EVALUATIONS THAT CHALLENGE THE STATUS QUO:

USE OF STATISTICAL TECHNIQUES IN MEASURING ADDITIONALITY

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Abstract:

This paper presents results from an evaluation of publicly-funded research and development (R&D) grants and services provided to New Zealand firms. The policy objective of public R&D subsidies is to increase and enhance the R&D undertaken by firms. This is, in turn, expected to lead to an increase in the economic performance of firms over a longer time period. We report on our experiences in developing and testing a quantitative approach using statistical techniques to evaluate the R&D subsidies. We use a new wide-coverage business database linking firm administrative and survey information of financial performance, employment, merchandise trade, business practices and other data, including participation in government funded business support programmes. This enables us to compare the changes in performance of assisted firms to matched similar New Zealand firms that have not received government assistance. We find a statistically significant impact on economic performance of the firms due to the R&D subsidies, however the impact is significantly less than that measured by previous evaluations using more traditional approaches (e.g. case studies and surveys). Previous evaluations showed that the subsidies resulted in new and enhanced products, processes and services following completion of the grants. However, the questions is not what happened after the completion of the grant, but whether it happened any faster as a result of the grant, i.e. whether there was any *additional* impact. The more robust statistical methods address this question by comparing the performance of an assisted firm to a matched similar firm over the same time frame following assistance, whereas previous evaluations have only looked at the performance of the assisted firm and thus have overestimated the economic impact. We believe that our statistical estimates provide a less biased estimate of the actual economic impact due to the subsidy and we encourage evaluators to incorporate these techniques into their evaluation toolbox.

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Statistics New Zealand protocols were applied to the data sourced from the New Zealand Customs Service; the Foundation for Research, Science and Technology; New Zealand Trade and Enterprise; and Te Puni Kōkiri. Any discussion of data limitations is not related to the data's ability to support these government agencies’ core operational requirements.

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# Introduction

This paper presents results from an evaluation of publicly-funded R&D assistance provided to New Zealand firms. We use recent statistical techniques to assess the additional impact of R&D grants and subsidies on the economic performance of New Zealand firms. The additional impact on the firm is the impact that occurs as a result of the public subsidy alone, rather than the impact due to other factors that also affect firms’ economic performance. The additional impact can truly be assessed only by comparing actual and counterfactual outcomes. The counterfactual, i.e. the situation that would have occurred in the absence of a public subsidy, is not observed. So the challenge for an evaluator is to create a convincing and reasonable comparison group for assisted firms. We assume the comparison group will behave in the same way that the assisted firms would have done had they not received subsidies. Our methodology involves matching assisted firms to comparable unassisted firms based on firm characteristics, e.g. their industry classification, size, exporting histories, etc. We then compare changes (or more precisely difference in changes) in performances of the assisted group to the group of matched unassisted firms.

Alternatively, we might ask firms to report the impact due to the public subsidy, or just measure the changes in economic performance before and after receiving the subsidy and ascribe all changes in performance to the subsidy. These more cursory analyses often generate very positive reports of a programme’s impact. However, as Storey (2000) has noted, it is not uncommon for these positive reports to disappear under further scrutiny, when the performance of assisted firms are compared to comparable unassisted firms. Note that the problem is not that firms receiving assistance do not do well following their grants. Rather, they are not doing any better on average than a group of similar firms drawn from the control group. Rigorous evaluations of these programmes typically found little or no impact on the ultimate outcomes of value-added or productivity[[1]](#footnote-1). Some, however, have identified impacts on intermediate outcomes, such as employment growth or increased R&D expenditures (Storey, 2000 and OECD, 2007).

The main constraint of our analysis is that we do not have suitable data on the R&D expenditure history for all firms. This means that we are unable to estimate the most appropriate outcome from public R&D subsidies - whether or not receiving this assistance led to a higher level of R&D activity than would otherwise have been undertaken had the firm not received support (this is known as R&D additionality). Instead, we assess the impact of R&D assistance on firm sales, employment, labour productivity and multifactor productivity within four years after a firm first receives assistance. A total of 555 assisted firms are included in our sample.

In the next section, we present the statistical methodology and data. Section 3 describes the models. Results and conclusions are presented in Section 4.

# Method and data

In this evaluation, we wish to assess the direct impact of receiving R&D subsidies on the performance of firms that received the assistance. At the heart of evaluation is the following: In seeking to know the impact of a programme on a firm, we wish to compare what happens if they receive government assistance to what would happen otherwise. If we call the first *Y*1 and the second *Y*0, then the *additional* impact for each firm *i* at any time *t* is defined as the difference between its potential outcomes:

1. 

where the outcomes of interest might be intermediate outcomes, such as increases in a firm’s R&D activity or final outcomes such as improvements in productivity. The fundamental evaluation problem arises because we cannot observe both what would happen if the firm received assistance (*Y*1) and what would happen if it did not (*Y*0). The outcome that we do not observe is called the ‘counterfactual’.

We set out the core evaluation issue in Figure 1. Consider a firm that produces at **a** prior to assistance (at time *t*1). Assistance occurs at time *t*1, and after receiving assistance the firm’s sales rise until it produces at point **d** (at time *t*2). One simple way to measure the impact of the assistance would be to compare the firm before (**a**) and after (**d**) assistance. This is the same as assuming that the firm would not grow (i.e. it would have been at **b** at time *t*2). If we did this, we would infer that the impact was measured by the distance **bd**. That is, the assistance increased sales by *Y*1 - *Y'*. However, this ignores what was happening to the firm already (as well as the other changes that affected the firm since assistance). We can see from the figure that the firm was already on an upward sales path. Indeed, if they had maintained their pre-assistance trajectory, they would have ended up at **d** anyway. The difference between a zero impact and **db** in our figure is quite significant.

Figure 1: Defining a counterfactual

Shaded area = impact

of assistance

Firm with assistance

Firm without assistance

**a**

**b**

**c**

**d**

Outcome, *Y*
(e.g. sales)

Time

*t*1

*t*2

Zero growth

O

*Y*0

*Y*1

*Y'*

If somehow we knew that the firm would have actually ended up at **c** if it had not received assistance, we could clearly identify the impact as the distance **dc**. At time *t*2, the additional sales the firm enjoyed as a result of receiving assistance is *Y*1 - *Y*0. The total additional sales enjoyed by the firm is the shaded area between the two lines describing what happened after the firm received assistance and what would have happened if it did not receive assistance.

Because when we conduct evaluations we do not observe the counterfactual, we have to somehow estimate it. One way to do this is to find a suitable comparison group of firms and compare the outcomes of the firms receiving assistance with those of the control group. However, we cannot simply compare a group of firms receiving assistance with another random group selected from the business population.

Firms that receive government assistance are on average higher performing than the average New Zealand firm, *even before they seek out R&D assistance* (see also MED, 2009; Statistics NZ, 2010). Therefore, a simple comparison of outcomes between assisted and non assisted firms would reveal a spuriously high treatment effect for receiving R&D assistance because it would also include pre-existing differences in firms’ outcomes.

**R&D subsidies to NZ firms**

We have classified the government R&D subsidies between 2002 to 2008 into two different types of assistance: assistance to build R&D capability and assistance for R&D projects for firms with more highly developed R&D capability. Both categories of R&D subsidies target a wide range of firms at different stages of their life cycle - from early stage to maturity. Interestingly, there does not appear to a large degree of differentiation between firms that receive Capability Building and Project Funding assistance, at least in the year prior to first receiving a subsidy. Figure 2 shows that, on average, assisted firms are larger, have higher sales and capital intensity and are more likely to be exporting goods and undertaking R&D than firms that do not receive assistance (in the year prior to receiving their first subsidy). Assisted firms appear to have slightly lower multifactor productivity (MFP) than unassisted firms.

**Use of micro-data sets in evaluation**

Micro-data[[2]](#footnote-2) sets are increasingly used by researchers to examine a range of social and economic policy questions. Typically, they comprise data sets held at a national statistical bureau. Very often these data sets are accumulated from multiple sources to allow complex research questions to be examined. Their use for evaluation purposes appears to be relatively new.

We used a new micro-data set, Statistics New Zealand prototype Longitudinal Business Database (LBD), which contains high quality and comprehensive firm-level data (micro-data) from 2000 to 2008. This is a wide-coverage business database linking firm administrative and survey information of financial performance, employment, merchandise trade, business practices and other data. This enables us to compare the changes in performance of assisted firms to matched similar New Zealand firms that have not received government assistance.

The LBD also contains information of which firms received different types of government assistance to improve their economic performance. One of the benefits of this database is that we are able to isolate the impact due to R&D subsidies from the impact due to other types of government assistance (many NZ firms receive multiple types of government assistance to improve their economic performance). Earlier evaluations have failed to take multi-agency assistance into account. The database continues to evolve over time. It is described in more detail in Fabling (2009) and Statistics NZ (2010).

Figure 2: Kernel density plots of firm variables by assisted status

|  |  |
| --- | --- |
| A: Sales | B: Employment |
| kdensity_L2ln_sales_adj | kdensity_L2ln_rme_adj |
| C: Value added | D: Labour productivity |
| kdensity_L2ln_va_adj | kdensity_L2ln_prod_adj |
| E: Capital-labour ratio | F: Multifactor productivity |
| kdensity_L2klratio_adj | kdensity_L2mfp_adj |

**Statistical evaluation technique**

We use a combined propensity score matching and difference-in-difference approach. The matching method identifies similar unassisted firms from the rest of the population on the basis of observable characteristics (e.g. firm size, industry, etc). Fortunately, our database has a wide range of different firm characteristics that we can use to match assisted firms to similar unassisted firms. The LBD also contains all the firms in the New Zealand population so if a comparable firm exists in NZ, we can find it. The difference-in-differences aspect of our approach allows us to see what happens to assisted and unassisted firms over time; we compare changes in performance of assisted firms before and after receiving subsidies compared to changes in similar unassisted firms over the same time period. This means that we difference away any influence of factors that do not change over time, e.g. management capability or essential business model and focus only on the additional impact due to the assistance. This is the first time that this type of methodology has been applied in an evaluation of public R&D subsidies in NZ.

# Models

We investigate how the impact of R&D subsidies varies across schemes and firms. Schemes are designed with different outcomes or recipients in mind and firms respond to and benefit from assistance in different ways. Therefore we consider different sets of firms to isolate particular impacts.

Capability Building

Project Funding

All unassisted firms

Assisted firms

Control group

Figure : Model 1 - Capability Funding
 and Project Funding

With our first model, we investigate the separate impacts of Capability Building and Project Funding assistance. The two sets of assistance would be expected to have different impacts: both subsidies will build R&D capability, however the Project Funding is expected to result in more tangible outputs, such as new or improved products, processes and services and therefore higher economic performance.

Our first model divides firms into three groups: Those that received Capability Funding, those that received Project Funding and those that received no government assistance at all.

We might also expect the impact of assistance may vary by firm size and this is investigated in Model 2. Larger firms may be at different stages of their development and also gain from economies of scale. An important aspect of economies of scale is the ability to specialise and conduct potentially resource-intensive activities such as R&D.

Small firms with CB or PF

Large firms with CB or PF

Assisted firms

Control group

Small unassisted firms

Large unassisted firms

Figure :

Model 2 – Variations in impacts by firm size

In this model, we divide both the group of assisted firms and unassisted firms by size (in terms of employment). Our split point is chosen so as to split the group of assisted firms in half[[3]](#footnote-3). Because this reduces the sample size of our assisted firms, we pool the Capability Building and Project Funding recipients into one group. This is set out schematically in Figure 4. This means that in our analysis, we do two comparisons. In the first, we compare small firms receiving Capability Building and/or Project Funding assistance with small firms receiving no government assistance. In the second, we compare large firms receiving either or both types of R&D subsidies with large firms receiving no government assistance.

Another important dimension over which we might expect the impact of R&D subsidies to vary is whether firms had previously conducted R&D or not. The ability to benefit from some types of funding will be higher when a firm has already done some R&D previously as they already have the systems and capability in place. Indeed, Project Funding is aimed at firms with existing R&D capability. One would expect these firms to have conducted some kind of R&D activity previously. Similarly, one would expect firms that had not previously conducted R&D to have lower R&D capability and benefit more from Capability Building programmes.

Firms in receipt of CB or PF with prior R&D activity

Assisted firms

Control group

Unassisted firms with prior R&D activity

Firms in receipt of CB or PF with **no** prior R&D activity

Unassisted firms with **no** prior R&D activity

Figure : Model 3 – Variation in impact
by previous R&D activity

In Model 3, we split the sample into firms that have undertaken any R&D in the two years prior to first receiving R&D assistance and those that have not. We then compare firms in receipt of Capability Building and/or Project Funding assistance with firms receiving no government assistance.

# Results and conclusions

In this study, we focus on whether the R&D assistance actually improved the performance of the firm. Firms that receive Capability Building assistance show significantly higher employment growth compared to matched unassisted firms. Most of this growth occurs at the start of R&D assistance and then grows only slightly after that till three years following first receiving assistance. We also see a short term impact on sales and infer a positive impact on value-added because labour productivity does not become negative even though labour has increased. However, our most encouraging result is the impact on multifactor productivity four years following first assistance because this is an ultimate outcome for government assistance. If this impact is due to firms using resources more efficiently or adopting better business strategies and/or practices then we should expect to see the impact continue to be positive at longer lags.

In contrast, there are no impacts for Project Funding even on intermediate outcomes. We found this counterintuitive because we know that Project Funding involves larger dollar amounts compared to Capability Building. In order to understand this result better, we pooled both types of assistance and examined the influence of firm size and prior R&D activity on the results. We only found impacts for small firms and firms that had not undertaken R&D two years prior to receiving their first assistance. We saw no positive impacts for large firms and no positive impacts for prior R&D performers. Our results show that government R&D subsidies have a significant positive impact when it is targeted at firms that are building capability; that are small and that have not previously undertaken R&D.

Previous evaluations report an increase in R&D capability as a result of receiving assistance. Firms surveyed mentioned that R&D would not have occurred, at least at the same level, without assistance. This is consistent with R&D additionality, but it is not an actual measure because it is based on self-reported performance. Previous evaluations found very positive impacts on sales, with quantitative estimates ranging from on average increase in 7% to 29% due to government R&D subsidies.

These results are much more positive than our estimates. This is not surprising as the estimate is a before/after measure, i.e. it measures what happened as after receiving assistance. This might severely overstate the impact. It does not compare the performance of assisted firms with similar firms that received no assistance. It is not that assisted firms did not develop new products, processes or services and generate excess sales; it is clear that they do. However our analysis suggests that they would have done that anyway and attributing the entire change in sales to government R&D subsidies leads to overestimates of sales impact. Previous evaluations did not identify or quantify the counterfactual.

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1. Surveys by Cerulli (2010) and Abbring and Heckman (2007) deal with the statistical issues arising when estimating impacts. [↑](#footnote-ref-1)
2. The European Commission statistical office, Eurostat, defines micro-data as being “confidential data which contain information about individual statistical units”. Such information is termed ‘micro-data sets’ because they are essentially unit records from surveys and other sources stored on computer data banks. Multiple data can be linked to a united record identifier such as the name of a firm or an individual. [↑](#footnote-ref-2)
3. This means that small firms are defined as having employment of less than 6.2. Our measure of employment is the average over the years of the number of employees in each month and so need not be an integer. [↑](#footnote-ref-3)