Returns of Public Support to Industry R&D in Israel

This country case study discusses a 2007–08 effort to measure the returns of public support to industry research and development (R&D) in Israel. It involved applying quantitative econometric modeling tools to data collected through surveys of manufacturing and other firms over a period of several years.

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Introduction

The link between government R&D investment and innovation can be measured by data on straightforward indicators such as patents, research publications, and commercialized products and processes.

On the other hand, the link between innovation and growth in the gross domestic product (GDP) is harder to establish. No database can provide an answer to the question of what a firm’s R&D expenditures would have been if government support had not been granted; therefore, specific methods are needed to estimate this type of variable. Furthermore, attribution is more difficult to establish with outcome and impact indicators like GDP growth.

Many countries, including Israel, now use industry surveys and econometric methods to quantify the effects of their R&D investment, and control groups to help address the issue of attribution. OECD (Organization for Economic Co-operation and Development) and Eurostat (2005) jointly publish what is called the “Oslo Manual,” which provides guidelines on country R&D and innovation surveys and methods for analyzing the survey findings. Due to a growing concern about the need for surveys that are more appropriate to developing country needs, the most recent version of the manual published in 2005 contains an appendix on innovation surveys in developing countries. In addition, in 2011 the UNESCO Institute for Statistics began compiling an inventory of innovation surveys by developing countries (UNESCO 2011).

For many years the Israeli Government has allocated resources to support and promote civilian R&D by private firms. From 1991 to 2007 this support totaled approximately 3 billion New Israeli Shekels (NIS). The Government first needed certain basic monitoring data on its R&D program funding. Beyond that, policymakers were interested in a quantitative estimate of how the GDP
would change with each additional NIS of Government support (the marginal rate of return). Was the public funding leading firms to invest more in R&D than originally planned? Or was it leading to a substitution of public funds for private funds?

The calculations and analyses for this evaluation effort were performed by a team of knowledgeable people from the Government, academia, and government support contracts. The staff at the Israeli Central Bureau of Statistics processed the data from the industry surveys and provided a portion of the analyses. In addition, a steering committee comprised of government and private sector representatives contributed its expertise throughout the entire process.

There are some barriers to using a quantitative econometric approach to evaluating the Government’s R&D investment. First, the effort requires a long-term focus on collecting data over time and then analyzing it. Second, the sophisticated procedures and methodologies for analysis are not always easy for non-specialists to understand and communicate.

**Program design**

Of the various rationales for providing government R&D support to the private sector (the intervention being studied) one is to provide a reduction in business-related risk. For this reason, government R&D intervention is justified in the presence of market failures, such as limited access by firms to capital markets.

The rationale for this evaluation of R&D and innovation was that more data were needed. Some information was already being collected and reported by the Israeli Government; however, more detail was needed to answer specific questions, such as whether the same firms were being supported every year or new firms were selected from year to year.

Since this approach required specialized expertise, MOITAL/OCS and the Ministry of Finance commissioned an external study to evaluate the impact of financial support provided by the Government to Israeli firms’ R&D. The resulting report was published in 2008 (Lach et al, 2008).

The first step in the evaluation process was to compute the R&D productivity for each firm individually, using data collected directly from the firms through surveys. Based on the survey findings, one or two different models could be used to estimate firm productivity (and ultimately, the return to the economy from government support). The two models are well-known and widely accepted in economic literature. The first model was developed by Professor Zvi Griliches (1998) and assumes that a company’s R&D capital (or “stock”) is computed similarly to how the company’s physical capital stock would be computed. Physical capital is computed by accumulating the existing investments in fixed assets over a period of time, and R&D capital is summed up over time to form an R&D capital series. Returns on R&D investments last over several years, just as they do for equipment and physical machinery. That is, R&D capital depreciates over time, and the depreciation rates are a linear function of the firm’s R&D investments. Further, assumptions are made about R&D depreciation rates just as they are made for equipment and machines. The second model was developed by economists Richard
Blundell and Steve Bond (2000). In this model, firm productivity is estimated over time using available data.

For each firm, the Government was concerned about whether the public funding was leading firms to invest more in R&D than originally planned (“additionality”) or whether it led to a substitution (“crowding out”) of private funds by public funds, resulting in firms undertaking the same amount of research as they originally planned. The research design involved combining the two estimates (the additionality/crowding out estimates and the estimates of returns to R&D in firm production terms) into a single model for estimating the total returns to the economy that stem from government R&D support. The integrated model enabled estimation of the amount of new R&D created due to government R&D support and its impact on the executing firms and other firms which benefited via knowledge spillovers.

The computation of GDP was an aggregate of the direct effect of the companies receiving R&D support, along with the “spillover” effect of that R&D on the performance of other firms. Spillovers are analogous to the mobility of workers between firms: After workers are exposed to knowledge from the research departments of larger firms, they then move to other firms or establish new small firms. They then make further use of the knowledge acquired at previous workplaces through this diffusion of knowledge and technology transfer.

Total Factor Productivity (TFP) is the most widely used approach for estimating the total growth over the longer term from R&D and resulting technology changes. Traditional views of a country’s economic growth assume that it can be measured by changes in labor, capital investment, technology, and other factors. TFP is a measure of the technological part of that overall change, which cannot be measured directly and its relationship to growth cannot be explained by traditionally measured labor and capital inputs. Thus TFP is treated as a residual after accounting for labor and capital outputs. This residual is called the “Solow residual” after economist Robert Solow (Solow 1957). While investments in labor and capital are important contributors to economic growth in many economies, often the real driver of economic growth is TFP—which may account for up to 60 percent of growth in some countries.

As is apparent, evaluating the impact of government R&D support was a methodologically complex task that leads essentially to a forecast of the GDP change for those sectors receiving government R&D support over a period of years. One goal of the methodology was to determine if observed changes can be directly attributed to program intervention (the R&D support). However, isolating the effect of public support was difficult because of other factors influencing the outcome in a country, for example, shifts in the global economy or industrial changes. To isolate the effect of public support, it was necessary to investigate a counterfactual situation by contrasting the group of firms receiving R&D incentives with a control group not receiving incentives.

Finding a suitable control group is usually a difficult task. Businesses selected to receive public support are often those with the best innovation strategies, thus the most likely to increase their R&D expenditures anyway. Therefore, it is also necessary to account for a selection bias based on firms having been selected to receive government funding.
Implementation

For this calculation, there were three key data sources:

- annual survey data on manufacturing firms (the surveys, 1995–2003);
- annual survey data on R&D in manufacturing firms (the surveys, 1996–2004); and
- annual survey data on firms involved in computer services, software, and R&D (surveys, 1997–2005).

For the manufacturing sector, the Israeli Central Bureau of Statistics surveyed a representative sample of 2,800 firms, based on a standard classification of industry sectors and their R&D activities. The firms were surveyed on a broad set of economic variables. The survey compiled detailed firm-level data such as sales, R&D expenditures, capital investments, the labor hours and earnings of employees engaged in R&D, outside financing, patent acquisition and licensing, revenues, exports, value-added (a firm-level GDP estimate), and other variables. Panel data is the term given to this set of data used for monitoring the economic activity of a firm over time.

Because the data resulting from the general manufacturing survey were not particularly complete with regard to R&D, the Government supplemented the general manufacturing data with data from surveys focused specifically on the R&D in the manufacturing sector.

In addition to the manufacturing sector, the Government similarly surveyed 470 firms involved in the computer services, software, and R&D sectors. The firms were engaged in activities such as data processing, maintenance of data banks, programming services, computer consulting, and related activities. The R&D sector companies included firms engaged in basic research in life sciences and natural sciences (versus R&D in other fields and sectors like manufacturing), and start-up firms. The survey of the computer services, software, and R&D sectors was conducted identically to the annual manufacturing R&D survey.

The survey findings were compiled into a database and analyzed. The firms were divided into four categories according to technology intensity: high technology, medium-high technology, medium-low technology, and low technology, examples of which are:

1. The high technology category includes aircraft and electronic communication equipment and components industries.
2. The medium-high technology category includes machinery and equipment and the chemicals and refining petroleum industries.
3. The medium-low technology category includes mining and quarrying and the jewelry and silversmithing industries.
4. The low technology category includes wood products and furniture, beverages and tobacco, textiles and leather, and printing and paper products.

The firms were also categorized by size:
1. Firms categorized as medium-large firms were those with sales turnovers of NIS 50–300 million (approximately $13.5 to $81.5 million).

2. The very large firms were those with a sales turnover of more than NIS 300 million (approximately $81.5 million).

Once the businesses were sorted into these categories, the CR4 index—a widely accepted index for measuring the level of concentration in industries and markets—was calculated both within and between the different technology categories and firm sizes. The research team also used price indices to adjust for price changes in the monetary variables over the years.

For a systematic comparison of the firms’ total productivity, researchers conducted a simple (regression) analysis including only the input variables capital and work. Based on the results, the Solow residuals, which represent Total Factor Productivity, were calculated.

To build a synthetic control group, unsubsidized firms that were otherwise similar to the group with subsidized R&D were observed on a firm-by-firm basis. The sets of firms were as similar as possible to each other, except that one group received government funding and the other did not. The R&D expenditures of the subsidized firms were compared to those of the unsubsidized firms in the control group by running a linear regression analysis which examined the differences in their levels of R&D expenditures. Then the impact of received government support on the two groups’ expenditures was examined.

Results

Based on the analysis, this evaluation effort provided policy makers with a number of conclusions and answers to their questions noted earlier. It provided a clear picture of the impact in GDP terms of many years of government innovation policy.

There was ample justification for the continuation of government R&D support to the private sector—at least at the levels that prevailed during the study period and perhaps at even higher levels of funding. High additionality demonstrated that the government R&D investment was effective and succeeded in selecting projects that would otherwise not have been conducted. The high return to the economy from government R&D investment justifies the shifting of government budget allocations to this activity from other government mechanisms that reap lower returns.

In the future, however, it will be more efficient to design policy tools that recognize differences among the sectors and categories of firms. The findings showed, for the first time in Israel, data beyond the average figures traditionally published in the official publications of the Central Bureau of Statistics, and these data indicated that the aggregate national data did not adequately reflect the situation in the country. The new data from this analysis provided a broader understanding of government R&D support, which would enable policy makers to adjust their policies for the large variety of needs among Israeli firms.

Based on the results, the Government’s Office of the Chief Scientist was encouraged to commit in advance to multi-year financing, thus sparing Israeli firms the uncertainty associated with the
approval of applications on a yearly basis. This is all the more important in light of the findings that a large percentage of firms were expected to receive support during at least two consecutive years. In the case of a high-risk process such as R&D, it is important not to create a new uncertainty associated with the process of allocating the R&D awards.

**Specific findings**

**Data on output**

The survey findings provided, first, basic facts on the dynamics of the government R&D funding awards. Government R&D support from the OCS is granted for two consecutive years to approximately 70 percent of the firms, and for three consecutive years to approximately 50 percent of the firms. In other words, a firm whose request was approved for the first time in a certain year has an average expected probability of 70 percent of receiving continued support in the following year, and a 50 percent probability of receiving support for three consecutive years.

**Findings on outcome**

The results of the econometric analysis were statistically significant and robust throughout the different industry sectors—in the manufacturing sector and in the computer services, software, and R&D sectors—and among the firms whose technological level and size differed from one another. However, the average data for the industry sectors were not accurate due to the extreme heterogeneity among the firms in terms of production levels, size, and R&D financing. In the computations for this study, the standard deviations (the spread around the averages), equaled approximately 50 percent in some cases—quite high! This would not allow policymakers to develop programs with the optimal intended effect. For example, four high technology firms were responsible for approximately 30 percent of total R&D expenditures in the entire Israeli manufacturing industry! About two-thirds of productivity in manufacturing originates in only 10 percent of the firms. A similarly extreme picture emerged from the data on the computer services, software, and R&D sectors.

In summary, the analysis found sound evidence of high and positive returns to the economy based on government R&D support during the years examined. The returns were good even in sectors where extensive government support had not been provided in the past. Government R&D support during the years studied did not crowd out private funds, that is, it did not finance R&D that would have been conducted anyway, as determined by the use of control groups.

Further, government support resulted in statistically significant additionality, regardless of the sector or size of the supported firms. Government support induced the creation of new R&D (which would not have been undertaken if not for the support) of up to 2 to 3 times the amount of the grants.

More specifically, in the manufacturing sector, a government grant of NIS 1 million created an increment in private R&D expenditures amounting to NIS 1.28 million. This is a total increment
of NIS 2.28 million in R&D expenditures for the economy. The results were even higher for the computer services, software, and R&D sectors.

Most of the R&D spillover effect derived from the larger firms. There were positive and statistically significantly spillover effects for very large and medium-large firms. No evidence was found of significant technological spillovers from small firms - their levels of statistical significance were low and the coefficients were negative. Due to the nature of spillover effects described earlier, these results were not unexpected.

It should be noted that the R&D rates of return were calculated per gross NIS of R&D funding—that is, without deducting royalty payments to the Government. Several tens of percentage points, on average, are returned to the Government as royalties; therefore, the additionality rates are lower bound multiplier estimates of the actual net returns.

Using the Griliches model yielded results based on technology level and firm size. From the perspective of firm-level resource allocation, the marginal returns on the R&D investments showed that R&D investments are preferable over physical capital investments in most cases (that is, most technology levels and firm sizes). In the high technology category, it was clear that the marginal return on R&D was about equal to that resulting from investing in physical capital. In the rest of the manufacturing sector, the return on R&D investment was at least six times—and up to 200 times—higher than the return on capital investments. Specifically, in the low technology categories, a reasonable return ratio was estimated to be up to 8 times in favor of investments in R&D over physical capital, but this was based on scarce data.

A grant to a medium-large firm creates a net effect on GDP (that is, deducting the grant) of 475–751 percent. Thus, a multiplier of 4.7 to government funds was obtained for medium-large firms, which is a positive and high rate of return for government support. Even within the high technology category—where the vast majority of R&D expenditures in manufacturing were concentrated and which received high levels of government support throughout the analyzed years—a multiplier of 4.7 to government funds was attained.

Upon calculating the results based on the Blundell and Bond model, the estimates for firm size and technology level were similar. Assuming the same size firms (medium-large) and grant amounts, it was found that the R&D return levels estimated using both models were within a reasonable range of each other. This was definitely the case for the high technology category.

**Findings on longer term impacts**

In terms of the longer term impact on economic growth, after computing the results of the *integrated* econometric model, it was ascertained with a high degree of confidence that a multiplier of 5–6 times the government investment reflected the returns to the economy that stemmed from government R&D support to medium-large firms and total future industry GDP increment to medium-large firms. For very large firms, the results demonstrated a multiplier of 1.5–2 times the government support and total future industry GDP increment to very large firms.

It was also found that, as the number of consecutive years of R&D activity rose, so did the values for Total Factor Productivity.
The overall results of this initiative were successful: they showed that it would also be useful to do further analyses at the R&D project level (versus the firm level) on project-level data from the Office of the Chief Scientist to confirm all the findings and conclusions related to multi-year funding.

The study report also stated that, in sectors for which there is no extensive past survey data (biotechnology, nanotechnology), it is probable that one can expect a similar performance from the existing Government R&D support mechanisms.

**Lessons learned**

The firm surveys show that there is still insufficient data for some innovation policy questions. The lessons learned in Israel could be useful for other countries intending to undertake a similar type of evaluation, so they are noted as follows:

1. In the survey of R&D in manufacturing, few companies belonged to the low technology category since low technology firms tend to do less R&D. This limited the analysis that could be done for this group.

2. The distribution of R&D expenditures and productivity were characterized by a high degree of heterogeneity among the businesses. The inclusion of more detailed firm characteristics in official government statistical publications (versus merely averages among firms) should be considered, so as to enable a more informed use of the data.

3. The variable, “other funding”, in the R&D surveys included data on investments that are not R&D funding, but reflect investment activities, such as venture capital and parent firm funding. These data are necessary to conduct the type of analysis presented here, but may not be able to be published in official publications.

4. If more information is collected on patents (such as the class of patent as indicated on the patent application), this will enhance the indices related to technology closeness between firms. In cases where there is no patent, the firms could be allowed to choose an identifier based on a list of technology classes from the Patent Office.

5. Survey data on R&D workers and investments should be collected separately from overall explanatory data on workers and investments to avoid the issue of double counting these variables. Currently, there is no way to avoid this problem although, as part of this study, tests were conducted as to determine the extent of the problem and it was determined to be negligible.

6. For this type of analysis, it is necessary to create a uniform identification code for firms. In Israel, this type of code exists only as of 2003.

7. There were differences between the questions on the manufacturing and R&D surveys. It will be necessary to harmonize the wording, definitions, and economic variables (such as, output and value-added) among the surveys. Further, there would be benefits to harmonizing the Israeli surveys with the European Union’s community innovation survey.
8. There is a need to differentiate between gross and net R&D grants—that is, before and after deducting royalty payments to the Government when R&D projects result in sales. The grants data used for the analysis were gross data because the R&D surveys do not monitor royalty payments. A typical firm’s decision variable when determining an R&D expenditure level would be the net grant (that is, net of royalties to be paid in the future, or currently being paid for other projects). This means that the study estimates are lower bound estimates of the actual levels of additionality.

9. Given the current variety of international R&D funding programs, the R&D surveys should contain a variable to track data on international R&D funding.

10. The surveys should differentiate between the various R&D funding schemes available in Israel - for example, the traditional government R&D funding program is that of the Israeli Office of the Chief Scientist. There is also a “MAGNET” program, which is for generic R&D undertaken jointly by a consortium of firms and other R&D programs. Finally, the results might be taken to justify the preference of allocating R&D to larger firms over smaller firms, given that no spillovers (or even negative spillovers) stem from smaller firms. However, this perspective does not take into account that government R&D intervention is intended to compensate for market failures such as limited access by firms to capital markets. For smaller firms, market failures are critical. For this reason, many government programs (in Israel and abroad) provide support to small- and medium-sized enterprises (SMEs).

References


**Government Web addresses**

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Office of the Chief Scientist (OCS) [http://www.matimop.org.il/ocs.html](http://www.matimop.org.il/ocs.html)

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