

BUDGET ALLOCATION UNDER UNCERTAINTY  
AND THE COSTS OF WAR AND INSECURITY

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# **Budget Allocation under Uncertainty and the Costs of War and Insecurity**

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## **Abstract**

This study presents a framework and models for the analysis of government budget allocation into defense and civilian expenditures in situations of uncertainty about the incidence of war. The models display the intricate relationships between security levels, subjective probabilities of the occurrence of war, and potential war damages. We show that poor countries tend to perceive greater probabilities of war than their richer rivals and that the psychological burden of insecurity is larger when the country's wealth is larger and when its preference for security is higher. We apply our models to the Israeli-Syrian arms race and show that the very different growth rates of the Israeli and Syrian economies are likely to lead to an increase in Syria's perception of the likelihood of war and to a decrease in Israel's perception of such a likelihood. We also show that if Syria's regime becomes ideologically more extreme, the monetary cost of maintaining Israel's security at the level that it enjoyed prior to the change will be very high, whereas the monetary cost of maintaining Israel's welfare would be moderate.

**Keywords:** Arms race, budget allocation, uncertainty, war damage, deterrence

**JEL codes:** D74, D78, D90, H56, H68

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## 1. Introduction

Conflicts among countries often develop into costly arms races since national security, an important element in the rivals' welfare functions, is generally measured as a function of a country's military capabilities relative to those of its rival, prompting each country to respond to exogenous changes in the military capabilities of its rival (Levine and Smith, 1995; Shefi and Tishler 2005).<sup>1</sup> However, as more often than not, arms races do not lead to the outbreak of war<sup>2</sup>, most of the defense economics literature does not consider the consequences of a war in the context of an arms race.<sup>3</sup>

This paper develops a framework of analysis for government budget allocation under uncertainty about the occurrence of war. In our models each country chooses its optimal levels of civilian consumption and military expenditure, taking into account that the probability of a war with its rival is positive. Given this choice, the actual level of civilian consumption may not be realized if a war erupts between the two arms race rivals. The actual civilian consumption in this case will decline relative to that in the optimal solution due to the damages that both rivals will suffer during the war. Hence, the magnitude of the potential war damages to each rival may have a significant effect on the solution of the arms race.

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<sup>1</sup> Definitions and analyses of arms races can be found, among many others, in Hirshleifer (1991), Levine and Smith (1995), Golde and Tishler (2004), Dunne et al. (2007) and Bar-El et al. (2010).

<sup>2</sup> This point about arms races not immediately if at all leading to the outbreak of war is made by Bar-El et al. (2010). Israel and Syria have not been actively at war for the last two decades, South Korea and North Korea have been in a more or less cold stand off since the war of the 1950s, and the USA and USSR mercifully never went to war, thanks to the fear of mutually assured destruction. Wallace (1982) lists 19 major disputes (since 1945) that did not end in a war outcome.

<sup>3</sup> In fact, the literature contains a number of examples of arms races serving as an insurance mechanism against war among the adversaries; see, for example, Smith (1980), Brito and Intriligator (1984) and Morrow (1989).

The novelty of our models is in their ability to predict the magnitude of potential war damages and of subjective probabilities of war, and assess their effects on the optimal security level and welfare of the rivals. They display the intricate relations among security levels, subjective probabilities of war and potential war damages and, therefore, can be used to explain how (possibly very different) economic conditions and attitudes towards security can lead to very different solutions by the rivals and to escalation (reduction) of the arms race.

The main results of this paper are as follows. We demonstrate that the rapid economic development of Western countries heightens perceptions of the threat of war among countries with lower GDP and/or stagnant economic growth. Such differences in the perceptions of the threat may lead the poorer rivals into arming themselves with terror weapons (Kagan et al. 2005, 2009). Iran's latest efforts to produce weapons of mass destruction (WMD) capabilities may be an example of this phenomenon. We also show that the psychological burdens on the country's residents due to insecurity are larger when the country's wealth is larger. Finally, we demonstrate that a threat of war (even if no war is fought) decreases the rivals' expected welfare.

The models that we develop here describe a non-cooperative arms race<sup>4</sup> between two rivals. Following Bolks and Stoll (2000) and Shefi and Tishler (2005), we define a country's national level of security as the ratio between the country's military capability and that of its rivals, and let each country's assessment of the probability of the eruption of a war between itself and its rival be a function of its security level. Clearly, the two rival countries may have different beliefs about the probability of war

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<sup>4</sup> Analyses of arms races can be found, among many others, in Hirshleifer (1991), Levine and Smith (1995), Golde and Tishler (2004), Dunne et al. (2007) and Bar-El et al. (2010).

between them. We interpret each country's perception of this probability as a measure of the level to which it is intimidated by its rival<sup>5</sup>.

Jackson and Morelli (2007) suggest that wealthier countries fear the potential cost of a war and are willing to pay to avoid it by transferring some of their wealth to their poor rival. Hirshleifer (1991), Rathbone and Rowley (2002), Collier and Hoeffler (2005) and Jackson and Morelli (2007) assess the motivation to fight. They claim that terror organizations and poor countries share similar motivations to fight since their potential benefits far exceed their potential losses compared to those of their more established (wealthy) rivals. Hence, we assume in this study that the damage that a country will suffer from a war is proportional to its civilian expenditure (approximating the country's wealth). That is, the potential war damage to a wealthy country is greater than that of a poor one.

The main contributions of this paper are as follows. First, we develop and apply an analytical framework that defines how the (expected) welfare of a nation is affected by its attitude to security, the expected damage from a potential war, and the probability of war. Second, using the methodology of Kagan et al. (2009), we assess the monetary value of the psychological burden due to the likelihood of wars and to the sense of insecurity during periods of peace<sup>6</sup>. The ability to set a monetary value on the physical and psychological damages due to war and/or insecurity allows decision makers to better gauge the total costs and benefits of their policies in times of conflict. For example, it facilitates the comparison of the following two scenarios: (a) a policy of aggressive action towards a hostile rival and the likely consequent retaliation by the

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<sup>5</sup> See Powell (1990), Snyder (1959, 1961), Wirtz and Russell (2003) for definitions and analyses of deterrence.

<sup>6</sup> Our findings support those of Glick and Taylor (2005), Berrebi and Klor (2008) and Brauer and Dunne (2010), demonstrating the negative effects of military conflicts on welfare.

rival; (b) a passive policy towards the hostile aggressor engendering insecurity and consequently reducing welfare.

Finally, we focus here on an arms race between a developed country characterized by a high gross domestic product (GDP) and a less developed country with a lower GDP, and verify the relevance of our models and their predictions by applying them to the Israeli-Syrian arms race.

The paper is organized as follows. Section 2 provides background information on the Israeli-Syrian arms race. Two models of arms races under uncertainty are developed and discussed in Section 3. Section 4 applies our basic model to the Israeli-Syrian arms race. Section 5 measures the monetary value of welfare (or security) loss due to an increase in the rival's perceptions of security and Section 6 concludes.

## **2. Background**

Of all the conflicts in the persistently troubled Middle East, the Israeli-Arab conflict is one of the most costly and enduring.<sup>7</sup> Bearing in mind that the vast majority of the population in the Middle East is Muslim, the fundamental conflict between the two major strands of Islam, the Sunni (85%) and the Shia (15%), and the close ties between Middle Eastern and arms-producing governments, it is little surprise that the Middle East is the most militarized region in the world.

Clearly, the Arab-Israeli conflict, which evolved over the establishment of the State of Israel among hostile Arab countries, is also a major source of instability in the Middle East. It spans decades of political tensions and open hostilities, which have thus far

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<sup>7</sup> The opportunity cost of the Middle East conflict from 1991–2010 is estimated at \$12 trillion. See Strategic Foresight Group (2010).

included five major wars, two major Palestinian uprisings, and ongoing violence.<sup>8</sup> To further complicate the problem, Iran and Al Qaeda use the conflict as justification for their aggression against the West. Nevertheless, throughout the conflict, negotiations and attempts to reach peace have been virtually continuous. Israel has signed peace treaties with Egypt and Jordan. Its relations with the Palestinians remain a central issue of the Arab-Israeli conflict, though the current Israeli government perceives Iran as the most dangerous threat. Relations with Syria have also worsened since the Second Lebanon War of 2006 with the Hizballah, which is backed by both Syria and Iran.

Table 1 and Figure 1 present the military expenditure and the share of military expenditure in GDP for Israel and several of its rivals. The arms race between Syria and Israel is reflected in Figure 1, which shows that the two countries exhibit similar trends in their military expenditures.<sup>9</sup> The arms race between Israel and Egypt has declined since the two countries signed a peace agreement in 1979, which explains why Egypt has a relatively low and (almost) constant ratio of military expenditure to GDP. It is also noticeable that Iran's share of military expenditure in GDP has increased significantly in the past decade, although some studies claim that the increase in Iran's military expenditure is aimed at deterring rivals in the Western world, particularly the USA, and not Israel.<sup>10</sup>

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<sup>8</sup> This review is based on The Economist (2010) and on the World Bank Country Data Profile Database. The data were taken from the SIPRI 2010 Yearbook.

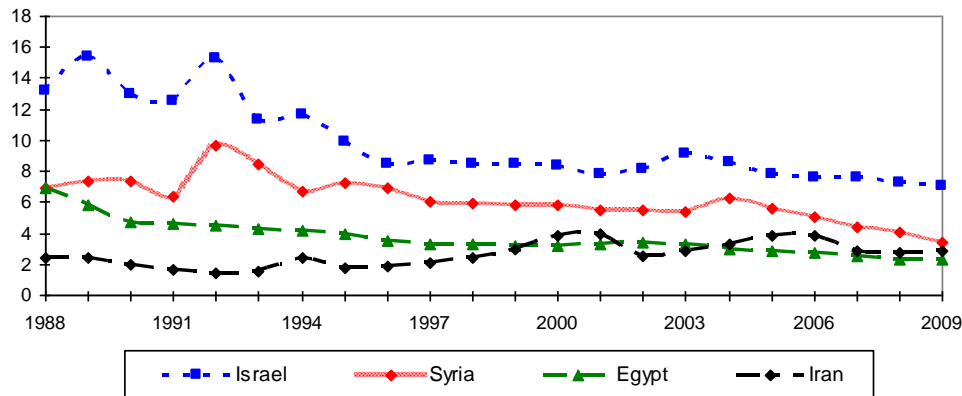
<sup>9</sup> The findings of Abu-Qarn and Abu-Bader (2009) suggest that, with the exception of Jordan, Arab countries, including Egypt, respond both to Israel's military expenditures and to the share of military expenditures in GDP. Moreover, Israel responds only to the Syrian share of military expenditures in GDP.

<sup>10</sup> See, for example, Takeyh (2007).

**Table 1: Annual military expenditure: Israel and several of its rivals (US\$, billion, 2005 prices)<sup>11</sup>**

|                       | 1988-1990 | 1991-1993 | 1994-1996 | 1997-1999 | 2000-2002 | 2003-2005 | 2006-2008 |
|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Syria                 | 7.2       | 8.2       | 6.9       | 5.9       | 5.6       | 5.8       | 4.5       |
| Egypt                 | 2.7       | 2.3       | 2.2       | 2.2       | 2.6       | 2.7       | 2.7       |
| Iran                  | 1.4       | 1.3       | 2.0       | 2.6       | 4.6       | 5.9       | 6.8       |
| Palestinian Authority |           |           | 2.2       | 0.4       | 0.5       | 0.7       | 0.7       |
| Israel                | 7.7       | 8.8       | 8.2       | 8.8       | 10.0      | 11.0      | 12.0      |

**Figure 1: Share of military expenditure in GDP: Israel and several of its rivals (%)<sup>12</sup>**



For the last 50 years, the hostilities between Israel and Syria have been the most active and dynamic facet of the Arab-Israeli conflict. Syria<sup>13</sup> was a major participant in the Six-Day War in 1967 and the Yom Kippur War in 1973. Syria was also involved in the 1982 war between Israel and the Palestinians in Lebanon. Clearly, Syria has been Israel's main rival since the 1979 Egypt-Israel Peace Treaty and the peace treaty between Israel and Jordan in 1994.<sup>14</sup> However, despite occasional strong verbal clashes between the governments and various politicians in Israel and Syria,

<sup>11</sup> Data source: SIPRI (2009) Yearbook and PCBS (2010).

<sup>12</sup> Data source: SIPRI (2009) Yearbook and PCBS (2010).

<sup>13</sup> This review is based on Bar-Siman-Tov (1995), Harris (2007) and Cordesman and Nerguizian (2010). Data were taken from the IMF World Economic Outlook Database (2010), the CIA World Factbook (2010) and the SIPRI (2010) Yearbook.

<sup>14</sup> See the website of the Israeli Ministry of Foreign Affairs:

<http://www.mfa.gov.il/MFA/Peace+Process/Guide+to+the+Peace+Process/The+Washington+Declaration.htm>



these two countries have not clashed militarily in the last two decades, despite the fierce arms race in which they are engaged.

The Golan Heights, which Israel captured from Syria in 1967, have always been at the heart of the Syrian-Israeli conflict. Talks regarding the future of this area dragged on through the 1990s and finally collapsed in 2000. The debate intensified during the summer of 2006, following the war between Hizballah and Israel (the Second Lebanon War).

While proxy warfare (through Hizballah in Lebanon and Hamas in Gaza) is an important component of Syria's regional asymmetric strategy versus Israel, its current position would not have been possible without regional alliances. Cordesman and Nerguizian (2010) claim that the Second Lebanon War of 2006 showed that Syria and Iran could work together in proxy warfare. It also showed that Syrian and Iranian transfers of advanced weapons, such as modern antitank guided weapons and a variety of short- to long-range rockets and missiles, could hurt Israel and limit the capabilities of its military.

We conclude that Syria has been by far the most important of Israel's adversaries during the last 20 years and, hence, the application of this paper is focused on the Israeli-Syrian arms race.<sup>15</sup>

### **3. Models**

To clarify how uncertainty about the likelihood of a war and the damage that such a war can inflict on a country affect the solution of an arms race, we begin our analysis with a simple model of an asymmetric arms race between two players, and let the functions that describe national security, the rivals' welfare (utility) and war damage

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<sup>15</sup> An arms race between Israel and a coalition including Egypt and Syria is analyzed in Shabtay (2012).

be linear. Due to its simplicity, this model can be solved analytically. We then proceed to develop our basic model, in which the functional forms of the war damage and the rivals' welfare and security are less restrictive.

### **3.a. A simple model**

This model describes a one-period arms race between two, possibly asymmetric, countries (denoted  $i$  and  $j$ , respectively). The welfare function of each country depends on its expenditure on civilian goods and services. The security of each country depends on its own and its rival's military capability (quantity of arms to be purchased, say). A war may erupt between the two rivals when one of them feels that it is likely to gain from such a war. We do not, however, model here the process leading to the outbreak of war and assume that each country is truly concerned about its rival's intentions and attempts to deter it from starting a war, but does not plan to initiate one<sup>16</sup>. In the event of war, each side suffers damage in proportion to its wealth (measured as a function of the government's expenditure on civilian consumption). The war damage to each country is a decreasing function of its military capability, and each country's perception of the probability that it will be attacked by its rival is a decreasing function of its own military capability, since a country with greater military capability features a higher capacity to both defend itself and inflict greater damage on its rival.

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<sup>16</sup> The incentives of countries to start a war are presented, for example, in Jackson and Morelli (2007). Senese and Vasquez (2004) provide theoretical considerations about changes in the probability of war. War will or will not break out, they claim, depending on whether the dispute is over territory, policy or regime questions, and whether the rivals involved have an outside alliance.

Finally, each country decides how to allocate its budget between military and civilian expenditures in order to maximize its expected welfare function, subject to a given (government) budget constraint.<sup>17</sup>

Let the quantity of arms to be purchased by country  $i$ ,  $x_i$ , represent  $i$ 's military capability. Similarly, let  $x_j$  represent the military capability of country  $j$ . The security level of a country may also depend on its economic capacity, represented by its GDP, since it may affect the size of the government budget in the future. Thus, following Dunne et al. (2007), we assume that the security level of country  $i$ ,  $S_i$ , is its GDP plus its quantity of arms minus the quantity of arms of its rival (country  $j$ ). That is,

$$S_i = GDP_i + x_i - x_j. \quad (3.1)$$

Country  $i$ 's perception of the probability that it will be attacked by its rival (the probability of war),  $P_i(S_i)$ , is a subjective measure of deterrence and depends on how intimidated country  $i$  is by its rival. A country with a weak military (a small stock of weapon systems) relative to that of its rival is likely to feel that its stronger rival is more likely to initiate a war. The stronger country, which does not necessarily share the same perception, may be less intimidated. Hence, the stronger country is likely to attribute a lower probability to the outbreak of war than its weaker rival. We model country  $i$ 's perception of the probability of war as follows:

$$P_i = 1 - \frac{S_i}{S_i + S_j} = \frac{S_i + S_j - S_i}{S_i + S_j} = \frac{S_j}{S_i + S_j} \quad (3.2)$$

Note that  $S_i = 0$  implies  $P_i = 1$  and  $S_j = 0$  implies  $P_i = 0$ .

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<sup>17</sup> The process of government budget allocation is not in the focus of this paper. See Ringel and Tishler (2011) for a review of such processes.

Each country's welfare function,  $U_i$ , depends on its expenditure on civilian goods and services,  $C_i$ . That is,  $U_i = a_i C_i$  where  $a_i$  is a positive constant.

The (government) budget of country  $i$ ,  $B_i$ , is exogenously given in this model. The budget is allocated to government civilian services,  $C_i$ , and military expenditure,  $x_i$ . That is,  $C_i + q_i x_i = B_i$ , where  $q_i$  is the price, in civilian services units, of one unit of weapon systems. The damage that country  $i$  will suffer in the event of war with its rival,  $A_i(C_i)$ , is assumed to be an increasing function of  $i$ 's economic wealth, measured by the country's expenditure on civilian services. Therefore, we model this damage as some proportion of  $i$ 's civilian expenditure. Specifically,  $A_i(C_i) = d_i C_i$ , where  $d_i$  is a positive constant.<sup>18</sup>

Finally, the decision problem of country  $i$  is given by:

$$\begin{aligned} \text{Max}_{x_i, C_i} \quad & P_i(S_i)[U_i(C_i, S_i) - A_i(C_i, S_i)] + [1 - P_i(S_i)]U_i(C_i, S_i) & (3.3) \\ \text{s.t.} \quad & C_i + q_i x_i = B_i \end{aligned}$$

Simplification of (3.3) yields:

$$\begin{aligned} \text{Max}_{x_i, C_i} \quad & U_i(C_i) - A_i(C_i, S_i)P_i(S_i) & (3.4) \\ \text{s.t.} \quad & C_i + q_i x_i = B_i \end{aligned}$$

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<sup>18</sup> Damage is modeled here in units of welfare (modeling damage in monetary units is straightforward and will be discussed in detail in Section 5), accounting for tangible and intangible damages. For example, in the 2006 Second Lebanon War, Lebanon suffered direct (tangible) damages of about \$2 billion, which account for about 10% of its GDP. Clearly, Lebanon (the Lebanese people) suffered extensive, though difficult to estimate, intangible damage as well.

That is, country  $i$  allocates its budget to civilian services and military expenditure to maximize its welfare function net of its expected loss from a war<sup>19</sup>. It is straightforward to show that higher military expenditure decreases the probability of war, which, in turn, increases the country's expected welfare (due to the decrease in the expected loss from a war), but that such expenditure decreases the country's civilian expenditure, thus decreasing its expected welfare. Hence, problem (3.4) above is well defined.

Substituting  $U_i = a_i C_i$  and (3.1)-(3.2) into (3.4) yields the following decision problem of country  $i$ :

$$\begin{aligned} \max_{x_i, C_i} \quad & a_i C_i - d_i C_i \frac{S_j}{S_i + S_j} \\ \text{s.t.} \quad & C_i + q_i x_i = B_i \end{aligned} \quad (3.5)$$

Using the budget constraint to substitute out the civilian expenditure yields:

$$Y_i = \max_{x_i} (B_i - q_i x_i) \left( a_i - d_i \frac{GDP_j + x_j - x_i}{GDP_i + GDP_j} \right) \quad (3.6)$$

Solving (3.6) for country  $i$ , for a given value of  $x_j$ , together with a similar expression for country  $j$ , implies the following optimal solution of the arms race (game) between the two rivals:

$$\begin{aligned} x_i^* &= \frac{2B_i}{q_i} + \frac{B_j}{q_j} + GDP_i \left( 1 - \left( \frac{a_j}{d_j} + \frac{2a_i}{d_i} \right) \right) + GDP_j \left( 2 - \left( \frac{a_j}{d_j} + \frac{2a_i}{d_i} \right) \right) \\ x_j^* &= \frac{B_i}{q_i} + \frac{2B_j}{q_j} + GDP_i \left( 2 - \left( \frac{a_i}{d_i} + \frac{2a_j}{d_j} \right) \right) + GDP_j \left( 1 - \left( \frac{a_i}{d_i} + \frac{2a_j}{d_j} \right) \right) \end{aligned} \quad (3.7)$$

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<sup>19</sup> It is straightforward to account here only for tangible damage by subtracting the monetary damage from the civilian services in the welfare function. Expected intangible damages can still be computed at the equilibrium solution.

Generally, a larger government budget,  $B_i$ , implies higher expenditures on weapon systems by both countries. However, the increase in military capability of country  $i$  is larger than that of country  $j$ , implying a larger (smaller) security level for country  $i$  ( $j$ ). Clearly, country  $i$  allocates more resources to both civilian and military expenditures when  $B_i$  is larger. In this case, country  $i$  enjoys an increase in its welfare and security level and a decrease in its perception of the likelihood (probability) of a war<sup>20</sup>. The opposite holds for country  $j$ . The increase in country  $i$ 's military expenditure (caused by an exogenous increase in  $i$ 's government budget, say) induces country  $j$  to increase its military expenditure in order to avoid a sharp decline in its security level and, consequently, reduces  $j$ 's civilian expenditure (since the government budget is given). We also expect larger marginal damage,  $d_i$ , to yield greater military expenditure aimed at preventing damages due to a possible war. Using (3.7) it is straightforward to show that a larger  $d_i$  ( $d_j$ ) implies a larger  $x_i$  ( $x_j$ ). As country  $i$  anticipates greater damage from a war ( $d_i$  increases), it allocates more resources to military expenditure (and fewer resources to civilian expenditure), increasing its own security level and reducing that of country  $j$ . As a result, country  $i$ 's perceived probability of war decreases, while that of country  $j$  increases. The increase in country  $i$ 's military expenditure induces country  $j$  to increase its military expenditure in order to avoid a

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<sup>20</sup> Large differences in the perceptions of threats and the inability of a poor rival to compete, financially and technologically, with its rich rival may lead the poor rival to pursue an asymmetric response by acquiring terror weapons (see Cordesman, 2007; Kagan et al., 2005, 2009; Rathbone and Rowley, 2002).

sharp decline in its security level and, consequently, reduces  $j$ 's civilian expenditure (since the government budget is given)<sup>21</sup>.

Finally, the analytical results and the intuition that is obtained from the simple model of this section can be used to develop and solve a more general model that better mimics reality. This task is pursued in the next section.

### 3.b. The basic model

The basic model uses several of the simple model's assumptions, but to better mimic reality and conform to acceptable notions of security it extends the simple model in several important ways. In particular, the basic model employs a more flexible welfare function that depends on each country's expenditure on civilian goods and services and on its security level. In addition, it posits more flexible definitions of security level, probability of war and war damages. That is, the military capability of country  $i$ ,  $X_i$ , consists of its existing stock,  $X_i^0$ , and the quantity of arms to be purchased,  $x_i$ . That is,

$$X_i = X_i^0 + x_i \quad (3.8)$$

Following Golde and Tishler (2004), we assume that the security level of country  $i$ ,  $S_i$ , equals the ratio between  $i$ 's military capability and the military capability of its rival (country  $j$ ):

$$S_i = \left( \frac{X_i^0 + x_i}{X_j^0 + x_j} \right)^{\gamma_i} \quad (3.9)$$

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<sup>21</sup> These findings support Jackson and Morelli (2007), who suggest that wealthier countries may be more easily deterred than poor countries. Wealthier countries fear greater war costs and therefore are willing to allocate greater resources to avoid them.

where  $\gamma_i > 0$  is a given constant. Country  $i$ 's welfare function,  $U_i$ , depends on  $i$ 's security and on its expenditure on civilian goods and services,  $C_i$  and expected war damage,  $A_i(C_i, S_i)$ <sup>22</sup>. That is,

$$U_i(C_i - A_i, S_i) \quad (3.10)$$

Country  $i$ 's perception of the probability of war with its rival,  $P_i(S_i)$ , is as follows:

$$P_i(S_i) = (1 + S_i)^{-\alpha_i} \quad (3.11)$$

where  $\alpha_i \geq 1$  is given constant<sup>23</sup>.

The damage,  $A_i(C_i, S_i)$ , that country  $i$  will suffer from a war with its rival is a decreasing function of  $i$ 's security and an increasing function of its economic wealth, measured by the country's expenditure on civilian services. Therefore, we model this damage as some proportion,  $D_i(S_i)$ , of  $i$ 's civilian expenditure. Specifically<sup>24</sup>,

$$A_i(C_i, S_i) = C_i D_i(S_i) \quad (3.12)$$

where  $D_i(S_i)$  is a decreasing function of  $i$ 's security. That is,

$$D_i(S_i) = (F_i + S_i)^{-\theta_i} \quad (3.13)$$

where  $F_i \geq 1$  and  $\theta_i \geq 1$  are given constants.

Finally, let the welfare function of country  $i$  be given by:

$$U_i(C_i, S_i) = \left[ \mu_i C_i^{\beta_i} + (1 - \mu_i) S_i^{\beta_i} \right]^{\frac{1}{\beta_i}},$$

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<sup>22</sup> It is also possible to measure damage in units of welfare, where  $U_i(C_i, S_i) = U_i(C_i) - V_i(A_i)$  stands for country  $i$ 's loss of welfare due to a war. The equilibrium results using this type of functional form in modeling war damage are similar to those of the basic model.

<sup>23</sup> This function implies that the probability of war is 1 (0) when security is zero (approaches infinity).

<sup>24</sup> Damage is defined here in units of welfare (defining damage in monetary units is straightforward and will be discussed later on).



where  $\mu_i$  and  $\beta_i$  are constants and  $\beta_i/(1+\beta_i)$  denotes the elasticity of substitution between security and civilian services. Using expressions (3.11)–(3.13) and the CES welfare function implies the following decision problem of country  $i$ :

$$\begin{aligned} \text{Max}_{x_i} \left\{ \begin{array}{l} (1+S_i)^{-\alpha_i} \left[ \mu_i \left( C_i - C_i (F_i + S_i)^{-\theta_i} \right)^{\beta_i} + (1-\mu) S_i^{\beta_i} \right]^{\frac{1}{\beta_i}} - \\ \left( 1 - (1+S_i)^{-\alpha_i} \right) \left[ \mu C_i^{\beta_i} + (1-\mu) S_i^{\beta_i} \right]^{\frac{1}{\beta_i}} \end{array} \right\} \quad (3.14) \\ \text{s.t.} \quad C_i + q_i x_i = B_i \end{aligned}$$

The functions and decision process are assumed to be similar for country  $j$ . There is no explicit solution for problem (3.14); however, it is not difficult to solve the arms race (game) using numerical methods. In the next section we apply the basic model to the Israeli-Syrian arms race.

## 4. Application to the Israeli-Syrian arms race

### 4.a. Calibration methodology

This section applies real data to assess the Syrian-Israeli arms race.<sup>25</sup> Several of the model parameters, such as the elasticity of the probability of war,  $\alpha$ , and the elasticity of the damage from war,  $\theta$ , cannot be obtained from the available data or from surveys. Thus, we calibrated the values of these parameters using non-linear least-squares regressions under the assumption that past allocation decisions (i.e., values of variables) were optimal.

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<sup>25</sup> The data and procedures used in this section are detailed in Appendices A and C.

The basic model of Section 3 is a one-stage game, represented by the decision problem (3.14) for country  $i$  together with similar expressions for  $i$ 's rival.<sup>26</sup> Using the budget constraint,  $C_i + q_i x_i = B_i$ , we substituted out the civilian services from country  $i$ 's decision problem to obtain the following decision problem of country  $i$  at period  $t$  ( $t=1, \dots, T$ ):

$$F_i^t(x_i, x_j, B_i, P_i, A_i). \quad (4.1)$$

We then used the best response (reaction) functions derived from (4.1) to estimate the parameters of the model, i.e.,  $g(x_i, x_j, B_i, q_i) = \frac{\partial F_i^t}{\partial x_i}(x_i, x_j, B_i, q_i) = \varepsilon_i^t$ , where  $\varepsilon_i^t$  is the random residual value of country  $i$  in time period  $t$ , where  $1 \leq t \leq T$ . That is, we employed the least-squares method to find the “best” estimates of  $\theta_i$  and  $\alpha_i$  as follows:

$$\min_{\alpha_i, \theta_i} \sum_{t=1}^T (\varepsilon_i^t)^2 \quad (4.2)$$

We conducted a similar calibration procedure for the rival country. Since the calibration equations were formulated for each country and for each time period, the estimation procedure employed  $2T$  observations.<sup>27</sup>

#### **4.b. Calibration of the basic model for the Israeli-Syrian arms race<sup>28</sup>**

The baseline model was calibrated using aggregated data for 1988–2009. Specifically, we used the variables government budget, defense budget and price data for ten periods, each consisting of the sum of two successive years, during 1988–2009. All parameters were calibrated simultaneously. That is, we applied the non-linear least-

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<sup>26</sup>In the calibration process we used CES welfare functions, as presented in (3.14). The calibration results are similar to those obtained for the simpler Cobb-Douglas welfare function.

<sup>27</sup> The calibration procedure was repeated, with similar results, for damage functions in which the damage from war was assumed to be proportional to GDP (instead of civilian services).

<sup>28</sup> The outcome of the entire process of data gathering is the final data set, provided in Appendix A.

squares regression procedure to calibrate the elasticities of the probability of war,  $\alpha_i, \alpha_j$ , and of war damage,  $\theta_i, \theta_j$ . We set the values of  $\mu_i, \mu_j$  equal to the budget shares allocated to civilian expenditure in Israel and in Syria, respectively.

The quality of the data collected differs across the two countries (Israel and Syria). The data for Israel were gathered from a single data source, and different price indexes were computed for the government budget and for the defense budget. Owing to insufficient public data for Syria, data sets describing the annual government budget were composed on the basis of two data sources, and the same price index was used for the government budget and for the defense budget.

Using CES utility functions we obtained  $\sum_{t=1}^T (\varepsilon_i^t)^2 = 0.04$  with  $\alpha_i = 1, \theta_i = 0.96$  for Israel and  $\alpha_j = 0.03, \theta_j = 3.78$  for Syria. The calibrated values of the parameters were found to be robust under various different assumptions about the value of  $\mu_i, \mu_j$ .<sup>29</sup>

#### 4.c. Analysis

This section assesses two scenarios of the possible evolution of the arms race between Israel and Syria. The first scenario focuses on the economic discrepancies between the two countries, and the second assesses the effect of regime change on the arms race solution. Consider the decision problem (3.14) for the conflict between Israel and Syria. The values of the relevant variables in 2010 and the calibrated parameters are presented in Table 2.<sup>30</sup> The Syrian and Israeli government budgets are set at 11.3 and 64.0, respectively, reflecting their current values. Most of the parameter values were

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<sup>29</sup> The main results of the analysis are unchanged when one employs somewhat different functional forms for the welfare, damage and probability of war functions (see Shabtay, 2012).

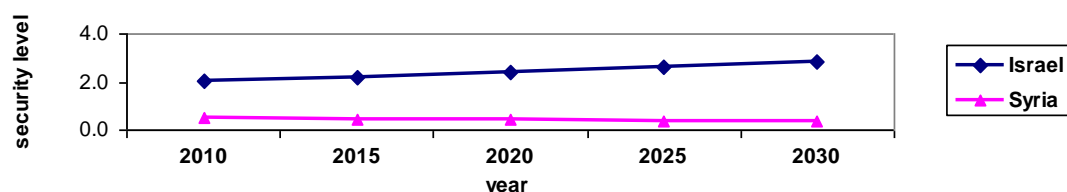
<sup>30</sup> See the Israeli Ministry of Finance website, <http://www.finance.gov.il/budget.htm>, the American Embassy in Damascus website, <http://damascus.usembassy.gov>, the Syrian Central Bureau of Statistics website, <http://www.cbssyr.org/> and Egypt state information service, <http://www.sis.gov.eg>.

obtained from the calibration procedure.<sup>31</sup> First, suppose that during the next 20 years the annual growth rate of the government budget will be 5% for Israel and only 2% for Syria. Figures 2 and 3 present the equilibrium values of the security levels and the two countries' perceptions of the probability of war during the next 20 years.

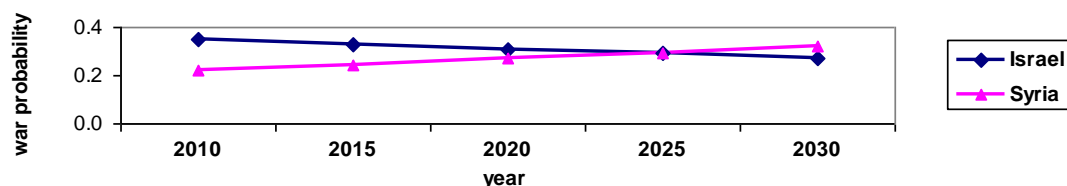
**Table 2: The values of the parameters and the exogenous variables for Israel and Syria**

| Parameter description   | Country |       |
|---|---------|-------|
|   | Israel  | Syria |
| $\theta$ The elasticity of war damage; see eq. (3.13)             | 1       | 0.03  |
| $\beta$ The elasticity of civilian expenditure; see eq. (3.14)    | 0.8     | 0.5   |
| $\gamma$ The elasticity of security; see eq. (3.9)                | 1       | 1     |
| $\mu$ Preference for civilian expenditure; see eq. (3.14)         | 0.8     | 0.5   |
| $\alpha$ The elasticity of the probability of war; see eq. (3.11) | 0.96    | 3.78  |
| $F$ The shift parameter of the damage from war; see eq. (3.13)    | 1       | 1     |
| $B$ The government budget; see eq. (3.14)                         | 64.0    | 11.3  |
| $q$ The cost of one unit of weapons; see eq. (3.14)               | 1       | 1     |

**Figure 2: The effect of economic discrepancies on security levels<sup>32</sup>**



**Figure 3: The effect of economic discrepancies on the perceptions of the probability of war**



At its current budget level, Israel allocates more resources to both civilian and military expenditures than Syria does. As a result, Israel's security level is higher and

<sup>31</sup> We normalized the shift parameter of the damage from war in eq. (3.13) to 1 and, for simplicity, set the elasticity of security in eq. (3.9) equal to 1.

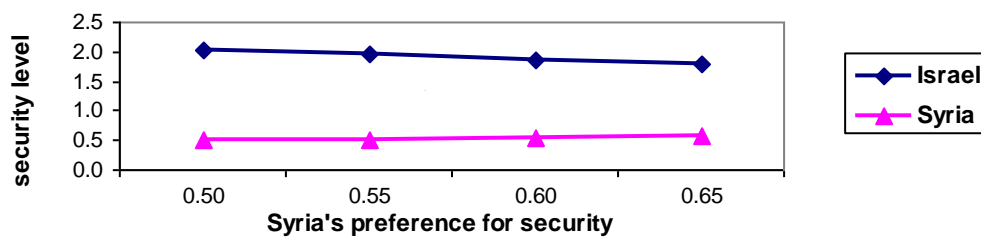
<sup>32</sup> The numerical values of the solutions in Figure 2 are detailed in Appendix B.

its perception of the likelihood of a war with Syria is lower compared with Syria's. In the future, the Israeli government budget will increase more rapidly than Syria's; hence, Israel will allocate more resources to both civilian and military expenditures, to an extent that cannot be equaled by Syria. Note that the difference between the government budgets of the two countries has two opposing effects on their perceptions of the likelihood of war. On the one hand, Israel (the richer country) tends to feel less threatened due to its superior military and higher security levels. On the other hand, it will endure a higher cost (damage) if a war between the two rivals erupts. These two effects seem to lull Israel into a false sense of security about the possibility of war. At the same time, Syria feels more threatened than Israel and, having a low alternative cost to a war, is more likely to initiate war in order to improve its position in the conflict with Israel. These findings are consistent with the conclusions that can be derived from the simple model of Section 3.1. This interpretation of the model seems to be a good representation of the current realities of the Israeli-Syrian conflict.

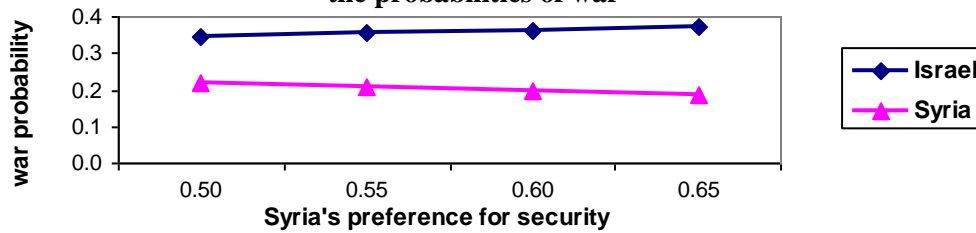
Next, we visualize Syria's regime becoming ideologically more extreme and, thus, increasing its preference for security over civilian expenditure. We also assume that Syria's change in preferences will not affect Israel's preferences, which will remain constant (for example,  $1 - \mu_i = 0.2$ ). Figures 4–6 describe the equilibrium values of the perceptions of the probability of war and the security levels for various values of Syria's preference for security. The effect of Syria's becoming ideologically more extreme is expressed in an increase in its preference for security ( $1 - \mu_j$ ). A larger share of the government budget is allocated to military expenditure in both countries as a result of the change in Syria's preferences. That is, Israel increases its military expenditure in response to the increase in Syria's military expenditure (which is the

result of Syria's higher preference for security) and reduces its civilian expenditure. Consequently, Israel sustains a substantial reduction in its security level and in its civilian expenditure and, hence, a decline in its welfare (we do not assess Syria's welfare since its welfare function has changed). Note also that although civilian expenditure is reduced in both countries, Israel's perception of the probability of war increases due to the reduction in its security, while that of Syria declines.

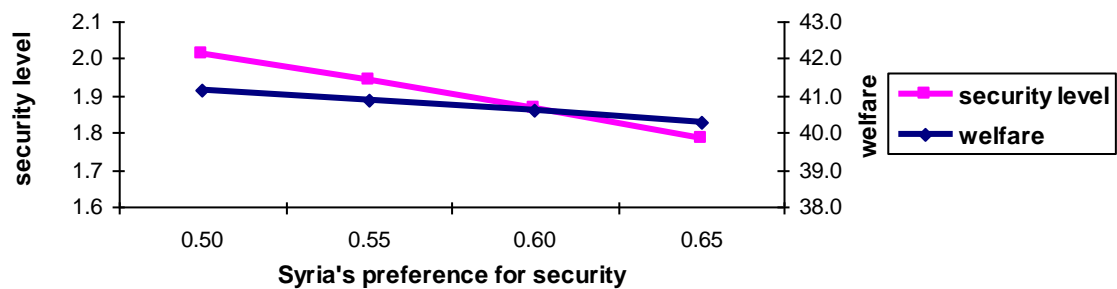
**Figure 4: The effect of an ideologically more extreme regime in Syria on security levels<sup>33</sup>**



**Figure 5: The effect of an ideologically more extreme regime in Syria on perceptions of the probabilities of war**



**Figure 6: The effect of an ideologically more extreme regime in Syria on Israel's welfare and security level**



<sup>33</sup> See Appendix B for the exact values of the variables depicted in Figure 4.

## 5. The monetary value of insecurity

An exogenous increase of the country's government budget or an increase in its taste for security is likely to cause a decline in the rival's security and welfare. In this section we show how to measure the monetary value of such a decline in the welfare or security levels of the rival, with an application to the Israeli-Syrian arms race.

Following Kagan et al. (2009), we measure the monetary value of welfare losses caused by changes in the model parameters. This monetary value equals the compensation required to ensure that a country's expected welfare (or security level) does not decline due to such changes to the model parameters or exogenous variables.

We assess the monetary value of the welfare loss (gain) in country  $i$  as a result of changes in the preferences of country  $j$ , e.g., when country  $j$  becomes more (or less) ideologically extreme while the preferences of country  $i$  remain unchanged.

Specifically, this assessment can be formulated as follows. Suppose that the value of one of country  $j$ 's parameters changes (for example, the value of the country's preference for security,  $1 - \mu_j$ , increases). Country  $i$ 's decision problem (when  $1 - \mu_j$  is set at a new, higher, level) may now be given by:

$$\begin{aligned} \underset{x_i, C_i}{Max} \quad & U_i(C_i - A_i, S_i)P_i(S_i) + U_i(C_i, S_i)(1 - P_i(S_i)) & (5.1) \\ \text{s.t.} \quad & \begin{cases} (a) C_i + q_i x_i = B_i + \Delta B_i \\ (b) E(U_i) = E(U_i)^0 \end{cases} \end{aligned}$$

where  $\Delta B_i$  denotes the additional budget required by country  $i$  to maintain its expected welfare at the optimal solution, equal to the one that it could have attained before the change in the value of  $1 - \mu_j$  (that is at the level  $E(U_i)^0$ ). Country  $j$ 's

decision problem is unchanged and is given by problem (3.14) (using the new value of  $1 - \mu_j$ ).

In addition to the welfare loss, country  $i$  suffers a decline in its optimal security level when  $1 - \mu_j$  increases. It is possible to measure the monetary compensation required to ensure that country  $i$ 's security level does not decline as a result of country  $j$ 's change in preferences. This assessment can be carried out by formulating country  $i$ 's decision problem as follows (using the new value of  $1 - \mu_j$ ):

$$\begin{aligned} \underset{x_i, C_i}{Max} \quad & U_i(C_i - A_i, S_i)P_i(S_i) + U_i(C_i, S_i)(1 - P_i(S_i)) & (5.2) \\ \text{s.t.} \quad & \begin{cases} (a) C_i + q_i x_i = B_i + \Delta B_i \\ (b) S_i = S_i^0 \end{cases} \end{aligned}$$

where  $\Delta B_i$  denotes the additional budget that country  $i$  would require in order to maintain its initial (prior to the change in  $1 - \mu_j$ ) optimal security level,  $S_i^0$ . Country  $j$ 's decision problem is unchanged and is given by problem (3.14).

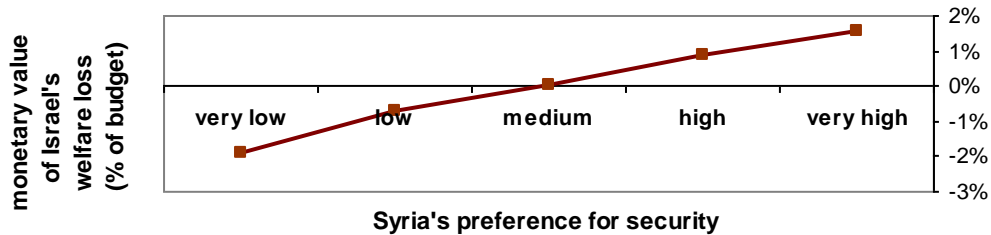
We applied problems (5.1) and (5.2) to the conflict between Israel and Syria, hypothesizing that if Syria's regime becomes ideologically more extreme, its preference for security will increase. We also assumed that Israel's preferences remain unchanged, and used the current values of the relevant variables and the calibrated parameters that are listed in Table 2. We defined Syria's current preference for security ( $1 - \mu_j = 0.5$ ) as "medium". Syria's preference for security is defined as "low" when  $1 - \mu_j = 0.4$  and as "very low" when  $1 - \mu_j = 0.3$ . It is defined as "high" when  $1 - \mu_j = 0.6$  and "very high" when  $1 - \mu_j = 0.7$ .

Figures 7 and 8 describe the monetary values of losses (gains) in welfare and security that Israel experiences as a result of changes in Syria's preference for security. That

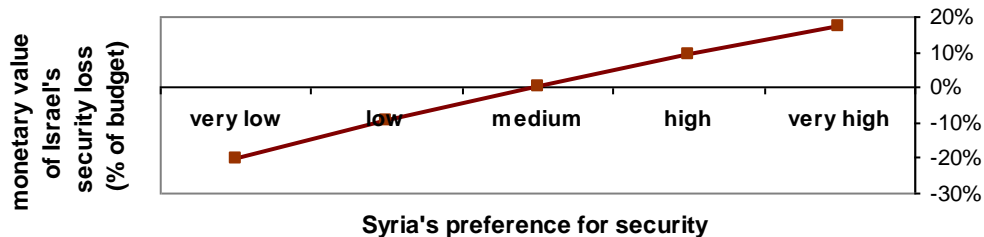


is, Figures 7 and 8 present the additional government budget required in order for Israel's expected welfare or security level to remain unchanged when Syria's preferences for security vary from 0.3 to 0.7.

**Figure 7: The monetary compensation (in percentage of government budget) required to keep Israel's expected welfare unchanged when Syria's preference for security changes**



**Figure 8: The monetary compensation (in percentage of government budget) required to keep Israel's security level unchanged when Syria's preference for security changes**



Clearly, when Syria becomes ideologically more (less) extreme, the required budget to keep Israel's expected utility or security unchanged increases (decreases). Particularly high compensation is required for Israel to maintain its security level when Syria's preference for security increases (see Figure 8), since a higher preference for security for Syria translates into a higher share of the Syrian budget for defense expenditures and, consequently, a larger defense budget in Israel. Note that in this case Israel's welfare declines since it maintains its security level but reduces its expenditure on civilian services by a very large amount in order to increase its expenditure on the military. In fact, the required levels of compensation for maintaining Israel's security level when Syria's preferences for security increase from "medium" to "very high" reach 18% of Israel's government budget.

The cost of maintaining Israel's welfare at the level that it enjoyed prior to Syria's change in preferences is less than that of maintaining Israel's security level at the level it enjoyed prior to Syria's change in preferences. In fact, the cost of maintaining Israel's welfare is not more than 1.5% of Israel's annual government budget. This is because of the option that Israel has to change its welfare by changing its expenditure on defense and on civilian services.

The findings in this section show that during periods of peace, the monetary value of the psychological burden due to wars and insecurity (which is equal to the cost of keeping security constant) may be significantly higher than the monetary value of welfare losses (which is equal to the cost of keeping welfare constant). Second, we show that the monetary cost of keeping Israel's expected welfare and security levels unchanged is positively correlated with Israel's own wealth and preference for security. It is also positively correlated with Syria's preference for security (greater ideological extremism requires higher monetary compensation). This implies that a threat of war with Syria (even if no war is actually fought) or a change in Syria's preferences for security is likely to result in a large increase in Israel's sense of insecurity and in a substantial reduction in its welfare.

## **6. Summary and Conclusions**

This paper develops and assesses models of government budget allocation to civilian and military expenditures under uncertainty about the incidence of war, and presents analyses of the effects of various parameters and exogenous variables on the arms race rivals' optimal welfare, security level, perceptions of the probability of war and the damage due to war. One of these models was applied, using real-world data, to the Israeli-Syrian arms race.

The main results of this study are as follows. We first demonstrate that the richer a country is relative to its rival, the lower its perception of the probability of war with its rival. Correspondingly, poorer countries perceive a greater probability of war with richer rivals. This suggests that the rapid economic development of Western countries heightens perceptions of the threat of war among countries with lower GDP and/or stagnant economic growth. We show that the current, very different, growth rates of the Israeli and Syrian government budgets may lead to an increase (decrease) in the likelihood of war as perceived by Syria (Israel) in the near future. Such differences in the perceptions of the threat may lead the poorer rival into arming itself with terror weapons (see Cordesman 2007; Kagan et al. 2005, 2009; Rathbone and Rowley 2002). Iran's latest effort to produce weapons of mass destruction (WMD) capabilities may be an example of this phenomenon. We then present and apply a methodology for measuring the monetary value of welfare loss (gain) or changes in security level due to changes in the parameters and/or variables that may affect the solution of the arms race. We show that the psychological burden due to insecurity, which may result when the rival's preferences for security increase, are larger when the country's wealth is larger and when its preference for security is higher; when Syria's regime becomes ideologically more extreme, the cost of maintaining Israel's security level (expected welfare) at the level that it enjoyed prior to Syria's change in preferences is very high (moderate). Our findings support those of Bridgman (2008) and show that a threat of war (even if no war is fought) is sufficient to significantly decrease output (expected welfare in our research).

The outcomes of the recent social protests in the Middle East remain to be seen. One possible scenario is the establishment of fundamental Islamic regimes which may, as is shown in this study, lead to a substantial reduction in Israel's security and welfare.

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## Appendix A: Data for Israel, Syria and Egypt

The entire data set of government budget ( $B$ ), military and civilian expenditures ( $qx$  and  $C$ ), unit prices of the military expenditure ( $q$ ) and civilian expenditure ( $p$ ) that we employed in this paper appears in Table A1.

**Table A.1: Final data set used for calibration  
(US\$, billions, 2009 prices)**

| variable name   | government budget          |       |       | military expenditure |       |       | civilian expenditure |       |       | price index of civilian Expenditure |       |       | price index of military Expenditure |       |       |
|-----------------|----------------------------|-------|-------|----------------------|-------|-------|----------------------|-------|-------|-------------------------------------|-------|-------|-------------------------------------|-------|-------|
| units           | USD, billions, 2009 prices |       |       |                      |       |       |                      |       |       | base year = 2009                    |       |       |                                     |       |       |
| variable symbol | B                          |       |       | qx                   |       |       | C                    |       |       | p                                   |       |       | q                                   |       |       |
| year            | Israel                     | Syria | Egypt | Israel               | Syria | Egypt | Israel               | Syria | Egypt | Israel                              | Syria | Egypt | Israel                              | Syria | Egypt |
| 1988-1989       | 76.9                       | 7.8   | 26.6  | 10.6                 | 3.4   | 21.1  | 66.3                 | 4.3   | 5.5   | 113.0                               | 73.3  | 19.6  | 44.5                                | 73.3  | 19.6  |
| 1990-1991       | 68.9                       | 8.6   | 19.3  | 10.6                 | 4.2   | 13.5  | 58.4                 | 4.4   | 5.8   | 119.5                               | 77.9  | 27.8  | 52.5                                | 77.9  | 27.8  |
| 1992-1993       | 63.9                       | 9.1   | 23.4  | 10.6                 | 4.3   | 9.3   | 53.3                 | 4.8   | 14.0  | 112.6                               | 80.2  | 38.0  | 57.9                                | 80.2  | 38.0  |
| 1994-1995       | 63.5                       | 11.3  | 25.6  | 11.4                 | 4.1   | 7.6   | 52.1                 | 7.2   | 18.0  | 111.4                               | 82.6  | 45.7  | 66.1                                | 82.6  | 45.7  |
| 1996-1997       | 64.2                       | 10.4  | 24.2  | 11.5                 | 3.9   | 6.7   | 52.8                 | 6.5   | 17.5  | 107.8                               | 82.6  | 52.7  | 75.8                                | 82.6  | 52.7  |
| 1998-1999       | 61.7                       | 10.4  | 23.1  | 9.9                  | 4.3   | 6.8   | 51.8                 | 6.1   | 16.3  | 106.2                               | 87.2  | 58.0  | 84.7                                | 87.2  | 58.0  |
| 2000-2001       | 69.4                       | 10.6  | 23.8  | 9.8                  | 5.5   | 6.0   | 59.6                 | 5.1   | 17.7  | 102.2                               | 89.2  | 61.5  | 90.9                                | 89.2  | 61.5  |
| 2002-2003       | 73.9                       | 8.8   | 27.0  | 9.7                  | 5.7   | 6.6   | 64.2                 | 3.1   | 20.4  | 108.6                               | 91.2  | 64.8  | 93.0                                | 91.2  | 64.8  |
| 2004-2005       | 56.5                       | 8.8   | 29.0  | 10.1                 | 6.9   | 5.8   | 46.4                 | 1.8   | 23.2  | 104.4                               | 95.7  | 74.3  | 93.1                                | 95.7  | 74.3  |
| 2006-2007       | 61.8                       | 11.5  | 31.1  | 11.0                 | 6.3   | 5.0   | 50.9                 | 5.2   | 26.1  | 104.2                               | 96.7  | 85.1  | 96.7                                | 95.7  | 85.1  |
| 2008-2009       | 66.0                       | 11.3  | 33.9  | 13.5                 | 6.6   | 3.9   | 52.6                 | 4.7   | 30.1  | 100.0                               | 100.0 | 100.0 | 100.0                               | 100.0 | 100.0 |

## Appendix B: Data for selected figures

Data for Figure 2

| Year                    | 2010 | 2015 | 2020 | 2025 | 2030 |
|-------------------------|------|------|------|------|------|
| Israel's security level | 2.02 | 2.21 | 2.41 | 2.63 | 2.86 |
| Syria's security level  | 0.50 | 0.45 | 0.41 | 0.38 | 0.35 |

Data for Figure 4

|  |             |             |             |             |
|--|-------------|-------------|-------------|-------------|
| <b>Syria's preference for security</b> | <b>0.50</b> | <b>0.55</b> | <b>0.60</b> | <b>0.65</b> |
| Israel's security level                | 2.02        | 1.94        | 1.87        | 1.79        |
| Syria's security level                 | 0.50        | 0.51        | 0.54        | 0.56        |

## **Appendix C: Data processing**

Data were collected for two purposes: first, to better understand current and past arms races in the Middle East, particularly between Israel and Syria; and second, to calibrate the parameters of the model. For each country we collected demographic, political, historical, economic and military data (the latter data include expenditures on and quantities of weapon systems). Demographic, political and historical data were collected to understand political and military alliances and rivalries and the elements of the dispute (ethnic and religious differences, economic differences, territorial disagreements, foreign affairs policies, regime nature, etc.). Information on expenditures and sources of finance (including foreign aid sources) was collected to assess budget constraints (see equation (3.3)) and potential war damage (see equation (3.5)), to gain an understanding of the significance of security (see equation (3.9)) to the regime, and to assess the rivals' overall nature and culture. Military data (quality and quantity of weapons and troops, source of weapon systems) were collected to examine magnitudes of deterrence, to identify supporters, and to assess the likelihoods (probabilities) of war (see equation (3.11)) and the preference for security. Finally, we reviewed Israel's past and current relations with countries and non-national entities in the Middle East in order to assess whether rivalries were likely to evolve into war.

We used various sources to obtain the data required for the evaluation of the models in Sections 4 and 5. Generally, sources were selected on the basis of their accuracy and credibility, and the provision of time-series data. Demographic, historical, economic and financial data were obtained from the IMF World Economic Outlook Database (IMF, 2010), the World Bank database, the Organization for Economic Co-operation and Development (OECD), the CIA World Factbook (2010), the European Commission's website and the Syrian Central Bureau of Statistics. Military and

security data were obtained from, the CIA World Factbook (2010), World Military Expenditures and Arms Transfers (WMEAT) reports (US Department of State, 1998, 2000, 2005, 2010), and Stockholm International Peace Research Institute (SIPRI) databases and yearbooks (SIPRI, 2009, 2010a, 2010b). Syria's military expenditure during 1988–1998 is the only data item marked as an estimate in SIPRI's military database. Nevertheless, we believe that these data are reasonably accurate.

The model was analyzed using data for 1988–2009. Prior to constructing the final database, it was necessary to determine the length of a “single period”. The availability and reliability of data allowed an overall estimation period of 20 years. Government budgets are usually determined on a yearly basis and are constrained by fiscal projections and the commitments of previous years. The same is generally true for defense budgets. In order to reduce their annual (possibly random) variability and examine their long-term properties, we divided the data into ten observation points for the years 1988–89, 1990–91, 1992–93, 1994–95, 1996–97, 1998–99, 2000–01, 2002–03, 2004–05, 2006–07 and 2008–09. Since data series were given in different currencies and prices, all data was converted into the same currency (USD) derived from annual average exchange rates. Subsequently, all data were converted into 2009 prices using the appropriate price indices for each country.

All unit prices were arbitrarily set to 100 in the first period. The price changes between periods were then calculated using a price index specifically designed for each type of expenditure. Each index was developed as a weighted average of the prices of its main cost drivers, based on their weight in the overall budget.

The data include the annual government budget and the annual defense budget in 2009 prices. The annual budget of the Israeli government was obtained from the Israeli Ministry of Finance (2009) annual report titled *Major Provisions of the Budget*

*and Multi-Year Budget Plan*. The original data were presented in local currency and current prices, and we converted them into 2009 prices using the Israeli Consumer Price Index (CPI), published by the Israeli Central Bureau of Statistics (CBS).

The annual budget of the Syrian government was obtained from the Economist Intelligence Unit (EIU), where government budgets appear as a ratio of the GDP. Data were available until 2006. The GDP data were taken from the IMF World Economic Outlook Database. The annual budget of the Syrian government for the years 2007–2008 was obtained from the Syrian Central Bureau of Statistics. The original data were presented in local currency and current prices. We converted the data into 2009 prices using the local CPI, which was obtained from the Syrian Central Bureau of Statistics (CBSSYR).

There were a number of data sources for annual defense budgets, such as the WMEAT 1998, 2000 and 2005 reports, which together provide data on military spending for the years 1987–2005. The SIPRI Database on Military Expenditure provides similar data until 2010. We used SIPRI data up to the year 2008. Both sources provide data in current and constant prices. We converted constant prices into 2009 prices using a price index constructed for each country.

The Israeli security price index incorporated a weighted average of the main cost drivers in the defense budget, based on their shares in the defense budget for the period of 1988–2009. More than half of Israel's military expenditure<sup>34</sup> was dedicated to wages, pension payments and payments to families of war casualties, and approximately 5% was utilized for R&D activities. The remainder was spent on procurement and logistics. Each type of key expenditure was assigned a suitable price index. Most prices were determined according to indices published by the CBS. The

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<sup>34</sup> See the Ministry of Defense website ([http://www.mod.gov.il/pages/general/pdfs/takziv\\_2008.pdf](http://www.mod.gov.il/pages/general/pdfs/takziv_2008.pdf)).

wages of military personnel were directly associated with those of the public sector. Therefore, we used the average annual salary in the public sector to represent the price index of wages, pension payments and payments to families of war casualties. The main cost-driver of R&D activities was the cost of personnel. Hence, we defined the price index of R&D as the average annual salary of employees in the R&D sector. Expenditure on logistics is on the main components of the CPI, that is, the typical groups of civilian consumer goods. Therefore, we selected the CPI as the unit price of logistics. Finally, we constructed a price index for procurement, using a weighted average of the prices of various pieces of equipment, based on their shares in the overall acquisition budget for the period of 1988–2009.

Due to lack of publicly available data, we were not able to construct similar price indices for the Syrian military expenditures. Hence, we chose SIPRI's method for price conversion<sup>35</sup> of military expenditure. SIPRI's data were available in constant dollars (2008 prices). We converted the data to 2009 prices using the local CPIs.

We analyzed the data for Israel across several sources and compared them with information on the defense budget published in the Israeli Ministry of Finance (2009). We found the data and trends from the various sources to be similar. We compared Syrian data from SIPRI with data from WMEAT and found them to be similar as well.

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<sup>35</sup> SIPRI Yearbook 2009: Chapter 5. Military Expenditure: Armaments, Disarmament and International Security.