The Effects of the World Defense Industry and US Military Aid to Israel on the Israeli Defense Industry: A Differentiated Products Model

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Abstract

This paper models the interactions between the defense industry market structure and the defense needs of Israel, the USA and Western Europe, which produce several heterogeneous defense goods. The model specifies that the defense industries of the US and Europe are "large" while that of Israel is "small". The US military aid to Israel is also an integral part of the model. The results show that net defense costs of Israel are minimal when the number of its defense firms is one. The model predicts that an increase in the US military aid reduces Israel's government expenditure, its defense industry's profits and its net defense costs.

JEL classification: H56, H57, L11, L13

Key words: Defense industry, security levels, US military aid, net defense cost, industry profits

1. Introduction

The optimal structure of the Israeli defense industry is the focal point of this study. The defense industries of the US and Western Europe are led by a small number of very large firms (integrators) that employ state-of-the-art technologies and sell most (about 90%) of their production to their own governments. The US and Western European defense firms compete in the global international market for modern weapon systems, but their existence does not depend on their sales in this global market. The Israeli defense firms also employ state-of-the-art technologies, but they are much smaller than their US and European counterparts. The Israeli firms are highly dependent on the sales of their products, which are often very similar in quality and price to those of the US and European firms, in the international markets (Israeli defense exports amount to about 70% of production). Thus, the research questions of this study are similar to those of others in the literature on the structure of the world's defense industry, but the setup and assumptions differ in several important respects[1]. First, we define and model "large" and "small" defense firms. Since the production technologies used by the US, European and Israeli firms are similar, we specify similar cost functions in the production stage of all firms. Marketing cost is what separates a defense firm in a small country from one in a large country. European and US defense firms enjoy the economic and political leverage of their governments in

[1] Anderton (1995), Sandler and Hartley (1995), Levine and Smith (1997) and Bolks and Stoll (2000) provide surveys and assessments of models of international arms trade, covering industry structure, interactions between security and economic conditions, arms imports and exports and arms races. Detailed theoretical models of arms trade can be found, among others, in Levine and Smith (1995, 1997, 2000), Garcia-Alonso (1999, 2000), Bolks and Stoll (2000), Garcia-Alonso and Hartley (2000), Golde and Tishler (2002) and Mantin and Tishler (2005).

their marketing efforts[2]. Marketing defense goods by Israeli firms is more difficult, and its cost increases as these firms attempt to increase their sales (particularly, by acquiring more customers), due to the small size of the Israeli economy (hence, the limited economic leverage of the Israeli government and the Israeli defense firms) and the political constraints under which the Israeli government operates[3]. We account for this dissimilarity by assuming that the cost functions, at the marketing stage, of the US and European firms are linear in output, and those of the Israeli firms are

[2] Governments are the only customers in the market for modern weapon systems. Thus, the governments of all arms-producing countries, including Israel, are actively involved in the marketing efforts of their defense firms. This involvement may include direct political pressure, large subsidies to local defense firms, offsets, economic aid which is (at least indirectly) conditional on defense sales, restrictions on use (or exports) of locally produced weapons which include foreign-made (US or European) components, and more.

[3] The use by the US and European governments of economic/political leverage in favor of their defense firms, even though their products are not superior, and may even be more expensive, is demonstrated in the following examples. (1) In the competition between IAI's and Boeing's Airborne Early Warning Aircraft (AEWA), IAI was forced by the US government to cancel the sale of its AEWA to China in 2002 and lost bids in Australia and Turkey (Globes, 8/3/04). In 2004 IAI finally sold three AEWAs to India after being put through a long and debilitating confirmation process by the US. (2) IAI lost a bid to upgrade Bulgarian attack helicopters due to Bulgaria's current efforts to join NATO. EADS was the eventual winner of this bid (Globes, 26/6/03). (3) EADS declined to use IAI's components in its Airbus commercial planes, even though EADS acknowledged that doing so was to its advantage, due to El Al's preference to purchase US commercial planes (Boeing) rather than Airbus (Globes, 1/7/03). (4) US government pressure precluded Israel from selling its Merkava tanks to Turkey in 2000. In general, Israel needs special permission to sell Israeli weapon systems that include American components (however small the share of these components in the product's value) or components that were financed by US military aid to Israel.

quadratic in exports[4]. Second, we assume that the marketing cost functions of the Israeli defense firms may depend on the number of defense firms in the Israeli defense industry. Third, an integral part of the model is the US military aid to Israel, which affects the optimal behavior of both the Israeli government and the Israeli and US defense industries. Fourth, most global models assume that the governments choose their security levels in order to maximize a welfare function (see Levine and Smith (1995, 1997, 2000), Garcia-Alonso (1999, 2000) and Golde and Tishler (2002)). Following Mantin and Tishler (2005), it is assumed that the target security level of the country is exogenously determined by its politicians and generals[5]. Finally, this paper does not consider arms races within the developing world. Rather, it emphasizes the interactions between the major developed countries' defense needs and the defense industry market structure[6].

The model of the interactions between the choice of defense levels and market structure presented in this paper views three developed countries (corresponding to

[4] Assuming that marketing, and/or production, costs of the US and European firms are quadratic in output (exports) does not change the results of this paper, as long as the marginal marketing (and/or production) costs of the Israeli defense firms increase at a faster rate than those of the US and European defense firms.

[5] This decision rule may be viewed as a proxy for welfare maximization, subject to the availability of the country's resources. It emphasizes the strong connection between the country's defense expenditure and that of its potential enemies, and the seemingly small correlation between defense expenditure and other government expenditures (on education, welfare, health, etc.). A-priori it is not clear which decision rule is a better approximation of reality.

[6] See Levine and Smith (1995, 1997, 2000), Garcia-Alonso (1999, 2000) and Garcia-Alonso and Hartley (2000) for models of arms races among the countries in the "rest of the world".

Israel, the USA and Western Europe) that produce heterogeneous defense goods[7]. The "rest of the world" includes all the other countries in the world. There is no production of defense goods in the rest of the world. The three producer-countries are not enemies, but each has (possibly different) potential enemies in the rest of the world. Furthermore, the model accounts for the US military aid to Israel. The rest of the world features downward-sloping demand functions for the various defense goods and it purchases the defense goods produced by the three developed countries at the equilibrium world prices[8]. The security level of each of the three developed countries depends on their purchase of defense goods (from their own defense industry) relative to the amounts of the defense goods that are purchased by the rest of the world. Target security levels are exogenous in this model. They are assumed to be determined by the country's culture, social fabric, political structure, religions, beliefs, etc.

The model includes two stages. First, the governments of the three producer-countries commit themselves, simultaneously and non-cooperatively, to the amounts of the defense good that they will purchase, at the world price, from their defense

[7] This model extends the two-country model of Mantin and Tishler (2005) to include Israel as a "small" country. Whereas the *Bertrand* model with *heterogeneous* goods is the basis of Mantin and Tishler (2005), this paper employs *Cournot's conjecture* with *heterogeneous* goods.

[8] Following Garcia-Alonso (1999), Levine and Smith (1995, 1997, 2000), Garcia-Alonso and Hartley (2000) and Mantin and Tishler (2005), we assume that suppliers in the two producing countries know the aggregate demand functions of the recipients (countries in the rest of the world), can discriminate between recipients through export licenses and the like, and know how the military capability of the recipients will affect their own security (see Garcia-Alonso (2000) and Levine and Smith (2000) on the optimal policy of security restrictions on exports by the producing countries).

industry[9]. Second, the defense firms in the three producer-countries play a Cournot game to determine the quantities of the exports (and, indirectly, prices) of the goods that they produce.

Some of the results of the model are intuitive and straightforward, while others depend on a strategic interaction between market structure and security and on the marginal cost structure of the defense industry. First, the net defense costs (government expenditure on procurement minus the defense industry's profits)[10] of the producer-countries are minimal when the number of defense firms in the world is small. Using a calibrated model we suggest that the optimal number of Israeli defense firms is one. Second, an increase in the target security level in an arms-producing country which, following the events of September 11th and the Palestinian uprising (the Intifada) in 2001, seems to be the case for the USA and Israel (but not for Europe) will cause an increase in their spending on military procurement and, hence, an increase in the world prices of the defense goods and a reduction in the rest of the world's imports of the defense goods. Third, an increase in production cost and a continuing consolidation of the defense industry are in favor of the USA and Western Europe (these effects will reduce these countries' net defense costs), but not necessarily of the Israeli defense industry, which relies heavily on exports. Therefore,

[9] We assume, as is the case in reality, that the governments of the producing-countries do not altogether prohibit, or tax, exports. The interplay of market structure and government trade policy whereby governments simultaneously and non-cooperatively choose whether or not to tax or provide subsidies for their firms is detailed in Balboa, Daughety and Reinganum (2004).

[10] Since the model exhibits a single equilibrium, in the static analysis we use the measure "net defense cost", which is not part of the government's objective function. See Miyagiwa (1991) for a similar measure.

mergers and acquisitions across the Atlantic (between US and European defense firms) are likely to further develop, and the massive investments made by the USA and Western Europe in military R&D are expected to continue, aiming, in part, at raising world prices to a level that is likely to crowd out the rest of the world from the market for modern weapon systems. The Israeli defense industry is likely to suffer from this trend, unless it is able to play an active role in this consolidation process. Fourth, we show that the US military aid to Israel is beneficial to the Israeli economy in the short term, since it reduces Israel's net defense cost. However, this aid reduces the profits of the Israeli defense industry and may, in the long term, hurt the sustainability and viability of Israel's defense industry.

Finally, several other characteristics of the model are similar to those in Mantin and Tishler (2005). For example, a rise in the rest of the world's demand for the defense goods (due, say, to increased regional conflicts or an increase in the GDP of the rest of the world) increases exports (mostly by US and European firms) to the rest of the world as well as the equilibrium world prices. These changes, in turn, increase the defense industry's profits, but normally also increase the arms-producing countries' net defense cost (their expenditure on defense minus the profits of their defense industry). Furthermore, a rise in the producer-countries' target security levels increases these countries' purchases of the defense good and the world prices. As a result, we observe an increase in the producer-countries' defense expenditures, an increase in the defense industry's profit, and, generally, a rise in the producer-countries' net defense cost.

The structure of this paper is as follows: Section 2 provides a background on the world's defense industry. Section 3 presents the Israeli defense industry and the US military aid to Israel. Section 4 presents the concept of security and describes the

model. The model is solved in Section 5 and the optimal solution is analyzed in Section 6. Section 7 presents the calibration of the model, and analysis of the model predictions, based on real data, to changes in exogenous variables or parameters. Section 8 discusses policy issues and concludes.

2. The International Arms Trade – Background

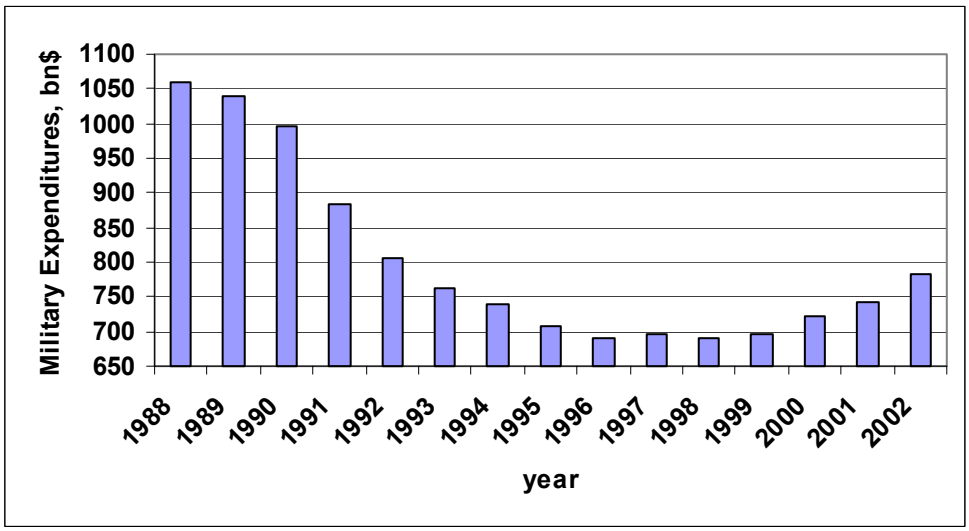
The international markets for arms trade in the last two decades have been strongly influenced by four factors: (a) the end of the Cold War during the 1980s, the increase in local disputes towards the end of the 1990s and, consequently, the sharp increase in terror activities worldwide; (b) the emergence of the USA and Western Europe as the only strong military powers with state-of-the-art technological know-how and the economic means to develop it into sophisticated weapon systems; (c) the "buy local" policy of the USA and Western Europe, which has meant that almost all of the procurements in these countries have been from the local industry; (d) the process of consolidation of the US and Western European defense firms during the 1990s.

This study analyses the defense industry in Israel, the USA and Western Europe. However, data on defense expenditures, production, exports, prices and costs in the Western world are scarce and mostly unreliable. Publicly available defense data on Israel are practically non-existent. Thus, although the general trends in the development of the markets for defense goods are fairly clear, the results of any analysis that employs these data should be interpreted with caution. The main sources of aggregate defense data are SIPRI (Stockholm International Peace Research Institute) and WMEAT (World Military Expenditures and Arms Transfers). Other

important data sources are the International Institute for Strategic Studies (IISS), the Center for Strategic and International Studies (CSIS), the UN Arms Transfer Register, the International Monetary Fund, and the published government budgets of Western countries. Data on Israel are derived from the sources mentioned above, as well as from the annual budget reports issued by the Israeli Ministry of Finance, published studies of local research institutions, the US annual budget, and the Israeli press.

The end of the Cold War caused a sharp decline in the world's defense expenditures, procurement and exports of weapon systems. Defense budgets in the world shrank, most notably in the developed countries, where the share of defense spending in GDP declined by about 50% from 1985 to 1998 (SIPRI, 2003, Mantin and Tishler, 2005). The reversal of this decline towards the end of the 1990s (see Figure 1) is dominated by a large increase in the US defense budget, and was caused by the eruption of local disputes in the Middle East, Kosovo, East Timor and other countries, and the wars in Afghanistan and Iraq following the events of September 11th 2001.

Figure 1: Defense expenditures in the world during 1988-2002 (2000 prices)

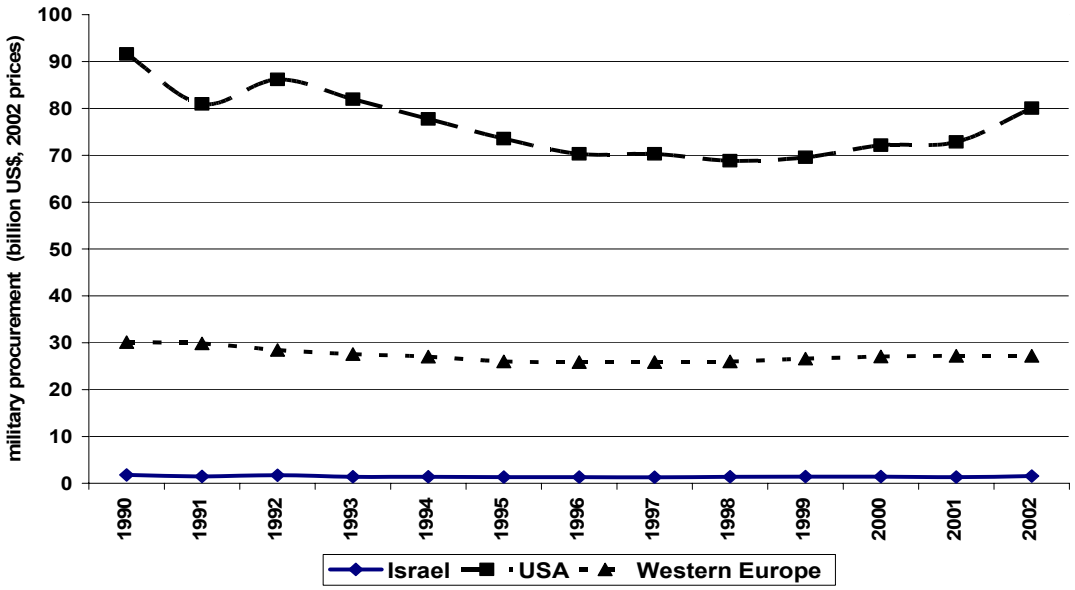


Source: SIPRI 2003, WMEAT 2003

The combined share of the USA and Western Europe (mainly – the UK, France, Germany, Italy, Sweden, Switzerland and Spain) in the world's exports of weapon systems has been about 85% since 1992. Figures 2 and 3 show the levels of defense procurement and defense exports, respectively, of the USA, Western Europe and Israel during 1990-2002.

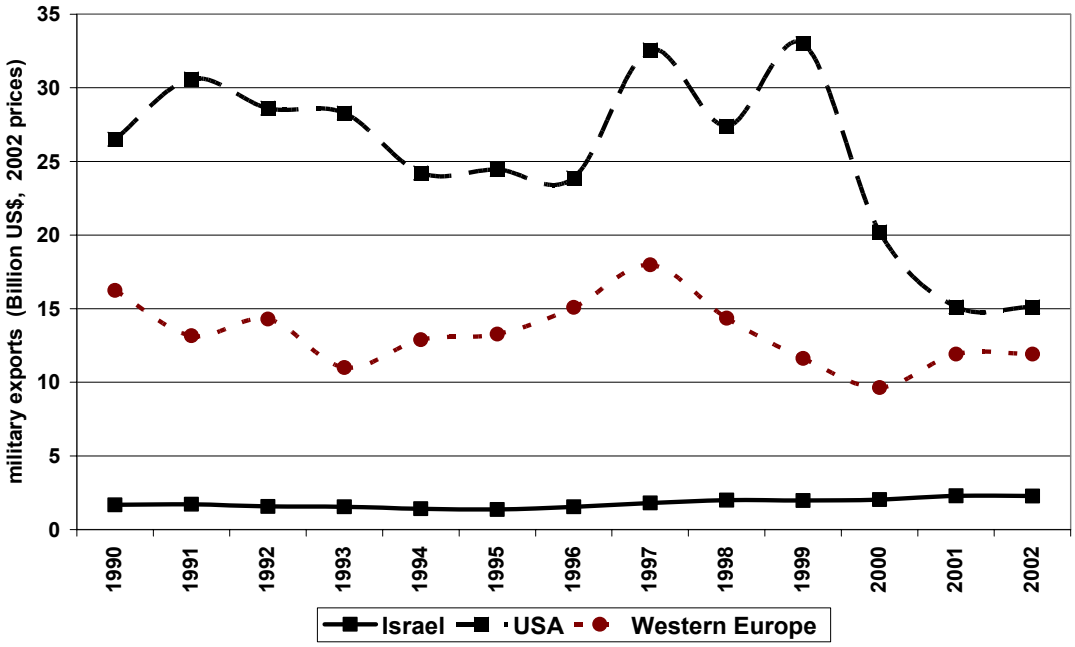
The decline in defense procurements and exports in the first half of the 1990s prompted the US government to adopt a new policy with regard to the structure of its defense industry, resulting in the formation of four huge defense firms in the USA between 1990 and 1998 (Lockheed Martin, Boeing, Northrop Grumman and Raytheon; see Mantin and Tishler, 2005). A similar process took place in Western Europe, though the pace was somewhat slower. It started in the 1980s with the emergence of national champions, and reached its peak in 1999, resulting in the formation of three large intra-European defense firms: BAE Systems, EADS and Thales (see The Economist, 2002, SIPRI 2000, Dunne and Smith, 2001). European countries have been purchasing European-made defense systems (James, 2000, Lovering, 2000), while the USA enforces a "buy American" policy (Flamm, 2000, Markusen, 2000). Thus, the "buy local" policy of the major arms-producing countries has meant that almost all of the procurements in the USA and Western Europe have been from the local industry. It also means that global arms exports are much smaller than global procurements. Figures 2 and 3 present the military procurements and exports of the USA, Western Europe and Israel during 1990 and 2002. .

Figure 2: Military procurements of the USA, Western Europe and Israel during 1990-2002



Source: SIPRI 2001, 2003; WMEAT 2003; Shefi 2004.

Figure 3: Military exports of the USA, Western Europe and Israel during 1990-2002



Source: SIPRI 2001, 2003; WMEAT 2003; Shefi 2004.

3. The Israeli Defense Industry and the US Foreign Military Aid to Israel

3.a The Israeli Defense Industry

The Israeli defense industry was established during the early 1920s[11]. In the 1950s, following the creation of the state of Israel, the defense industry was developed primarily by establishing new government-owned organizations. An R&D division was established in 1952 within the Ministry of Defense (MOD), and was reorganized in 1958 as a separate entity, Rafael (the Armament Development Authority), which over the years turned into Israel's central defense development organization. Bedek, established in 1953 for the purpose of maintaining and refurbishing aircraft, later developed into the Israel Aircraft Industries (IAI). Several refurbishing and maintenance centers were also established within the army for the purpose of maintaining armored and support vehicles. Some privately owned defense firms were also founded during the 1950s. The rapid growth of the Israeli economy that followed the 1967 Six Day War prepared the ground for the subsequent continuous growth of the defense industry of the next two decades. This rapid growth was due mainly to the large increase in internal demand (especially after the 1973 Yom Kippur War), the French embargo on the Israeli army (initiated during the Six Day War) and the difficulties that Israel experienced in purchasing modern weapon systems and platforms from the West. The growth of Israel's defense industry from 1976 to 1985 was based mainly on a tenfold increase in defense exports during this period (Lifshitz, 2003). The major spurt to the Israeli defense industry occurred in the late 1960s and early 1970s when the local industry was called on to develop entirely new weapon systems. Since then, the Israeli defense industry has developed a fighter

[11] The first part of this section is based on Dvir and Tishler (2000) and Lifshitz (2003).

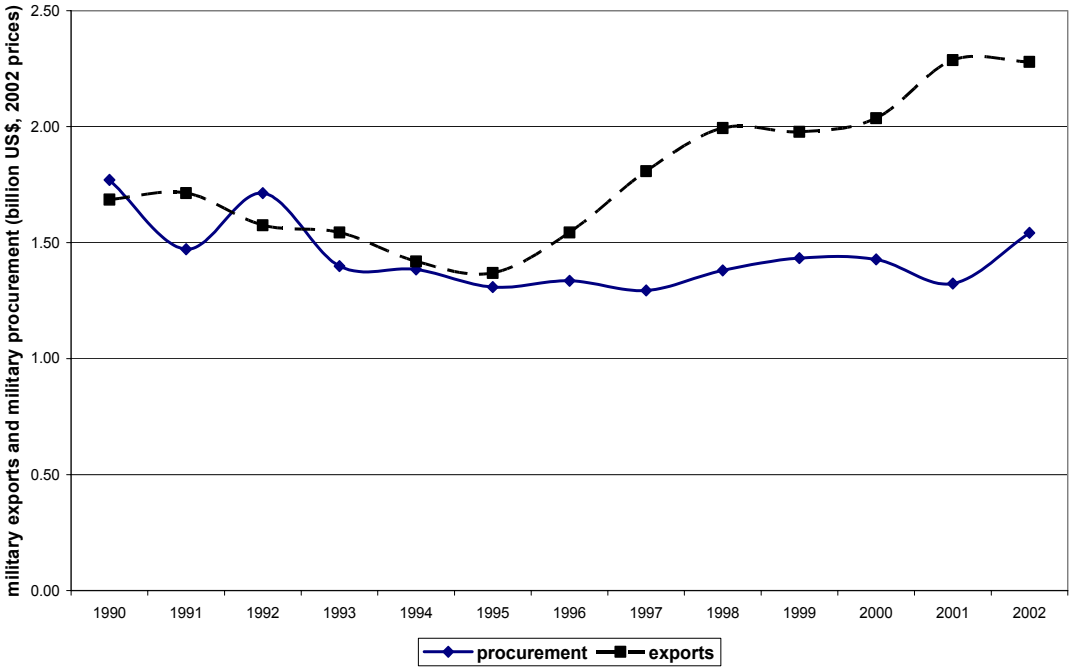
plane (the “Lavi”), unmanned airborne vehicles (UAVs), a modern main battle tank (the Merkava), missile boats, various types of air-to-air, air-to-ground and ground-to-ground missiles, intelligence and command and control systems, air defense systems, and various communication and intelligence space craft. The slow-down in the growth of the defense industry, which started in the mid-1980s, turned into a severe crisis at the beginning of the 1990s, following the termination of the Cold War and the signing of peace treaties between Israel and several of its Arab neighbors.

Currently, Israel's defense industry consists of about 150 firms. About 70% of the sales of the Israeli defense industry are exported. Israeli defense firms can be divided into three groups. The first group includes the three large government defense organizations – IAI, IMI (Israeli Military Industries – TAAS) and Rafael – which mainly develop and produce defense systems. The second group consists one large and several medium-size privately owned firms, most notably Elbit Systems, which concentrates almost entirely on defense products. Other firms in this group – such as ECI, Motorola and Tadiran – produce mainly civilian products (communication equipment), but have small defense system divisions. The third group consists of relatively small, privately owned firms, each producing a narrow line of defense products. Beside the three groups mentioned above, there are several large refurbishment and maintenance centers which are part of the army's Division of Technology and Logistics. Table 1 provides information on the sales, number of employees and areas of expertise of Israel's six largest defense firms.

The Israeli government is heavily involved in the defense industry, being the owner of some of the main defense organizations and, at the same time, acting as the industry's main customer. The government also controls the defense exports via a special division in the Ministry of Defense, which is in charge of authorizing exports

of classified products. The relations between the military and the defense firms are very close, mainly because Israel is a small country, almost all its citizens share a common background of military service, and the number of engineering schools is small. Over the years, these close relations have enabled the development of some unique weapon systems suitable to the particular conditions in the Middle East and to the special needs of the Israeli Defense Forces (IDF). Figure 4 shows the levels of defense procurement and defense exports for Israel during 1990-2002.

Figure 4: Military procurement of the Israeli government and Israeli defense and exports during 1990-2002



Source: Shefi 2004.

The Israeli defense industry suffers from two major problems. First, the Israeli defense firms are small in comparison to their large US and European counterparts, and thus suffer the considerable disadvantage of competing in the world defense market against firms that can more easily market their products worldwide. Second,

several Israeli firms with similar technologies are competing fiercely among themselves for the same international markets. Although these Israeli defense firms have made several efforts to collaborate over the last several years in order to acquire more contracts abroad, the trend of mergers which can be clearly seen over the last decade in US and European defense firms is not evident in the Israeli case.

3.b The US Defense Aid to Israel

The Israeli and the US defense systems have an extensive and complex relationship that spans over almost all facets of possible relations between two sovereign countries. The US military aid to Israel, which totaled more then 45 billion US$ (in 2003 prices) from 1948 to 2003, can be classified into three distinctive periods, according to its form and volume and the political circumstances prevailing at the time it was provided. Until the beginning of the 1970s, the total US aid to Israel was rather small, averaging about 63 million US$ per year. Its volume was substantially increased during the 1970s, to about 600 million US$ per year. Following the Israeli withdrawal from Sinai, it was further increased to about 2 billion US$ annually. Thus, since the late 1970s, Israel has become the major foreign aid receiver from the US foreign aid program (Israel receives about 50% of total American Foreign Military Funding and about 25% of total American Economic Support Funding).

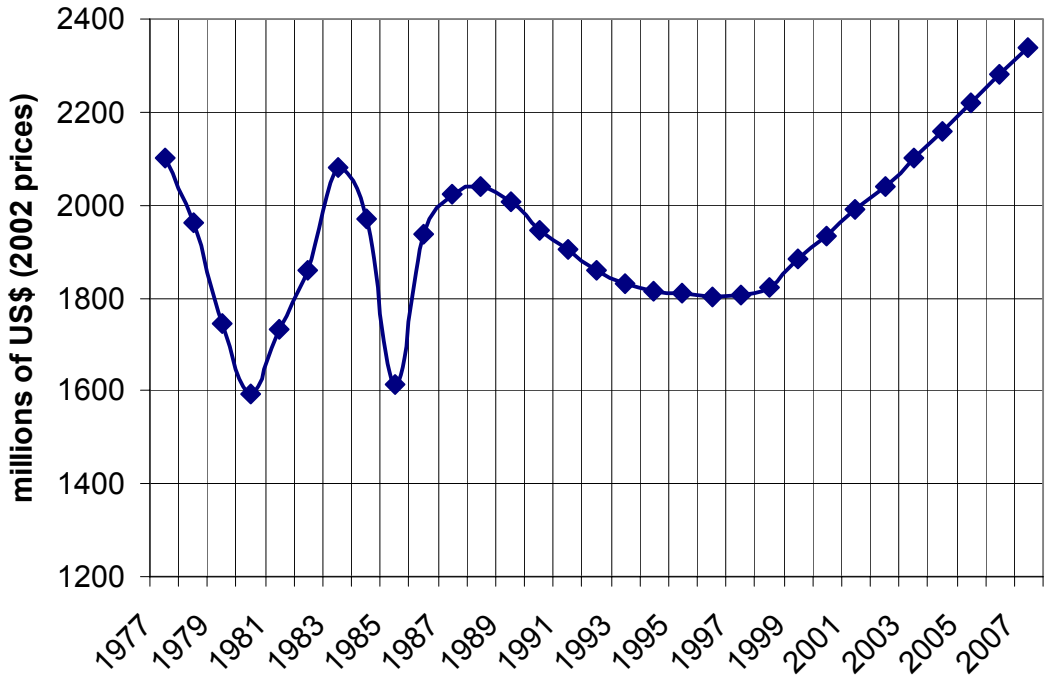
Table 1: Sales, number of employees and areas of expertise of Israel's six largest defense firms in 2001

	Number of Employees	Sales (billions of US$, 2001 prices)	
IAI Israel Aircraft Industries	12,000	1,760	Maintenance and refurbishment of military aircraft and helicopters; UAVs; intelligence systems; space systems; theatre ballistic missiles and defense systems; naval attack and defense systems; air-to-ground weapons; air defense systems.
Rafael	4,815	720	Air-to-air missiles; air-to-surface weapons; air defense; infantry weapons; anti-armor missile systems; combat vehicles systems; naval weapon systems; electronic warfare; targeting systems; naval combat suits; command & control systems; space propulsion; micro satellites; satellite launchers.
IMI (TAAS) Israeli Military Industries	3,747	386	Heavy ammunition; aircraft systems; rocket systems; smart weapon systems; electronic equipment; weapons & armored fighting vehicles; small arms, small arms ammunition.
Elbit	5,000	718	Aircraft & helicopter upgrades and systems; helmet mounted systems; combat vehicles upgrades and systems; UAV's; battlefield information systems; sensors & countermeasures; intelligence, surveillance and reconnaissance.
Elta (daughter comp. of IAI)	2,498	378	Radars; sigint systems; airborne early warning systems.
Elisra (partially government owned)	1,530	288	Self protection suits for fighter jets and helicopters; comint and elint systems; battlefield management and control systems, theater missile defense system; microwave sub-systems and components.

During this period, there have been several special additions to the annual foreign military support given to Israel, most notably the support for the redeployment in Sinai (1979), special support for Israeli redeployment due to the Wye agreement (2000), and the special support for the war in Iraq (2003). Moreover, since 1998, due to a special agreement between the two governments, there has been an annual reduction of the American Civilian Economic Support Fund (1,200 million US$ in 1998) and an annual increase in the American Foreign Military Support to compensate for half of the reduction. Thus, by the year 2008, the entire Civilian Economic Support to Israel will be nullified and Foreign Military Support will stabilize at 2,400 million US$.

Most of the US foreign aid to Israel is in the form of Foreign Military Support (FMS), provided in the form of "coupons" that gives Israel the right to purchase US military systems up to the amount of the aid. These funds are used to purchase both major items (such as main defense platforms) and non-major items (such as jet fuel). For the last several years, about 25% of the FMS has been converted into Israeli currency for use by Israel as a supplement to its own military budget sources. Other support methods include Special Military Support (such as special support for counter-terrorism activities), Special Military Gifts (which mainly include US military surplus items) and the interest that the FMS accumulates due to pre-depositing it in special US funds. Figure 5 presents the development of the US FMS to Israel from 1977 to 2004.

Figure 5: The US foreign military aid to Israel during 1977-2004



Source: www.dsca.osd.mil; www.fas.org

4. The Model

The model of this paper describes the optimal behavior of the defense industries in three developed countries, country ***A*** (representing Israel) and countries ***B*** and ***C*** (representing the USA and Western Europe, respectively)[12]. The products of the defense firms are substitutes (they may be similar, but they are not identical). The product, the defense good, of each firm is an aggregate of modern platforms (fighter planes, missiles, integrated weapon and intelligence systems, etc.) and their

[12] This model extends the model of Mantin and Tishler (2005) which included only two (similar) large countries (the USA and Western Europe). The third country in this paper is "small" (see text for a definition of a small country). Extending the model to include several additional countries, large or small, would complicate the presentation but would not change the nature of the results.

peripherals, as well as sophisticated munitions and other high-tech equipment. We denote the output of the defense industry in country *i*, *i*=***A***,***B***,***C*** ,by x_i. The "rest of the world", denoted *W*, includes all the other countries in the world. There is no production of defense goods in the rest of the world. Countries ***A, B*** and ***C*** are not enemies, but they may have enemies or potential enemies in the rest of the world. The rest of the world features downward-sloping demand functions for the defense goods that are produced by the defense firms in countries ***A***, ***B*** and ***C***. There are *k*, *n* and *m* defense firms in countries ***A, B*** and ***C***, respectively. We denote:

x_{ij}^i - procurement of government *i* from its *j*-th defense firm.

x_{ij}^W - exports (to the rest of the world) of the *j*-th firm in country *i*.

$x_{ij} \equiv x_{ij}^i + x_{ij}^W$ - total production of firm *j* in country *i*.

$x_i \equiv \sum_j x_{ij}$ - total production of the defense industry in country *i*.

Finally, let $x_i^i \equiv \sum_j x_{ij}^i$; $x_i^W \equiv \sum_j x_{ij}^W$; $x_i \equiv x_i^i + x_i^W$, *i*=***A***, ***B***, ***C***.

The defense industry in country *i* (*i*=***A***, ***B, C***) must satisfy local demand by its government (x_i^i) before it is allowed to export the defense good to the "rest of the world" (x_i^W). The governments of ***A, B*** and ***C*** purchase the defense goods only from the local defense industry. In addition, we assume that country ***B*** (USA) is committed to send military aid to country ***A*** (Israel). The amount of this aid, *G*, which is given in the form of defense goods produced in country ***B***, is exogenous to the model.

Security in each of the arms-producing countries is a function of the size of the country's stock of weapon systems relative to the stock of weapons of its potential

enemies. Thus, the security, S_i, of country *i* is dependent on the amount of the defense good procured by country *i*, and the amount of the defense good procured by the "rest of the world" (sold by the defense industries of ***A***, ***B*** and ***C*** to the "rest of the world"). That is, the security levels of the arms-producing countries are as follows:

$$S_A = \frac{x_A^A + \lambda G}{x_A^W + x_B^W + x_C^W}, \tag{1a}$$

$$S_B = \frac{x_B^B}{x_A^W + x_B^W + x_C^W}, \tag{1b}$$

$$S_C = \frac{x_C^C}{x_A^W + x_B^W + x_C^W}. \tag{1c}$$

Note that the procurement of country ***A*** (Israel in our model) includes the aid it receives from country ***B*** (the USA in our model). The parameter λ denotes country ***A***'s perception of the quality of the defense goods of country B (relative to those produced by its own defense industry).

The *target* security level of country *i* ($S_i^0 \geq 0$) is determined by military and political decision makers who assess the country's potential enemies. The *target* security levels are exogenously given in this model[13].

[13]In the model we assume that the defense goods exhibit the same quality (and that the quantities of all the defense goods are measured in the same units). The definition of security is somewhat different when the defense goods produced in country ***A*** are different in quality from those produced in country ***B*** or ***C***. This extension can be handled as follows. Denote by ω_B and ω_C the quality of the defense goods produced in ***B*** and ***C***, respectively**,** relative to those produced in ***A*** (that is, ***A***'s quality equals 1). In this case expressions (1a), (1b) and (1c) become $S_A = (x_A^A + \lambda\omega_B G)/(x_A^W + \omega_B x_B^W + \omega_C x_C^W)$, $S_B = \omega_B x_B^B/(x_A^W + \omega_B x_B^W + \omega_C x_C^W)$ and $S_C = \omega_C x_C^C/(x_A^W + \omega_B x_B^W + \omega_C x_C^W)$, respectively. It is

The "rest of the world" features the following demand functions for the defense goods that are produced by the defense industries of countries ***A***, ***B*** and ***C***:

$$x_{Ai}^{W} = a_{Ai0} + \sum_{j=1}^{k} a_{AAij} p_j + \sum_{j=1}^{n} a_{ABij} q_j + \sum_{j=1}^{m} a_{ACij} v_j \qquad i = 1,....,k\,, \tag{2a}$$

$$x_{Bi}^{W} = a_{Bi0} + \sum_{j=1}^{k} a_{BAij} p_j + \sum_{j=1}^{n} a_{BBij} q_j + \sum_{j=1}^{m} a_{BCij} v_j \qquad i = 1,....,n\,, \tag{2b}$$

$$x_{Ci}^{W} = a_{Ci0} + \sum_{j=1}^{k} a_{CAij} p_j + \sum_{j=1}^{n} a_{CBij} q_j + \sum_{j=1}^{m} a_{CCij} v_j \qquad i = 1,....,m\,, \tag{2c}$$

where p_i, q_j and v_k are the unit prices of the defense goods of the *i*-th firm in country ***A***, the *j*-th firm in country ***B*** and the *k*-th firm in country ***C***, respectively. The parameters $a_{Mi0} > 0$, $a_{MMii} < 0$, $a_{MMij} > 0 \ \forall j \neq i$, $a_{MNij} > 0 \ \forall M \neq N$, (*M,N*=***A***,***B***,***C***) are known constants. We further assume that the value of the own-price effect in each demand function is larger, in absolute value, than the sum of all the cross-price effects. That is,

$$|a_{AAii}| > \left|\sum_{j=1, j\neq i}^{k} a_{AAij}\right| + \left|\sum_{j=1}^{n} a_{ABij}\right| + \left|\sum_{j=1}^{m} a_{ACij}\right|, |a_{BBii}| > \left|\sum_{j=1, j\neq i}^{n} a_{BBij}\right| + \left|\sum_{j=1}^{k} a_{BAij}\right| + \left|\sum_{j=1}^{m} a_{BCij}\right|,$$
$$|a_{CCii}| > \left|\sum_{j=1, j\neq i}^{m} a_{CCij}\right| + \left|\sum_{j=1}^{k} a_{CAij}\right| + \left|\sum_{j=1}^{n} a_{CBij}\right|.$$

The inverse demand functions corresponding to (2a), (2b) and (2c) are given by:

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straightforward to further extend the model to allow each country to exhibit a different perception of the quality of its defense goods relative to the defense goods produced by the other countries. The results of the model with differentiated qualities are similar in nature to those of a model without differentiated qualities, though somewhat more complicated. To simplify the analysis and presentation, we proceed to analyze differentiated defense products with similar qualities.

$$p_i = \alpha_{Ai0} + \sum_{j=1}^{k} \alpha_{AAij} x_{Aj}^W + \sum_{j=1}^{n} \alpha_{ABij} x_{Bj}^W + \sum_{j=1}^{m} \alpha_{ACij} x_{Cj}^W \qquad i = 1,....,k\,. \tag{3a}$$

$$q_i = \alpha_{Bi0} + \sum_{j=1}^{k} \alpha_{BAij} x_{Aj}^W + \sum_{j=1}^{n} \alpha_{BBij} x_{Bj}^W + \sum_{j=1}^{m} \alpha_{BCij} x_{Cj}^W \qquad i = 1,.....,n\ . \tag{3b}$$

$$v_i = \alpha_{Ci0} + \sum_{j=1}^{k} \alpha_{CAij} x_{Aj}^W + \sum_{j=1}^{n} \alpha_{CBij} x_{Bj}^W + \sum_{j=1}^{m} \alpha_{CCij} x_{Cj}^W \qquad i = 1,....,m\,, \tag{3c}$$

where $\alpha_{Mi0} > 0$, $\alpha_{MMii} < 0$, $\alpha_{MMij} < 0 \ \forall j \neq i$, $\alpha_{MNij} < 0 \ \forall M \neq N$, (for M,N=A,B,C) are constant parameters[14].

The technology of firm j in country i (i=***A***, ***B***, ***C***) is represented by the following cost function:

$$C_{ij} = C_{i1j} + C_{i2j}\ , \tag{4a}$$

where C_{i1j} denotes the cost function of the production stage, and C_{i2j} denotes the cost function of the marketing stage. There is no reason to suppose that the production techniques, and hence the cost function of the production stage, are very different in countries ***A***, ***B*** and ***C***. Thus, following Mantin and Tishler (2005) we assume linear cost functions at the production stage. However, marketing advanced weapon systems to a small group of customers (governments are the only relevant customers for such weapon systems) may be a difficult task for the smaller country. In practice, marketing of weapon systems normally involves the active help, as well as the economic and political leverage, of the governments of the arms-producing countries. This implies that marketing is more costly for the smaller country. Thus, we assume

[14] The signs of the parameters of the inverse demand functions (3) are derived from the assumptions on the parameters of the demand functions (2).

that the cost functions of the marketing stage of the large arms-producing countries (***B*** and ***C***) are linear, while the cost function of the marketing stage of the small country (***A***) is quadratic. Formally, the cost functions in the production stage are:

$$C_{i1j} = c_{i1j0} + c_{i1j1} \cdot x_{ij} \ , \quad i = A, B, C \ , \tag{4b}$$

where c_{i1jk} are constant parameters, j denotes the firm index and x_{Bj} includes the military aid to Israel. The cost functions in the marketing stage are:

$$\begin{aligned} C_{A2j} &= c_{A2j0} + c_{A2j1} \cdot x_{ij}^{W} + c_{A2j2} \cdot (x_{ij}^{W})^2 \\ & \qquad , \\ C_{i2j} &= c_{i2j0} + c_{i2j1} \cdot x_{ij}^{W} \ , \ i = B, C \end{aligned} \tag{4c}$$

where c_{i2jk} are constant parameters .

Following the model presented in Golde and Tishler (2002) and Mantin and Tishler (2005), the decisions in this model are taken in the following order:

Stage 1 – conditional on the values of the S_i^0s, the governments of the arms-producing countries commit themselves, simultaneously and non-cooperatively, to the amounts of the defense goods that they will purchase from their defense industries. That is, each country seeks to make its actual security level, S_i , match its target security level S_i^0.

Stage 2 – given the commitments of the arms-producing governments to purchase the defense good from their own defense industries, and the rest of the world's

demand functions for the defense goods, the defense firms in countries ***A, B*** and ***C*** determine the exports of their defense goods in order to maximize their profits. Specifically, the firms in countries ***A, B*** and ***C*** play a Cournot game to decide on the quantities of the defense goods that they would like to export to the rest of the world.

5. The Solution of the Model

The model is solved in two steps. First we solve the Cournot game among the defense firms. Then, given the reaction functions of the firms, the governments of ***A, B*** and ***C*** determine their optimal purchase of the defense good (their commitment levels) such that the initial security measures, S_i^0, are simultaneously attained in both countries.

In the following analysis we assume that the governments of ***A, B*** and ***C*** are paying the world price for their purchase of the defense goods from their own industries[15]. Thus, the profit functions of the defense firms in countries ***A, B*** and ***C***, respectively, are given by:

$$\pi_{Ai} = p_i(x_{Ai}^W + x_{Ai}^A) - C_{Ai} = \\ = (\alpha_{Ai0} + \sum_{j=1}^{k} \alpha_{AAij} x_{Ai}^W + \sum_{j=1}^{n} \alpha_{ABij} x_{Bi}^W + \sum_{j=1}^{m} \alpha_{ACij} x_{Ci}^W)(x_{Ai}^W + x_{Ai}^A) - C_{Ai} \quad , \tag{5a}$$

$$\pi_{Bi} = q_i(x_{Bi}^W + x_{Bi}^B + G_i) - C_{Bi} = \\ = (\alpha_{Bi0} + \sum_{j=1}^{k} \alpha_{BAij} x_{Ai}^W + \sum_{j=1}^{n} \alpha_{BBij} x_{Bi}^W + \sum_{j=1}^{m} \alpha_{BCij} x_{Ci}^W)(x_{Bi}^W + x_{Bi}^B + G_i) - C_{Bi} \quad , \tag{5b}$$

[15] See Mantin and Tishler (2005) for a discussion of this and other pricing rules.

$$\pi_{Ci} = v_i(x_{Ci}^W + x_{Ci}^C) - C_{Ci} =$$
$$= (\alpha_{Ci0} + \sum_{j=1}^{k} \alpha_{CAij} x_{Ai}^W + \sum_{j=1}^{n} \alpha_{CBij} x_{Bi}^W + \sum_{j=1}^{m} \alpha_{CCij} x_{Ci}^W)(x_{Ci}^W + x_{Ci}^C) - C_{Ci} \quad . \tag{5c}$$

Solution of stage 2

The solution of the second stage of the model is as follows. Solving $\partial \pi_{Mi} / \partial x_{Mi}^W = 0, M = A, B, C$ (conditional on the exports of the defense goods of the rest of the firms in ***A, B*** and ***C*** and the demand functions of the rest of the world), and assuming that all firms within each country are identical (but possibly different than the firms in the other two countries), yields the following solution of stage 2 (the optimal exports of the defense goods produced by the firms in countries ***A , B*** and ***C*** as functions of the commitments of the governments of ***A, B*** and ***C***):

$$x_A^W = kF_{A0} + F_{A1} x_A^A + \frac{k}{n} F_{A2}(x_B^B + G) + \frac{k}{m} F_{A3} x_C^C \ , \tag{6a}$$

$$x_B^W = nF_{B0} + \frac{n}{k} F_{B1} x_A^A + F_{B2}(x_B^B + G) + \frac{n}{m} F_{B3} x_C^C \ , \tag{6b}$$

$$x_C^W = mF_{C0} + \frac{m}{k} F_{C1} x_A^A + \frac{m}{n} F_{C2}(x_B^B + G) + F_{C3} x_C^C \ , \tag{6c}$$

where the constant parameters F_{Mi} are simple functions of the basic parameters of the demand functions (2) and the cost functions (4)[16].

Solution of stage 1

Substituting the solutions of the optimal exports (expression (6)) in stage 2 into the security functions (1) and solving for x_A^A , x_B^B and x_C^C yields:

[16] The detailed expressions of the parameters F_{ij} and the evaluation of their signs appear in Shefi (2004).

$$x_A^A = \frac{D_0 S_A^0 + [\lambda(D_2 S_B^0 + D_3 S_C^0 - 1) + S_A^0 D_2]G}{1 - S_A^0 D_1 - S_B^0 D_2 - S_C^0 D_3} \ , \tag{7a}$$

$$x_B^B = \frac{D_0 S_B^0 + (D_2 - \lambda D_1) G S_B^0}{1 - S_A^0 D_1 - S_B^0 D_2 - S_C^0 D_3} \ , \tag{7b}$$

$$x_C^C = \frac{D_0 S_C^0 + (D_2 - \lambda D_1) G S_C^0}{1 - S_A^0 D_1 - S_B^0 D_2 - S_C^0 D_3} \ , \tag{7c}$$

where the constant parameters $D_0 > 0$, $D_i < 0$, $i = 1,2,,3$ are simple functions of the basic parameters of the demand functions (2) and the cost functions (4)[17].

6. Analysis of the Model: Analytical Results under Partial Symmetry[18]

The large number of basic parameters in the setup of the model[19] makes its analysis complicated and cumbersome, with results that are often dependent on the values of the parameters. Therefore, in this section we present analytical results for restricted versions of the model. First, adopting a procedure that is common in the literature (see, among others, Garcia-Alonso, 1999; Levine and Smith, 1997; Mantin and Tishler, 2005), we impose symmetry. However, we continue to maintain the differences among the three countries. Thus, the symmetry is only partial, as follows: (i) the rest of the world's demand functions for the defense goods for firms of the same country are identical, and (ii) the cost functions of all firms from the same

[17] The detailed expressions of the parameters D_i and the evaluation of their signs appear in Shefi (2004).

[18] The results presented in this section are similar to those in Mantin and Tishler (2005). Detailed results for changes in the parameters of the small country appear in Section 7.

[19] The general model includes: (a) *k*+*n*+*m* demand functions, each with *k*+*n*+*m*+*1* parameters, and (b) *k*+*m*+*n* marginal cost functions with a total of *2k*+*m*+*n* parameters.

country are identical. Now, straightforward analysis of expressions (6) and (7) yields the effects of changes in the target security levels on the production in and exports of the arms-producing countries, as shown in ***Result 1***.

Result 1:

An increase in the target security level in one arms-producing country leads to higher production, but lower exports, in that country, and lower production, but higher exports, in the other two countries.

In the rest of this section we assume symmetry and identical target security levels in ***A, B* and *C*** ($S_A^0 = S_B^0 \equiv S_C^0 = S^0$).

Result 2:

An increase in the target security levels in ***A, B*** and ***C*** implies:

- An increase in the profits of the defense firms in ***A, B*** and ***C***.
- An increase in government expenditure on defense in ***A, B*** and ***C***.
- An increase in net defense costs in ***A, B*** and ***C***.

The increase in the target security levels in ***A, B*** and ***C*** induces the arms-producing countries to increase their purchases of the defense goods from their local industries which, in turn, causes an increase in the world prices of the various defense goods, a subsequent decline (due to the increase in price) in the quantities demanded by the rest of the world (a decline in exports) and an increase in the defense firms' profits. The increase in government expenditure is, mostly, larger than the increase in the profits of the defense firms, yielding an increase in the net defense costs of the arms-producing countries.

Next, we analyze the effect of an increase in the level of the rest of the world's demand for the defense goods (an increase in the a_{Mi0} in the demand functions (2)). This increase may be the result of an increase in regional conflicts, or, for example, due to an increase in the GDP of countries in the rest of the world.

Result 3:

An increase in the level of demand for the defense goods implies:

- An increase in the profits of the defense firms in ***A, B*** and ***C***.
- An increase in government expenditure on defense in ***A, B*** and ***C***.
- An increase in the arms-producing countries' net defense cost.

The increase in the defense industry's profits is a straightforward result of the increase in demand. The increase in the government expenditures is due to the increase in the demand of the rest of the world and the requirement to maintain the target security levels. An increase in the rest of the world's demand for the defense goods is harmful to the arms-producing countries (it increases their net defense costs). The increase in the rest of the world's demand for the defense goods increases the profits of the firms that produce them but it also increases these countries' expenditure on the defense goods at a faster rate.

7. Applying the Model to Real Data

The effects of some of the exogenous variables on the model's solution are dependent on the model's parameters. Therefore, in order to better understand and predict trends in global arms markets, we apply the model to actual data. This section describes the use of actual data to calibrate the model's parameters for the year 2002,

and then uses the calibrated parameter values to assess the effects of changes in several exogenous variables on the model's solution.

In order to perform the calibration, we extracted US, Western European and Israeli annual data of arms procurement, arms exports and prices for the years 1990-2002. In addition, we obtained annual data on the US military aid to Israel during the same period[20]. In order to examine the long-term properties of these data sets, and reduce short-term (annual) random variability in the data[21] we divided the data into five observation points (for the years 1990-92, 1993-95, 1996-98, 1999-2000 and 2001-2002). The calibration of the model's parameters was carried out, in two stages, under the assumption of symmetry (the rest of the world's demand functions for all firms in each arms-producing country are identical; these demand functions differ across ***A***, ***B*** and ***C***), using the following steps (details are available from the authors upon request):

1. The numbers of firms in each arms producing country during 1990 and 2002 were as follows[22]:

	90-92	93-95	96-98	99-00	01-02
USA	8	6	4	4	4
Western Europe	6	6	5	4	4
Israel	4	4	4	4	4

[20] See Sections 2 and 3 for data sources and data limitations.

[21] This variability may be caused by accounting procedures or one-time large transactions (which are common in the arms market).

[22] The number of firms in the table represents actual trends. The calibration results were not sensitive to small variations in the number of firms over this period.

2. Real, quality adjusted, annual price increases were about 1.5%, 1% and 1.2% in Israel, the USA and Western Europe, respectively, during 1990-2002. The shares of marginal costs in prices were set equal to 0.5, 0.8 and 0.8 for Israel, the USA and Western Europe, respectively[23].

3. The security levels of the USA (about 2.7 in 2002) Western Europe (about 0.9 in 2002) and Israel (about 0.12 in 2002) were estimated using the data in SIPRI 2003 and the functional forms in expression (1).

4. The first stage of the calibration of the model employed three sets of functions which were solved simultaneously: the solution of the first stage (expression (7)), the solution of the second stage (expression (6)), and the inverse demand functions (expression (3)). Thus, we calibrated the model by estimating its basic parameters (the parameters of the demand functions (2) and the cost functions (4)) with five observations (the average data for 1990-1992, 1993-1995, 1996-1998, 1999-2000, 2001-2002) using, at the same time, the following regressions[24] (the terms u_j denote error terms): the solution of the first stage: $x_i^i = f(S_i^0, G) + u_1$, the reaction functions: $x_i^W = g(x_i^i, G) + u_2$, and the inverse demand functions: $p = h_A(x_i^W) + u_A$, $q = h_B(x_i^W) + u_B$, $v = h_C(x_i^W) + u_C$.

[23] See Kagan, Tishler and Weiss (2004) and Setter and Tishler (2004) for the estimates of the real price changes during 1990-2002, and Golde and Tishler (2002) for the estimates of the marginal costs of production during 1990-2000.

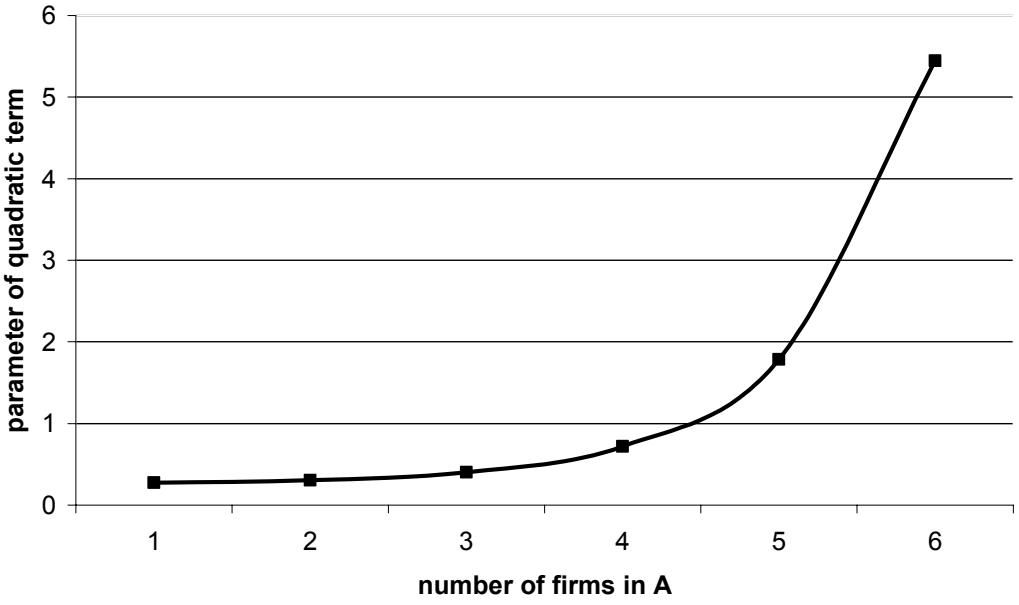
[24] The calibration used nine equations (expressions 3, 6 and 7 in the text), each with five observations, for a total of 45 data points, to calibrate the 12 parameters of the demand functions and 8 parameters of the cost functions (three linear terms which are fixed over time; five parameters of the quadratic term in the marketing cost of country ***A***, one parameter for each observation).

5. The functional form of the parameter of the quadratic term in the marketing cost function of each defense firm in ***A*** (Israel), denoted c_{A2j2} (see (4c)), was calibrated by using the estimates of c_{A2j2} obtained in step 4 above. This parameter was hypothesized to decline when the number of firms in ***A*** declines. That is, the marginal marketing cost of each firm in country ***A*** is smaller the smaller is the number of firms in ***A*** (and, hence, the larger is each firm in ***A***). However, the aggregate marginal marketing cost of ***A*** declines when the number of firms in ***A*** increases. There are many functions that may possess this property. For example, let k be the number of firms in country ***A*** and let c^k_{A2j2} be the parameter of the quadratic term in the marketing stage of the j-th firm in country ***A***. Then, $k > s$, implies that $(c^k_{A2j2} / c^s_{A2j2}) > (k/s) > 1$ and $k\,c^k_{A2j2} > s\,c^s_{A2j2}$. We specify the functional form of the parameter of the quadratic term in the marketing stage, of the j-th firm in country ***A***, as follows[25]: $c^k_{A2j2} = \gamma_1 \cdot (\textit{country leverage}) + (\gamma_2 / k)\,\theta^{\gamma_3 k}$, where $\gamma_1, \gamma_2, \gamma_3$ and θ are constant parameters, k is the number of firms in country ***A*** and the variable *country leverage* represents the leverage, or marketing power, of the government of country ***A*** relative to those of countries ***B*** and ***C***. *Country leverage* at period t is approximated by the exports of country ***A*** (in period t-1) divided by the average of the exports (in period t-1) of countries ***B*** and ***C***. Only one parameter, out of γ_2, γ_3 and θ, is identifiable since $k = 4$ for all five data points c_{A2j2} that were calibrated in the first stage. Thus, we set $\gamma_2 = 0.01$ and $\theta = 5.00$, and estimated γ_1 and γ_3 by least squares (over five observations) to obtain $\gamma_1 = 2.20$

[25] See Shefi (2004) for the mathematical derivation and properties of this functional form.

and $\gamma_3 = 0.87$. This set of parameters obeys the requirements specified above. Figure 6 presents the value of c_{A2j2} for $1 \le k \le 6$.

Figure 6: The value of c_{A2j2} for $1 \le k \le 6$



The calibrated parameters are used to analyze the effects of changes in the number of defense firms in Israel (country ***A***) and the size of the US (country ***B***) military aid to Israel and Israel's perception of the quality of the US military aid on the Israeli defense industry's exports and profits, and Israel's procurement of arms and net defense cost.

Figures 7 and 8 present the effects of changing the number of firms in Israel and the size of the US military aid to Israel, respectively, on the solution for Israel. The effects of these changes on the solution for the USA and Western Europe are negligible, due to the size of these countries relative to that of Israel and, hence, are omitted.

Generally, an increase in the number of Israeli defense firms has two conflicting effects[26]. First, it slightly reduces the price of the Israeli defense products since there are more Israeli (and overall) defense firms in the world market. Second, it increases the marginal marketing costs of each Israeli firm, and hence raises the price of the Israeli defense products. Currently there are four major Israeli defense firms (integrators). Reducing this number to three or two results in a decrease of the price of the Israeli defense goods (that is, the effect of the reduction in marginal cost dominates the effect of the reduction in the number of defense firms in Israel and worldwide). As a result, Israeli exports increase. This conclusion is reversed when the number of defense firms in Israel is one, causing a reduction in Israel's exports (that is, the effect of the reduction in the number of defense firms in Israel dominates the reduction in marginal marketing cost). Increasing the number of defense firms in Israel from four to five or more results in an increase in the price of the Israeli defense goods (that is, the fast increase in the marginal marketing cost of each Israeli firm dominates the rather small effect of the increase in the number of defense firms in Israel). The prices in the USA and Western Europe are practically unaffected by a small change in the number of firms in Israel (due to the small size of the Israeli firms relative to those in the other two countries). These prices, particularly the US price, change in the opposite direction to the Israeli price (the defense goods of Israel, the USA and Western Europe are substitutes). Overall, an increase in the number of Israeli defense firms reduces Israeli procurement since, on average, world prices decline somewhat and Israeli procurement (and the procurement of the USA and Western Europe) is proportional to world exports.

[26] See Perry and Porter (1985) on this issue.

Operating profits of the Israeli defense industry increase when the number of firms are reduced from four to three or less[27] (the decline in the marginal cost of marketing of each Israeli defense firm dominates the decline in the number of Israeli firms). Operating industry profits (in contrast to profits per firm) of the Israeli defense industry increase when the number of Israeli firms is larger than four (the number of defense firms dominates the increase in marginal cost of each firm). However, industry operating profits are maximal when the number of defense firms in Israel is one. Israel's net defense cost (government expenditure on defense minus the defense industry profits) is minimal when the number of Israeli defense firms is one. That is, Israel is better off having only one defense firm.

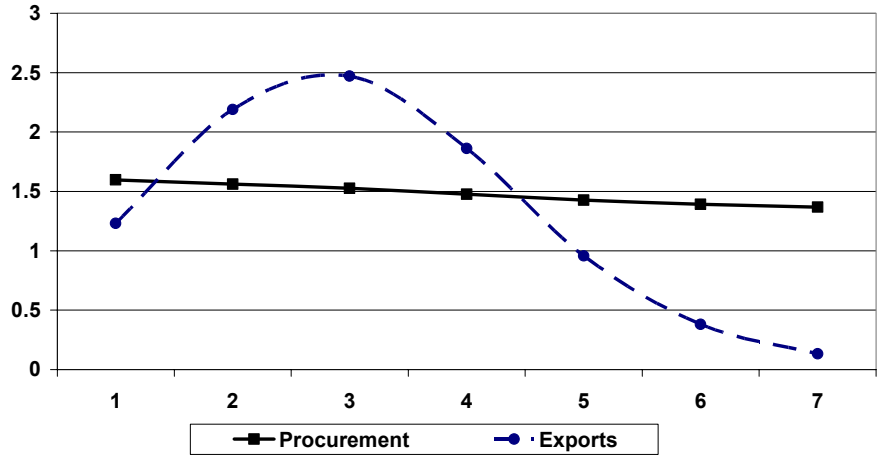
Changes in the US aid to Israel have only a minimal effect on the USA and Western Europe. They have, however, a large impact on Israel. The 2002 value of the US FMS to Israel was about 2 billion US$. As is evident from Figure 8, Israel's exports are unaffected (slightly increase) by the size of the US aid to Israel. Israel's procurement from its own defense industry declines when US aid increases, since this aid is a close substitute for local production. Consequently, the profits of Israel's defense industry decline too. Larger US military aid to Israel reduces government expenditure in Israel at a faster rate than the reduction in the Israeli defense industry's profits and, hence, reduces Israel's net defense cost.

Finally, a reduction (increase) in Israel's perception of the quality (usefulness) of the military aid it receives from the USA is similar to, but somewhat less pronounced than, the effect of a decrease (increase) in the size of the aid.

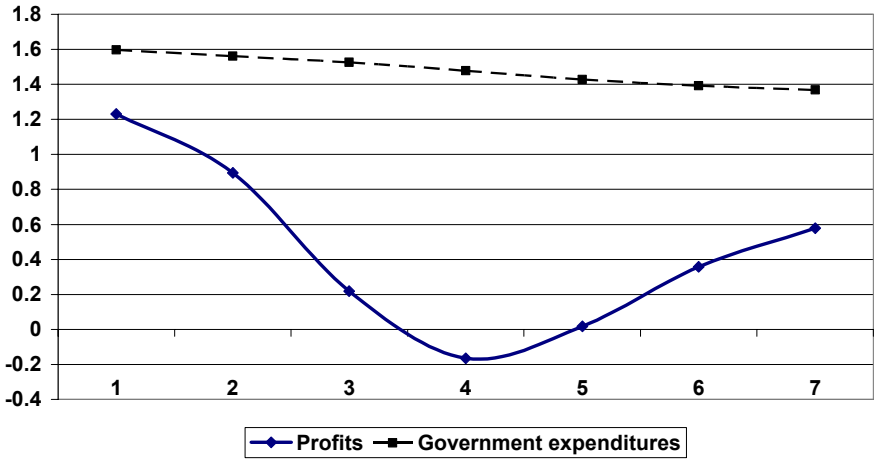
[27] This overall profit is larger when one takes into account fixed costs (per firm), which are ignored in the current analysis.

Figure 7:

Procurement by and exports of Israel as a function of the number of defense firms in Israel



Profits and government expenditure in Israel as a function of the number of defense firms in Israel



Net defense cost of Israel as a function of the number of defense firms in Israel

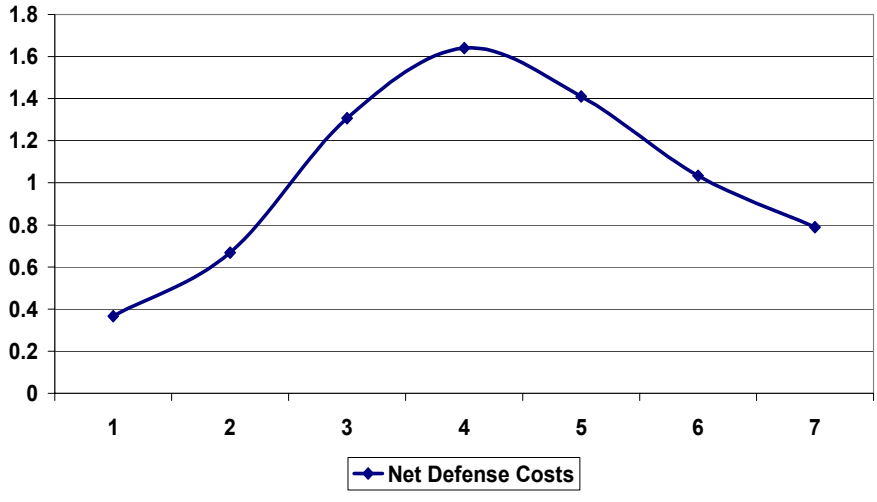
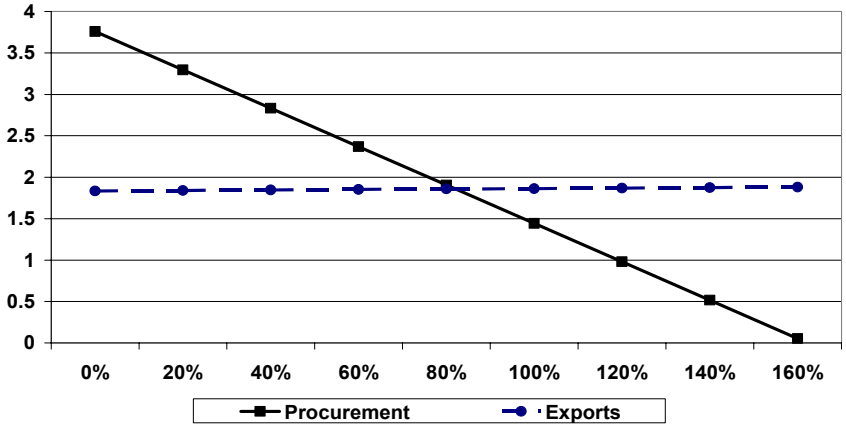
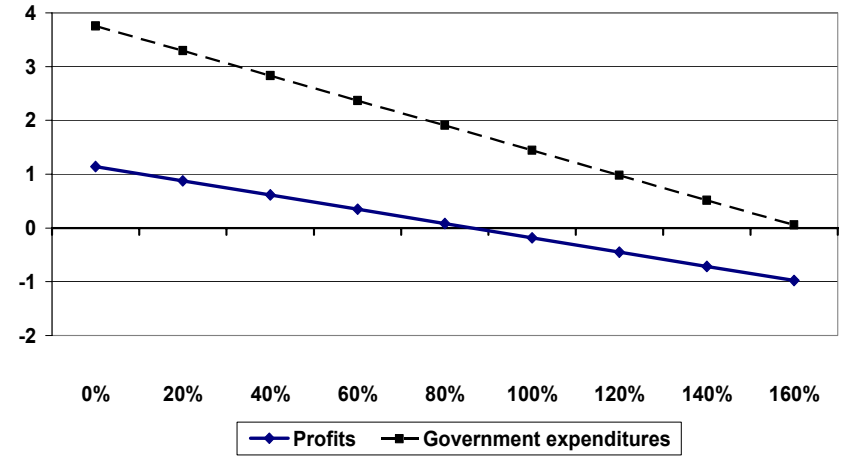


Figure 8:

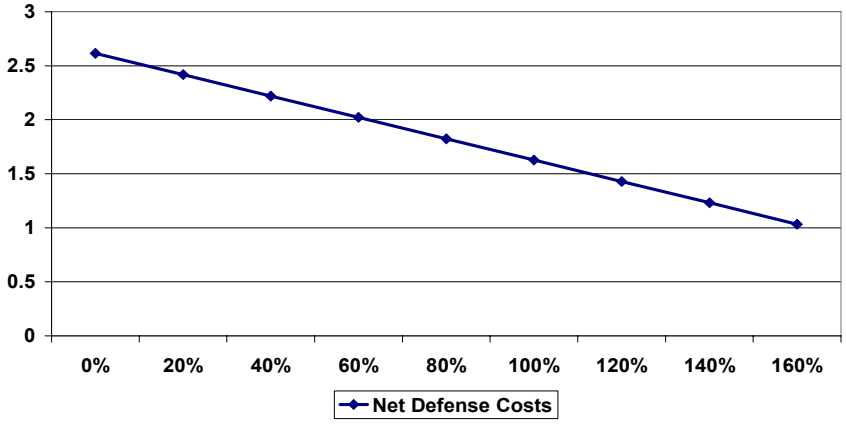
Procurement by and exports of Israel as a function of the size of the US aid to Israel



Profits and government expenditure in Israel as a function of the size of the US aid to Israel



Net defense cost of Israel as a function of the size of the US aid to Israel



8. Summary and Conclusions

This paper presents a model of the interactions between the choice of security levels in Israel, the USA and Western Europe, and the market structure of the world defense industry. The model assumes that the target security levels in the arms-producing countries are exogenously determined by military and political decision makers who evaluate the potential external threat to their countries. The decisions in this model are taken in two stages. In stage 1, each of the arms-producing governments commits itself to the amount of the defense good that it will purchase from its defense industry. In stage 2, given the commitments of the governments to purchase the defense good from their own defense industries, and the rest of the world's demands for the defense goods, the defense firms play a Cournot differentiated products game to decide on the exports (and, indirectly, on the prices) of the defense goods. There exists a unique solution to the game.

The results of the paper depend on the strategic interaction between market structure and security. The main results and the implied policy recommendations for Israel are as follows.

1. The net defense costs of Israel (its expenditure on defense minus the profits of its defense industry) are minimal when the number of defense firms in Israel is one. Thus, Israel is likely to gain from a consolidation of its defense industry, similarly to the consolidation that took place in the USA and Western Europe during the 1990s.

2. A future reduction in Israel's target security levels, such as occurred at the end of the Cold War, will decrease its purchase of defense goods. As a result, we will observe a decrease in Israel's defense expenditures, a reduction in its defense

industry's profit, and, generally, a decline in its net defense costs. An increase in Israel's target security level, such as occurred after the beginning of the Palestinian uprising (the Intifada) at the end of 2000, and again during Israel's preparation for the US-Iraq war in 2002, increases its purchase of the defense goods. As a result, we observe an increase in Israel's defense expenditures, an increase in Israel's defense industry's profit and, generally, a rise in net defense cost.

3. A rise in the rest of the world's demands for the defense goods (due, say, to increased regional conflicts or an increase in the rest of the world's GDP) increases exports of the defense goods to the rest of the world and equilibrium world prices. These changes, in turn, increase the defense industry's profits, but, at the same time, they also increase Israel's and the other arms-producing countries' net defense cost.

4. Increasing production costs and continuing consolidation of the defense industry act in favor of Israel, the USA and Western Europe insofar as these effects reduce their net defense costs. Thus, the trend would appear to be toward trans-Atlantic mergers and acquisitions, a consolidation in the Israeli defense industry and continuing investments by the USA, Western Europe and Israel in military R&D, aiming in part at raising world prices to a level that is likely to crowd out the rest of the world from the market for modern weapon systems. This outcome, in turn, forces countries in the rest of the world to develop and be prepared to use "cheap and dirty" weapon systems[28].

[28] The analysis of the Israeli-Syrian arms conflict in Kagan, Tishler and Weiss (2004) supports this conclusion.

5. The US military aid to Israel is beneficial to the Israeli economy in the short term, since it reduces Israel's net defense cost. However, this aid reduces the profits of the Israeli defense industry and may, in the long term, hurt the sustainability and viability of Israel's defense industry.

Finally, the simulation results of this paper are somewhat similar, though not identical, to those of Blume and Tishler (2001), who employ a similar model for the case of two symmetric large countries with a Cournot conjecture (in a market for a homogeneous defense good) in the second stage of the game, and to those of Golde and Tishler (2002), who use a similar model in the second stage of the game but a different objective function in the first stage of the game. This outcome suggests that the basic setup of the two-stage model, and the definition of security that we use here, are robust, even for the analysis of a small country like Israel. Furthermore, the model and simulation results for the USA and Western Europe are also in general agreement with those of Levine and Smith (1995, 1997, 2000), Garcia-Alonso (1999, 2000) and Mantin and Tishler (2005), which lends further support to the conclusions that we draw in this paper.

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