the United Nations Conference on Trade and Development (UNCTAD), International Trade Center (ITC), United Nations Statistical Division (UNSD), and World Trade Organization (WTO). See http://wits.worldbank.org/wits/)

[14] We also tested the CES aggregation method where $d_{ij} = \left[\sum_{g \in i} \left(\sum_{h \in j} \varpi_h d_{gh} \right) \varpi_g \right]^{1/\theta}$ as suggested by Head and Mayer (2010) and found estimates that are very close.

[15] See http://data.worldbank.org/indicator.

[16] See at http://www.unido.org/en/resources/statistics/statistical-databases.html.

Table 1. Summary statistics of data for two selected years

Years	Variables	Mean	Standard deviation	Minimum	Maximum
2005	GDP (USD)	5.74e+10	3.79e+10	2.18e+09	1.03e+11
	Population	2.98e+07	2.46e+07	3.15E+06	7.18e+07
	GDP per capita (USD)	2 035.478	1 008.095	694.3201	3218.961
	Total trade	64 714.780	90 689.740	0	357 573.8
	Trade in Agricultural products (HS range 01-24)	5 809.248	8 628.975	0	27 895.3
	Trade in Mineral Products (HS range 25-27)	24 498.52	62 407.940	0	269 412.2
	Trade in Chemicals & Allied Industries (HS range 28-38)	7 207.636	12 576.330	0	48 042.26
	Trade in Plastics & Rubbers (HS range 39-40)	3 127.647	4 860.626	0	15 408.76
	Trade in Raw Hides, Skins, Leather & Furs (HS range 41-43)	166.384	446.048	0	1 931.218
	Trade in Wood & Wood Products (HS range 44-49)	2 899.107	4 188.183	0	13 004.15
	Trade in Textiles; Footwear & Headgear (HS range 50-67)	1 292.473	3 349.657	0	14 986.71
	Trade in Stone; Glass & Metal (HS range 68-83)	11 927.110	16 319.190	0	54 922.47
	Trade in Machinery; Electrical & Transportation (HS range 84-89)	5 499.385	10 533.860	0	39 448.5
2012	GDP (USD)	1.22e+11	9.96e+10	3.96e+09	2.63e+11
	Population	3.33e+07	2.77e+07	3 796 141	8.07e+07
	GDP per capita (USD)	3 351.503	1 454.572	1 042.823	5309.822
	Total trade	2 89377.8	354 401.50	117.242	1 127 520
	Trade in Agricultural products (HS range 01-24)	23 074.37	29 288.37	0	94 663.25
	Trade in Mineral Products (HS range 25-27)	176 335.8	356 410.5	0	1 071 413
	Trade in Chemicals & Allied Industries (HS range 28-38)	20 278.26	26 605.83	0	75 354.13
	Trade in Plastics & Rubbers (HS range 39-40)	7 464.012	12 863.78	0	46 149.11
	Trade in Raw Hides, Skins, Leather & Furs (HS range 41-43)	240.7774	493.9478	0	1 935.905
	Trade in Wood & Wood Products (HS range 44-49)	7 586.412	11 451.33	0	44 668.62
	Trade in Textiles; Footwear & Headgear (HS range 50-67)	3 952.826	5 786.085	0	18 978.87
	Trade in Stone; Glass & Metal (HS range 68-83)	29 150.13	47 832.17	0	158 008
	Trade in Machinery; Electrical & Transportation (HS range 84-89)	18 686.73	24 017.57	0	75 773.22

Note: Trade in 1000USD.
Source: Author's calculations based on UN Comtrade data.

4. Estimation Results

4.1 Intensity of Trade: Gravity Model Estimates

Table 2 presents the estimated results of the stochastic frontier specification of the gravity model of imports between the five North African countries, estimated by maximum likelihood over the period 2001-2012. Column [1] presents the results of the benchmark model.

Distance is expected to have a negative significant value, and the value we find (-2.557) is close to the results reported in the literature (See Head and Mayer, 2014).17 In addition, political tension influences trade; the coefficient of the variable representing the contentious relationship between Algeria and Morocco is negative and significant, as expected. This result is in line with the findings of Davis et al. (2014). According to these authors, this effect holds for countries in which the central government seeks to achieve political goals through state-owned enterprises, which distort the profit-maximizing behavior that encourages trade with all viable partners. Moreover, Algeria only joined the GAFTA agreement in 2005 and does not seem to benefit enough from its central geographical position. In fact, the negative value of the variable representing the contiguity between Algeria and the other countries (except Egypt) is negative and significant for the 2001-2012 period, indicating that, all thing being equal, Algeria does not conduct noteworthy trade with its first round neighboring countries.

Our results regarding global food and economic crises (2007, 2008, and 2009) indicate that these events had no statistically significant impact on the value of imports among North African countries. The 2011 sociopolitical crisis had a negative impact on imports (at the 10 percent level), with a decrease of 0.811 percent. Finally, the coefficients of the special status of Morocco with the EU are not significant.

Columns [2] to [4] of Table 2 present some robustness tests of our results. In specification [2], we estimate a non-adjusted trade frontier model. Our results indicate that overall, the estimated coefficients are stable in signs and values. The results of the estimation using and OLS procedure (Specification [3]) are also close to those of the benchmark model for the distance and the variable $Contiguity\_Algeria$ and the variable $Morroco\_Algeria$. Overall, our results are stable across estimation procedures, as also indicated by the results of the estimations using the PPML (Specification [4]).

[17] However, the value of the coefficient of distance is lower in absolute value when considering the results of Elshehawy, Shen Ahmed (2014) for Egypt.

Table 2. Estimated results of the gravity model

		Frontier estimation				**OLS estimation**		**PPML estimation**	
		Adjusted trade $Log\left(M_{ij}/Y_iE_j\right)$ **[1]**		**Non adjusted trade** $Log\left(M_{ij}\right)$ **[2]**		**Adjusted trade** $Log\left(M_{ij}/Y_iE_j\right)$ **[3]**		**Non adjusted trade** $Log\left(M_{ij}\right)$ **[4]**	
Variables		**Value**	**Standard error**	**Value**	**Standard error**	**Value**	**Standard error**	**Value**	**Standard error**
Years dummy	2007	-0.173	0.490	2.235***	0.494	-0.111	0.483	0.978	3.370
	2008	-0.120	0.493	2.432***	0.489	-0.212	0.445	1.115	3.530
	2009	-0.340	0.492	2.252***	0.484	-0.545	0.444	1.108	3.533
	2011	-0.811*	0.479	2.633***	0.488	-0.851	1.598	1.049	3.558
	2012	-0.391	0.464	3.053***	0.472	-0.656	1.598	1.238	3.483
Log of distance		-2.557***	0.539	-2.447***	0.539	-2.429***	0.670	-2.646***	0.004
MAR_DZA		-0.798***	0.145	-0.727***	0.150	-0.739***	0.366	-0.795***	0.001
Contiguity_DZA		-1.686***	0.411	-1.746***	0.413	-1.796***	0.661	-1.385***	0.003
MAR_EU_o		-0.352*	0.186			0.257	0.635	0.415***	0.002
MAR_EU_d		-0.176	0.179	-0.006	0.164	0.327	0.613	-0.532***	0.011
Number of observations		240		240		240		240	
Log likelihood		-156.322		-153.793		0.403 (R^2)		-1.876 10^6	

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia. Robust standard errors clustered within country pairs in parenthesis. ***, **, * indicate significance at 1%, 5% and 10% respectively. Estimates of fixed effects and some year dummy variables are omitted for brevity.

4.2 Regional Integration and Trade Facilitation Analysis

Table 3 presents the results for the variables that condition trade inefficiency. A negative sign indicates that the variable has a positive impact on market penetration by firms (reducing the inefficiency term), whereas a positive sign indicates that the variable disfavors trade efficiency. Column [1] of Table 3 presents the results for the variables that condition trade inefficiency, using the benchmark specification of the gravity equation (Column [1] of Table 2). Column [2] presents the results of the estimation when considering non-adjusted trade, while in Column [3], the estimated coefficients of a model with interaction variables between countries of origin and the year 2012 is presented. Overall, Table 3 shows that the results are mostly stable in sign and magnitude.

Table 3. Estimation results of variables that condition trade efficiency

			Adjusted trade [1]		Non adjusted trade [2]		Adjusted trade [3]	
Variables			**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Time			-0.220***	0.062	0.082	0.16	-0.237***	0.063
Sim			-4.620*	2.063	-3.241	2.201	-4.766*	1.99
Country of destination	EGY		-4.909***	1.019	-6.569***	1.262	-5.050***	1.132
	TUN		-3.069***	0.566	-2.225***	0.562	-3.036***	0.554
	MAR		-2.331***	0.665	-2.821***	0.815	-2.421***	0.641
	MRT		3.380***	0.718	-0.516	2.445	3.433***	0.698
	DZA							
Country of origin	EGY		-1.014**	0.488	-1.187*	0.526	-1.115*	0.495
	TUN		-3.402***	0.681	-3.082***	0.626	-3.629***	0.647
	MAR		-1.788**	0.691	-1.562*	0.697	-1.912**	0.67
	MRT		4.833***	0.812	4.354***	0.877	4.782***	0.803
	DZA							
Crises	2008		0.459	0.537	0.292	0.622	0.411	0.538
	2011		0.446	0.529	0.421	0.555	0.455	0.53
	2012		1.694*	0.742	1.653*	0.786	1.763	0.95
		MAR_o					-29.693	1625.135
		DZA_o					-0.344	1.246
		MRT_o					-0.023	1.347
		TUN_o					1.526	1.414
		EGY_o						
Sigma_v			0.166	0.02	0.181	0.020	0.163	0.019

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia. Robust standard errors clustered within country pairs in parenthesis. ***, **, * indicate significance at 1%, 5% and 10% respectively.

4.2.1 Estimated Results

The value of -0.220 of the coefficient of the variable *Progress (time)* indicates that every year, all things being equal in our empirical model, there is more market integration between North African countries. This result is expected because, at the firm level, the learning-by-doing process makes the trading relationship more efficient over time. Economic similarity has a negative impact on trade inefficiency. This result can be interpreted as evidence of Heckscher-Ohlin forces; accordingly, the more comparable the GDP per capita between trading partners, the greater the trade efficiency.[18]

Our model includes countries of origin and countries of destination as indicator variables, with Algeria as a country of reference because of its geographical position at the heart of North Africa. The value of -4.909 for Egypt as a country of destination indicates that the value of trade inefficiency is 4.909 lower than Algeria's trade inefficiency. Our results indicate that, with a value of coefficient of 3.380, Mauritania as a country of destination is where the region's trading relationship is the least efficient. Therefore, "behind Mauritania's border," there are geographical and/or institutional constraints to trade efficiency. Also, as a country of origin, Mauritania faces the most important beyond-the-border constraints to trade (coefficient of 4.833). As countries of origin, Tunisia and Morocco exhibit the fewest trade inefficiencies. Note that Egypt and Mauritania are both located at the extreme East and the extreme West of North Africa, respectively. However, while Mauritania is the least integrated in the region, Egypt does not face low integration.

We also analyze the impact of financial and political crises on trade efficiency. Our results indicate that the 2008 and 2011 crises had no impact on trade efficiency (the coefficients of the variable *2008* and *2011* are not significant, even at the 10 percent level). However, the results are different when considering the year 2012. They indicate that, *all things being equal*, for countries of destination, the political crises have had a negative impact on trade efficiency. In specification [3] of Table 3, we also experiment with interaction variables between country of origin and the year 2012. Our results indicate that there are no differences between countries of origin, all interaction variables being non-significant.

4.2.2 Evolution of Trade Efficiency Scores by Country

Figure 4 presents trade efficiency evolution by country while considering countries' position as an importer or exporter during the period 2005-2012. A value of 1 implies a high integration between markets, whereas a value close to 0 indicates that trade flows are far from trade potential.

The key finding of our trade efficiency estimates, when considering the very scant literature that uses stochastic frontier analysis applied to a gravity model (Bhattacharya and Das, 2014; Ravishankar and Stack,

[18] Elshehawy et al. (2014) shows that GDP similarity has a positive impact on the intensity of trade.

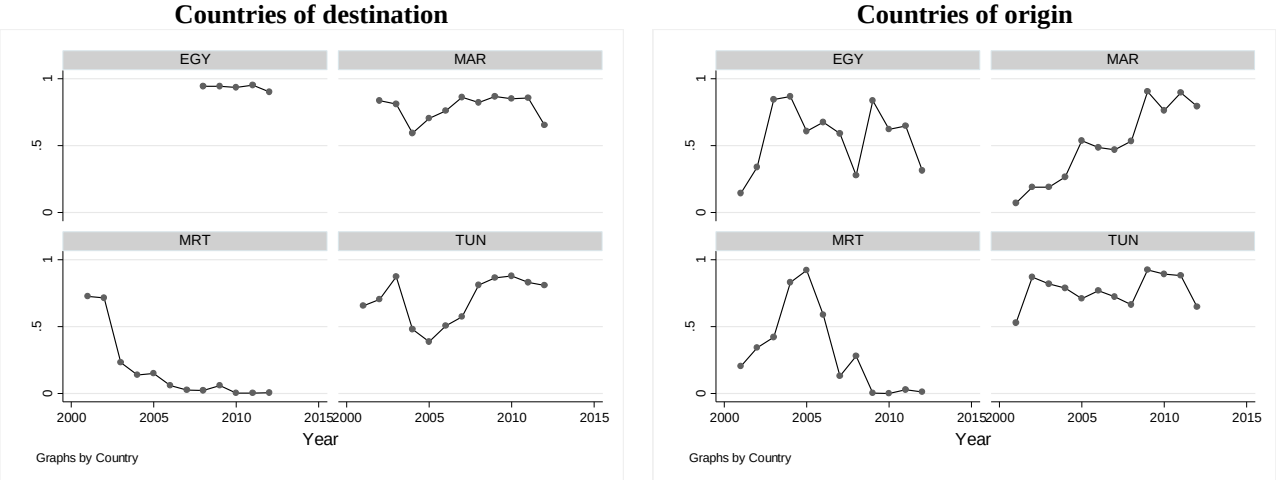
2014), is that trade efficiency has increased over time and has reached relatively high levels, with the exception of Mauritania and Algeria. The trade efficiency scores estimated as a measure of market integration reveal that Tunisia and Morocco are the two most integrated countries in North Africa. In addition, Tunisia and Morocco have the highest trade efficiency scores as countries of destination with their other trading partners, apart from Mauritania. Moreover, Morocco as a country of origin reached a high trade efficiency score in the last years of our dataset. Tunisia's scores are also high as a country of origin, albeit lower its scores than as a country of destination.

As shown in Figure 4, Algeria's best and most stable trade efficiency exists with Tunisia as a partner. For its other trading partners, Algeria is far from being at trade potential; however, it is important to note that there was a continuous improvement in its score with Morocco (as a country of origin) during the period 2001-2012. This result is in line with the findings of Hosny (2012), which provide empirical evidence that Algeria's trade with GAFTA countries would have improved if Algeria had signed the GAFTA agreement in 1998.

Overall, Figure 4 shows that Egypt has a relatively low and very instable trade efficiency score with Algeria and Mauritania, as countries of destination.

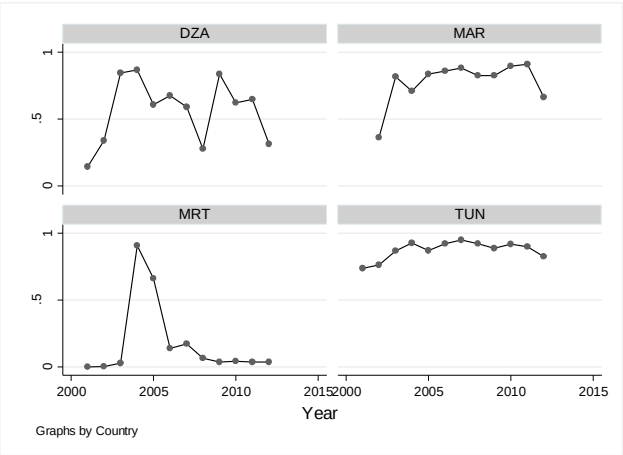
Mauritania is the least integrated country in the North African market. As mentioned, Mauritania is at the extreme West of North Africa. This fact, coupled with its border with the disputed territory of Western Sahara, could explain this situation[19]. Furthermore, our results confirm that Mauritania's "natural" trading partners are not North African countries.

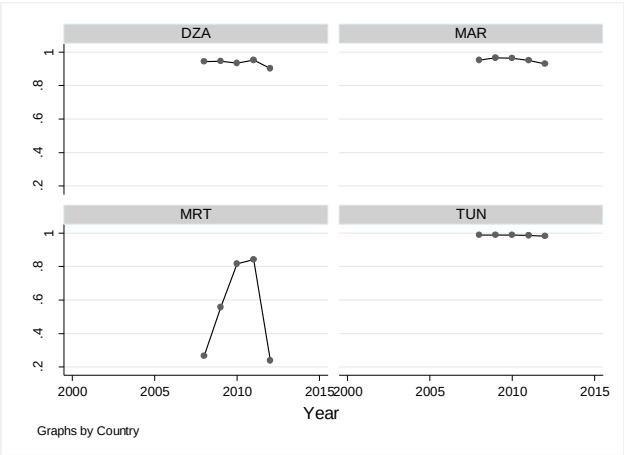
Figure 4. Trade efficiency of North African countries.



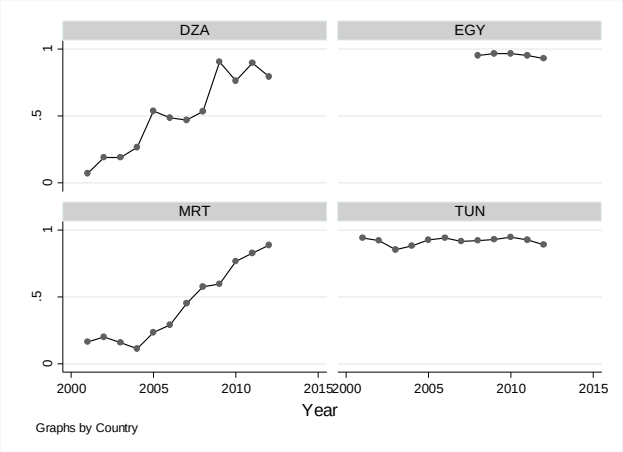
Trade efficiency of Algeria (DZA)

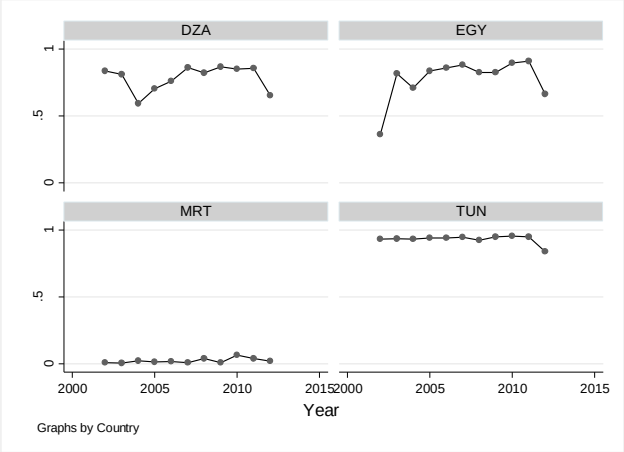
[19] Note that Mauritania left the Economic Community of West African States (ECOWAS) zone in 2001 and joined the Community of Sahel-Saharan States (CENSAD) in 2009.



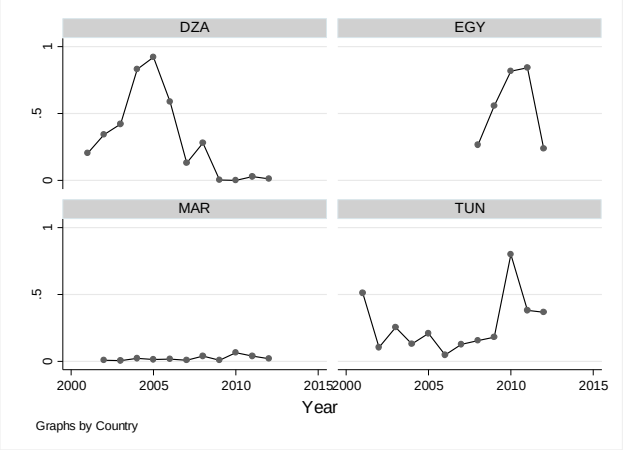


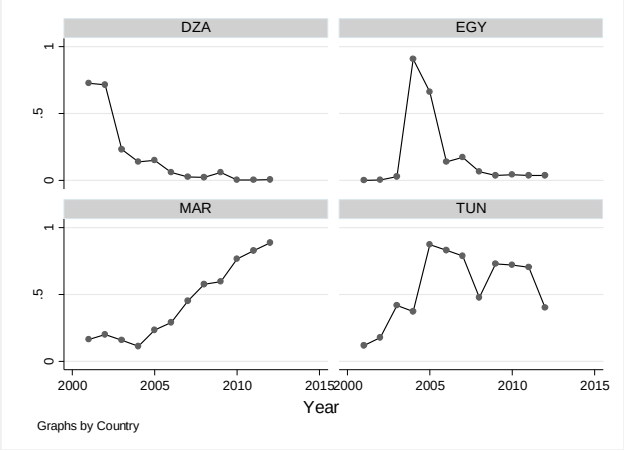
Trade efficiency of Egypt (EGY)



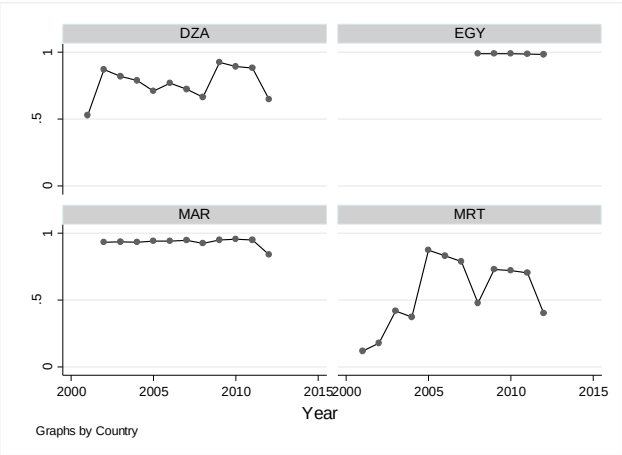


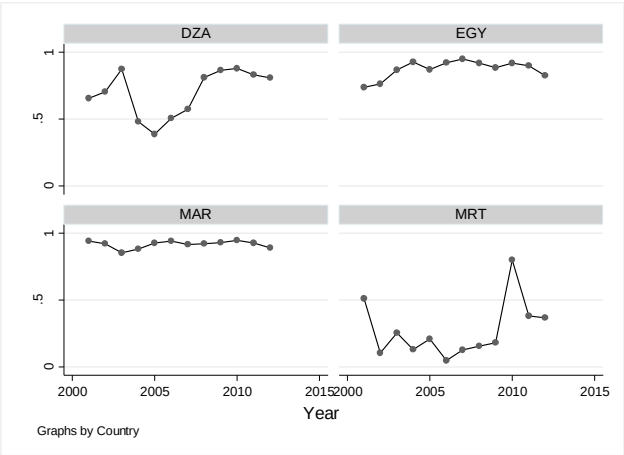
Trade efficiency of Morocco (MAR)





Trade efficiency of Mauritania (MRT)





Trade efficiency of Tunisia (TUN)

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia.

Finally, estimates of trade efficiency scores confirm that the 2011 political crisis had an impact on trade efficiency in the region. Indeed, when comparing the years 2010 and 2012, it is apparent that trade efficiency decreased sharply for most trading relationships.

4.2.3 Country Policies and Trade Efficiency

The purpose of this section is to shed light to the impact of country-level policies on trade efficiency in North Africa. As policy variables, we use the Logistic Performance Index – Overall (LPIO)[20] and the Country Policy and Institutional Assessment (CPIA)[21] for the period 2005-2012.[22] Table 4 provides some summary statistics of these policy variables for two selected years (2005 and 2012). North African countries experienced a modest improvement in their scores in these years (except in the case of policies for social inclusion); however, the data shows that there is still room for improvement in the quality of policies and institutions for the most countries in the region.

[20] As defined by the World Bank "Logistics Performance Index overall score reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time." See at http://data.worldbank.org/indicator/LP.LPI.OVRL.XQ . Accessed September 19, 2015.

[21] The Country Policy and Institutional Assessment (CPIA) of the African Development Bank (AfDB) is a rating system designed to capture the quality of countries' policies and institutional arrangements. The CPIA rates countries on a set of 16 criteria grouped in four sectors: economic management, structural policies, policies for social inclusion and equity, and public sector management and institutions. The AfDB published data for all eligible African countries up to, and including, 2011. For the year 2012, we use raw data from The Ibrahim Index of African Governance (The Mo Ibrahim Foundation) for Morocco, Algeria, Tunisia, and Egypt.

[22] We restrain the period because of the availability of data.

Table 4 – Summary statistics of policy indicators for two selected years

Years	Variables	Mean	Standard deviation	Minimum	Maximum
2005	CPIA (1=low to 6=high)				
	Economic Management	4.233	0.645	3.333	5.000
	Structural Policies	3.633	0.273	3.167	4.000
	Policies for Social Inclusion and Equity	3.920	0.451	3.500	4.700
	Public Sector Management and Institutions	3.560	0.641	2.900	4.500
	LPIO (1=low to 5=high)	2.440	0.248	2.060	2.760
2012	CPIA (1=low to 6=high)				
	Economic Management	4.366	0.545	3.500	5.000
	Structural Policies	3.729	0.517	3.194	4.361
	Policies for Social Inclusion and Equity	3.824	0.270	3.400	4.127
	Public Sector Management and Institutions	3.648	0.647	2.725	4.475
	LPIO (1=low to 5=high)	2.798	0.335	2.400	3.170

Source: World Bank Development indicators (http://data.worldbank.org/indicator?tab=all)

We regress the trade efficiency scores on the selected policy variables and expect these variables to have a positive impact on trade efficiency. The estimation results are presented in Table 5. In specification [1], trade efficiency scores are regressed on the country of origin and the country of destination variables, while in specification [2], trade efficiency scores are regressed on country of origin variables. Finally, specification [3] regresses scores on country of destination variables.

"Economic management and structural policies" (policies affecting trade, the financial sector, and the business environment) of both the country of origin and the country of destination have a positive significant impact. The marginal impact is higher when considering the country of destination. In addition, the "Public sector management and Institutions" variable is statistically insignificant (and wrongly signed for a country of destination) and points to the presence of a poor and counterproductive regulatory environment, largely due to weak institutions (i.e., customs administrations). These results underline the importance of improving domestic policies to encourage entrepreneurial development and business facilities.

The logistic performance index of the country of origin has a positive impact on trade efficiency and a non-significant impact for the country of destination.

Table 5- Estimation results of the policy variables that explain trade efficiency

	Dependent variable : Trade efficiency score					
	Specification [1]		**Specification [2]**		**Specification [3]**	
Variables	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Country of origin						
CPIA - Economic Management	0.294**	0.117	0.21	0.142		
CPIA - Structural Policies	0.317**	0.143	0.167	0.211		
CPIA - Policies for Social Inclusion and Equity	-0.221	0.136	-0.152	0.179		
CPIA - Public Sector Management and Institutions	0.018	0.09	0.078	0.176		
LPIO	0.352**	0.129	0.312**	0.126		
Country of destination						
CPIA - Economic Management	0.338***	0.099			0.265	0.154
CPIA - Structural Policies	0.576***	0.136			0.497**	0.174
CPIA - Policies for Social Inclusion and Equity	-0.266*	0.15			-0.211	0.242
CPIA - Public Sector Management and Institutions	-0.245	0.186			-0.249	0.26
LPIO	0.198	0.157			0.11	0.156
Number of observations	148		148		148	
R2	0.532		0.283		0.172	

Note: Robust standard errors clustered within country pairs in parenthesis. ***, **, * indicate significance at 1%, 5% and 10% respectively.

4.2.4 Analyses by Product Categories

The results of the computed trade efficiency scores are presented in Table 6 for the year 2012; these indicate that there is a high variability in trade efficiency between the nine categories of products.[23] North Africa's market integration is highest for the "Wood and Wood products" category. Conversely, market integration is worst when considering goods from the "Textiles; Footwear & Headgear" category. Our results can be explained by the similar specialization and the structure of the textile and garment industry in Morocco, Tunisia, and Egypt; all of these countries act as subcontractors for European textile and garment suppliers.

Although some studies show that GAFTA has been effective in increasing bilateral trade between Arab countries (e.g., Abedini and Péridy, 2008 and Parra, Martinez-Zarzoso and Suárez-Burguet, 2016), our estimates indicate that for the case of North African countries, trade efficiency for agricultural products remains relatively low. This indicates the existence of significant inefficiencies in the region's agricultural trade.

We also compute the mean of trade efficiency by country and for the year 2012. Our results indicate that, as a country of destination, Egypt has the highest coefficient of variation of trade efficiency, while Algeria has the lowest. As a country of origin, Mauritania has the highest coefficient of variation, whereas Morocco has the lowest. Overall, Morocco exhibits relatively stable efficiency when considering all subgroups of goods.

[23] Estimated results of the stochastic trade frontier model at the disaggregated level are presented in Appendix Table A2.

Table 6. Trade efficiency by Product categories and countries for the year 201

	Product categories											
	Agricultural products (HS range 01-24)	**Mineral Products (HS range 25-27)**	**Chemicals & Allied Industries (HS range 28-38)**	**Plastics & Rubbers (HS range 39-40)**	**Raw Hides, Skins, Leather & Furs (HS range 41-43)**	**Wood & Wood Products (HS range 44-49)**	**Textiles; Footwear & Headgear (HS range 50-67)**	**Stone; Glass & Metal (HS range 68-83)**	**Machinery; Electrical & Transportation (HS range 84-89)**	**Standard error**	**Mean**	**Coefficient of variation**
Country of destination												
DZA	0.579	0.665	0.561	0.782	0.462	0.941	0.489	0.466	0.629	0.159	0.573	0.278
EGY	0.173	0.765	0.180	0.939	0.148	0.674	0.356	0.107	0.322	0.307	0.397	0.774
MAR	0.531	0.297	0.461	0.420	0.718	0.906	0.393	0.377	0.563	0.190	0.486	0.392
MRT	0.691	0.230	0.528	0.420	0.495	0.401	0.409	0.512	0.567	0.129	0.438	0.294
TUN	0.184	0.769	0.634	0.811	0.679	0.859	0.358	0.714	0.570	0.221	0.580	0.380
Total	0.445	0.521	0.459	0.645	0.560	0.744	0.403	0.431	0.541	0.111	0.486	0.228
Country of origin												
DZA	0.593	0.455	0.107	0.535	0.689	0.533	0.001	0.302	0.011	0.262	0.349	0.752
EGY	0.365	0.624	0.526	0.567	0.401	0.603	0.363	0.421	1.000	0.200	0.507	0.394
MAR	0.447	0.925	0.718	0.913	0.548	0.872	0.524	0.549	0.757	0.184	0.644	0.285
MRT	0.429	0.062	0.000	0.103	.	1.000	0.037	0.011	0.316	0.342	0.256	1.339
TUN	0.428	0.307	0.713	0.698	0.623	0.904	1.000	0.526	0.565	0.219	0.598	0.366
Total	0.445	0.521	0.459	0.645	0.560	0.744	0.403	0.431	0.541	0.111	0.486	0.228

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia.

5. Concluding Remarks

Our paper has analyzed the trade potential versus actual realized trade among North African trading partners. We use a stochastic trade frontier representing the maximum possible level of bilateral trade that could be construed based on a gravity model. The trade efficiency term was conditioned by country of destination and country of origin variables, along with variables characterizing the bilateral relationship. This approach allows us to estimate not only trade efficiency scores but also incidence of sellers and buyers for each country.

In general, our analysis of the evolution of these countries' trade potential suggests that efficiencies have increased over time, especially for Morocco and Tunisia, the two most integrated countries in North Africa. Unsurprisingly, Tunisia faces the fewest behind-the-border and beyond-the-border effects.

In contrast, Algeria is far from meeting its trade potential and does not engage in noteworthy trade with its first round neighboring countries. It is also important to note that as a country of both destination and origin, Mauritania has the least efficient trading relationship; our results confirm that Mauritania's "natural" trading partners are not North African countries.

Moreover, our estimates indicate that recent economic crises and trade collapses did not have a significant adverse impact on the value of imports or on trade efficiency among North African countries. On the other hand, intra-regional imports were negatively affected by both political tensions and the 2011 Arab revolutions. Consequently, trade efficiency decreased significantly for most trading relationships in 2012, reflecting the lagged effects of the deterioration in business conditions and productive activity on North African trade.

Our estimates of the impact of country-level policies on trade efficiency in North Africa point to the presence of a poor and counterproductive regulatory environment that is largely due to weak institutions (i.e., customs administrations). This underlines the importance of improving domestic policies to encourage entrepreneurial development and business facilities.

Our findings also confirm the need for North African countries to improve their trade logistics at the national level to enhance trade efficiency and to implement trade facilitation reform programs.

Our analysis of market integration and trade efficiency at the disaggregated level indicates that trade efficiency scores exhibit high variability between categories of products. Our estimates also indicate that trade efficiency for agricultural products is relatively low, indicating the existence of significant behind-the-border and beyond-the-border inefficiencies. Countries' similar specialization can explain the existence of these inefficiencies in part, but the presence of high and frequent technical barriers to trade and sanitary and phytosanitary measures is also a contributing factor.

Integration of North Africa's market should be pursued by improving structural policies to reap the benefits of international trade and improve trade efficiency. The removal of procedural inefficiencies, obstructions,

and discriminatory regulations are important aspects of trade reform that need to be pursued by North African countries. National trade facilitation policies and agendas need to be coordinated to reduce inefficiencies.

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Appendix

Figure A1. Trade potential under stochastic trade frontier representation

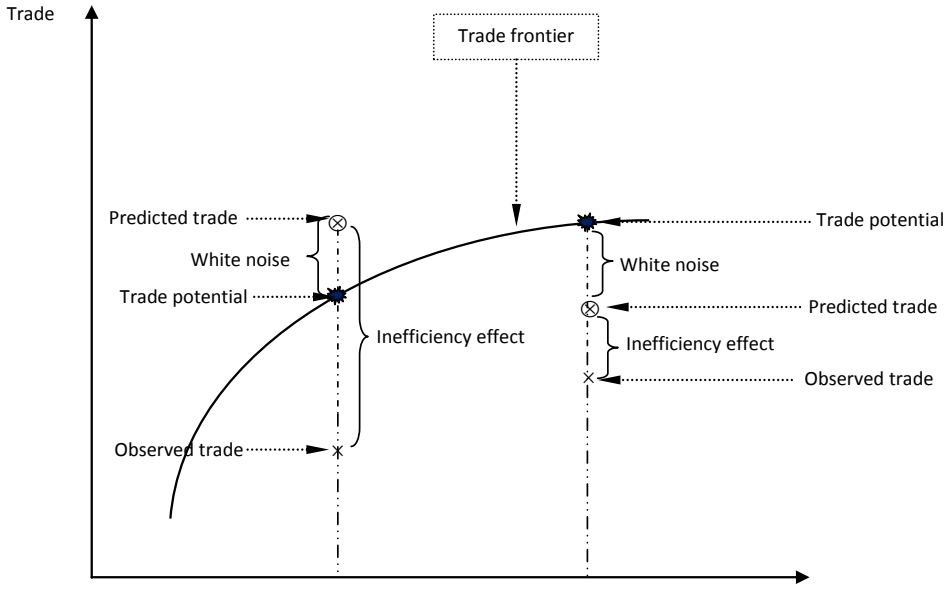

Table A1. Estimated results of the stochastic trade frontier model at the disaggregated level

	Agricultural products (HS range 01-24)	**Mineral Products (HS range 25-27)**	**Chemicals & Allied Industries (HS range 28-38)**	**Plastics & Rubbers (HS range 39-40)**	**Raw Hides, Skins, Leather & Furs (HS range 41-43)**	**Wood & Wood Products (HS range 44-49)**	**Textiles; Footwear & Headgear (HS range 50-67)**	**Stone; Glass & Metal (HS range 68-83)**	**Machinery; Electrical & Transportation (HS range 84-89)**
	First stage Probit estimates								
Log of distance		-2.071**	0.444	-2.695***	-2.407***	-2.373***	-1.788**	-2.837***	-3.774***
Log of distance X TUN_d		-0.236**	0.326***	-1.064***	-0.303*	-0.768***	-0.461**	-0.991***	-0.277**
Log of distance X EGY_d	-1.142***	-0.236**		-0.872***	-0.326***	-0.625***	-0.553***	-0.797***	0.03
Log of distance X MAR_d	-0.870***	-0.015	0.250***	-0.698***	-0.257**	-0.428***	-0.386***	-0.632***	0.200**
Log of distance X MRT_d		0.247							1.046***
Log of distance X DZA_d			0.288***	-0.692***	-0.307*	-0.545***	-0.492***	-0.634***	
Contiguity	0.335	-1.424**	0.44	-3.756***	-2.160***	-2.260***	-1.705***	-3.666***	-3.339***
MAR_DZA	-0.721	-0.927							0.167
Log of GDP per capita_origin	-0.621	0.178	2.296***	-0.208	-0.662	0.354	0.007	-0.409	-1.136*
Log of GDP per capita_destination	5.612***	1.557**	-0.740**	2.481***	1.743***	2.335***	2.457***	2.431***	3.663***
	Gravity model estimates								
Log of distance	-1.671***	-2.317**	-1.893***	-4.419***	3.278	-0.823	-0.866**	-0.147***	-2.724***
Log of distance X TUN_d	0.287***	0.249***	-0.080***	0.602***	-1.167	-0.087	2.950***	-0.035***	-0.188***
Log of distance X EGY_d	0.318***	0.125		0.324***	-1.207	-0.223	0.325	-0.234***	-0.033
Log of distance X MAR_d	0.197***	1.118	0.112***	2.722***	-3.518	0.069	-0.645	-0.090***	1.189
Log of distance X MRT_d	0.336***	0.445***	0.251***	1.114***	-0.845	0.172	-0.688*	-0.043	-5.886***
Log of distance X DZA_d									
MAR_DZA	-1.749***	1.113	-0.804***	-0.317***	-4.340**	-2.771***	-1.962***		-1.355**
Contiguity _DZA	-0.985***	-1.763		-4.421***	5.847	0.281			
IMR	0.141***	-0.684	0.848***	2.059***	-2.719**	1.505***	0.013	0.326***	-0.909*
MAR_UE_o	0.544***	-0.6	-0.017	-0.703***	-0.883	-0.305	0.477	-0.296***	0.881*
MAR_UE_d	0.366	-0.576	0.031***	-2.197***	-1.046	0.117	-0.084	-0.287***	0.148

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia. Note: Robust standard errors clustered within country pairs in parenthesis. ***, **, * indicate significance at 1%, 5% and 10% respectively.

Table A1. Estimated results of the stochastic trade frontier model at the disaggregated level (Continued)

	Agricultural products (HS range 01-24)	**Mineral Products (HS range 25-27)**	**Chemicals & Allied Industries (HS range 28-38)**	**Plastics & Rubbers (HS range 39-40)**	**Raw Hides, Skins, Leather & Furs (HS range 41-43)**	**Wood & Wood Products (HS range 44-49)**	**Textiles; Footwear & Headgear (HS range 50-67)**	**Stone; Glass & Metal (HS range 68-83)**	**Machinery; Electrical & Transportation (HS range 84-89)**
	Trade inefficiency estimates								
Progress (time)	-0.006	0.221*	0.004	-0.347***	-0.236*	-0.451***	0.064	-0.125**	0.028
Economic similarity (Sim)	-2.216	7.112	-4.556***	0.461	-5.453	2.458	-3.953	0.06	7.852**
EGY_d	1.599***	4.994***	0.941	0.536	1.395	6.039***	1.01	1.128*	1.719
TUN_d	1.046**	3.874**	-1.655***	-2.723***	-3.237***	0.842	-1.682*	-2.854***	0.525
MAR_d	-1.599***	5.671***	-1.480***	0.987*	-1.444	1.451	0.343	-1.132*	0.261
MRT_d	0.992*	5.026**	1.376**	0.908	0.977	5.619***	2.848***	0.795	-1.388
DZA_d									
EGY_o	-1.508***	-0.593	-2.175***	-0.511	0.219	0.605	-3.787***	-0.382	-33.063
TUN_o	-1.232**	3.331***	-3.559***	-1.950***	-2.958*	-5.440***	-31.714	-3.317***	-2.827***
MAR_o	-1.279**	-0.784	-3.808***	-0.982*	-0.808	-2.313***	-3.354***	-1.530**	-3.618***
MRT_o	-0.13	2.88	2.876***	0.283	-26.875	-30.926	0.558	1.078	-2.084*
DZA_o									
a2008	0.215	-0.243	0.273	0.42	-0.524	0.968	0.059	-0.611	0.346
a2011	-0.327	-1.211	-0.369	0.391	0.933	0.489	0.75	0.798	-0.538
a2012	-0.255	-0.356	-0.318	0.735	0.382	0.963	1.329*	0.79	-0.613

Note: DZA: Algeria; EGY: Egypt; MAR: Morocco; MRT: Mauritania; TUN: Tunisia. Note: Robust standard errors clustered within country pairs in parenthesis. ***, **, * indicate significance at 1%, 5% and 10% respectively.

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