A Complementary Analysis of Impact of Training Practices on Return on Investment

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Abstract

This paper identifies the complementarities in both on-the-job and classroom based training practices with respect to a return on training investment using a Canadian dataset on workplace practices. After using factor analysis to reduce the number of training variables, we provide a constrained regression model with supermodularity or submodularity constraints to test for complementarities and substitutes. Log-likelihood ratio test is performed to test the significance of the estimation of the parameters. We identify that, depending on the industry where a firm operates and the size of the firm, some training practices are complements and should be adopted simultaneously in order to improve labor productivity and/or profit of firms, while others should not be conducted in tandem as they are substitutes.

I. Introduction

One of the central problems in innovation and managing technological change in business is improving the skills of the workforce through the investment in human capital and a variety of training practices. In many industries, relevant and effective training programs have been important factors driving the growth of firms and improving their performance. Many researchers have found that there exists a positive relationship between workplace training and profitability, revenue, and productivity (Bartel, 2000)-(Barren and Loewenstein, 1989). While some studies discovered that increases in training can improve labor productivity and offer higher return on investment (ROI) than otherwise, however, few papers have addressed the cumulative ROI provided by complementary training practices with respect to profitability and productivity. In this paper, we use a comprehensive longitudinal dataset to investigate the relationship between various forms of training practices to determine if there are greater returns to completing multiple training initiatives. We will identify which training practices are complementary and which are substitutes based on firm size and industry classification. By simultaneously investing in complementary training practices and avoiding substitute practices, managers will be able to increase the ROI of their training investments.

The remainder of the paper is structured as follows. Section II presents the literature reviews of return on investment training and complementarities in organizational practices. Section III proposes the methodology and the model used to perform the complementary analysis. Section IV gives numerical results and relevant analysis and discussion. Section VI provides conclusions and future research.

II. Background

A. Return on Investment of Training

The importance of return on investment of training has been realized in industry as organizations always try to cut costs and improve their productivity and profit (Kumpikait, 2007). As a result, how to evaluate the importance and the impact of training practices on these outcomes becomes an interesting and crucial area in both academia and industry. Kumpikait (2007) introduced the importance of human resource development evaluation in terms of improving performance of organizations. He described the details of evaluating human resource development costs and ROI, and discussed advantages of the evaluation. He further concluded that with careful planned methodologies and valid analyses ROI evaluation can be procured for almost any type of human resource program. Rowden (2005) also explored the methods used to evaluate the ROI of training. He provided models and approaches with different levels of complexity so that human resource mangers in organizations can use them to evaluate ROI of training given their needs.

Black and Lynch (2001) presented insights on impact of human-capital investment on business productivity. Using relatively accurate survey data, they estimated the impact of human-capital investment on productivity for three training activities: computer training, teamwork training, and supervisor training. The numerical results show that training activities and education play an important role in productivity for manufacturing and non-manufacturing industry. Particularly, off-the-job training can improve the performance of manufacturing firms, and computer-skills training positively impacts business productivity in non-manufacturing industry. However, due to lack of data of the number of workers trained, their estimate of impact of training may be underestimated. In our paper, we have sufficient data of 7 continuous years; therefore, we have a measure of accumulated stock of training for all workers.

Tharenou et. al. (2007) provided a most recent and complete review for the results of previous studies about the relationship between training and human resource, organization performance, and financial outcomes. They investigated 67 studies and concluded that training is positively related to human resource development and organizational performance, such as labor productivity, but weakly related to financial outcomes, e.g. ROI. In addition, they suggest that emphasis of future research be given to effects of training contents, type of training, and why transfer of training improves organizational effectiveness.

B. Complementarities in Organizational Practices

Some studies have applied the framework to identifying complementarities in various areas including innovation policy, research and development strategies, and innovative employment practices. Mohnen and Röller (2005) used European data to test complementarities in innovation polices. They not only identified the existence of complementarities but investigated the degree of innovation. The approach they adopted to test complementarities was to verify that if the innovation function is supermodular; statistical tests were developed for supermodularity and submodeuliarity.

Ichniowski et al. (1997) investigated the impact of innovative employment practices on productivity using 36 steel production lines in 17 companies. The productivity model they used was formulated to represent the steel production in the real world; key technical parameters were taken as the factors determining steel output. Their results showed that production lines using innovative work practices achieve higher productivity than lines only adopting traditional approaches.

Belderbos et al. (2006) assessed the performance of research and development firms using different cooperation strategies with different partners. They estimated the productivity equation; productivity growth from a previous year was the dependent variable and was measured as the value added per employee; cooperation strategies and other variables affecting labor productivity growth were independent variables. They demonstrated that firm performance may either improve or recess with joint adoption of cooperation strategies. The methodologies used in these papers were all regression models.

Cassiman and Veugelers (2006) combined a productivity approach and an adoption approach with a two-step model; the results obtained from the adoption approach were used in the productivity approach. They not only tested the complementarities among internal R&D and external knowledge acquisition but estimated a multinomial logit model to exam the drivers for joint adoption of these innovation activities. They used the constrained regression model to test if complementarities existed.

Most of previous studies used a limited number of the independent variables in their regression models for testing complementarities in training practices, for example, in (Cassiman and Veugelers, 2006) there were 2 variables. Therefore, this paper will expand the depth of knowledge on the ROI of training by demonstrating the forms of training which are complementary or substitutes for each other using a comprehensive dataset.

III. Methodology

With the data from Statistic Canada’s Workplace and Employee Survey (WES), we can have access to the datasets of innovation and training of Canadian firms; the data contain survey results from 5000 Canadian firms over 6 years, e.g. 1999-2004. There are 13 in-classroom trainings (ICT) and 13 on- the-job trainings (OTJT) in the dataset; each category of the two trainings has the same training practices; for example, orientation ICT has a counterpart in OTJT, e.g. orientation OTJT.

In this study, the ROI is measured by two different metrics; labor productivity or profit. Independent variables include binary variables representing the availability of training practices and other variables that may have impact on perceived ROI: union relevant variables and innovation variables, both types of variables are binary, i.e., 1 if a firm is involved with union bargain agreement, 0 otherwise; 1 if a firm performs any type of innovation activities, 0 otherwise. Industry and size of firms are used as dummy variables. We classify the size of firms into 3 groups: small firms for those with, more than 4 employees and less than 51 employees, medium firms where the total employee is between 51 and 250 (inclusive); and large firms where there are more than 250 employees.

The results obtained from the constrained regression analysis are used to identify complementarities or substitutability between training practices. We adopt the framework proposed by Kodde and Palm (1986) to analyze the complementarities in training.

The constrained regression model is shown as follows.

$$
\begin{aligned}
& L^k(z_j^k, x_n^k, \alpha_{m_1 \ldots m_M}, \varepsilon^k) \\
& = \sum_{m_M=0}^{1} \ldots \sum_{m_1=0}^{1} \alpha_{m_1 \ldots m_M} [\prod_{j=1}^{M} (1 - m_j - (-1)^{m_j} z_j^k)] \\
& + \sum_{n=1}^{N} \alpha_n^k x_n^k + \varepsilon^k
\end{aligned}
$$

where k refers to firm k and j represents training practice, from 1 to M. z_j^k are the binary independent variables which indicate the state of training practice j; 1 if the training j is available, 0 otherwise. m_j is the state of training practice j, 1 available; 0 otherwise. x_n^k , running from 1 to N, is a vector of other variables that may have impact on the dependent variable, labor productivity or profit, which are represented by $L^k(z_j^k, x_n^k, \alpha, \varepsilon^k)$. ε^k is the error term. $\alpha_{m_1 \ldots m_M}$ are coefficients relevant to their training practice states.

The complementary between any two training practices, i, $i+1$, is tested by following set of constraints.

$$
\alpha_{m_1 \ldots,1,1,\ldots m_M} + \alpha_{m_1 \ldots,0,0,\ldots m_M} \geq \alpha_{m_1 \ldots,0,1,\ldots m_M} + \alpha_{m_1 \ldots,1,0,\ldots m_M}
$$

If the constraints are strictly satisfied for any other m_j, training practices, i, j are perceived as complementary to each other. Unbiased estimation of the coefficients will be tested in later section to prove the existence of the complementarity.

However, conditional on the number of the types of training practices, the size of the models can increase exponentially; we may have 2^M constrained regression models and each has 2^{M-1} constraints. This will increase the computation cost and could unnecessarily complicate the whole framework. Therefore, we need to perform factor analysis to group different trainings with similar characteristics into one category so that number of variables can be reduced.

After factor analysis, the 26 training practices can be grouped into 3 categories:

1. *Management (general) training*: Orientation, management, sales & marketing, office and non-office equipment, group decision making, team building & leadership, and health and safety
2. *Technology training*: professional training, computer hardware, and computer software
3. *Apprenticeship and analysis:* apprentice, literal and numerical

Table 1. Variance Explained By Factors

Factor	Variance Explained (Weighted)	Variance Explained (Unweighted)
1-GeneralTraining	52.53%	53.31%
2-Professional and Technology Training	29.87%	19.67%
3-Apprentice & Analysis	17.60%	27.02%

We then created binary variables for the training factors. Based on the survey dataset, the sum score of each factor for each observation was calculated, then the average. If a respondent's average score was greater than or equal to the group average score, it would be coded as 1, 0 otherwise. We also included other explanatory variables represented by x_n in the regression model: union relevant variables, innovation variables; both are binary variables.

Constrained regression models are used to estimate the coefficients relevant to the binary variables, based on the model previously described. Furthermore, two sets of hypothesis were conducted to test supermodularity and submodularity, respectively. By the results of the hypothesis tests for supermodularity, we could determine which pairs of training practices should be adopted simultaneously so that the firms can perform better than otherwise, e.g. they only adopt them separately. Meanwhile, we can also find out that which set of training practices should not be adopted simultaneously in order for a firm to obtain the optimal labor productivity and profit.

Therefore, there are two sets of hypothesis tests: supermodularity test:

H_0: $\alpha_{m_1\ldots,1,1,\ldots m_M} + \alpha_{m_1\ldots,0,0,\ldots m_M} = \alpha_{m_1\ldots,0,1,\ldots m_M} + \alpha_{m_1\ldots,1,0,\ldots m_M}$

H_1: $\alpha_{m_1\ldots,1,1,\ldots m_M} + \alpha_{m_1\ldots,0,0,\ldots m_M} > \alpha_{m_1\ldots,0,1,\ldots m_M} + \alpha_{m_1\ldots,1,0,\ldots m_M}$,

and submodularity test:

H_0: $\alpha_{m_1\ldots,1,1,\ldots m_M} + \alpha_{m_1\ldots,0,0,\ldots m_M} = \alpha_{m_1\ldots,0,1,\ldots m_M} + \alpha_{m_1\ldots,1,0,\ldots m_M}$

H_1: $\alpha_{m_1\ldots,1,1,\ldots m_M} + \alpha_{m_1\ldots,0,0,\ldots m_M} < \alpha_{m_1\ldots,0,1,\ldots m_M} + \alpha_{m_1\ldots,1,0,\ldots m_M}$

We would use log-likelihood ratio test as the significance test to determine if we should reject the null hypothesizes. Individual productivity and profitability models were created for each size class and industry.

IV. Results and Discussion

Table 2 displays the hypothesis test results for the analysis by size class. From these results we can tell that for large firms, with a significance level of 0.1 and 0.01, training factor 2 and training factor 3 should not be adopted simultaneously with respect to labor productivity and profit since the null hypotheses are rejected. This means that the additional return for investments in both training types simultaneously is less than the return on investing in either one individually. There is not a significant amount of return for investing in both of these types of training together.

Medium firms have one pair of complements with respect to labor productivity, i.e. general training and technology, and have one pairs of substitutes with respect to labor productivity, i.e., technology and apprenticeship. We find that general training and apprentice training is inconclusive with respect to profit and independent with respect to labor productivity.

Small firms seem to be able to improve their labor productivity and/or increase their profit by separately adopt most of the three training factors, although profit increases with a significance level of 0.05 if factor 2 and factor 3 are adopted together. This can be explained as the small firms in the dataset come from different industry, and perform training practice given their individual needs, i.e. these firms usually focus on certain of business areas and do not adopt complex interdisciplinary training programs.

Each industry tends to adopt its own unique set of training practices. The nature of the industry may determine which training it may adopt more extensively than others. Here we analyze some representative industries to show the insights behind the results of the hypothesis tests (refer to Table 3 for test result values).

Business services only show a pair of complementary practices with respect to profit: general training and apprenticeship and analysis training. This result is due to the fact that business service generally involves with experience-relevant skills such as sales & marketing, group decision making, office equipment using, so apprenticeship and analysis relevant training practices can be easily incorporated into them.

Not surprisingly, capital intensive manufacturing exhibits a complementary pairing between management training and technology training. Among capital intensive manufacturing firms, in general, manufacturing processes are highly automatic, and employees are required to be able to use computers and other high technologies which are combined with general management training practice in order to improve labor productivity. Meanwhile, apprenticeship, basic analysis training, and management training are not typically adopted simultaneously within capital intensive manufacturing with respect to labor productivity because apprenticeship is usually a prerequisite requirement in labor intensive manufacturing industry.

The education and health services industry seems to show complements between general training and apprenticeship, and between general training and apprentice and analysis. In this case, apprenticeship would include continuing education requirements as well as internships and clinical rotations. Due to the somewhat distinct nature of two industries in this category, education and health service, the analysis for this industry may be confounded by the government regulatory requirements and structural differences between the industry components.

Table 2 Likelihood ratios for training factors-by size of firms

Firms	Factor Pairs	Supermodularity Test: Labor Prod	Supermodularity Test: Profit	Submodularity Test: Labor Prod	Submodularity Test: Profit
Large Firms	1&2	0.503	0.000	0.067	1.186
	1&3	0.000	0.000	1.599	1.278
	2&3	2.382*	21.812+	0.000	0.000
Medium Firms	1&2	0.004	0.343	10.034+	0.000
	1&3	2.377*	0.182	2.244*	0.000
	2&3	5.406+	0.000	0.496	0.010
Small Firms	1&2	2.015*	9.742+	1.373	0.000
	1&3	3.824+	5.228+	0.436	0.250
	2&3	6.813+	1.259	0.000	2.717**

*Significant at 0.1 level **Significant at 0.05 level + Significant at 0.01 level

The finance and insurance industry grouping can benefit from separately adopting general management and technology training with respect to labor productivity and profit. Finance and insurance is a complicated industry; big financial firms require all training practices relevant to teamwork, sale and marketing, group decision making, as well as technology side: information system, database etc. Running a comprehensive training program for so many employees can lead to low efficiency and high costs. However, there are a lot of small financial institutions. In these firms, probably only some of training practices are performed, depending on need. In addition, the roles within a big firm may be very fine; some of the roles may require more professional & technology training or more apprenticeship and analysis training, but not both. That is why factor 2 and factor 3 are not complements with respect to labor productivity and profit.

General training and apprenticeship are complements in forestry, mining, gas and oil industry. This is due to nature of jobs in this industry: these jobs require a lot of field operations. As a result, apprenticeship should be incorporated into general training, e.g., teamwork, safety, health and leadership, so that new employees can be trained and tutored by experienced employees.

Retail and consumer service firms can perform better with respect to profit if general training and technology training are adopted separately. However, combining these two training factors can improve labor productivity because employees' efficiency can improve by using computers or Internet, for example, online shopping and delivery, and online reservations. In addition, retail and consumer service may highly count on experience and sales and marketing; that is why apprenticeship is so important and should be adopted separately from other training practices in order to improve labor productivity.

Firms in transportation, warehousing and wholesale can improve labor productivity by adopting technology training and general training simultaneously. For example, a powerful software system can help build up a reliable supply chain network and an efficient logistic system, with the help of efficient management, communication and teamwork, labor productivity can be improved. However, an advanced software system and relevant training can be expensive; therefore, combining factor 1 and factor 2 cannot increase profit. Meanwhile, literal and numerical training is also very important; employees in this industry need to have strong literal and numerical skills; the jobs may include, for example, inventory management, database maintenance, stock record update. The common sense may explain why factor 2 and factor 3 are complements with respect to profit; managers purchase computer systems and software packages, and train their employees to use them through apprenticeship while improving their employees' literal and, particularly, numerical skills given the working context.

Table 3 Likelihood ratios for training factors-by industry

Industry	Factor Pairs	Supermodularity Test		Submodularity Test	
		Labor Prod	Profit	Labor Prod	Profit
Business Service	1&2	2.509^{**}	2.182^{*}	0.000	0.280
	1&3	0.073	0.487	0.635	2.052^{*}
	2&3	1.338	1.181	0.000	0.598
Capital Intensive Manufacturing	1&2	0.000	5.420^{+}	3.310^{**}	0.000
	1&3	142.929^{+}	1.467	0.000	0.000
	2&3	0.007	0.592	0.251	0.000
Communication & Utilities	1&2	0.195	0.117	0.000	0.000
	1&3	0.351	0.000	0.000	0.071
	2&3	0.020	1.002	0.045	0.000
Construction	1&2	1.974	0.000	0.000	12.981^{+}
	1&3	2.769^{**}	9.188^{+}	0.166	0.000
	2&3	0.000	0.000	10.036^{+}	5.774^{+}
Education & Health Services	1&2	0.838	0.000	0.000	3.472^{**}
	1&3	0.000	0.099	2.115^{*}	0.000
	2&3	0.411	0.266	0.000	0.000
Finance & Insurance	1&2	2.606^{**}	8.922^{+}	0.000	0.359
	1&3	0.000	4.721^{+}	2.169^{*}	0.144
	2&3	2.481^{**}	2.149^{*}	0.000	2.420^{*}
Information & Cultural Services	1&2	0.415	0.000	0.000	0.535
	1&3	0.000	0.216	2.060	0.000
	2&3	0.000	0.000	0.068	0.128
Labor Intensive Manufacturing	1&2	0.000	0.007	1.364	0.001
	1&3	0.000	0.103	0.714	0.000
	2&3	0.060	0.028	0.000	0.000
Forestry, Mining, Oil, and Gas	1&2	20.239^{+}	0.072	0.000	0.640
	1&3	0.089	0.006	3.706^{+}	1.665
	2&3	0.512	0.580	1.609	0.159

Primary Product Manufacturing	1&2	4.589+	0.000	0.000	0.850
	1&3	0.466	0.000	0.327	4.585+
	2&3	0.585	2.303*	0.139	0.000
Real estate Rental and Leasing	1&2	0.000	0.000	3.532**	13.696+
	1&3	0.149	0.147	0.338	2.062
	2&3	1.513	5.262+	0.000	0.000
Retail and Consumer Service	1&2	0.091	11.118+	5.773+	0.087
	1&3	2.497**	6.114+	0.248	1.029
	2&3	3.439**	1.485	0.583	4.423+
Secondary Product Manufacturing	1&2	0.000	0.599	7.207+	2.241*
	1&3	0.000	4.204+	0.685	0.000
	2&3	0.000	0.014	0.783	4.691+
Transportation Warehousing Wholesale	1&2	1.155	4.557+	8.126+	0.020
	1&3	6.904+	8.932+	2.134*	0.000
	2&3	6.681+	0.122	1.780	3.058**

*Significant at 0.1 level **Significant at 0.05 level + Significant at 0.01 level

V.Conclusions

In this paper, we investigated the impact of various types of training on labor productivity and profit using WES data provided by Statistics Canada. Furthermore, a complementary analysis was conducted to explore the interactions between training practices by the size of firms and by industry. Depending on the size of the firm and the industry in which it operates, we found out that firms can perform better with respect to labor productivity and/or profit if some training practices are adopted simultaneously. On the other hand, some training practices can reduce labor productivity and/or profit if they are adopted at the same time within the firm. There is no universal standard of training practices which are complements or substitutes demonstrating that detailed industry specific analysis is required to obtain meaningful results for application by managers and government stimulus training programs. The insights obtained from the hypothesis tests of the underlying constrained regression models can help managers in firms of different sizes from various industries determine their complementary training sets in order to improve the performance of their firms.

The next phase of this research will focus on the incremental and cumulative ROI using the longitudinal data. We will pay special attention to the ROI change between consecutive years, such as labor productivity and profit, and the impact that training practices have on that change.

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