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Abstract

In this paper we explore the patterns of interactions between military expenditure shares in the MENA region over the period 1979-2007. We explore if there are latent common factors that impact on the military expenditures of 15 countries in the MENA region and whether these factors can be interpreted. Unobserved common factors induce cross-sectional dependence and may lead traditional panel-time series estimators to be inconsistent. To identify these latent factors we apply the Principal Component Analysis. We evaluate the interpretation of the estimated factors using the Multiple-Indicator Multiple-Cause model. We found that there is a substantial evidence of cross-sectional dependence in the MENA region, induced mainly by two unobserved factors, but these factors are difficult to interpret.

Keywords: Cross-sectional dependence, Unobserved common factors, MIMIC, Military expenditures, MENA.
JEL Classification : C33, H56

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1 INTRODUCTION

Since the work of Richardson (1960) on arms races and Olson and Zeckhauser (1966) on alliances, a large body of literature has developed providing quantitative models of military expenditure. A country's military expenditures are usually seen as a function of ability to pay; perceptions of internal and external threats, with the external threats reflecting the behaviour of potential enemies and allies; and the operation of domestic institutions which shape threat perceptions. The arms race and alliance effects are usually measured by other countries military expenditures, since these are usually the only available proxies, but these leave out the effects of qualitative influences such as military technologies, morale, strategy etc. Such omitted qualitative factors will not only cause the estimates to be biased, if they are correlated with included regressors, but will induce correlations between the errors in different countries. If there is an unmeasured technological or strategic development in a particular country, it will not only effect the military spending of that country, it will cause a response in the military expenditure of that country's allies and enemies. The shift in US policy in the 1960s from massive retaliation to flexible response is an example. This was a large change, which is usually approximated by a dummy variable, but there are many other smaller changes.

This is a matter of particular concern in a closely coupled region like the Middle East and North Africa (MENA), where there are many sociological and economical connections, which means that strategic events have wider repercussions. Over the period studied (1979-2007) the region has been the stage for the Arab-Israeli conflict and associated clashes; substantial Superpower involvement; an eight year war between Iraq and Iran (1980-1988); bloody civil wars in Algeria and Lebanon; insurrections in Egypt, Tunisia, Yemen, Turkey and Iran; clashes between Algeria and Morocco in the ex-Spanish Sahara since 1976; and various other border clashes, e.g. Jordan-Syria, Syria-Iraq, Egypt-Libya. The long-lasting tensions between Arabs and Israelis have generated forms of arms races between Israel and some Arab countries as studied in Abu-Qarn and Abu-Bader (2009); at the same time, there are patterns of alliance between Arab states.

A feature common to the region is a lack of legitimacy of the ruling authorities such that internal dissents often break out in violent confrontations. Governments often lack legitimacy and feel threatened by various groups, including separatists and militant islamist groups; not rarely, governments use force to suppress the Islamic militants as it happened in Algeria and Egypt (1993). The socio-economic causes behind such resurgence are reviewed in Maddy-Weitzman and Inbar

(1997). These forms of instability are domestic sources of shocks but their occurrence is a regional phenomenon. Also, they have repercussions across-borders while fomenting rivalries or tense relationships as the Algerian-Moroccan tensions demonstrated. Either geopolitically or domestically driven, these sources of shocks impact on the perception of threat to which the military expenditures respond.

Similarly there are poorly quantified economic shocks which may influence more than one country, such as oil price variations which are shared across the MENA region through labour migration (Richards and Waterbury (2008)) or variations in foreign aid. Thus there is reason to believe that the military expenditures of the MENA countries are intertwined by a variety of arms races, alliances, economic and sociological factors and that the available quantitative measures may not fully capture these interconnections leaving omitted common factors in the residuals of equations estimated for each country. With a single time-series or a single cross-section, there is nothing that one can do about such factors, but with panel data there is a possibility of identifying them. That is the objective of this paper.

The structure of this work is as follows. Section 2 presents a concise literature review on the theory of interactions. It points out the main issues to take into consideration while studying military expenditure interactions within a given region. Section 3 presents a critical discussion on the data used in this study and their sources. In section 4 we explore the cross-sectional dependence of military expenditures using various econometric techniques. We identify how many common factors are important to explain military expenditures in the MENA region using the Principal Component Analysis. In Section 5 we evaluate the interpretation of the estimated factors using the multiple-indicator multiple-cause model. Section 6 contains some conclusions.

2 THE THEORY OF MILITARY INTERACTIONS

The theory of military interactions broadly falls into two groups, arms races and alliances, which are usually not integrated[1]. However, in regional systems they are likely to overlap with each others, because they both contribute to shape the same defence demand function. A general specification for the military activity demand of country i, M^i is

$$M^i = M^i(y^i, p, \tilde{M}^i, T^i, E^i)$$

where y^i is country i national income, p is price per unit activity, $\tilde{M}^i$ is the total military activity of country i's allies, T^i is the threat posed by an enemy and E^i is a vector of environmental influences including political and socio-economic variables. The literature on alliances focuses on the form of the "reaction path" $\partial M^i/\partial\tilde{M}^i$, that is how country i responds to the actions of its allies, which is assumed to be negative, Murdoch (1995) provides a survey. The literature on arms races focuses on the path of $\partial M^i/\partial T^i$, that is how country i reacts to its enemy over time, which is assumed to be positive. In regional context, countries may be allies on some issues and competitors on others, complicating the matter. The end of the Cold War saw "new" arms races, not shaped by the East-West confrontation, with new actors, including non-state actors and new features (see Brito and Intriligator (1995) and Intriligator and Brito (2000)). Within the context of MENA countries, causal analysis have found evidence of arms races between Israel and its neighbouring countries. Linden (1991) and Seiglie and Liu (2002) consider the pattern of military expenditures between Israel and a combination of its neighbouring countries. Abu-Qarn and Abu-Bader (2009) study the evidence of arms races between Israel and individual enemies. Also, the structural analysis in Abu-Qarn and Abu-Bader (2008) has pointed out the importance of political developments in the evolution of military expenditures in Egypt, Israel, Jordan and Syria. However, by focusing only on arms race behaviours these models offer a partial vision of many of the complexities and interrelations occurring in regional systems, including the collective action among the historical enemies of Israel (e.g. Egypt, Jordan, Lebanon and Syria). Furthermore third parties and regional events often play a crucial role in shaping military expenditure interactions within a given region. The importance of third party influences was first noted by Rosh (1998). He introduced the concept of Security Web, in which a nation's security is made dependent on the military capability of other influential countries. Dunne, Perlo-Freeman, and Smith (2008) point out many of the econometric issues involved in estimating military demand equations in regional systems. Their example is explanatory: they present the military demand equation for 3 actors, i is an enemy, j and k two allies:

$$\begin{aligned}
m_i &= \alpha + \beta^e(m_j + m_k) + \gamma' x_i + \epsilon_i \\
m_j &= \alpha + \beta^e m_i + \beta^a m_k + \gamma' x_j + \epsilon_j \\
m_k &= \alpha + \beta^e m_i + \beta^a m_j + \gamma' x_k + \epsilon_k
\end{aligned}$$

where β^e captures the arms race effect and β^a captures the spillover effect from the alliance. The existence of common factors which simultaneously affect all the countries and patterns of threat and alliance driven by strategic concerns in the region will make the error terms correlated, which has important consequences for estimation.

In the defence literature on the Middle East, Lebovic and Ishaq (1987) offer an early example where security needs of a country are dependent on the military capabilities of all its neighbouring countries. They weight these needs by the geographical distance between countries. The regional perspective has been attracting increasing attention, especially to assess damaging spatial spillovers of civil wars and arms build-ups, like in Murdoch and Sandler (2002) and Collier and Hoeffler (2004). These methods require that the spatial link matrix be known, whereas modern panel-data techniques may allow the links to be estimated.

3 THE DATA

Determining how much is spent on defence entails difficult measurement issues. The military capability of a country is a function of domestic forces and several intangible factors, such as strategy, tactics and leadership. Strategic considerations, such as the perception of threat, influence how many resources are devoted to the military but capturing those factors is difficult. Ideally, we would like a measure of military capability, the ability to fight and prevail in a hypothetical conflict, which can be used to attack or defend, to deter or to maintain peace. Military capability is an output measure from the "security production" function, but measuring it is problematic, since it depends not just on the forces available but also on intangible factors, such as strategy, tactics, leadership and morale. Some studies have used stock measures of domestic forces to proxy military capability. This can be the number of troops or the stock of a certain type of weapons, e.g. Intriligator and Brito (2000) use the number of nuclear warheads. This would be appropriate in the Cold War, but not the Global War on Terror. Data are rarely available for such stock measures so that scholars generally use military expenditures.

Military expenditures are an input measure to the "security production" function, capturing the resources devoted to defence, not military power. The best available source for internationally comparable estimates of military expenditures is the Stockholm International Peace Research Institute (SIPRI). SIPRI provides three measures of military expenditures: 1) in local currency, at current prices: 2) in US dollars, at constant (2005) prices and exchange rates; and 3) as a percentage share of gross domestic product (GDP). Deflating the series to remove the effect of inflation requires to choose a price index. However, there is not a commonly accepted measure of defence inflation. SIPRI used the consumer price index. To make the series comparable across countries, military expenditures are converted in US dollars. SIPRI uses Market Exchange rates or Purchasing Power Parity (PPP) exchange rates and the choice can make a large difference.

These problems are avoided by expressing military expenditures as a share of GDP. The shares capture the resources devoted to the military, that is they are measures of the priority a country is giving to defence. This is discussed in Dunne and Smith (2007). Also, since prices are unavailable and excluded from the demand equation, using the shares imposes the implicit assumption that the conditional price and income elasticities of demand for military expenditures are equal to unity. While this is a strong assumption, it is convenient for our purposes, since the use of shares of military expenditure in GDP captures ability to pay in a parsimonious way. A fuller discussion of tests of this assumption is available from the author.

We use data on the shares of military expenditures from the online SIPRI dataset for the period 1988-2007 and a number of SIPRI Yearbooks for the preceding years (Yearbooks 1980, 1985, 1986, 1988, and 1989), which record data since 1975. Splicing the data backward in time involves a certain degree of arbitrariness and SIPRI advises against it. But the benefits of a larger sample seem to outweigh the loss in precision. The details of the construction of the data are available from the author. Figures 1975-1978 for Egypt are outliers with respect to the rest of the series. To the purpose of this analysis, we prefer to restrict the sample period to 1979-2007 over which data are more reliable[2]. Our sample includes 15 MENA countries[3]. Iraq, Qatar, Libya and Lebanon have large gaps in their time series so they are excluded from the analysis[4].

4 INVESTIGATING CROSS-COUNTRY DEPENDENCE

Common unmeasured shocks that influence all countries, similarly or to different degrees, introduce an unobserved heterogeneity in panel time-series models, which introduce cross-sectional dependence or correlation between the errors. If these common shocks are correlated with the regressors, the conventional estimators are biased and inconsistent. The literature has suggested several techniques to control for cross-sectional dependence, whose appropriateness depends upon the problem at hand and whether particular assumptions are met. These techniques include:

1. SURE-GLS estimation: for $N < T$ (otherwise the disturbance covariance matrix is rank defi-

cient); however, pooled and GLS estimators are biased and inconsistent if the dependence is due to common omitted variables correlated with the country-specific regressors.

2. Two-way Fixed Effect estimator this estimator is unbiased and efficient if the country slopes and variances are homogeneous ($\beta_i = \beta$; $\sigma_i^2 = \sigma^2$). In addition, only one single common unobserved factor is allowed which impacts on all countries identically. This latter effect will manifest in a time parameter.

3. Orthogonalisation.

4. The common correlated effect estimator (CCE) proposed by Pesaran (2006).

5. The Fixed Effect with Residual Principal Component estimator (FE-RPC): this estimator includes linear combinations of the OLS residuals (J < N largest residual PCs) in an augmented regression. The estimator is unbiased and consistent provided that the PCs are good proxies of the unobserved factors. This method is explained in Coakley, Fuertes, and Smith (2002). The Mean-Group with Residual PCs can also be an appropriate alternative to FE-RPC to allow for heterogeneity in the slopes. Coakley, Fuertes, and Smith (2006) discuss the two approaches.

This paper will apply some of these techniques to quantify and interpret the cross-sectional dependence among the shares of military expenditures of 15 countries in the MENA region. In the defence literature, some concerns about possible patterns of cross-country dependence in the explanation of military expenditures have initially gained attention in the literature on arms races (Dunne and Smith (2007)).

Since the MENA region is interconnected and shares important economical and political trends, there are likely to be some common factors which affect the military expenditures of all countries in the region.

This section aims to answer two questions:

1. How much commonalities are there in the region?
2. Is it possible to interpret them?

If there are strategic unobserved factors that impact military expenditures on all the region, the model may be written as

$$s_{it} = x'_{it}\beta_i + f_t\gamma_i + \epsilon_{it}$$

where s_{it} is the dependent variable, shares of military expenditures, x'_{it} is a $k \times 1$ vector of regressors including observable influences (e.g. wars, resources, revolutions, etc.), f_t is a $r \times 1$ vector of unobserved factors and ϵ_{it} is an unobserved disturbance with $\mathrm{E}(\epsilon_{it}) = 0$, $\mathrm{E}(\epsilon_{it}^2) = \sigma_i^2$ which is independently distributed across i and t. If we ignore the factors and estimate

$$s_{it} = x'_{it}\beta_i + v_{it}$$

it will give us inconsistent estimates of β_i if the factors f_t are correlated with x'_{it} and inefficient estimates if the factors f_t are not correlated with x'_{it}.

The correlation matrix among the residuals, say $|\rho_{v_{ij}}|$ is an indicator of the degree of cross-sectional dependence. The presence of unobserved factors may shape these correlations so that the matrix may reveal some specific patterns among the residuals. We use the residuals from an ability-to-pay model: the model is a log-linear specification as follows

$$s_{it} = \beta_1 + \beta_2 s_{it-1} + \beta_3 y_{it} + \beta_4 y_{it-1} + ct + v_{it} \tag{1}$$

Military expenditure shares, s_{it}, are explained by the availability of resources, y_{it}, and a time trend. A lagged value of resources and a lagged value of the dependent variable are included to represent bureaucratic inertia or implementation lags. This dynamic model has the best fit over a number of alternative specifications. We look at the matrix of residual correlations for 15 MENA countries. The matrix covers the period 1990-2007 because Yemen has missing observations on income until 1989. There are few high correlations ($> |0.5|$) among the country residuals. Strong positive correlations exist between Egypt and Oman (0.72), Oman and Morocco (0.74), Israel and Jordan (0.74), Israel and Syria (0.51), Syria and Jordan (0.43). Yemen is strongly correlated with Oman (0.59) and, to a lesser extend, with Egypt(0.41) and UAE (0.34). There are also strong negative correlations, such as between Egypt and Tunisia (-0.63), Israel and Algeria (-0.62), Algeria and Syria (-0.62). If an unobserved factor(s) is influencing these correlations, the matrix suggests us two main areas where these effects are stronger: one includes the southern part of the Gulf (Yemen, Oman, UAE); the second has its centre on Israel and includes its neighbouring countries. This interpretation suggests the presence of two different strategic environments which can drive these correlations: the first one involves the animosities around the Gulf of Oman and the Strait of Hormuz and the second one reflects the long lasting Arab-Israeli conflict.

Excluding Yemen from the sample would allow to compute the correlations over all the period 1979-2007. In this case the correlations are somehow weaker. However, many of the strongest correlations of the 15-country sample are confirmed: for example, there is still some evidence of between-country dependence around Israel (Israel-Syria, 0.45; Syria-Jordan, 0.34; Algeria-Israel, -0.21). There are few countries, such as Algeria and Bahrain, which have mostly negative correlations with all the countries in the region or almost no correlation at all. This may suggest a different behaviour of these countries within the region. We conclude that the residual matrix suggests some evidence of cross-country dependence. We propose various econometric techniques to quantify and interpret the factors that lead to this cross-sectional dependence.

We also investigated endogenous structural breaks using the Quandt-Andrews test. While there was substantial evidence for structural breaks, which is consistent with there being unobserved common factors, it was difficult to interpret the pattern across the region. A break-event correspondence suggests that the first break often corresponds with domestic political confrontations. We also experimented with the Common Correlated Effect estimator (CCE), see Pesaran (2006), which involves augmenting the model with cross-sectional averages of the dependent and independent variables. It was difficult to give the results a clear interpretation; however, they helped to understand that the common factors in the region do not have a common weight. These are areas for further research.

4.1 The Analysis of Principal Components

The use of the Principal Component Analysis (PCA) is an attempt to extract from the matrix of MENA military expenditures a small number of latent variables that account for most of the variation of the data. Algebraically, the principal component (PCs) are linear combinations of the data matrix X, which explain as much as possible its variance, that is $X = F\Lambda + E$. Λ are called factor loadings. The analysis of the loadings helps to study the underlying structure of the variables of interest. Evaluating their signs and sizes helps to understand whether there are important commonalities across the series or peculiar trends in any of the countries.

Firstly, we apply the PCA to the military expenditures expressed as a share of GDP and to the levels of military expenditures. In model $s_{it} = x'_{it}\beta_i + f_t\gamma_i + \epsilon_{it}$ the PCA sets $\beta_i = 0$. Secondly, we apply the PCA on the residual matrix from the ability-to-pay model in equation (1). This allows $\beta_i \neq 0$ but assumes the factors to be independent of x'_{it}.

4.1.1 PCA on the military shares

We compute the PCs on the military expenditures expressed as shares of GDP. Due to data availability we restrict the sample to 15 MENA countries over the period 1979-2007. This is because a technical requirement to apply the PCA is to have a balanced panel of observations. The PCA on the shares shows that 4 unobserved factors explain 87% of the sample variation. Table 1 reports the variance and the cumulative variance for each eigenvalue greater than 1. The first two components are the most important as they explain higher proportions of the variance.

Table 1: Principal Component Analysis. Variable: s_{it}

Number	Eigenvalue	Variance	Cumulative Proportion
1	8.5716	0.57	0.57
2	2.1108	0.14	0.71
3	1.3117	0.08	0.79
4	1.2047	0.08	0.87

The loadings biplot in Figure(1) plots the component scores and loadings for the first two components. It displays the component scores as circles and the variable loadings as lines. Figure(1) shows that the first component has positive values for all the countries except Algeria and Kuwait. The first factor is usually a roughly equal linear combination of all the shares. It has a positive value close to 0.25 for all countries with the exception of Algeria and Kuwait, for which is negative, and Iran and Bahrain, for which is close to zero. These results suggest that military expenditures in Algeria and Kuwait have a heterogenous behaviour with respect to the rest of the region. This may be explained by the peak of Kuwait's military shares in 1990-1991, as a response to the Iraqi invasion. Similarly, Algeria witnessed a remarkable and continuous rise in military shares over the years 1991-1997, which reflects the fight of the Algerian government against the militants from the Mouvement Islamique Armé and the Group Islamique Armé. Algeria has few peculiarities with respect to the region in few respects. Essays in Maddy-Weitzman and Inbar (1997) argue that the historical identity, the violent struggles for independence from the French colonisation and its model of development make Algeria to be sui generis in the Arab world. Algeria's quest for preeminence in North Africa makes its political unrest over the 90s a source of regional instability. This has been seen in few tense episodes in the history of Algerian-Moroccan and Algeria-Tunisian

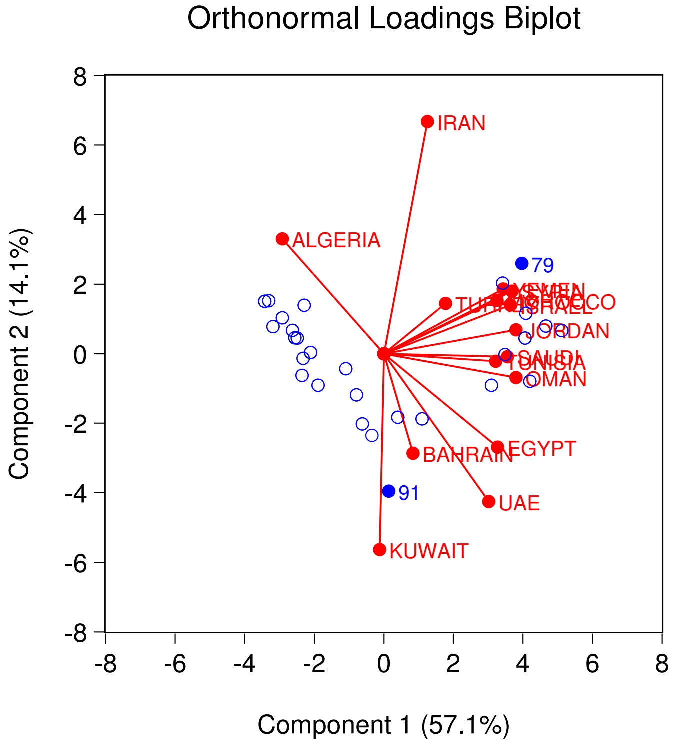

Figure 1: Loadings Biplot. Variable: s_t

foreign affairs. From this analysis we read that there are two main geopolitical shocks affecting the common trend of military expenditures in the region: the Gulf War and the Algerian civil war.

The second component has a strong negative value for Bahrain, Kuwait, UAE and Egypt; a negative but close to zero value for Oman, Tunisia, and Saudi Arabia. Jordan has a close to zero positive value. The group of countries with positive loadings includes: Algeria, Iran, Israel, Morocco, Syria, Turkey and Yemen. We see two patterns in the analysis of this component. The negative loadings seem to pertain to oil-rich countries or aid-recipients. This suggests that the second component picks up the effect of domestic resource availability. It remains to be understood the position of Israel, which is an exception in this group given its resources.

A second line of interpretation suggests that the second component is related to a security concern. The group of countries with positive loadings shares histories of violent internal upheavals: Algeria experienced the civil war, Iran went through a Revolution, Israel faced clashes with the Palestinians, Morocco fought forms of opposition to the monarchy, Syria and Yemen had episodic outbursts of violence, Turkey fought its Kurdish minority. This uncertainty is related to the difficulty in interpreting the estimated factors. This is the main limitation of the PCA: we will discuss this at the end of this section.

We are more inclined toward the first interpretation: the reason relies on the two outliers observations picked up by the plot. The score labels in Figure(1) show that years 1979 and 1991 are special in the period under consideration. Year 1979 coincides with the second oil shock. The Iranian Revolution and the reaction of Saudi Arabia to the unsatisfactory outcome of the Camp David talks cause the price of oil to hike. The massive transfer of resources may have trigger a different path of expenditures. It is also true that the overthrow of the Shah triggered a sense of instability which has its repercussion elsewhere in the region. Year 1991 corresponds to the Gulf War. The shares of military expenditures reflect the outbreak of the war: this event has increased the variation in the data matrix and it is picked up by the analysis.

The correlation matrix for the shares of military expenditures shows strong correlations (exceeding 0.8) for several pair of countries. Pairwise-correlations point out that Yemen, Oman and Morocco are highly correlated with the expenditure patterns of Israel, Egypt and Jordan. Also, the Arab-Israeli conflict may reasonably explain the high correlations between Israel and Jordan (0.88), Israel and Syria (0.95), and Jordan and Syria (0.90).

We also compute the PCs on the log of the shares: this gives similar results despite the correlations are less strong. This is due to the log operator which smoothes the variance of the data matrix.

4.1.2 PCA on the residuals

Residual Principal Components (RPCs) may be introduced in a panel model to deal with cross-sectional dependence as it is suggested in Coakley, Fuertes, and Smith (2002). This consists in augmenting the regression model by the RPCs to proxy the unobserved factors. This procedure gives consistent estimates of the parameters of interest if the unobserved factors do not influence x'_{it} or there are no factor that influence x'_{it} but not y_{it}.

We explore this procedure by extracting the PCs from the residual matrix from the ability-to-pay model (1) as above:

$$s_{it} = \beta_1 + \beta_2 s_{it-1} + \beta_3 y_{it} + \beta_4 y_{it-1} + ct + v_{it}$$

Our sample covers the period 1991-2007 since Yemen has missing values for income until 1989. Thus the residuals from the dynamic model are computed from 1991.

The analysis shows the presence of 5 factors explaining 79% of the total residual variation; again, the first two factors are the most significant (46% of the residual variation is explained) and the fifth factor is marginal (Table 2). The first factor loadings are negative for 6 countries: Bahrain, Iran, Kuwait, Jordan, Tunisia and Turkey. The rest of the countries (Syria, Egypt, Saudi Arabia, Yemen, Oman, Morocco, UAE and Algeria) have positive loadings, ranging from values close to zero for Syria to a value of 0.49 for Oman. Despite the first component explains a relative important percentage of the total variation in the residuals (24.1%), it is difficult to give a clear interpretation. We can see again the pattern of internal political unrest as this division almost coincides with the former grouping in the analysis on the shares (section 4.1.1). However, Iran and Turkey are excluded.

The second component has high positive loadings for Jordan, Syria, Israel and Kuwait and positive smaller values for Egypt and Saudi Arabia. Iran, Bahrain, Yemen, Oman have values close to zero; Turkey, Tunisia, UAE, Morocco and Algeria have negative loadings, with a remarkable low value for Algeria. We see in this plot a geopolitical classification of security concerns: we have the Arab-Israeli conflict explaining the assemblage of Israel, Syria and Jordan in the upper part of the Figure 2 (i.e. high positive loadings). We have the Gulf countries grouping around zero-values. Iran's search for hegemony and the geopolitical importance of the Strait of Hormuz are likely to be sources of different security priorities. Finally, it is noteworthy that most of the Maghreb countries appear on one side of the graph (i.e. most have negative loadings). This may suggest some form of commonalities in the security concerns of North African countries.

If we exclude Yemen from the sample, we can extend the period to 1981-2007[5]. For this latter sample, the PCA points out 6 factors explaining 77% of the residual variation. The first factor loadings maintain a negative sign for Bahrain and Kuwait and a positive sign for Algeria, Oman, Saudi, Syria and Morocco. The second component is similar for Bahrain, Tunisia and Turkey (negative loadings) and Iran, Israel, Jordan, Saudi Arabia and Egypt (positive loadings).

4.1.3 Conclusions and discussion

The PCA is a useful tool to learn more about the underlying structure of the data and to uncover the role unobserved factors play in determining the variation of some observed variables. The PCA on military expenditures in 15 MENA countries brings evidence that there is a great

Table 2: Principal Component Analysis. Variable: residuals from model (1)

Number	Eigenvalue	Variance	Cumulative Proportion
1	3.61	0.24	0.24
2	3.31	0.22	0.46
3	2.18	0.14	0.60
4	1.75	0.11	0.72
5	1.08	0.07	0.79

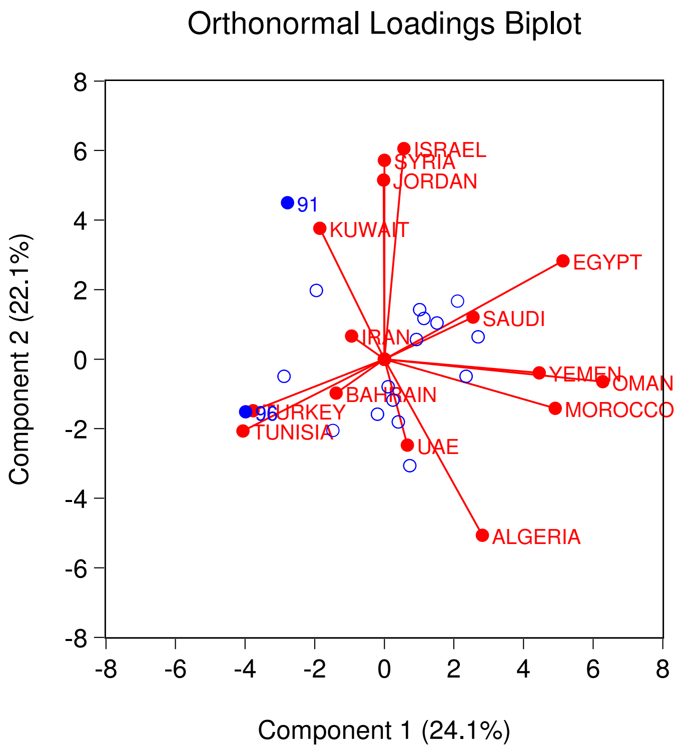

Figure 2: Loadings Biplot. Variable: residuals from model (1)

degree of commonality within the region.

Despite the evidence supporting the presence of two main unobserved factors explaining the variation of military expenditures in the region, the interpretation of them can only be tentative. The difficulty arises from the fact that there are a large number of similar factors, which have a different weight in each country. These factors can be geopolitical shocks related to the intensity of political tensions in the area, or economic shocks related to availability of resources. The first group includes the Arab-Israeli conflict, the high number of violent internal disputes (Islamist oppositions, the

Islamic Revolution in Iran), the Iran-Iraq war, the Cold War and sub-regional security priorities. The second group includes oil revenues and aid inflows. The clear identification of these factors and their weights is difficult. The PCA has a number of limitations in this respect. To trace down the loadings we need to impose just-identifying restrictions since any non-singular transformation gives observationally equivalent factors and loadings: $X = (FP^{-1})(P\Lambda) + E$. Therefore, unless we know the weights that the matrix P attributes to each factor, there may be infinite linear combinations for each factor. Identification is usually achieved by a normalisation assumption (e.g. $PP' = I$). This raises a concern about the interpretation of the factors because the normalisation needs not have an economic meaning. Interpreting the estimated factors may be possible with relatively sample structures, nevertheless it is always tentative.

In the context of RPCs this is also true. The limitations of the RPC approach are explained in details in Coakley, Fuertes, and Smith (2002). This difficulty creates the need to explain these common factors together.

5 MIMIC MODEL

The multiple-indicator multiple-cause (MIMIC) model aims to measure latent variables using observable variables. Since the common shocks are unknown, they cannot be quantified directly. The MIMIC model considers that latent factors are reflected in some "indicators" and influenced by some "causal" variables. The framework relates the latent variables to their observable "indicators" and "causes" to give an empirical measure of such unobservable factors. Spanos (1984) offers an application to the case of liquidity and Pieroni and d'Agostino (2009) for a latent index of corruption.

The Principal Component Analysis in the previous section identified two main unobserved factors which explain most of the cross-country variation in military expenditure shares. The political economy of the region and empirical studies suggest a number of "causes" for this cross-country dependence. The MIMIC model enables to validate which observable variables account for these common factors.

5.1 The model specification

The MIMIC model applied in this paper can be presented as follows. Let the latent variable be ξ_t, a 2×1 vector of unobserved factors and s_t a 15×1 vector of shares of military expenditures, as 15 are the countries included in the sample. These latter are our "indicators" variables. Let z_t be a 4×1 vector of potential regional 'causes' of the detected commonalities in the region. The MIMIC model consists of two relationships: a behavioural equation

$$\xi_t = \alpha + \beta z_t' + \epsilon_t \tag{2}$$

where $\epsilon_t \sim IN(0, \sigma_\epsilon^2)$. And the measurement equation

$$s_t = d + \Lambda \xi_t + v_t \tag{3}$$

where $v_t \sim IN(0, \Sigma)$. Equations (2) and (3) are two systems of equations for $t = 1, 2, ..., T$.
The reduced form of this system is

$$\begin{aligned} s_t &= d + \Lambda \xi_t + v_t && (4) \\ &= d + \Lambda(\alpha + \beta z_t' + \epsilon_t) + v_t \\ &= (d + \Lambda\alpha) + (\Lambda\beta) z_t' + (\Lambda \epsilon_t + v_t) && (5) \\ &= c + \Pi z_t' + u_t \end{aligned}$$

where $u_t \sim IN(0, \Omega)$ and $\mathbf{E}[u_t u_t'] = \Lambda \sigma_\epsilon^2 \Lambda' + \Sigma$.
When estimating the reduced form (5), we are a-priori imposing the restrictions $\Pi = \Lambda\beta$ and $\Omega = \Lambda \sigma_\epsilon^2 \Lambda' + \Sigma$. To identify all the MIMIC parameters $(\beta, \Lambda, \sigma_\epsilon^2, \Sigma)$ we need to be able to solve these two sets of equations.
We follow the MIMIC estimation procedure suggested by Spanos (1984). We proceed in two steps. First, we ignore the restrictions $\Pi = \Lambda\beta$ and estimate Λ and Σ through the Principal Component Analysis[6]. Using these estimates ($\hat{\Lambda}$ and $\hat{\Sigma}$) we estimate the unobserved ξ as the scores of the Principal Components. Secondly, we try to identify the form of the behavioral equation (2) by regressing $\hat{\xi}$ on z_t'. This gives estimates of $\hat{\beta}$ (as $\hat{\beta} = (z'z)^{-1} z' \hat{\xi}$) which satisfy the restrictions $\Pi = \Lambda\beta$. Separately we estimate the reduced form parameters in equation (5). If the two sets of estimates, $\hat{\beta}$ and the reduced form coefficients, do not differ much we can infer that equation (2)

is a common behavioural equation for the military expenditure shares in the MENA region. This comparison will be informative about the validity of our interpretation of the regional common factors[7].

5.2 Empirical results

Our vector of "causes" include oil prices, the average GDP of the region for year t, foreign assistance and a conflict dummy variable[8]. This choice is based on the economic theory and data availability. The first three variables represent sources of economic shocks, while the conflict dummy is a proxy for insecurity.

The political economy of the region suggests that oil prices is the most direct economic factor influencing government revenues in the region (Richards and Waterbury (2008)). National income constrains the resources a country can afford to pay for the military. Oil prices can also reflect instability in the region since it is not rare that oil-price hikes correspond with political events. For example, the 1979 price drama reflects the Iranian Revolution and the outcomes of the Camp David Accords. The average GDP is strictly related to the ability to pay and it can be a proxy for economic development. Aid inflows to the region affect the availability of government resources. Two kind of arguments have been offered for the relationship between aid and military expenditures. One is that aid is fungible (Devarajan and Swaroop (1998)) so that cash inflows can be diverted to purposes other than those originally targeted, such as the acquisition of weapons. The other is that aid may have important macroeconomic side-effects (such as inflationary pressures and overvaluation of the exchange rate) in a Dutch Disease fashion or impact negatively on the rate of investment (Heller (2005) and Gupta and Heller (2002)). These effects are detrimental to growth and development, dwarfing the possibilities of public expenditures and hence, defence outlays.

The conflict dummy is a proxy for political shocks. The conflict dummy is set to 1 for those years in which there is an armed conflict in any part of the region. It should capture some form of "threat" in the region which gears the "demand for security" of these countries.

Table 3 shows the results of the parameter estimates of the MIMIC model. The dependent variables are the two most important factors estimated by the PCA on the shares of military expenditures. Two specifications are presented for each factor: specification 1 is preferred in both cases based on the goodness of fit measures.

The first factor is significantly determined by oil price fluctuations and regional average GDP.

The level of government revenues, as measured by the oil price fluctuations, shows a significant positive relationship with the first factor. This supports the argument that oil prices and regional insecurity are positively related. In insecure environments, additional resources coming from oil-price increases may result in larger sizes of military sectors. The size of the coefficient is close to the average of the oil parameters for the single-country regressions (equations 5). So the estimate for β_{oil} in Table 3 may be a compromise among the single country values. One explanation for the very small size of the estimate of GDP is that regional average GDP is not a good proxy for the level of economic development[9]. This is also similar to the results from the reduced form equations. This may suggest that average regional income has negligible influence in explaining the common factors.

The conflict variable and aid inflows have no significant effect on the first factor. The analysis shows they are significant determinants of the second factor. Aid inflows show a significant and negative relation with the second factor. The previous analysis has suggested the second factor to be related to the ability-to-pay of these countries. The negative sign may represent the fact that massive aid, especially if tied, may limit the discretionality of public expenditures. The regional conflict variable has also a significant and negative sign. In the single-country equations the conflict dummy is positive for 6 countries and negative for 9 countries. This may suggest that different countries react differently to regional insecurity threats. Equation (4) imposes restrictions

Figure 3: MIMIC model results: dependent variables f_1, f_2*

Specification n. "Causes"	1 f_1	2 f_1	1 f_2	2 f_2
oil	0.113***	0.059***	0.008	0.099***
regional GDP	-0.000**		0.000**	
conflict	-0.260	0.489	-3.331***	-4.593***
aid	6.026	-10.099***	-36.523***	-9.322***
SER	0.951	1.050	1.679	1.836
$\bar{R}^2$	0.893	0.869	0.613	0.537

$*$ f_1, f_2 are the estimated factors from the PCA.
SER: Standard Error of Regression.
Constant is included but not reported.

on model (5). We cannot test these restrictions directly on the covariance-matrix. This is because the residual covariance matrix from model (4) is singular due to the fact that the PCs are linear combinations of the military expenditure shares. An alternative solution is a comparison of the two sets of equations. This is equivalent to say whether the estimated factors explain the shares of military expenditures better or worse than the observed variables. If the factors capture completely the influences of the observed "causes" (i.e. oil prices, average regional income, conflict and aid), a direct estimation on the observed variables will perform better. On the contrary, if the estimated components capture different factors influencing the shares (e.g., Islamic oppositions threatening stability) there are advantages in including the factors in a panel regression. In the latter case there are two channels that influence the shares: the observed variables on one side and the factors on the other side.

The regression results suggest that the restricted model has a better fit. This is measured by the Standard Error of Regression (SER). Over the region, the SER for the two specifications are as follows:

$s_t = c + \Pi z_t + u_t$	SER = 30.48
$s_t = d + \Lambda \xi_t + v_t$	SER = 25.55

This may suggest that there are unobserved factors, other than the "causes" included, that influence the shares of military expenditures in the MENA region directly. Hence, these are better accounted for by the estimated components.

6 CONCLUSIONS

In regional contexts such as the MENA region, if there are unobserved common shocks that influence all countries, there is likely to be a cross-sectional dependence or correlation between the residuals in a panel time-series model. If these common shocks are correlated with the regressors, the conventional estimators are biased and inconsistent. In this study we explore the pattern of interactions between military expenditure shares in the MENA region over the period 1979-2007. The unobserved common shocks arise from economic influences (e.g. oil and aid inflows), political and social influences (e.g. militant oppositions) as well as arms race and alliance influences. To identify the unobserved common factors we apply the Principal Component Analysis (PCA) to the shares of military expenditures in the region and on the residuals from a military demand equation. To evaluate the results from the PCA, we use the multiple-indicator multiple-cause model (MIMIC). The MIMIC model enables to validate which observable variables account for the two most important estimated factors.

We found evidence of important commonalities in the MENA region, but it proved difficult to interpret them in terms of a simple factor or spatial structure. The PCA on the shares of military expenditures indicates that there are two main factors which are responsible for 71% of the total variation of military expenditures in the region. Interpreting these factors in term of observable economic variables is complicated. It is possible that the first factor is related to regional instability. The analysis points out that Algeria and Kuwait have a heterogenous behaviour with respect to the rest of the region. The Gulf war and the Algerian civil war are likely to be important shocks in the common trend of military expenditures in the region. The second factor is related to resource availability, in particular the impact of oil prices and possibly aid flows to the region. The importance of oil and aid in explaining the unobserved factors is supported by the results of the MIMIC model. The PCA on the residuals highlights the presence of two main components explaining 46% of the residual variation. The first factor has a difficult interpretation: it might pick up the effect of internal political instability. The second component suggests a classification based on geopolitical security concerns: the hotbed of the Arab-Israeli conflict, the Gulf region, the North Africa together with Turkey.

There is some evidence that domestic political factors are important in determining military expenditures. When we introduced an augmented specification which captures common correlated effects, this does not result in statistically significant estimates. This may reflect the absence of common responses of the same magnitude to regional shocks. Also, when testing for structural breaks, the break-event correspondence highlights that military expenditures may respond to political imperatives, either internally or externally enforced. Domestic political factors are likely to be difficult to measure. The MIMIC framework suggests that there are unobserved factors that influence the shares of military expenditures in the region directly. These factors cannot be fully explained by oil price variations, average regional income, aid inflows and wars. They are likely to capture different influences such as internal tensions, Islamic pressures or other domestic politics. Hence, there are advantages in including the estimated factors in a panel regression.

A major constraint on our analysis remains that of the quality of the data. Chaining the series and filling in estimated missing values introduces noise which makes the interpretation even more difficult. Despite this limitation, this paper shows that we are not dealing with a simple story of interactions: defence expenditures in the MENA region are intertwined. Contrary to what one might expect, there is not a simple pattern of arms race model between Israel on one side and Syria, Egypt, Jordan and Lebanon on the other. Military expenditures in MENA follow both alliance and arms race behaviours and, to a substantial degree, internal political influences.

Notes

[1]Okamura (1991) offers an early attempt, while testing the public good model for the USA-Japan military alliance: he controls for the Soviet Union (i.e. an enemy) and NATO defence expenditures (i.e. an ally) in the reaction functions of the two allies. Nevertheless, approaches of this kind are few.

[2] In the data collection process, observations 1975-1979 for Egypt were set to zero. In a panel model, this implies to include a dummy to account for the missing observations. This approach has the advantage to preserve the information contained in the additional control variables when estimating a military demand equation.

[3] The sample includes Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Kuwait, Oman, Saudi Arabia, Syria, UAE, Morocco, Yemen, Tunisia and Turkey.

[4] These exclusions due to data unavailability are unfortunate as there are important interactions between these countries and their neighbours. Syria armed forces carved spheres of influence in the Lebanese civil war since 1976. Iraq was engaged with Iran into one of the most grisly conflict of the last century (1980-1988). Iraq's military expenditures had influences not only in Iran. As Iran gained advantage during the confrontations, Turkey was in alert whether to intervene militarily to secure its southern borders. Libya has been ruled by a military regime since 1969 and had border skirmishes with Egypt.

[5]This is because Bahrain has missing values for income until 1980, hence the residuals from the dynamic model are computed from 1981.

[6]This is equivalent to estimate a Multiple-Indicators model.

[7]There are a number of criticisms to the use of the MIMIC model in empirical works. In the literature on the informal sector, Thomas (1999) and Breusch (2005) argue that the MIMIC model lacks a theoretical base and estimates produced are not robust to changes in the data or in the selected indicators.

[8]Oil prices are Crude oil spot prices (Arab light) from the *International Energy Agency (IEA), Oil Information 2008, ESDS International*, (Mimas) University of Manchester; GDP is Gross Domestic Product in constant 2000 USD from *World Development Indicators*, the World Bank; foreign assistance is measured by Official Development Assistance Disbursements from *DAC Statistics (OECD)*; the conflict dummy is computed by the author on the basis of the definition of 'international armed conflict'.

[9]Sen (1995) has explained that economic variables such as GDP might give a misleading picture of economic progress and development. Disease indicators, economic activities per sector, crime levels and access to other social services can be additional indicators to consider.

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