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Dans *Journal of Innovation Economics & Management* 2013/2 (N°12), Pages 37 à 57
Éditions *De Boeck Supérieur*
DOI 10.3917/jie.012.0037
DEFENCE, INNOVATION AND DEVELOPMENT: THE CASE OF ISRAEL

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The research on the macroeconomic impact of defence spending on the aggregate economy is still ambiguous, after almost 40 years of empirical analysis. Since Benoit’s pioneering paper (1978) in the major development journal, Economic Development and Cultural Change, there has been considerable debate in the literature about the relative positive and negative impact of military expenditure on economic growth. Deger and Sen (1995) survey the earlier literature while Aizenman and Glick (2006) analyse the role of conflict in this process. Most of the literature relies on cross sectional or panel data to demonstrate the channels through which the relationship operates. However, the nexus may be too complicated particularly for structurally diverse countries, for there to be a definitive impact of defence on development which can be demonstrated empirically. It may be more useful to look at single country studies and find whether defence has a positive or negative impact on development. In this paper we intend to look at Israel and ask whether military spending has had a net negative or positive effect on aggregate economic growth.

The overall consensus in the macro literature (Deger, Sen, 1995) is that military expenditure reduces economic growth, except for some exceptional circumstances and countries, if all inter-relationships are adequately accounted for. However, defence also has major spin-offs particularly for economies with a relatively large Defence Industrial Base, DIB (also known as
the defence industrial and technological base) which could have potential positive externalities for the civilian sectors in terms of scientific innovation and technological progress. If economies can capitalise on these positive spin-offs then military spending orientated towards procurement and R&D could tip the balance and demonstrate that the impact of militarisation is relatively more benign and positive.

Israel is relatively unique in the sense that it has emerged as a rapidly growing and relatively developed economy over the last six decades yet continues to have one of the highest military burden (military expenditure as share of GDP) in the world. At the same time it has received very high amounts of economic and military aid from the United States which in turn contribute to both a higher defence spending (through an effective subsidy via military aid) but also to its economic growth (via the multipliers that foreign assistance may provide). Further, Israel's defence industrialisation and its high ranking among developing countries in terms of its DIB, implies that the macroeconomy is capable of benefiting from the spin-offs that the innovations in the defence industry can bring to whole economy. If there is any one country where military spending would potentially increase economic growth, it should be Israel. Our paper therefore looks at this issue, from an econometric point of view, to see whether the aggregate impact is indeed positive.

Given the structure of the Israeli defence industry, and the role that military expenditure plays within a conflict-prone economy, one would expect that defence would have a positive impact on growth. The technology spin-off from high-tech industries would have a receptive relationship with civilian industries and there could be a reciprocal and virtuous interaction with human capital intensive industries feeding into the defence sector. In addition, as Aizenman and Glick (2006) point out, conflictual economies tend to gain more from defence since the military may be able to help in creating an enabling environment with secure property rights – all of which are good for growth. They consider the non-linear interaction between military expenditure and external threat and demonstrate that defence spending per se reduces growth but when it is accompanied by external conflict then the impact of military expenditure on growth may be positive. Clearly, there are few countries in the world as much affected by external threats as Israel, so one would intuitively expect, from this type of analysis, for defence to have a positive impact on growth. To summarise, all in all, if we could find a hypothetical country where the positive impact of military industrialisation and innovation would be found on GDP growth, in the shadow of conflict, it would be potentially a country such as Israel.
In this paper we concentrate on economic growth and its links with the defence sector. We appreciate that wider issues of development are important and that our emphasis on growth is relatively narrowly focussed. However, we agree with Lucas (1988) when he states: “By the problem of economic development I mean simply the problem of accounting for the observed pattern, across countries and across time, in levels and rates of growth of per capita income” Lucas (1988).

The paper is organised as follows. Section 2 gives us a background to the Israeli economy and military with special emphasis on the military industrial complex. Section 3 discusses the analytical framework within which the impact of defence on the macroeconomy may be estimated. Section 4 discusses the estimation methodology in the context of Israel and sets up the empirical model. Section 5 provides the econometrics results and a discussion of the parameters and their implication. Section 6 concludes with a brief analysis of the policy implications of the results for Israel.

STRUCTURE OF THE ISRAELI ECONOMY AND THE DEFENCE INDUSTRIAL BASE

Israel was accepted into the OECD in 2010, a remarkable achievement for a country which began as an underdeveloped economy riddled with external and internal conflict only 60 years ago. Israel is only the second country in the modern world which was a state created from a religious ideology (Pakistan is the other) but its growth outstrips any country of its age and size. It has always utilised a human capital intensive growth strategy and this is reflected in its remarkable education structure and facilities for higher education. It ranks very high in its quality of education, most international rankings put the country among the highest in the world order. R&D expenditure as a share of GDP is also one of the highest in the world, outstripping any other developing country. The importance that Israel places on science and technology is exemplified by its high density of scientists and technicians as a proportion of its population – again high enough to compete with any European country. There are over 59 Israeli companies which are listed on NASDAQ, a number higher than the combined total of the United Kingdom (32), France (9) and Germany (10) (see NASDAQ 2012, reference http://www.nasdaq.com/screening/regions.aspx).

Israel’s per capita income in comparable terms, purchasing power parity values, is around $31,000 which is not fundamentally different from the EU average ($34,000). Its economic growth performance is impressive averaging
4% per annum during the first decade of the 21st century (except the recessionary years of 2001-2002). It has a massive stock of human capital, and infrastructural investment, fuelled by foreign aid and investment, is exceptional. As mentioned earlier, Israel has now joined the OECD thus transiting to the status of a developed economy.

However, structural weaknesses remain. The percentage of the population below the poverty line is high at almost 24%; and income inequality is also high. The top 10% earn almost a quarter of GDP while the bottom 10% earn one-tenth of that sum. Public debt is far lower than Western countries and the government is strict in trying to balance the budget with a deficit of less than 3%. Israel is in a fortunate position of debt sustainability. It is a technologically advanced market economy, with a strong government, but with significant weaknesses such as dependence on foreign aid, lack of natural resources (except in recent years with the discovery of natural gas fields such as the Leviathan field), a sizeable section of the economy being poor as well as growing inequality. The growth of the labour force is high and this creates significant potential for structural unemployment as in many developing countries.

At the same time, Israel is one of the top ten countries in the world in terms of military expenditure as a share of GDP. Given strict controls over public debt, a conservative fiscal policy and the need for a low inflationary stable macroeconomy, Israel would have found it difficult to finance defence at a great cost to social welfare if it had not received quite massive military aid from the United States. Its military expenditure has remained almost constant over the decade in spite of budgetary retrenchment (see Table 1) although high growth in GDP has meant a decline in the share of national output spent on defence.

<table>
<thead>
<tr>
<th>Year</th>
<th>Military Spending (constant 2010 US $ million)</th>
<th>Military Burden (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>14,194</td>
<td>8.4</td>
</tr>
<tr>
<td>2002</td>
<td>15,971</td>
<td>9.6</td>
</tr>
<tr>
<td>2003</td>
<td>15,982</td>
<td>9.6</td>
</tr>
<tr>
<td>2004</td>
<td>15,275</td>
<td>8.7</td>
</tr>
<tr>
<td>2005</td>
<td>14,704</td>
<td>8.0</td>
</tr>
<tr>
<td>2006</td>
<td>15,668</td>
<td>8.1</td>
</tr>
<tr>
<td>2007</td>
<td>15,213</td>
<td>7.5</td>
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<tr>
<td>2008</td>
<td>14,610</td>
<td>7.1</td>
</tr>
<tr>
<td>2009</td>
<td>14,737</td>
<td>7.0</td>
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<tr>
<td>2010</td>
<td>14,242</td>
<td>6.5</td>
</tr>
<tr>
<td>2011</td>
<td>15,209</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Military aid, as well as civilian foreign assistance, has meant that Israel has faced the guns versus butter dilemma in a better shape than many other countries. Israel has historically received massive amounts of civilian aid from the United States although it has tended to fall in recent years given the growth successes of the Israeli economy. This has traditionally allowed the country to follow a strict budgetary policy with a conservative stance. Israel has maintained its low deficit/debt status partly as an effect of overseas financial assistance acting as a ‘manna from heaven’ resource boom for the government. Foreign remittances from private sector inflows via the financial sector has also avoided liquidity problems for the banking sector – a core factor in Israel’s avoidance of the problems faced by the Western banking sector after the advent of the financial crisis. Aid is of course a two edged sword, it can become a ‘resource curse’ as the Dutch disease literature showed. Large availability of funds in foreign currency reserves often appreciates the domestic currency which in turn leads to trade deficits, a negative multiplier effect as well as the decline of the traditional export sectors. In Western Europe this has often led to de-industrialisation. In the case of Israel, the agricultural sector may have suffered in the past since it is the country’s major exchange earner. However, since 2008, Israel has stopped receiving bilateral foreign aid (usually called Economic Support Fund, ESF). Given the expansion of the hi-tech sector, supported by US military co-operation and aid, Israel has leapfrogged into the realm of a developed country from its status, for over six decades, as an emerging economy.

However, there is little doubt that military aid has few of the problems that civilian aid has for the macroeconomy. It increases the amount of resources available to the military and has few ‘de-industrialisation’ effects. Rather, by protecting other elements of the budget (such as health or welfare spending), it allow the government to have a more efficient budgetary policy than it would have otherwise. Government debts need not have been built up in an unsustainable fashion and the budget deficit may be kept under manageable proportions. In the late part of the last decade, US military aid financed over 18% of the Israeli defence budget. It is expected that between FY 2009 and 2018, Israel will have received on average almost 3 billion dollars per annum as Foreign Military Financing (FMS). More important, Israel can spend more than a quarter of its FMS on domestic procurement which is a huge impetus for the defence industrial base of Israel. No other military aid recipient of the United States is allowed this benefit (Sharp (2009). It is noteworthy that all three of the highest recipient of US military aid in the world (Israel, Egypt and Pakistan) have a better budgetary and public debt position compared to other regional economies. Mearsheimer and Walt (2007) call the United States, ‘the great benefactor’, often in a sarcastic and
critical vein. However, the impact on Israel has been positive economically since this mighty aid budget has allowed Israel to invest in defence productivity and military industrial complex much more than it could have done under more ‘normal’ circumstances. Military aid is expected to provide a qualitative military edge (QME, see Sharp (2009) to the Israeli armed forces given its quantitative inferiority in the presence of its vastly larger Arab neighbours. But the emphasis on QME also means that Israel can invest in force modernisation, purchase of superior equipment, and enhancement of defence technology – all of which are expected to have economic benefits to the larger economy. Given that this aid may be used for defence related R&D, as well government procurement and purchases of military equipment from Israeli arms manufacturers themselves, the multiplier effect of military aid is far more positive than civilian aid. Overall, therefore, we would expect military aid to have a positive impact on economic growth.

Let us now concentrate on the defence industries. Although a nascent defence industrial base was initiated in the 1920s, the establishment of a formal Israeli defence industry followed the creation of the state of Israel in 1948. In the 1950s, fuelled by government led and owned defence organisations, Israel’s defence industrialisation began in full steam. Most importantly, right from the beginning, the government emphasised military-related R&D since Israel had a comparative advantage in human capital. In 1958, the military R&D units within the Ministry of Defence were organized as a separate unit called Rafael Advanced Defense Systems Ltd (or the Armaments Development Authority) which six decades later has become Israel’s central organisation for defence systems production, technology and research. At the same time, given Israel’s security needs, and its reliance on airpower, Bedek (established in the early 1950s) developed into the Israel Aerospace Industries, IAI (see http://www.iai.co.il/22031-en/Homepage.aspx) which like Hindustan Aeronautics Limited in India has had significant successes and failures in terms of indigenous aircraft development (including the ill-fated ‘Lavi’ – a modern military fighter plane – whose production was ultimately cancelled due to economic and political pressures). A fundamental spurt in defence industrialisation took place after the Yom Kippur war in 1973 given the spurt in domestic demand from the military, the continuing arms embargo from France as well as the restrictions on the purchase of sophisticated weapons from Europe and the United States. At a time when Israel's neighbours such as Syria and Egypt were buying off-the-shelf major weapons system from the Soviet Union, Israel by necessity went for domestic weapons development and production. Although the domestic market was expanding, it was still relatively small to be fundamentally cost effective, Israel had to rely on exports which increased ten times between the
mid 1970s to the mid 1980s (Lifshitz, 2003). Israel, in its defence industrialisation expansion tried to develop the Lavi fighter aircraft, succeeded in producing unmanned airborne vehicles (UAVs) as well as creating air defence systems and communication satellites which have dual usage both for civilian as well as military purposes. The multiplier effects on R&D, as well as on the high-tech end of manufacturing industries, were enormous.

Today the Israeli defence industry is one of the most well developed among emerging economies and can compete in niche markets with the best in the West. Rafael is an outstanding example. It has the capability to simultaneously design, develop and manufacture a wide range of high technology based defense systems for air, land, sea and space applications. Established as a state owned enterprise about five decades back, as part of the Ministry of Defence, it was incorporated (in the early part of this century) as a limited company to improve efficiency, and has flourished in terms of profitability and sales, with a huge export component. It is also a major investor in defence related R&D with almost 10% of its revenue re-invested into research. What is even more interesting is that although it is a major player in the DIB, it has formed partnerships with civilian companies to develop commercial applications based on its advanced technology over which it has patent rights. This is defence co-operation and conversion at its most efficient. It also has a string of partnerships with both other Israeli companies but also with leading aerospace companies internationally, particularly in the United States but also in emerging economies like India (for sales of mobile air defense missiles). Over the last ten years Rafael has truly internationalized acting as prime contractor and as sub-contractor on major defence systems. As its website proudly but appropriately proclaims: “Rafael’s highly skilled and dedicated workforce tackles complex projects, from initial development, through prototype, production and acceptance tests. It provides customer service and support, upgrading existing systems and offering turnkey projects involving the transfer of basic technologies or complete production facilities”.

Overall, the defence industrial sector in Israel contains around 150 firms, divided into three categories for the purposes of classification. The large state owned or government controlled defence companies form the first group. These are Israel Aerospace Industries, Israeli Military Industries and Rafael. The second group contains medium-sized firms, all in the private sector, which relies on defence production for their viability but also have large-scale civilian production particularly in the production of telecommunication equipment. The third group are small and medium sized enterprises which each produce a narrow range of products mainly geared to the defence sector. It is important to note that although the Israel Defence Force and
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the Ministry of Defence are the sole customers domestically, the market is not strictly a duopsony. About 70% of the output of the military industry is exported (Shefi, Tisler, 2005) and this gives the industry its rich diversity and its edge in competitiveness. Domestic markets are very small, and the industry has to survive and prosper through exports. Adam Smith’s dictum that the size of markets produces specialisation, competitiveness and profitability is particularly true for the Israeli military-industrial sector. “As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market” (Smith 2008 re-issue). Israel’s defence industrial companies, at the forefront of innovation, are also aware that international markets are the catalyst for growth and profitability.

Israel is also interesting in the sense that it is a major exporter of arms (thus allowing its defence technology to face the full brunt of international competition which allows it to innovate better), but also a major arms importer (so that domestic technological spill-overs through adaptation or ‘learning by copying’ allows it to innovate better). Table 2 gives data for the volume trend in Israeli arms exports and imports. Note that arms exports seem to be rising fuelled by the factors mentioned above. At the same time, leaving out growth spurts, arms imports have fallen in the few years showing Israel’s domestic military industry being capable and competent enough to produce its own indigenous and sophisticated armaments at the frontiers of innovation and technology. To get a comparative picture of Israel’s position in the global arms export market, where it has been consistently in the top ten arms exporters in the world we need to look at other countries too. Table 3 gives the comparative data, showing Israel’s position in the world arms market during the first decade of the 21st century. Leaving aside the top 5-6 countries of the world, Israel emerges as one of the largest arms exporters in the rest of the world.

Table 2 – Israel’s arms exports and imports (SIPRI Trend Indicator Value, or volume index, constant US $ million at 1990 prices), 2001 to 2011

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<th>09</th>
<th>10</th>
<th>11</th>
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<tbody>
<tr>
<td>Import</td>
<td>145</td>
<td>355</td>
<td>272</td>
<td>852</td>
<td>1133</td>
<td>1142</td>
<td>859</td>
<td>653</td>
<td>153</td>
<td>43</td>
<td>76</td>
<td>5683</td>
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<tr>
<td>Export</td>
<td>417</td>
<td>442</td>
<td>378</td>
<td>606</td>
<td>379</td>
<td>347</td>
<td>511</td>
<td>318</td>
<td>814</td>
<td>528</td>
<td>531</td>
<td>5270</td>
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</table>
Table 3 – World arms exporters, top 10 countries, (SIPRI Trend Indicator Value, or volume index, constant US $ million at 1990 prices), 2001 to 2011

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<th>09</th>
<th>10</th>
<th>11</th>
<th>2001-2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>5902</td>
<td>5107</td>
<td>5627</td>
<td>6828</td>
<td>6696</td>
<td>7404</td>
<td>7919</td>
<td>6463</td>
<td>6656</td>
<td>8111</td>
<td>9984</td>
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<td>5235</td>
<td>6119</td>
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<td>5496</td>
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<td>5287</td>
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<tr>
<td>GER</td>
<td>925</td>
<td>958</td>
<td>1768</td>
<td>1156</td>
<td>2118</td>
<td>2627</td>
<td>3234</td>
<td>3283</td>
<td>2494</td>
<td>2767</td>
<td>1206</td>
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<tr>
<td>FRA</td>
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<td>2282</td>
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<td>1717</td>
<td>2400</td>
<td>2048</td>
<td>2037</td>
<td>856</td>
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<tr>
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<td>1956</td>
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<td>336</td>
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<td>1158</td>
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<td>538</td>
<td>5954</td>
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<tr>
<td>ITAL</td>
<td>239</td>
<td>448</td>
<td>346</td>
<td>247</td>
<td>805</td>
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<td>691</td>
<td>406</td>
<td>505</td>
<td>594</td>
<td>1048</td>
<td>5841</td>
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<tr>
<td>ISRAEL</td>
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<td>378</td>
<td>606</td>
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<td>814</td>
<td>528</td>
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<td>5270</td>
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<tr>
<td>SWE</td>
<td>864</td>
<td>166</td>
<td>508</td>
<td>290</td>
<td>523</td>
<td>415</td>
<td>348</td>
<td>430</td>
<td>370</td>
<td>653</td>
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</tbody>
</table>

Source: SIPRI

ANALYTICAL FRAMEWORK FOR MEASURING THE IMPACT EFFECT

How can we empirically estimate the impact of defence burden on the growth rate of the economy? There are three mainstream methods that have been used in the literature – apart from the relatively ad hoc and naïve method of estimating an atheoretical and straightforward single equation regression. All of these three methods suggested, have their strengths and weaknesses, but all are based on a formal and theoretical growth framework. Thus the estimated impact effect, of military burden on economic growth, can be related to the theoretical constructs of growth and development.

Biswas and Ram (1986), extending the Feder model for exports and economic growth, utilised a disaggregated two-sector structural model of economic growth where the military and civilian sectors have different production functions. However, the productivity of factors are different in the two sectors and, provided the military sector has higher productivity, there would be a GDP growth inducing effect of defence spending. In addition there could be an externality effect whereby militarisation has an indirect (positive) impact on the economy through features such as human capital formation, unifying cultural factors and security of property rights. They provide a single reduced form equation, where under core assumptions, the two effects can be separately estimated as to whether they are positive or negative.
Aizenman and Glick (2006) utilize the core optimising and empirical version of the classic Solow growth model, as presented in Barro (1991) and Barro and Sala-i-Martin (1998), to estimate an equation where military burden impacts on growth rate of GDP. It is postulated that military burden per se has a negative impact on growth; however, in the presence of ‘threats’ the impact of defence becomes positive. In the same way, threats per se reduces growth rate but when interacted with the military expenditure ratio the impact is positive. “While growth falls with higher levels of military spending, given the values of other independent variables, we show that military expenditure in the presence of threats increases growth” (Aizenman, Glick, 2006). Although the estimation method used is only a pooled cross sectional regression equation (rather than the more customary panel regressions) it manages to identify the parameters of the empirical equation with the relevant theoretical parameters of the augmented Solow growth model and its extension by Barro (1990) who study the impact of any form of government spending on economic growth. It is also possible to extend such a model to encompass endogenous growth theory since it has been suggested that the positive impact of the military is felt in terms of defence industrialisation which leads to endogenous technical progress which in turn increases the natural rate of growth. The classic endogenous growth model due to Romer (1990), can be adapted such that the defence industrial base (DIB) acts as his intermediate-goods sector (to produce capital goods for the final-goods sector) as well as his research sector which produces ‘ideas’ or designs which increases the productivity of capital thus creating technological progress. Military purchase, specialist companies in the DIB as well technology creating research units (universities, military R&D establishments) all create the supply side factors that induce growth. In a sense, this method of finding the empirical relationship between defence and growth is closest to the neo-classical methodology whereby the role of government expenditure (including the military) is to impact on a market economy creating supply side effects which could potentially affect the aggregate production function and technological progress.

Both these approaches rely on the working of a production function and its growth effect within a supply side model. On the other hand development literature argues that economic development is a complex structural phenomenon and the role of the military should be assessed not only directly on growth but also on resource allocation and mobilisation, which creates both demand and supply side effects. Thus the impact of the military on the economy is best modelled in terms of a simultaneous equation model (SEM) which in turn should reflect some of the structural characteristics of the economy. Obviously these models can be made as elaborate as one can possibly construct, but data availability and the difficult of identifying many
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channels, predicates that we keep these models relatively simple. Thus a three or four equation SEM is preferable particularly if we are able to identify the predominant conduit of the relationship. Furthermore, these SEM models take account of simultaneity bias since growth, investment and defence tend to be determined simultaneously and the final impact effect is what matters rather than a uni-directional causality as shown in a single equation reduced form estimate. Most importantly, they can account for both demand and supply side factors whereby the military sector is not only an input into the production function but also creases aggregate demand and thus induces the underemployed economy towards its production possibility frontier. For a detailed and formal discussion of these issues see Deger and Sen (1995).

In the next section we set up a core 3-equation model to show how defence burden affects economic growth.

ESTIMATION FRAMEWORK, ISRAEL AND THE EMPIRICAL MODEL

Single equation estimations, whether they be structural as in Ram (1995) or in a Solow-type neoclassical framework as in Aizenman and Glick (2006), have a number of similar problems. Some of the regressors such as savings or defence may not be exogenous and could be determined simultaneously as our core dependent variable i.e. economic growth. Secondly, there could be reverse causality where savings determines growth (as in Solow) but growth itself causes savings ratio to change. Thirdly, the stochastic error term of the growth equation could be correlated with some of the regressors (again the savings ratio is a prime candidate). Overall, all of these approaches lead to a simultaneous equation bias in the single equation estimates. In principle we could have an instrumental variables (IV) approach, but it is not easy to get adequate IVs for security related variables.

Since the military affects growth through a multiplicity of channels a good structural model should be able to capture some part of that complex interrelationship. Deger and Sen (1995) identify four major channels, but in principle there could be more. First, there is the resource allocation effect by which an increase in defence reduces the available savings for investment purposes. Additional military spending, unless compensated by extra taxation, would increase government budgetary deficits which in turn will reduce national savings. Further, an increased trade deficit via military imports would again mean capital outflows and a widening of the savings investment gap. Secondly, there could be potentially resource mobilisation effects. Here, an increased defence spending would bring forward higher saving or investment through higher
taxation, patriotism in the face of security threats, budgetary cuts in civilian areas and so forth. This is termed the resource mobilisation effect which could potentially have a growth promoting effect. Thirdly, the literature has also mentioned the concept of military Keynesianism or aggregate demand effects. Here defence spending not only creates aggregate demand but also increases capacity utilisation of the productive sectors which often suffers from underemployment not because of supply side deficiencies but because of a lack of effective demand which keeps firm output lower than at full employment. This is particularly true for emerging and developing countries where the economy often resides below the production possibility frontier.

Finally, there have been many claims that the military has important growth spin-offs and these positive impact effects are important in evaluating the postulated relationship. These spin-offs or positive externalities include the whole gamut of non-quantifiable factors such as ‘modernization’ or discipline that militarism can provide to a security-threatened society. But spin-offs also include the benefits of a conscripted army proficient in learning modern technology. Most importantly, for a country like Israel, which has a large arms producing sector, there could be inter-industrial linkages, utilization of dual purpose R&D, new industrial innovation at the frontiers of technology, as well as technological feedback from high-tech manufactures and dual-use technical progress. The symbiotic relationship between the sophisticated defence industry and modern civilian manufactures is well-documented.

Let us concentrate on these spin-offs which are unique to Israel. One of the major salient features of the Israeli economy is the presence of high technology sectors, the exceptionally creative set of scientists and engineers and an industrialisation geared to high-tech industries. Particularly in the military production sector, almost 75% of the arms need to be exported which therefore given a major impetus towards the creation and development of new technologies in the international arms market. Israeli Prime Minister Benjamin Netanyahu stated in an interview that “applying military technology to the civilian sector has become Israel’s greatest source of wealth.” (Rapaport, 1998). Israel’s determination to become self-sufficient in its weapon production came to a peak in the 1980s when IAI attempted to develop its own jet fighter, the Lavi. IAI soon realised that the costs associated were too high and abandoned the program. However, because of this hundreds of engineers who once worked on the cutting edge of technology with experience in computers, avionics and electronics were released into the civilian sector. The Lavi’s demise has been described as one of the greatest ever boosts to the Israeli high-tech industry (Yael and Karen, 2007). Having emerged as an innovator in security, Israel now exports around 75% of its weapon production.
The value of exports are high and rising even in an intensely competitive shrinking global arms market for security technology and modern weaponry (see Table 2). However, as Israel's and the world's defence market began to shrink in the 1990s, civilian application of technologies derived from the military have also become increasingly important. The Israeli Ministry of Defence began promoting the conversion of defence industry to civilian commerce in 1984 with the introduction of the R&D Encouragement Law. This became such a success as defence industries, trying to cut back on costs because of a decreasing budget, launched commercial spin-offs which soon outperformed their military counterparts.

Apart from the physical spin-offs associated with the Israeli defence sector, it can be argued that it has a large effect on human capital formation. Israel operates a conscription army in which all teenagers at the age of 18 have to join the Israel Defence Force (IDF). The structure of the IDF is unique in the way in which skills learnt during army service are transferable to civilian life and Israel reaps some of the richest rewards. Yael and Karen (2007) indicate two characteristics of the IDF that pervade into the civilian sector. The first is extensive networking; Senor and Singer (2009) put much emphasis on the IDF as a formative stage for the country’s next entrepreneurs and industry leaders. As a result of a young person’s work in the army, the soldier establishes many contacts in various areas. This is especially the case if they worked together in specific units in the IDF such as intelligence or the elite Unit 8100. Many start-ups and NASDAQ listed Israeli companies have been founded by alumni of this unit and many high-tech companies hire exclusively from this elite. Senor and Singer state that the unit in which an Israeli served says much more about them and is more influential than any CV, or even the quality of their education. The most unique case of this is the unit known as 'talpiot'. Thought of as the elite, this unit recruits only the best young Israelis across the country straight from school and combines their military service with an education in science and engineering that rivals degrees from leading institutions such as MIT. A start-up that involves a member from talpiot is said to guarantee business investment from U.S. and other foreign firms that are aware of the skill capabilities and technological prowess of alumni from these units. Several of the highest trading high-tech companies involve members from this prestigious group. Another characteristic is technological innovation, a large number of start-ups are based on technology originating from the army and in most cases the founders had worked together on this technology during their military service. There are currently over 4,000 high-tech firms operating in Israel, many taking their technologies from the military and turning them into some of the world’s best surveillance, internet, wireless, medical and technological
products (Rapaport, 1998). Daniel Rouach, an academic studying security and economics, summarises this effect nicely when designating the IDF as the ‘University of the Israeli Army’ (cited in Yael, Karen, 2007).

In our empirical model we would particularly like to quantify this concept of technical progress. In principle, since we emphasise technical spin-offs for an economy like Israel, we would like to introduce a specific variable to measure technical progress in an attempt to efficiently capture these effects. Smith (1978) used expenditure on R&D as a proxy for technological growth. Although R&D expenditure would be applicable in this case as Israel enjoys one of the highest expenditure on R&D as a per cent of GDP in the world, time series data for all the years in the period of analysis was difficult to find. The case was similar in other attempts to find a fitting proxy for technological growth such as density of scientists and engineers in the population (another statistic in which Israel leads the world). However, Jalles (2010) discusses the use of patent applications as a proxy for technological change in an economy and concludes that it is sufficiently significant. Thus we use rate of growth of patent applications as an independent variable in the growth equation of our empirical model in the next section. Growth of technology seems more appropriate then levels since it is the change in technology that is closest to Solow’s concept of the natural rate of growth.

To evaluate this complex set of relationships we propose a three equation SEM of the following type for the macroeconomy:

\[
\begin{align*}
g &= a_0 + a_1 s + a_2 m + a_3 y + a_4 f + a_5 ea + a_6 l + a_7 i + a_8 tp \\
s &= b_0 + b_1 g + b_2 m + b_3 y + b_4 f + b_5 ea + b_6 i + b_7 tp \\
m &= c_0 + c_1 b + c_2 y + c_3 e + c_4 p + c_5 ma + c_6 tp + c_7 D
\end{align*}
\]

where:
- \(g\): average annual growth rate of GDP
- \(s\): gross national savings as a percentage of GDP
- \(m\): Military expenditure as proportion of GDP
- \(y\): GDP per capita at official exchange rates
- \(f\): foreign capital flows as proportion of GDP
- \(ea\): US economic aid as percentage of GDP
- \(l\): percentage change in labour force
- \(i\): inflation, rate of change of GDP deflator
- \(tp\): growth rate of Israeli patent applications
- \(b\): government expenditure as percentage of GDP
- \(e\): rate of growth of government expenditure
Defence, innovation and development: the case of Israel

p: total population
ma: US military aid as percentage of GDP
D: Dummy for war years

Data sources: Variables are all annual time series, 1970-2010. The data was derived from the following sources:

- Patent growth – World Intellectual Property Organisation
- US military and economic aid – USAID Greenbook
- All other economic data – World Bank

The structural model, given by the three simultaneous equations (1) to (3), will be estimated empirically to find out the multiplier effect of military burden (m) on growth rate (g). However, prior to that we need some explanation on the reasons for including them.

The growth and savings equation (1) and (2) are quite standard (for details see Deger and Sen (1995). Growth depends inter alia on: national savings ratio (as in Solow type growth models); per capita income (which in turn depends on the capital labour ratio); foreign capital flows which increases domestic investible resources; economic aid which traditionally has been substantial for Israel and should have growth effects; growth of the labour force which is a proxy for the natural rate of growth; inflation which may have a growth reducing impact; technical progress which is potentially important since it is a part of the natural rate of growth (in an extended Solow model). Savings ratio depends on: growth rate (through the life cycle hypothesis); per capita income (given a standard Keynesian consumption function); foreign capital again, since it may act as complementary to domestic savings or alternatively be a substitute; economic aid which may reduces private and government savings (Dutch Disease effects); inflation which is detrimental to savers; technical progress which raises the demand for investment which in turn may cause savings to respond since its return rises. The military equation is standard with the usual mix of economic and security factors; government expenditure and its growth, since defence spending has to be constrained by total government spending and its ability to grow; per capita income because security may be a normal good; population given the public good aspect of national defence; American aid given its obvious importance for a country like Israel; and finally threats and wars. Variables for government expenditure and total population are particularly important in this equation because of the central concept of defence spending being a public good. This concept states that security is a public
good, non-excludable and non-rival, which has a market price of zero, but a positive cost. Its provision and supply require public sector financing and is therefore influenced by the government budget. The size of the population will have a positive impact on the size of the military since a larger population needs more security than a smaller one.

Consider now the impact effect of the military on economic growth. The channels through which military burden affects the macroeconomy are, to re-capitulate: spin-offs; aggregate demand creation; reallocation of resources; creation and mobilisation of new resources. These are now represented indirectly by the variables in the equation system. Spin-off and demand effects from the military are given by the coefficient of coefficient of defence in the growth equation. This coefficient \( a_1 \) in equation (1) will represent the demand creation and spin-off effects of defence spending and is expected to be positive. The resource effects are to be found in equation (2) where the coefficient \( b_2 \) represents the total impact of resource re-allocation and mobilization on the domestic savings ratio.

As discussed earlier, the spin-off effects of overall technological growth, on the aggregate economy and the savings-investment rates, are important for Israel, so we decided to include an extra variable in an attempt to efficiently capture these effects. We use rate of growth of patent applications as an independent variable in the growth equation and the savings equations.

What are our prior expectations from this model for the Israeli economy? It is expected for a high tech market economy such as Israel, that high military expenditure will create effective demand and thus reduce underutilisation of capital stock. In addition the myriad spin-offs discussed earlier, from technological externalities to export promotion will raise the economy’s growth rate. As for resource allocation and mobilisation, given that US military assistance could take care of resources that would have been spent on defence, the adverse impact on savings would be low or even non-existent. In principle, military expenditure may even raise the resource base since a conflict-ridden and threatened society will be willing and able to pay more taxes to alleviate the military burden. All in all, Israel is precisely the type of country where we expect the interactive influences all taken together will create the framework where defence helps development. In short the multiplier from defence to growth is potentially expected to be positive. Let us now see what the actual empirical results tell us.
EMPIRICAL RESULTS

Given the high covariance between the three equations (1) to (3), and to avoid simultaneity bias, it was thought necessary to estimate these equations jointly using a three-stage least squares estimation procedure which would improve asymptotic efficiency. The estimates are given as equations (4), (5), (6). Given the standard data problems for developing countries, and the difficulties with estimating non-stationary military variables, significance levels of 10% are considered to be satisfactory.

\[
g = 22.80 + 0.19s - 0.24m - 0.001y + 0.48f - 0.19ea + 0.20l - 0.005i + 0.001tp
\]

\[
(1.74) (1.71) (-1.17) (-2.72) (1.08) (0.62) (-0.88) (0.05)
\]

R squared: 0.3767 (4)

\[
s = 24.04 + 0.29g - 0.37m - 0.003y + 0.71f + 0.03ea + 0.009i - 0.03tp
\]

\[
(1.61) (0.73) (-1.58) (-0.47) (1.59) (0.18) (1.32) (-0.98)
\]

R-squared: 0.3325 (5)

\[
m = -3.89 + 0.84b - 0.008y + 0.03e + 0.00001p + 0.037ma + 0.40D
\]

\[
(-0.87) (10.7) (-1.68) (1.93) (0.69) (2.26) (0.43)
\]

R-squared: 0.9578 (6)

(t-ratios in parenthesis below estimates).

The R-squared for the growth and savings equation are not high, but this is to be expected for developing countries where a myriad of non economic factors often influence economic growth and a parsimonious model cannot incorporate all these variables at the same time. On the other hand, the R-squared for the military equation is particularly high and well defined. A stationarity test on the variables showed that the military variable was non-stationary and this is a perennial problem in defence studies since military expenditure tends to fluctuate independent of other variables. This non-stationarity might explain the high R-squared.

In the growth equation, military spending has a negative but insignificant effect on growth. It seems that the positive spin-off and demand factors are small and/or not significantly strong. This is, of course, contrary to expectations. The saving ratio has a large positive and significant effect with a ten per cent increase in savings ration resulting in a 2 per cent increase in increase in economic growth rate. Income per capita has a very small but significant negative effect on growth as was expected. Convergence theory in the neoclassical model of growth would predict a negative coefficient for this variable. The role of foreign capital flows is positive but is relatively
insignificant in its impact on growth which is not unusual since economic growth is often driven by domestic capacity. What is surprising is the negative and significant impact of US economic aid which seems to depress economic growth. There is of course the possibility of reverse causality where low growth makes the government request greater foreign aid from its main donor. In recent years, as the economy transited towards full development, this factor has lost its role in any case. In a sense this result follows the current consensus of the insignificance or even perverse effect foreign aid has on growth. The result also supports the claim of Looney and Winterford (1995) regarding U.S. aid. Inflation, as expected takes a negative effect on growth but this is very small being less than a 100th of a per cent for every one per cent increase in inflation. The most unanticipated result, however, is that of the role of technological growth on the economy. The coefficient gives a positive, yet highly insignificant value and thus we cannot conclude that it has had an impact on Israeli economic growth at all.

As has been observed elsewhere (see Deger, Sen, 1995), the results from the savings equation support the suggestion that military expenditure has a negative indirect effect on growth. The military burden variable shows a substantially high and relatively significant negative effect on the savings rate. Given the importance of savings in growth, this negative impact carries through to the final multiplier, as we show later. The (negative) resource effect seems to dominate the relationship. Additionally, foreign capital inflows present a highly positive impact on the savings ratio which implies that foreign inflows are complementary to domestic savings and help in increasing the national savings rate. US economic aid has no impact on home savings.

The military burden equation is well-defined shown by its high R² value. Reinforcing Deger and Sen (1995) survey conclusions, the military burden equation highlights the public good aspect of defence with a high and significant coefficient for government expenditure as a percentage of GDP, but on the other hand there is a lack of significance in the population variable. United States’ military aid to Israel is shown to have a significant positive effect on defence expenditure which can be understood from the evidence presented in section 2 and which is anticipated since foreign military aid can be used both to increase current defence budgets but also (given the exclusive right afforded to Israel) to spend a quarter of the aid on the domestic defence industry.

Considering (4) to (6), when the direct and indirect effects are taken together, the growth multiplier of defence spending is:

\[ \frac{dg}{dm} = \frac{[a_2 + a_1 b_1]}{1 - a_1 b_2} \]

Using the estimated coefficients, \( \frac{dg}{dm} = -0.33 \)
In other words, if the military burden rises by an additional percentage point, the growth rate falls by 0.33 percentage points. This is quite substantial given that current Israeli growth rates hover around 4%. Considering that Israel is a country where we expect defence spending should have had a substantial spin-off via technology transfer and human capital formation, it seems the negative impact of resource re-allocation and the failure to raise resources in spite of US military assistance (and past economic aid) are substantial. Ultimately the loss of resources to the defence sector dominates any positive effects which may have come from military industrialisation and aggregate demand creation.

The results are surprising to say the least. Given the growth enhancing aspects of the Israeli military, high defence spending, sophisticated defence industrial base as well as human capital formation in the arms industry, the macroeconomic effects should have been positive even if not necessarily high. The cross sectional results in the literature are ambiguous and it is possible to find studies where the military did have some positive impact on growth. Our anticipation was that something similar would happen in the Israeli case. However, we find that in an economy best placed to receive the substantive effects of defence industrialisation and armed force training, the spin-offs are swamped by resource re-allocation away from the productive sectors of the economy which happens to be the civilian sector. The military industrial complex may have benefits at the microeconomic level for the firms involved in production and conversion, but at the macroeconomic level the costs dominate the benefits.

CONCLUSION

In an important paper Barro (1991) claims that those parts of government expenditure which do have a growth-enhancing impact on GDP are to be found in public investment in human capital and security related spending. These forms of public spending allow private capital formation to flourish, lessen market distortions, protect the polity against external threats and secure property rights – all of which increases growth. “The idea is that expenditures on education and defense are more like public investment rather than public consumption; in particular these expenditures are likely to affect private-sector productivity or property rights which matter for private investment” (Barro, 1991, p. 430).

Israel has always placed high premium on education, technology and security. Clearly, within the framework postulated above, military expenditure would have been expected to have the maximum positive impact on GDP.
growth. In addition, a society threatened by external forces would have coa-
esced around the state and created high externalities from the military sec-
tor. Innovation and technology should have flourished within the military
industrial complex with concomitant spill-over for the civilian economy.

Whatever the microeconomic impact on individual sectors and indus-
tries, our empirical model shows that the macroeconomy has not benefited
from defence spending. The postulated impact effects simply have not ma-
terialised. Indeed, the multiplier from defence to growth is exceptionally high
and negative. Even though our econometric model can be criticised for spec-
ification errors, the coefficient for the multiplier is so large that it is bound
to be accepted as negative. Defence is not a boon for the Israeli economy in
spite of its much-vaunted technological sophistication. It is time to consider
from an economic point of view whether an alternative security strategy
would be more productive for the economy. The guns and butter trade-off
seems to be very high indeed for Israel.

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