Three Papers on Firm-Sponsored Training

By

Yunfa Zhu

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Department of Economics

University of Manitoba

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Abstract

This dissertation contains three essays on firm-sponsored training. Paper 1 develops a general theoretical framework in a frictional labour market to investigate how firms decide to sponsor how much general as well as specific training to workers assuming complementarity between the two types of training as well as education. It shows that firms' profit maximizing decisions provide firms with an incentive to provide more training, general as well specific, to the more educated workers, more training for more educated workers may lead to low turnover rate, and the resulting life-time profile of firm-sponsored training is U-shaped or decreasing. The policy implications are that governments can subsidize both education and training to improve efficiency. Paper 2 and paper 3 try to provide empirical evidence from different perspectives, respectively determinants and effects of three types of firm-sponsored training, i.e., class-room training, on-the-job-training, and career-related but not job directly related training based on Statistics Canada's Worker Place and Employee Survey (WES) of 2003/2004. The major empirical findings arising from our estimation results are: (1) Education is positively and significantly associated with the incidence of all three types of training, and significantly positively correlated with the intensity of on-the-job training. (2) Workers in larger firms are more likely to obtain classroom training and on-the-job training than workers in smaller firms. (3) Job tenure is significant and negative for the intensity of classroom training or on-the-job training. (4) Classroom-training and on-the-job training increases the average earnings of workers but less than average resultant firm-level productivity growth. Firm sponsored career related training has no significant impact on a worker's earnings but increases the firm's productivity significantly. All these findings by and large are consistent with the theory developed in first paper.

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Dedication

I would like to dedicate this publication to my wife Haiyan and my two lovely kids, my daughter Maggie and my son Allen for their encouragement, understanding and making my life happy.

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Introduction

This dissertation contains three essays on firm-sponsored training. Classic Beckerian training literature demonstrates that in a perfectly competitive market, firms have incentive to sponsor specific training but no incentive to sponsor general training. New training theory deviating from the perfectly competitive paradigm shows that firms have incentive to sponsor general training as well as specific training but the question of how much training is received by which workers needs to be answered. Empirical literature focuses on estimating determinants of intensity and incidence of firm-sponsored training, but do not compare the effects on the earnings of workers and productivity of firms. This dissertation contributes to the literature by developing a model in which the complementarity of general training, specific training and education provides an incentive for firms to sponsor training because the firm profits from the resulting productivity increase. It also shows that this complementarity will affect which workers are more likely to receive training.

Paper 1 analyzes how much and what kinds of training firms would provide for workers of different education levels in a relatively general framework based on the following simplified assumptions: 1) Labour market is competitive and information is perfect; 2) The future wage and training is non-contractible; 3) Wages are determined by simple Nash bargaining; and 4) education, specific skill and general skill are complementary to each other. While the firm has no incentive to provide general training where general and

specific training are independent of each other, the firm will provide general training where complementarity exists. The firm's profit maximizing decisions furnish firms with an incentive to provide more training, general as well specific, to the more educated workers, more training for the more educated workers may lead to low turn over rate and the life-time profile of firm-sponsored training may be decreasing or inverse U-shaped. Because firms only appropriate part of the productivity improvement from training, firm-sponsored training is below the efficient level. The policy implications are that governments can subsidize education or training or both to improve efficiency.

Paper 2 tries to contribute to the literature by estimating the incidence and intensity of firm-sponsored training in an integrated encompassing sample selection model, taking into consideration selection bias and utilizing the firm's and the worker's information supplied by the Workplace and Employee Survey (WES). Using 2003-2004 Workplace and Employee Survey (WES) data, we identify three firm sponsored training variables in the data, that is, class room training, on-the-job training, and career related but not job directly related training. Then we estimate the intensity and incidence of each of the three types of firm-sponsored training, in an integrated way, incorporating sample selection. The findings arising from on our estimating results are: (1) For all three types of firm-sponsored training, education is positively and significantly correlated with the incidence of training, but only significantly positively correlated with the intensity of on-the-job training. (2) Occupations are more important determinants than industry categories. Professionals, managers and technical /trades are more likely to obtain all three types of training. On the intensity, professionals, managers and technical /trades tend to obtain

more on-the-job training, while marketing/sales, professional and managers tend to obtain more classroom training, and marketing /sales tends to obtain more career related but not job directly related training. (3) Firm sizes are significant for the incidence of classroom training and on-the-job training and for the intensity of career related but not job directly related training. Larger firms have significantly higher incidence of classroom training and on-the-job training. The firm size profile of the intensity of the career related but not job directly related training is U shaped. (4) Job tenure is significant and negative for the intensity of classroom training and on-the-job training, but not significant for the career related but not job directly related training. The age profile is decreasing for the incidence of all three types of training. (5) Collective bargaining agreement is only significant and positive for the incidence of classroom training, and is not significant in all other cases. (6) Computer users are more likely to obtain all three types of firm-sponsored training.

Paper 3 tries to consistently estimate the impact of three firm-sponsored trainings, classroom training, on-the-job training and career related not job directly related training on both the firm-level labour productivity and worker's earnings controlling for the firm's and worker's fixed heterogeneities, employing the longitudinal property of Canadian linked employee-employer data, that is, Workplace-Employee Survey (WES), 2003-2004 panel. Our results show classroom training would increase the earnings of workers in the current period on average by 1.9% and the firm level productivity on average by 12%; On-the-job training would increase the earnings of workers in the current year by 0.6% and in the next year by 0.6%. Firm's productivity level in current year increases by 7% and in

next year by 7%; and firm sponsored career related but not directly job related training has no significant impact on both worker's current earnings and worker's next year's earnings but increases the firm's productivity in the next year by 12%. Our findings by and large are consistent with the theory developed in the first paper and the new firm-sponsored training theory.

Chapter 1: Firm Sponsored Training: Theory

Abstract

This paper attempts to analyze how much and what kinds of training firms would provide for workers of different education levels in a relatively general framework based on the following assumptions: 1) labour market is competitive and information is perfect; 2) the future wage and training is non-contractible; 3) wages are determined using simple Nash bargaining; and 4) education, specific skill and general skill are complementary to each other. The firm's profit maximizing decisions provide firms with an incentive to provide more training, general as well specific, to the more educated workers; and more training for the more educated workers may lead to low turnover rate. The resulting life-time profile of firm-sponsored training may be inverted U-shaped or decreasing. The policy implication is that governments can subsidize both education and training to improve efficiency.

1. Introduction

Accumulation of human capital is one of the crucial determinants of a country's productivity and living standard, as well as firms' competitiveness in the product market or workers' success in the labour market. Human capital, embodied in the skill and knowledge of workers, can be accumulated through formal education in school and formal or informal training after they enter into the labour market.

In the industrial era, a typical worker went through three distinct life cycle stages: school, employment and retirement. After finishing school, the worker only needed initial informal and brief on-the-job training and / or learning, and could be fully functional throughout their employment until their retirement. However, with the advent of the post-industrial era, especially the explosion of the knowledge economy, employment continuously shifts toward white collar and service industries, thus, the intangible assets such as the skill and knowledge of workers become dominantly important. Furthermore, the wide diffusion of information technology brings about rapid restructuring, reorganization and innovation of production processes and products. Thus, formal education in school, though essential and necessary, is not sufficient, and workers need to upgrade their skill throughout the working stage of their life cycle (Betcherman et al, 1998). Training while working is becoming more and more important, and as in Acemoglu's opinion, is at least as important as formal education (1998a).

In his seminal work, Becker (1964) presents the classical human capital theory of formal training: in a perfectly competitive labour market, firms have an incentive to provide specific training but no incentive to provide general training. Even though firms pay for general training for workers nominally, it is workers who actually end up paying through lower wages because in the perfectly competitive labour market, workers are paid according to their marginal productivities and are the only beneficiaries of general training. In this case, education and training, especially general training, are treated symmetrically and together with wages are determined by the agent's life cycle utility

maximization decision (Ben-Porath, 1967; Heckman 1976; Weiss, 1986). There is now a vast literature on human capital investment but it mainly focuses on formal education along the line of Beckerian theory. On the macro-side, the idea that human capital is central to economic growth revived economic growth theory (Lucas 1988; Mankiw et al, 1992; Aghion and Howit 1998). Growth accounting studies show that growth in the quality of workers usually represented by the years of formal education is the main driving force of productivity growth (Jorgenson et al 1967; Denison 1985). On the micro side, a lot of literature on estimations of Mincerian earning equations and treatment effects show that more educated workers earn higher wages; these papers are all explicitly or implicitly based on the neo-classical Beckerman assumptions (Mincer 1974; Card 1999; Heckman et al 2005). There are also alternative theories that view education or training as signals or screening devices to reveal abilities or self selection (Spence 1973; Riley 1976; Salop and Salop 1976; Stiglitz 1975; White 1980; Weiss 1995). All these theories are used to account for individuals' investment in human capital including education and training.

However, evidence shows firms do sponsor training and much of the firm sponsored training is general in essence. Not only do firms sponsor training, but employer sponsored training accounts for a bulk of the total training in the major OECD countries. Stylized facts from the evidence concerning the employer sponsored training include: 1) Participation in training is inverse U-shaped over the workers' life cycle. 2) More educated workers are more likely to obtain employer-sponsored training. 3) Larger employers are more likely to sponsor training for their workers. 4) More educated

workers not only have high wages, but also have better performance in areas such as labour market attachment and unemployment rate in their life cycle (Bishop 1996; Riddell et al 2002).

So why do employers sponsor training, especially general training? To answer this question, modern training literature has to depart from the perfectly competitive labour market paradigm. Acemoglu and Pischke (1999, 1998a, 1998b) note that in order for firms to have an incentive to sponsor general training, the labour market must display a "compressed wage structure", that is, after training, productivity increases more than the wages paid. They identify many specific mechanisms and institutions in the labour market that can lead to a compressed wage structure, A) search and monopsony; B) asymmetric information; C) firm-specific human capital; D) efficiency wage; E) minimum wages and other wage floors; F) unions; G) interaction of specific and general skill. The resultant distortion in the wage structure "turns technologically general skill into de facto specific skill" (Acemoglu and Pischke 1999). They also point out that labour market imperfections lead to inefficiencies in training, thus subsidies and regulation may be needed to correct the inefficiencies. Autor (2001) develops and tests a model that temporary help firms use general training, especially computer-skill training, to induce self selection and worker screening. Firm sponsored training is also associated with promotion, turnover in imperfect labour markets, and may bring about multiple equilibria which can explain that on the one hand, some countries, such as USA, are associated with high turnover, low firm sponsored training and possible better matching between workers and employers, and on the other hand, some countries, such as Japan

and Germany, display low turnover, high firm sponsored training and possibly less good matching between workers and employers (Gibbons and Waldman 1999; Owan 2004).

All above contributions in the new training theory help to answer the important question: Why do firms sponsor training, especially general training? However, the following questions still need to be answered systematically: Who provides how much training? Who gets how much training? How does one explain the empirically observed pattern of training?

Following Casas-Arce (2004) and Kessler and Lulfesmann (2002), this paper's contribution is to develop a framework to answer those questions theoretically and systematically. Kessler and Lulfesmann (2002) assume severability between general skill and specific skill, and use asymmetric information to motivate general training while Casas_Arce (2004) assumes a recursive game between firms and workers: Firms invest in general skill, and then workers accumulate specific skill. This paper will maintain the following basic assumptions from Cassa-Arce (2004): human capital is observable but non-verifiable and thus non-contractible; general skill, specific skill and education are complementary; wages are decided through Nash bargaining approach; otherwise labour markets are competitive, that is, there are many firms, which drive the firm's profit to zero. Unlike Cassa-Arce (2004), this paper develops a model in which a firm's profit maximization will lead the firm to provide both general and specific training if these are complementary.

The rest of the paper is organized as follows. Section 2 presents a basic model of two periods. Section 3 extends the basic model. Section 4 presents a brief explanation of the stylized facts based on developed theory, and section 5 concludes the paper.

2. Basic Model

2.1 Basic assumption

Consider a firm hiring workers; several skill groups of labourers are the only inputs in the production. A worker's marginal product is characterized by H(e, G, S), where e, G, S are the education level, general skill and specific skill of the worker respectively. There are two periods, period 0 and period 1. Before the start of period 0, education level e is acquired by the worker and is fixed throughout all periods. Only firms can invest in general and specific skills of the workers; let the general and specific training be *g* and *s* respectively in period 0, which form next period's general and specific skill, and the cost functions are $C_g(g)$ and $C_s(s)$ respectively, which are convex with $C_g`(0)=0$ and $C_s`(0)=0$. Obviously, firms have no incentive to provide training, specific as well general in period 1. The marginal product of labour at any period depends on *e*, *G* and *S* at the beginning of the period.

The departure from the perfectly competitive labour market paradigm is that both general and specific human capital are observable but not verifiable (Gross and Hart (1986), Hart and Moore (1990), so general and specific human capital are not contractible, or there is only an implicit contract between the workers and firms for general and specific human

capital (Rosen, 1985; Salanie, 1987). Since general and specific human capital are not contractible, a contract encompassing wage and training can not be negotiated ex ante, but wages are bargained between workers and firms ex post. The basic assumptions are the following:

Assumption 1: Both general and specific human capital is not contractible.

Assumption 2: Education, general human capital and specific human capital are complements of each other, that is, $\frac{\partial^2 H}{\partial i \partial j} > 0, i \neq j, i, j \in \{e, g, s\}$

Assumption 3: There are many firms with the same technology and entry and exit are free. Thus, in every period, the labour market is competitive.

Assumption 4: The wage bargaining process is a standardized Nash bargaining process.

The wage bargaining process is assumed to follow standardized Nash bargaining solution (Nash 1950, 1953). Let λ be the bargaining power of the worker and (1- λ), the bargaining power of the firm. Jobs are destroyed at exogenous rate q. The process proceeds as follows. In the period 0, the firm watches e, offers competitive wage $W_0(e)$, and invests g in general human capital and s in specific human capital by sponsoring training for the worker. The worker's marginal product is H(e, 0, 0). In period 1, the worker and the firm bargain for wage, $W_1(e, g, s)$ and the worker produces H(e, g, s).

Using backward induction, in period 1, the outside wage is H(e, g, 0), since general capital is transferable and specific human capital is not transferable. The surplus is, S(e,

g, s)=H(e, g, s)-H(e, g, 0).Through standard Nash bargaining, the wage for the worker at period 1 is ,

$$W_1(e,g,s) = H(e,g,0) + \lambda S(e,g,s) = \lambda H(e,g,s) + (1-\lambda)H(e,g,0) \qquad (1)$$

Anticipating this wage bargaining, the firm's problem is (ignoring the discount rate),

$$\begin{aligned} &\underset{g,s}{Max}\ \Pi(e,g,s) \\ &= H(e,0,0) - W_0(e) - C_g(g) - C_s(s) + (1-q)(H(e,g,s) - W_1(e,g,s)) \\ &= (1-q)(1-\lambda)(\mathrm{H(e,g,s) - H(e,g,0)}) + \mathrm{H(e,0,0)} - \mathrm{C_g}(g) - C_s(s) - W_0(e) \end{aligned}$$

The F.O.C.s are,

$$\begin{aligned} &\frac{\partial \Pi}{\partial s} = (1-q)(1-\lambda)\frac{\partial H(e,g,s)}{\partial s} - C_s^{'}(s) = 0 \\ &\Rightarrow C_s^{\ \prime}(s) = (1-q)(1-\lambda)\frac{\partial H(e,g,s)}{\partial s} \end{aligned} \qquad (2)$$

$$\begin{aligned} &\frac{\partial \Pi}{\partial g} = (1-q)(1-\lambda)\left(\frac{\partial H(e,g,s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g}\right) - C_g^{\ '} = 0 \\ &\Rightarrow C_g^{\ \prime}(g) = (1-q)(1-\lambda)\left(\frac{\partial H(e.g.s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g}\right) \end{aligned} \qquad (3)$$

Competition in the labour market will drive the firm's profit to zero; thus,

$$W_0(e) = (1-q)(1-\lambda)(H(e,g,s) - H(e,g,0)) + H(e,0,0) - C_g(g) - C_s(s) \qquad (4)$$

Equations (1)-(4) can simultaneously determine the wages W_0, W_1 and investment in general and specific skill, g and s. The second order conditions are assumed to hold. The solutions for wages and training would be functions of e, cost parameters and productivity parameters, firm or worker's bargaining power and job separation rate.

2.2 Beckerian case

Proposition 1 (Beckerian Case). Suppose that $\frac{\partial^2 H}{\partial g \partial s} = 0$ for all s and g, and all other assumptions 1, 3, and 4 hold, then s*>0, g*=0, and,

(i) if $\frac{\partial^2 H}{\partial e \partial s} > 0$, then, $\frac{\partial s^*}{\partial e} > 0$.

(ii) if $\frac{\partial^2 H}{\partial e \partial s} = 0$, then, $\frac{\partial s^*}{\partial e} = 0$.

(iii) if $\frac{\partial^2 H}{\partial e \partial s} < 0$, then, $\frac{\partial s^*}{\partial e} < 0$.

Proof. Given $\frac{\partial^2 H}{\partial g \partial s} = 0$ for all s and g, which means H(e, g, s) is separable in g and s, and we can write H(e, g, s) as, $H(e, g, s)=f_1(e, g)+f_2(e, s)$. Then from (3), we have,

$$C_g'(g^*) = (1-q)(1-\lambda)\left(\frac{\partial H(e,g,s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g}\right) = 0$$

And thus, g*=0.

From (2), s*>0, because if s*=0, then the left hand side equals zero but the right hand side is greater than zero, which is a contradiction.

Differentiate (2) around (g*, s*), to find,

$$C_s''(s^*)ds = (1-q)(1-\lambda)\left[\frac{\partial^2 H(e^*,g^*,s^*)}{\partial^2 s}ds + \frac{\partial^2 H(s^*,g^*,s^*)}{\partial s \partial e}de\right] \Rightarrow$$

$$\frac{ds}{de} = \frac{\dfrac{\partial^2 H(s^*,g^*,s^*)}{\partial s \partial e}}{c_s''(s^*) - (1-q)(1-\lambda)\dfrac{\partial^2 H(e^*,g^*,s^*)}{\partial^2 s}}$$

Since $C_s''(s) > 0$ and $\frac{\partial H^2(e,g,s)}{\partial^2 s} < 0$, the sign of $\frac{ds}{de}$ depends on $\frac{\partial^2 H}{\partial e \partial s}$. Thus we have,

(i) $\frac{\partial s^*}{\partial e} > 0$ if $\frac{\partial^2 H}{\partial e \partial s} > 0$.

(ii) $\frac{\partial s^*}{\partial e} = 0$ if $\frac{\partial^2 H}{\partial e \partial s} = 0$.

(iii) If $\frac{\partial^2 H}{\partial e \partial s} < 0$, then, $\frac{\partial s^*}{\partial e} < 0$.

End of proof.

2.3 Complementarities case

Proposition 2. Suppose that $\frac{\partial^2 H}{\partial g \partial s} > 0$ for all s and g, and all other assumptions 1, 3, and 4 hold, then s*>0, g*>0, and,

(i) if $\frac{\partial^2 H}{\partial e \partial s} > 0$ and $\frac{\partial^2 H}{\partial e \partial g} > 0$, $\frac{\partial s^*}{\partial e} > 0$ and $\frac{\partial g^*}{\partial e} > 0$

(ii) if $\frac{\partial^2 H}{\partial e \partial s} = 0$ *and* $\frac{\partial^2 H}{\partial e \partial g} = 0$, $\frac{\partial s^*}{\partial e} = 0$ and $\frac{\partial g^*}{\partial e} = 0$

Proof. From (2), we know, s*>0.

From (3), since $\frac{\partial^2 H}{\partial g \partial s} > 0 \; \forall$ s and g, the right hand side of (3) is greater than zero, thus,

$$C_g{}'(g^*) > 0 \Rightarrow g^* > 0$$

Totally differentiating (2) and (3), we derive, after some arrangements,

$$\left[C_s{}''(s) - (1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial^2 s} \right]\frac{ds}{de} - (1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial s \partial g}\frac{dg}{de} = (1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial s \partial e} \tag{5}$$

$$-(1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial s \partial g}\frac{ds}{de} + \left[C_g{}''(g) - (1-q)(1-\lambda)\left(\frac{\partial^2 H(e,g,s)}{\partial^2 g} - \frac{\partial^2 H(e,g,0)}{\partial^2 g} \right) \right]\frac{dg}{de} = (1-q)(1-\lambda)\left[\frac{\partial^2 H(e,g,s)}{\partial g \partial e} - \frac{\partial^2 H(e,g,0)}{\partial g \partial e} \right] \tag{6}$$

Using Cramer's rule, we can solve the simultaneous equation system (5) and (6),

$$\frac{ds}{de}=\frac{\begin{vmatrix} (1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial e} & -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial g\partial s} \\ (1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial g\partial e}-\dfrac{\partial^2 H(e,g,0)}{\partial g\partial e}\right] & C_g''(g)-(1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial^2 g}-\dfrac{\partial^2 H(e,g,0)}{\partial^2 g}\right] \end{vmatrix}}{\begin{vmatrix} C_s''(s)-(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial^2 s} & -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial g\partial s} \\ -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial g} & C_g''(g)-(1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial^2 g}-\dfrac{\partial^2 H(e,g,0)}{\partial^2 g}\right] \end{vmatrix}}$$

$$\frac{dg}{de}=\frac{\begin{vmatrix} C_s''(s)-(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial^2 s} & (1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial e} \\ -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial g} & (1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial g\partial e}-\dfrac{\partial^2 H(e,g,0)}{\partial g\partial e}\right] \end{vmatrix}}{\begin{vmatrix} C_s''(s)-(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial^2 s} & -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial g\partial s} \\ -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial g} & C_g''(g)-(1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial^2 g}-\dfrac{\partial^2 H(e,g,0)}{\partial^2 g}\right] \end{vmatrix}}$$

(i) From the second order condition of profit maximization, we have,

$$C_s''(s)-(1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial^2 s}>0$$

$$C_g''(g)-(1-q)(1-\lambda)\left[\frac{\partial^2 H(e,g,s)}{\partial^2 g}-\frac{\partial^2 H(e,g,0)}{\partial^2 g}\right]>0$$

and

$$\begin{vmatrix} C_s''(s)-(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial^2 s} & -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial g\partial s} \\ -(1-q)(1-\lambda)\dfrac{\partial^2 H(e,g,s)}{\partial s\partial g} & C_g''(g)-(1-q)(1-\lambda)\left[\dfrac{\partial^2 H(e,g,s)}{\partial^2 g}-\dfrac{\partial^2 H(e,g,0)}{\partial^2 g}\right] \end{vmatrix}>0$$

From the assumption of complementarity,

$$(1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial s \partial e} > 0$$

$$(1-q)(1-\lambda)\frac{\partial^2 H(e,g,s)}{\partial g \partial s} > 0$$

and

$$(1-q)(1-\lambda)\left[\frac{\partial^2 H(e,g,s)}{\partial g \partial e} - \frac{\partial^2 H(e,g,0)}{\partial g \partial e}\right] > 0,$$

Thus, we find,

$$\frac{ds^*}{de} > 0$$

and

$$\frac{dg^*}{de} > 0$$

(ii) If $\frac{\partial^2 H}{\partial e \partial s} = 0$ *and* $\frac{\partial^2 H}{\partial e \partial g} = 0$, then, $\frac{\partial^2 H(e,g,0)}{\partial e \partial g} = 0$, thus, we have,

$$\frac{\partial s^*}{\partial e} = 0 \text{ and } \frac{\partial g^*}{\partial e} = 0$$

End of proof.

From proposition 2, the complementarity between general skill and specific skill gives the firm incentive to provide general skill training besides specific skill training for the worker, and the complementarity between education and productivity gives the firm incentive to provide more training for the more educated worker.

Proposition 3: with either general training or specific training or both, the worker's wage increases not only in the second period but also in the first period.

Proof. From equation (1), the worker's wage in the second period would increase with any training under a standardized wage bargaining process.

Also in the second period, the firm's problem is to choose e and s to maximize its profit with the first period's wage already decided. The firm will only invest in training if it can earn a profit. Thus optimum choice e* and s* would lead to,

$$(1-q)(1-\lambda)(\mathrm{H(e,g^*,s^*)-H(e,g^*,0)}) > \mathrm{C_g}(g^*)+C_S(s^*)$$

Substituting the above equation into (4), we get,

$$W_0(e,g^*,s^*)=(1-q)(1-\lambda)(H(e,g^*,s^*)-H(e,g^*,0))+H(e,0,0)-C_g(g^*)-C_s(s^*)>W_0(e,0,0)$$

The worker's wage in the first period would increase with training. That means both specific and general training are sponsored by the firm explicitly and implicitly, but not paid implicitly by the worker through a lower wage, which contradicts with Becker (1964) in the case of general training.

2.4 Basic summaries

(1) The classical Beckerian theory corresponds to the case where general training and specific training are independent of each other. In this case, firms only have incentive to invest in specific training and worker's investment in education and general training is efficient given a perfect financial market.

(2) Complementarity between general training and specific training is essential for firms to have incentive to invest in general training, though firms always have incentive to invest in specific training. The general training "augments" the specific training, so that the technically general training partly becomes economically specific training.

(3) When education, general training and specific training are mutually complementary, both the firm-sponsored general training and specific training will increase with education.

(4) It is obvious that firm-sponsored training will decrease with the bargaining power of workers and the job separation rate.

(5) Given the firm cannot harvest all the benefits from the firm-sponsored training, neither the provision of general nor that of specific training is efficient.

(6) Firm-sponsored training will affect the choice of education. Since general training and specific training are not efficient, the choice of education is not efficient either.

2.5 An example

First, we make the assumption of the explicit functional form for the mutual complementarities between education, general skill and specific skill as follows,

$$H(e, G, S) = e(G+\eta)(S+1). \quad (7)$$

Where H(e, G, S) is the marginal productivity, e is the education, G is the general skill accumulated through general training at the beginning of the period, S is the specific skill accumulated through specific training at the beginning of the period, and η is a parameter that describes the basic outside opportunity that may depend on e but not on G or S.

Secondly, we define the convex cost function of training as follows,

$$C_g = \frac{1}{2} c_g g^2 \qquad (8)$$

$$C_s = \frac{1}{2} c_s s^2 \qquad (9)$$

Thirdly, and also for simplicity, the job separation and discount rate are not modelled.

In the second period, the firm has no incentive to invest in specific or general training because neither will bring benefit to the firm. In first period, let the firm sponsored general and specific training be g and s respectively.

Then the problem of the firm is to choose g and s to maximize profit,

$$\Pi = (1-\lambda)e(g+\eta)s - \frac{1}{2} c_s s^2 - \frac{1}{2} c_g g^2$$

The first order conditions are,

$$\frac{\partial \Pi}{\partial s} = 0 \Rightarrow (1-\lambda)e(g+\eta) - c_s s = 0 \tag{10}$$

$$\frac{\partial \Pi}{\partial g} = 0 \Rightarrow (1-\lambda)es - c_g g = 0 \tag{11}$$

Solving the above equation system simultaneously, we obtain,

$$s^* = \frac{(1-\lambda)ec_g\eta}{c_s c_g - (1-\lambda)^2 e^2} \tag{12}$$

$$g^* = \frac{(1-\lambda)^2 e^2 \eta}{c_s c_g - (1-\lambda)^2 e^2} \tag{13}$$

From the results of the solution, we can see that both general and specific training are increasing functions of educational level of the worker and decreasing functions of provision cost.

3. Extension of the basic models

3.1 Choice of education

Ignoring the discount factor, the worker's expected total wage is,

$$W(e) = W_0(e) + (1-q)W_1(e) + qH(e, g^*, 0) =$$
$$(1-q)(1-\lambda)\left[H(e, g^*, s^*) - H(e, g^*, 0)\right] + H(e,0,0) - C_g(g^*) - C_s(s^*)$$
$$+ (1-q)\left[\lambda H(e, g^*, s^*) + (1-\lambda)H(e, g^*, 0)\right] + qH(e, g^*, 0)$$
$$= (1-q)H(e, g^*, s^*) + qH(e, g^*, 0) + H(e,0,0) - C_g(g^*) - C_s(s^*)$$

Assume that the worker's preference is represented by the following utility function,

$$U(e) = W(e) - \frac{e}{\theta},$$

Where θ is a measurement of ability.

Anticipating the training that will be sponsored by the firm, the worker will choose an e to maximize her / his utility.

The first order condition is,

$$W'(e) - \frac{1}{\theta} = 0 \Rightarrow W'(e^*) = \frac{1}{\theta}. \qquad (14)$$

The second order condition implies $W''(e^*) < 0$.

Thus, differentiating with respect to θ, we get,

$$\frac{de^*}{d\theta} = -\frac{W''(e^*)}{\theta^2} > 0 \qquad (15)$$

Anticipating the training that will be sponsored by the firm, the person with high ability will choose a higher education. And higher education will lead to higher training in both specific and general skills. Also, because the training provided by the firm is not efficient due to the firm only retaining part of the productivity gain, the choice of education is not efficient either. Just as the firm provided training is below the efficient level, the education choice is also below the efficient level.

3.2 Turnover

In the basic model, the job separation rate is assumed to be exogenous. The job separation can come from either a shock to the outside opportunity or an inside matching quality change.

Here assume that there is an idiosyncratic shock to the matching quality of the current job in the second period in the form of a random monetary utility variable x with the cumulated symmetric distribution function F(x) and density function f(x). All other assumptions are retained. Thus, ignoring other factors such as mobility cost, when,

$W_1(e, g, s) + x \geq H(e, g, 0)$,

That is, if

$x \geq H(e, g, 0) - W_1(e, g, s) = \lambda(H(e, g, 0) - H(e, g, s))$,

the job will be retained; otherwise, the job will be separated.

Thus, the job separation rate is,

$$q(e,g,s) = 1 - F(\lambda(H(e,g,s) - H(e,g,0)) \qquad (16)$$

The firm will again maximize its profit to determine the training in general and specific skill. Thus the firm's problem is,

$$\begin{aligned}
&\underset{g,s}{Max}\,\Pi(e,g,s) \\
&= H(e,0,0) - W_0(e) - C_g(g) - C_s(s) + (1-q)(H(e,g,s) - W_1(e,g,s)) \\
&= F(\lambda(H(e,g,s) - H(e,g,0))(1-\lambda)(H(e,g,s) - H(e,g,0)) + H(e,0,0) - C_g(g) - C_s(s) - W_0(e)
\end{aligned}$$

The f.o.c.s are,

$$\begin{aligned}
&\frac{\partial \Pi}{\partial s} = F(\lambda(H(e,g,s) - H(e,g,0)))(1-\lambda)\frac{\partial H(e,g,s)}{\partial s} \\
&+ \lambda(1-\lambda) f(\lambda(H(e,g,s) - H(e,g,0)))\frac{\partial H(e,g,s)}{\partial s} - C_s^{'}(s) = 0 \qquad (17) \\
&\Rightarrow C_s^{'}(s) = (F(\lambda(H(e,g,s) - H(e,g,0))) + \lambda f(\lambda(H(e,g,s) - H(e,g,0)))) \bullet \\
&(1-\lambda)\frac{\partial H(e,g,s)}{\partial s}
\end{aligned}$$

$$\frac{\partial \Pi}{\partial g} = F(\lambda(H(e,g,s) - H(e,g,0)))(1-\lambda)(\frac{\partial H(e,g,s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g})$$
$$+ \lambda(1-\lambda) f(\lambda(H(e,g,s) - H(e,g,0)))(\frac{\partial H(e,g,s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g})) = 0 \qquad (18)$$
$$\Rightarrow C_g{}'(g) = (F(\lambda(H(e,g,s) - H(e,g,0))) + \lambda f(\lambda(H(e,g,s) - H(e,g,0)))) \bullet$$
$$(1-\lambda)(\frac{\partial H(e,g,s)}{\partial g} - \frac{\partial H(e,g,0)}{\partial g})$$

Equations (17) and (18) simultaneously determine the firm sponsored general skill g* and specific skill s*. Substituting those solutions into equation (9), we can obtain the job turnover rate. If we keep the four assumptions as before, we can easily show that the firm would have an incentive to sponsor general training as well as specific training. This is because general as well as specific training can increase the worker's marginal productivity, part of which the firm will appropriate as long as the bargaining power of the firm is not zero and job turnover is not 100%.

Also general training and specific training are increasing functions of education, and the job separation rate is a decreasing function of education. Here, as in the case of exogenous job separation rate, the firm would provide more training for the more educated worker. In addition, the consideration of job separation provides another incentive for the firm to sponsor more training, specific or general, for the more educated worker. A more educated worker therefore receives more training, has a lower job turnover rate, and is paid a higher wage. There is a reinforcing beneficial cycle between education, job security and wage. Therefore, we have the proposition 4

Proposition 4. If turnover is taken into consideration and all the 4 assumptions are kept, firms will have an incentive to provide general as well as specific training; both general

training and specific training are increasing functions of the education attainment of the worker; and the job separation rate is a decreasing function of education attainment of the worker.

The above already provides the intuitive explanation. Strict proof can proceed in the same manner as before but is more involved and will not be given here.

3.3 Multiple periods

In order to extend to multiple periods, we need to make further simplified and explicit assumptions to make the problem tractable.

First, we make the assumption of the explicit functional form of the mutual complementarities between education, general skill and specific skill as equation (7).

Secondly, we make further explicit the convex cost functions of training as equations (8) and (9) with c_g and c_s equal to one.

Thirdly, and also for simplicity, the job separation and discount rate are assumed out as zero.

Further, suppose there is no depreciation for education, and the depreciation rates for general and specific training are constant δ. All other assumptions are maintained.

Now consider three periods, 0, 1, and 2. In period 0, workers are hired and paid wage W_0. Sponsored general training is g_0 and specific training is s_0. In period 1, workers are

paid the wage W_1 and sponsored general and specific training are g_1 and s_1. In period 2, workers are paid the wage W_2 and sponsored general and specific training are g_2 and s_2.

Using backward induction, in period 2, the firm has no incentive to sponsor any training, since it is the end period, so the general as well specific training for all workers in period 2 are nil.

$g_2 = 0$ (19)

$s_2 = 0$ (20)

And

$$G_2 = g_1 + (1-\delta)g_0 \quad (21)$$

$$S_2 = s_1 + (1-\delta)S_0 \quad (22)$$

Because their marginal productivity of alternative option is $e(G_2+\eta)$, the total surplus of the match is, $e(G_2+\eta)S_2 = e(g_1+(1-\delta)g_0+\eta)(s_1+(1-\delta)S_0)$. As a result of Nash bargaining, the worker's wage is

$$W_2 = \lambda e(g_1+(1-\delta)g_0+\eta)(s_1+(1-\delta)s_0) + e(g_1+(1-\delta)g_0+\eta). \quad (23)$$

In period 1, the worker's general skill and specific skill are,

$$G_1 = g_0$$

$$S_1 = S_0$$

Let the wage be W_1 . As a result of Nash bargaining,

$$W_1 = \lambda e(g_0+\eta)s_0 + e(g_0+\eta) \quad (24)$$

In period 1, the firm's problem is to choose training g_1 and s_1 to maximize the sum of the expected profit of period 1 and period 2 taking into account the expected Nash bargaining in the period 2 , given period 0's optimum training choice and wage decision,

$$\Pi_1 = e(G_1 + \eta)(S_1 + 1) + e(G_2 + \eta)(S_2 + 1) - W_1 - W_2 - C_g(g_1) - C_s(s_1)$$
$$= (1-\lambda)e(g_0 + \eta)s_0 + (1-\lambda)e(g_1 + (1-\delta)g_0 + \eta)(s_1 + (1-\delta)s_0) - \frac{1}{2}{g_1}^2 - \frac{1}{2}{s_1}^2$$

The F.O.C. is,

$$\frac{\partial \Pi_1}{\partial g_1} = (1-\lambda)e(s_1 + (1-\delta)s_0) - g_1 = 0 \qquad (25)$$

$$\frac{\partial \Pi_1}{\partial s_1} = (1-\lambda)e(g_1 + (1-\delta)g_0 + \eta) - s_1 = 0 \qquad (26)$$

Solving the above two equations system, we obtain,

$$g_1 = \frac{(1-\lambda)e(1-\delta)s_0 + (1-\lambda)^2 e^2 (1-\delta)g_0 + (1-\lambda)^2 e^2 \eta}{1-(1-\lambda)^2 e^2} \qquad (27)$$

$$s_1 = \frac{(1-\lambda)e(1-\delta)g_0 + (1-\lambda)^2 e^2 (1-\delta)s_0 + (1-\lambda)e\eta}{1-(1-\lambda)^2 e^2} \qquad (28)$$

If there were no accumulation of specific or general skills, the results would reduce to the simple two period results, i.e. those of (12) and (13). Examination of equations (27) and (28) show that, 1) the firm has an incentive not only to sponsor specific training but also to sponsor general training; 2) firm sponsored general training and specific training are increasing functions of the worker's education level; 3) firm sponsored general training and specific training are increasing functions of both previous general and specific

training or accumulated general skill and specific skill; 4) firm sponsored general training and specific training are increasing functions of the bargaining power of the firm.

In period 0,

$G_0 = 0$

$S_0 = 0$

The wage W_0 would be determined by market competition, the firm would choose training g_0 and s_0 to maximize the firm's expected profit for the three periods taking the optimum future training choice and wage bargaining into account.

$$\Pi_0 = \eta - W_0 - \frac{1}{2}{g_0}^2 - \frac{1}{2}{s_0}^2 + (1-\lambda)e(g_0+\eta)s_0$$
$$+ (1-\lambda)e(g_1 + (1-\delta)g_0 + \eta)(s_1 + (1-\delta)s_0) - \frac{1}{2}{g_1}^2 - \frac{1}{2}{s_1}^2$$
$$= \eta - W_0 - \frac{1}{2}{g_0}^2 - \frac{1}{2}{s_0}^2 + (1-\lambda)e(g_0+\eta)s_0$$
$$+ (1-\lambda)e\frac{(1-\lambda)e(1-\delta)s_0 + (1-\delta)g_0 + \eta}{1-(1-\lambda)^2e^2} \bullet \frac{(1-\lambda)e(1-\delta)g_0 + (1-\delta)s_0 + (1-\lambda)e\eta}{1-(1-\lambda)^2e^2}$$
$$- \frac{1}{2}\left[\frac{(1-\lambda)e(1-\delta)s_0 + (1-\lambda)^2e^2(1-\delta)g_0 + (1-\lambda)^2e^2\eta}{1-(1-\lambda)^2e^2}\right]^2$$
$$- \frac{1}{2}\left[\frac{(1-\lambda)e(1-\delta)g_0 + (1-\lambda)^2e^2(1-\delta)s_0 + (1-\lambda)e\eta}{1-(1-\lambda)^2e^2}\right]^2$$

The F.O.C. is,

$$\frac{\partial \Pi_0}{\partial s_0} = 0 \Rightarrow \left[1 - \frac{(1-\lambda)^2e^2(1-\delta)^2}{1-(1-\lambda)^2e^2}\right]s_0 - \left[1 + \frac{(1-\delta)^2}{1-(1-\lambda)^2e^2}\right](1-\lambda)eg_0$$
$$= \left[1 + \frac{(1-\delta)}{1-(1-\lambda)^2e^2}\right](1-\lambda)e\eta \qquad (29)$$

$$\frac{\partial \Pi_0}{\partial g_0} = 0 \Rightarrow -\left[1+\frac{(1-\delta)^2}{1-(1-\lambda)^2 e^2}\right](1-\lambda)es_0 + \left[1-\frac{(1-\lambda)^2 e^2 (1-\delta)^2}{1-(1-\lambda)^2 e^2}\right] g_0 = \left[\frac{(1-\lambda)^2 e^2 (1-\delta)}{1-(1-\lambda)^2 e^2}\right]\eta \quad (30)$$

Solving the above two equation system for s_0 and g_0, we obtain,

$$s_0 = (1-\lambda)e\eta \frac{2-(1-\lambda)^2 e^2}{\left[1+3(1-\lambda)e+(1-\lambda)^2 e^2\right] * \left[1-3(1-\lambda)e+(1-\lambda)^2 e^2\right]} \quad (31)$$

$$g_0 = (1-\lambda)^2 e^2 \eta \frac{5-(1-\lambda)^2 e^2}{\left[1+3(1-\lambda)e+(1-\lambda)^2 e^2\right] * \left[1-3(1-\lambda)e+(1-\lambda)^2 e^2\right]} \quad (32)$$

Comparing the above two equations with the case of just two periods, we find the firm has greater incentive to sponsor specific training as well as general training in the first period compared with the case of only two periods because the first period's training not only increases the productivity of workers in the next period but also increases the productivity of later periods. Equations (31) and (32) can be substituted into (27) and (28) to obtain optimum firm sponsored specific training and general training in period 1. Thus equations (19), (20), (27), (28), (31) and (32) determine the specific and general training in period 0, 1 and 2. Examination of those 6 equations leads to the following observations:

(1) Firm sponsored general as well specific training tends to increase with educations level in every period as long as it is not the end period because the higher education level, the higher is the productivity increase under the same investment in training.

(2) Firm sponsored training, specific as well general, tends to decrease over the worker's later lifetime because the incentive for the firm to sponsor training is the future

productivity increase, at least part of which will accrue to the firm depending the bargaining power between the worker and the firm. Eventually, the worker would exit from the labour market for retirement. So approaching the end of the worker's career, the firm would have less or even no incentive to sponsor training, either specific or general.

(3) Firm sponsored training can lead to accumulated general and specific skill, which can enhance the productivity of the worker for all future periods. We define the above phenomenon as 'accumulative effect'. The earlier the period, the greater the accumulative effect. Because general skill and specific skill are complementary to each other, the higher specific skill, the higher marginal productivity increase of additional general training, or on the other hand, the higher general skill, the higher marginal productivity increase of additional specific training. We define the above phenomenon as the 'complementary effect'. As the worker accumulates general and specific skill, the complementary effect tends to increase, especially in the beginning and middle periods. In any period, the determination of firm sponsored training would depend on the combination of the accumulative effect and complementary effect. Thus, we can describe the time profile of firm sponsored training in an intuitive way. In the beginning, the accumulative effect is larger and complementary effect is small; as time passes, the accumulative effect would decrease, and the complementary effect would increase. Because the increase in the complementary effect may dominate the decrease in the accumulative effect, the combination of the complementary effect and accumulative effect may lead to an increase in firm sponsored training. Eventually, towards to the later part of the worker's career, the accumulative effect tends to be smaller and smaller and even the complementary effect may tend to decrease as the human capital depreciates,

thus firm sponsored training tends to decrease. Thus a typical time profile of firm sponsored training, either specific or general, is an inverted U shape curve.

4 Explanations of stylized facts

Based on the above theoretical results, we can reasonably explain the stylized facts about firm sponsored training.

1) Participation in training is an inverse U-shaped curve in a worker's life cycle. Given the complementarities between the specific skill and general skill, how much training the firm would like to provide to the worker depends on the combination of the accumulative effect and complementary effect. The combination of accumulative and complementary effects tends to increase in the earlier periods and decline in the later periods. Thus the training, specific and general, that the firm would like to sponsor for the worker tend to increase in the earlier period and decrease in the later periods. Therefore, it is usually observed that participation in training is inverse U-shaped in a worker's life cycle.

2) A more educated worker is more likely to obtain employer-sponsored training. Since education and skill obtained through training are complementary in enhancing worker's productivity and the firm can appropriate part of the benefit resulting from this enhanced productivity, the firm has more incentive to sponsor training for the more educated worker. Hence, the more educated a worker is, the more likely he will be to obtain employer-sponsored training.

3) Larger employers are more likely to sponsor training for their workers. Large employers offer higher entry wages on average, contributing to wage compression. The larger an employer, the larger the bargaining power the firm has over the workers, thus

the larger is the firm's proportion of the benefit from the productivity increase brought by the firm sponsored training, specific or general. Because large firms also pay higher wages, the worker may not bargain hard to receive a wage increase from training. And large firm may also have lower average training cost. Thus larger firms have more incentive to sponsor training.

4) More educated workers have better performance in labour market besides wages in their life cycle. More educated workers receive more training, specific and general, and more training would decrease the job turnover rate, which provides the firm with even more incentive to provide training. More training today means more training in the future, thus more educated workers have lower job turnover rate, greater attachment in the labour market besides having higher wages in their life cycle than less educated workers.

5. Conclusions.

This paper develops a theoretical framework to analyze the firm sponsored training, specific as well as general, and to explain some stylized facts about firm sponsored training. Our framework adopts the following simplified assumptions: 1) Labour market is competitive and information is perfect; 2)The future wage and training is non-contractible; 3) Wages are determined by per period bargaining; and 4) education, specific skill and general skill are complementary to each other. The firm's profit maximizing decisions would determine the firm-sponsored training. Our analysis leads to the following conclusions:

(1) The firm has incentive to sponsor general as well specific training; because the firm can reap a benefit from the productivity growth results from the specific and general training as long as the firm has some bargaining power.

(2) The firm has more incentive to sponsor the training, specific and general, for the more educated worker because the same training for the more educated worker can bring about more productivity growth and thus more benefit to the firm.

(3) The more bargaining power the firm has, the more benefit the firm can derive from the productivity increase resulting from the training, thus the greater is the incentive to sponsor the training, other conditions being equal.

(4) There is virtual reinforcement among education, firm sponsored training, and job retention rate. The firm has more incentive to sponsor training for the more educated worker. The more educated worker plus more training increases the job matching quality between the firm and the worker, and thus decreases the job separation rate and increases the job retention rate. The increase in job retention rate would provide further incentive for the firm to provide training for the worker.

(5) In a worker's life cycle, the firm has more incentive to sponsor training for the more educated worker in each period. Also the more training sponsored for the worker in the past, the greater is the incentive for the firm to sponsor training for the worker in the current period. For the same worker, eventually, firm sponsored training would decline because the future working time will shrink and eventually will end when the worker retires. The accumulative effect and complementary effect would jointly determine the life cycle profile of the firm sponsored training as an inverse U shaped curve.

(6) Since the firm does not appropriate all the benefit resulting from the productivity growth brought about by firm sponsored training, firm sponsored training is inefficiently lower; in addition, before entering the labour market, the worker's choice of education is also inefficiently lower because firm sponsored training is inefficiently lower. The policy implication is that government can subsidize not only education but also firm sponsored training, especially for the small and middle firms, to improve efficiency.

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Chapter 2: Determinants of Firm Sponsored Training: Evidence from Workplace and Employee Survey

Abstract

Using 2003-2004 Workplace and Employee Survey (WES) data, we identify three firm sponsored training variables in the data, that is, classroom training, on-the-job training, and career related training. Then we estimate the intensity and incidence of each of the three types of firm-sponsored training, in an integrated way, incorporating sample selection. The findings arising from our estimation results are: (1) For all three types of firm-sponsored training, education is positively and significantly correlated with the incidence of all three types of training, and significantly positively correlated with the intensity of on-the-job training. (2) Occupations are more important determinants than industry categories. Professionals, managers and technical /trades are more likely to obtain all three types of training. On the intensity, professionals, managers and technical /trades tend to obtain more on-the-job training, while marketing/sales, professional and managers tend to obtain more classroom training, and marketing /sales tends to obtain more career related. (3) Firm sizes are significant for the incidence of classroom training and on-the-job training and for the intensity of career related training. Larger firms have significantly higher incidence of classroom training and on-the-job training. The firm size profile of the intensity of the career related but not job directly related training is U shaped. (4) Job tenure is significant and negative for the intensity of classroom training or on-the-job training, but not significant for the career related training. The age profile is

inverse U shaped for the incidence of classroom training, but decreasing for the intensity of on-the-job training or the career related. (5) Collective bargaining agreement is only significant and positive for the incidence of classroom training, but is not significant in all other cases. (6) Computer users are more likely to obtain all three types of firm-sponsored training.

Key terms: Incidence of training, Intensity of training, sample selection method, estimation

1. Introduction

Not every worker obtains firm-sponsored training at every period. Some are more likely to obtain it and others are less like to obtain it. That is the issue of participation or incidence of training. In the same way, not every worker who receives firm sponsored training gets the same quantity of training, either specific or general. Given that they get training, some get more and others get less. The amount of training received is referred to as the intensity of training. Empirical studies are usually concerned with what determines both the incidence and / or intensity of training.

There are vast literatures on the empirical study of the determinants of firm sponsored training. Bishop (1996) provides a review of earlier empirical literature on the determinants, such as job characteristics, firm characteristics and worker characteristics. The stylized facts drawn from this review usually are: 1) participation in training is inverse U-shaped over a worker's life cycle, 2) a more educated worker is more likely to

obtain employer-sponsored training, 3) larger employers are more likely to sponsor training for their workers, and 4) the workers with more complex, responsible and skilled jobs obtain more firm-sponsored training. Blundell et al (1996)'s empirical results also show that more educated workers have higher probability to attain various kinds of training. More recent literature identifies other determinants. Gerfin (2004) identifies that internal wage floors may play an important role in firm-sponsored general training, especially for training in large firms. Beckman (2003) finds that the empirical evidence in firm-sponsored apprenticeship training in Germany supports the relevance of "active or passive poaching". There are also a lot of empirical studies in Canada (Dostie and Montmarquette, 2007). The common consensus arising from those studies is that, at the firm level, the incidence and intensity of firm sponsored training are positively associated with a firm's following characteristics, (1) innovation, (2) use of new technologies and (3) workforce turnover (Dostie and Pelletier, 2007;Chaykowski and Slotsve, 2005, 2006, Turcotte et al, 2003; Chowhan, 2005). On the employee side, the common findings are: (1) technology use, especially computer use, has a positive impact; (2) education has a positive impact on the probability of receiving classroom training; and (3) employer gender has no significant impact on the incidence of training (Havet, 2006; Belzil and Hasen, 2006; Gagnon and Doray, 2005).

The majority of the studies usually adopt the method of estimating the incidence and/or intensity separately, and are subject to sample selection bias if the incidence and intensity process are not independent (Heckman, 1979).

Firm sponsored training is both provided or supported by the firm and taken by the worker, so it is related to the behaviours of both the firm and the worker. It is important to take both the characteristics of firm and worker, and the characteristics of their job match into account when examining firm sponsored training. Otherwise, the estimation may be subject to omitted variable bias. The Workplace and Employee Survey (WES) provides information on the characteristics of the firm and the worker, and the job, as well as the various measures of firm sponsored training and so is a good data base for use in an empirical study on firm-sponsored training.

This paper makes contribution to the literature by estimating the incidence and intensity of firm sponsored training in an integrated way, taking into consideration selection bias and utilizing the firm's and the worker's information supplied by the Workplace and Employee Survey (WES).

The rest of the paper is organized as follows. Section 2 will briefly describe the determinants in theory. Section 3 will briefly introduce the survey data, and present the exploratory and descriptive statistics of the major variables. Section 4 will discuss empirical estimation strategies. Section 5 will discuss the estimation results. And section 6 will conclude the paper.

2. What determines firm sponsored training?

Firms need incentive to provide training to workers. In his seminal work, Becker (1964) argues that in a perfect market, firms have incentive to provide specific training and no

incentive to provide general training. Acemoglu and Pischke (1999, 1998a, 1998b) extend Becker's theory from a perfect market to an imperfect market and from specific training to general training and argue that a "compressed wage structure"-- after training, workers' productivity increases more than their wages—provides incentive for firms to sponsor general training as well as specific training. Thus, firm sponsored training is determined by productivity growth brought about by training, firm's ability to appropriate the productivity improvement and training cost born by firms. Many workers' characteristics, firms' characteristics and jobs' characteristics can influence how compressed the wage structure is and the training cost and thus influence firm sponsored training.

(1) Workers' education level. Considering the complementarity between workers' education level and firm sponsored training, the higher the education level, the higher the productivity growth under the same training, thus firms have incentive to provide more training to the more educated workers ceteris paribas.

(2) Age or job tenure. The longer a worker will work for a firm in future, the more the firm will have incentive to provide training. Since workers will eventually exit from the labour market to retirement, firms will have less incentive to provide training when they approach retirement. Thus, the age or job tenure profile of firm sponsored training would be decreasing or inverse "U" shaped.

(3) Job categories. Job characteristics can influence firm-sponsored training. Acemoglu and Pischke (1999) argue that if production of some tasks is more difficult to measure than that of other tasks, the degree of wage compression might be different across tasks. The task associated with a higher level of compressed wage structure

will lead to more firm sponsored training. Autor et al. (2003) and Spitz-Oener (2006, 2008) demonstrate that some tasks are more likely to be influenced by the process of computerization and reorganization and firms would have incentive to provide more training.

(4) Industry categories. Different markets may face different labour market situations. Acemoglu (1997) argues that the mere possibility of exogenous separation may impede training because the future firms would reap the rewards of training sowed by past employers.

(5) Firm size. A larger firm may have more bargaining power over workers' wage, so the wage would become more compressed. Larger firms tend to offer higher entry wages as they wish to attract the best workers. Therefore the wage compression is visible with the lowest wages being higher in larger firms than in small firms. In addition, the firm may more easily economize in providing the training to workers, thus, larger firms would provide more training.

(6) Union status. A union usually leads to more compressed wage, and thus leads to more firm-sponsored training.

(7) Technology usage. Modern technology usage, especially computer use may affect firm-sponsored training. Computer use on the job may mean firm sponsored training would be more conducive to productivity improvement, and thus firms have incentive to provide more training.

3. Descriptive statistics of major variables

3.1 Description of the WES data

Developed by Statistics Canada, the Workplace and Employee Survey (WES) data provides comprehensive, rich and integrated information on the characteristics of workplaces and their employees. WES data is divided into a workplace portion and an employee portion. The workplace portion covers technology adoption, innovation, organizational change, human resource practices, labour turnover and the business strategies of employers. The employee portion covers wages, training, technology use, working hours, demographic features and other workplace activities of employees (Hidiroglou et al, 1998. Patak et al, 1998).

In addition, the workplace survey and employee survey are linked at the micro data level by design: employees are sampled from within sampled workplaces. Thus, information from both the supply and demand sides of the labour market, including training, is available to enrich studies on either side of the market. WES not only provides cross-sectional linked employer-employee data, but the survey is also longitudinal. The firm is followed throughout the survey duration, and the workers are followed for two consecutive years before new workers within the firm are sampled. The WES started in 1999, and is available for the period 1999 - 2005. This study will use the 2003-2004 panel as the target data because the same worker is followed in the both years. The sample size for the workplace is 6565 and 6155 for the workplace, and 20834 and 16804 for the employee in 2003 and 2004 respectively (Statistics Canada, 4 Feb 2009)

There are three variables in the WES data set related to firm sponsored training, that is, (1) classroom training (job related classroom training), and (2) on-the-job training (career related on-the-job training) and (3) career related training (career related but not job directly related training). On-the-job training may be interpreted as mainly specific training; career related training may be considered as mainly general training, with classroom training in the middle. For each type of training, there are two variables to describe it, one is the incidence of training (that is, if the worker receives the training), and the other is the intensity of training (that is, for a worker who receives the training, how many courses of what duration). Thus, the incidence of job related classroom training is the binary variable to answer if the employee received the classroom training (d_classtr), whereas the intensity is the number of courses taken if received (courses)[1]. The incidence of on-the-job training is the binary variable to answer if the employee received on-the-job training (d_ jobtr), whereas the intensity is time (days) spent on-the-job training if received the training (jobtrtim). The incidence of career related training is the binary variable which indicates if the employee received career training (d_emp_hlp), whereas the intensity is the number of courses taken if the worker received the training (no_crsem). In the following, we will explore the relationship between the incidences or intensity of each of the three types of training and employee and firm

[1] Intensity of the training usually is represented by the duration of the training. In WES data, for the classroom training, only the durations of the first course and second course are reported. The correlation coefficient between the duration of the first course and total number of courses is 0.0086, and the correlation coefficient between the duration of the second course and the total number of courses is, -0.0078. Neither is significantly different from 0. So we choose the number of the training courses to represent the intensity of training. The same treatment is given to the intensity of the career related not job related training.

characteristics, such as education, age, firm size, and collective bargaining status in the 2003 and 2004 sample.

3.2 Major descriptive statistics of firm sponsored training

3.2.1 General statistics

Table 2-1: Incidence of firm sponsored training

Selection of Training type	Proportion of employee obtaining the training
Received the classroom training	35.30%
Received the on-the-job training	28.50%
Received career related training	3.80%

Table 2-2: Intensity of firm sponsored training

Type of Training	Mean	Standard error
Number of courses taken on classroom training	2.48	0.04
Time spent on-the-job	6.54	0.41
Number of course of career related training	1.97	0.09

As is shown in table 2-1, from the survey in 2003 / 2004, 35.29%, 28.45% and 3.83% of the employees in Canada received classroom training; on-the-job training and career related training respectively. And from table 2-2, conditional on receiving training, Canadian employees, on average receive 2.5 courses of classroom training, 6.5 days of on- the-job training and 2 courses of career related training.

3.2.2 Education and Training

Table 2-3: Incidence of training by education

Education level	Received classroom training	Received on-the-job training	Received career related training
Below high school	22.2%	18.9%	1.5%
High school only	30.1%	21.8%	2.2%
Some college	33.3%	31.4%	4.4%
College degree	38.5%	32.0%	3.8%
Some university	40.7%	34.4%	4.9%
University degree	41.5%	33.7%	5.2%
Some graduate	48.8%	37.4%	7.9%
Master degree	51.8%	37.1%	10.0%
Other education	40.0%	28.5%	5.4%

Table 2-3 shows the proportion of employees of different education levels who receive three types of firm sponsored training during 2003-04. It is observed that a higher proportion of more educated employees receive all three types of firm sponsored training-- that is, classroom training, on-the-job training and career related training -- than less educated employees. For example, among those employees whose education is below high school, only 22.2% receive classroom training, 18.9% receive on-the-job training, and 1.5% receive career related training; as a contrast, among those employees whose education is a master's degree, 51.8% receive classroom training, 37.1% receive on-the-job training and 10.0% receive career related training.

Table 2-4 shows conditional on receiving training, the average intensity of training for those employees with different education levels. It is observed that among those who

received the training, there seems no direct relationship between the intensity of training in all three types of firm sponsored training and educational attainment.

Table 2-4: Intensity of training by education

Education level	Number of courses taken on the classroom training	Time/Days spent on-the-job training	Number of course taken on the career related not directly job related training
Below high school	2.44	6.03	1.68
High school only	2.16	9.27	2.11
Some college	2.49	5.17	1.95
College degree	2.55	5.78	1.80
Some university	2.39	4.83	2.00
University degree	2.75	4.93	2.07
Some graduate	3.21	11.51	2.50
Master degree	2.67	5.48	1.80
Other education	2.51	10.65	1.94

3.2.3 Firm size and training

Table 2-5: Incidence of training and firm size

Firm size	Received classroom training	Received on-the-job training	Received career related training
1-19 employees	23.5%	23.9%	3.0%
20-99 employees	34.2%	28.0%	2.9%
100-499 employees	40.9%	31.4%	4.5%
500 employees and above	48.7%	32.8%	5.8%

Table 2-5 shows the proportion of workers in different firm sizes that receives firm sponsored training. It shows that a higher proportion of workers in larger firms receive all three types of firm sponsored training than in smaller firms.

Table 2-6 shows the intensity of firm sponsored training in different firm sizes. It can be observed that there is no direct relationship or explicit tendency between firm size and training intensity.

Table 2-6: Intensity of training and firm size

Firm size	Number of courses taken on the classroom training	Time/Days spent on-the-job training	Number of course taken on the career related training
1-19 employees	2.42	6.27	2.46
20-99 employees	2.56	6.99	1.71
100-499 employees	2.36	5.89	1.75
500 employees and above	2.53	6.89	1.96

2.2.4 Age and training

Table 2-7 shows the proportion of workers in different age groups who receive the three types of firm sponsored training. It is observed that the proportions for all three types of training first increase from age group of 24 and below to between 25 and 39, and then decrease from the age group between 25 and 39 to the next two older age groups, which is consistent with an inverse U shaped profile of age.

Table 2-8 shows the intensity of training of workers in different age groups. It can be observed once again that there seems to be no direct relationship or explicit tendency between the intensity of training in the all three forms of firm sponsored training and age groups.

Table 2-7: Incidence of training and age

Age group	Received classroom training	Received on-the-job training	Received career related training
24 and below	24.4%	33.3%	2.3%
Between 25 and 39	39.1%	30.9%	4.8%
Between 40 and 55	36.2%	27.3%	3.7%
Above 55	28.8%	20.9%	2.2%

Table 2-8: Intensity of training and age

Age group	Number of courses taken on the classroom training	Time/Days spent on-the-job trianing	Number of course taken on the career related training
24 and below	2.17	6.43	2.87
Between 25 and 39	2.55	7.07	1.88
Between 40 and 55	2.46	6.59	1.97
Above 55	2.50	3.86	1.60

3.2.5 Union and training

Table 2-9 compares the incidence of training under collective bargaining agreements to the incidence in the absence of an agreement. It shows that workers with collective bargaining agreements are more likely to receive all three types of firm sponsored training.

Table 2-10 shows the intensity of training of workers with and without collective bargaining agreements. It can be observed that, for employees who received training, those with a collective bargaining agreement tend to have slightly lower intensity in all three types of training than those without a collective bargaining agreement.

Table 2-9: Incidence of training and collective bargaining agreement

Union status	Received classroom training	Received on-the-job training	Received career related training
Have collective bargaining agreement	43.3%	29.7%	4.2%
No collective bargaining agreement	32.6%	28.0%	3.7%

Table 2-10: Intensity of training and collective bargaining agreement

Union status	Number of courses taken on the classroom training	Time/Days spent on-the-job training	Number of course taken on the career related training
Have collective bargaining agreement	2.42	5.92	1.88
No collective bargaining agreement	2.50	6.76	2.00

In sum, the descriptive statistics of three types of firm sponsored training show that there is a clear pattern between incidence of training and the major determinants such as education, firm size, age, and union status. More educated workers are more likely to receive training, workers in larger firms are more likely to receive training, workers with collective bargaining agreements are more likely to receive training, and the age profile of incidence of training is roughly inverse U shaped. However, there seems to be no clear pattern or explicit tendency between the intensity of training and the major determinants.

4. Empirical Estimation strategies

There are two variables describing each type of firm-sponsored training: incidence and intensity. As is shown above, the literature on the empirical estimation of firm sponsored training usually either focuses on estimating the incidence alone or the incidence and intensity of training separately. Here we consider a more general and encompassing approach: a sample selection model.

As is discussed in section 2, firm-sponsored training depends on such determinants as worker characteristics, firm characteristics, and job characteristics, for example: education, age, job category, industry category, firm size, and etc. Suppose the density of training Y_{it} is determined by those characteristics in a linear stochastic process as a function of some K element vector, X_{it} , the regression equation is

$$Y_{it} = \beta' X_{it} + \mu 1_{it} \qquad (1)$$

Where X_{it} is a vector of those characteristics of workers, firms and jobs and β is the vector of coefficients. And suppose the incidence is determined by a set of variables, some of which are shared with the estimations (1) and some different determinants, and the selection equation is the utility function as follows,

$$U_{it} = \gamma' Z_{it} + \mu 2_{it} \qquad (2)$$

Where Z_{it} is a vector of the determinants of selection; when utility function is greater than 0, training is sponsored for worker *i* at time *t*, and when utility function is less than or equal to zero, training is not sponsored for worker *i* at time *t*. And $\mu 1$ and $\mu 2$ are

statistical disturbances in equation (1) and (2) respectively, with correlation coefficient of ρ, and distribution

$$\mu 1 \sim N(0, \sigma) \quad (3)$$

$$\mu 2 \sim N(0,1) \quad (4)$$

$$corr(\mu 1, \mu 2) = \rho \quad (4)$$

The sample selection model is a more general method, and is less subject to specification error. If the two error terms are the same, then the sample selection model is reduced to a Tobit model, or censored regression model or truncated regression model (Heckman, 1976). If the correlation coefficient is zero, that is, the two error terms are independent of each other, and then the sample selection may be reduced to the two separate regressions.

Under sample selection model assumptions, the log likelihood for observation (*i*,*t*), $\ln L_{it} = l_{it}$, is,

$$l_{it} = \omega_{it} \ln \Phi\left[\frac{\gamma Z_{it} + (Y_{it} - \beta X_{it})\rho / \sigma}{\sqrt{1-\rho^2}}\right] - \frac{\omega_{it}}{2}\left(\frac{Y_{it} - \beta X_{it}}{\sigma}\right)^2 - \omega_{it} \ln(\sqrt{2\pi}\sigma) \quad (\text{Y}_{\text{it}} \text{ observed})$$

(5)

$$l_{it} = \omega_{it} \ln \Phi(-\gamma Z_{it}) \quad (\text{Y}_{it} \text{ not observed}) \quad (6)$$

Where $\Phi(\bullet)$ is the standard cumulative normal distribution function and ω_{it} is the weight for employee i at time t.

Maximizing the sum of the log likelihood over all the observations yields an estimation of the parameters of interest. And the maximum likelihood estimators are consistent and

efficient conditional on the correct specification of the data generation process (DGP) and normal distribution of errors. (Greene, 2003, 2008; Woolbridge 1995, 2002).

Another estimation method is to use Heckman's two step estimates: (1) First step, use Probit method to estimate the selection equation, and calculate the inverse of the Mill's ratio for every selected sample, $m_{it} = \frac{\phi(\hat{\gamma} Z_{it})}{\Phi(\hat{\gamma} Z_{it})}$; (2) second step, augment the regression equation with the non-selection hazard m, and regress Y on [X, m] (Heckman, 1979). Heckman's two step estimates are consistent. Two advantages of the Heckman's two step estimates are: (1) the estimates are consistent whether disturbance is normally distributed or not; (2) the estimates can utilize panel data to correct not only selection bias but also the individual heterogeneity (Woolbridge, 1995)

5. Empirical Results

In this paper, we choose Heckman's Two Step Method to perform the empirical estimation because it is more robust compared with the maximum likelihood estimator[2]. The regression variable is the log of the intensity of training, and is a linear function of the explanatory variables, inverse of Mill's ratio from selection and an additive disturbance. The selection variable is the incidence of the training, and it is a probit equation with a disturbance of unit normal distribution.

[2] The results from the Maximum Likelihood Estimator are quite similar to the Two Step method and so are not reported here.

We can view the two processes as distinct processes determined by different mechanisms. Although both the intensity and selection of firm provided training are determined by the interactions between the firm and its workers, the problem can be approached intuitively in this way: the intensity is by and large determined by the firms, because how much training to be provided is usually for firms to decide, while the selection can be deemed to be determined by and large by workers. Workers can choose either to accept or reject the offer of training from firms. There are common explanatory variables for both the intensity equation and selection equation, such as education levels, occupation categories, industry categories, firm sizes, collective bargaining agreement, sex, citizen status, computer use. To identify the estimation, the intensity equation and incidence equation have unique explanatory variables. Job tenure is one explanatory variable unique to the intensity equation. Marital status, presence of dependent children and age groups are the explanatory variables unique to the incidence equation.

As shown above, there are three types of firm sponsored training in the WES data. Thus, we have three independent variables: log number of courses taken in classroom training, log time/days spent on-the-job-training and log number of courses taken in career related training, and correspondingly three selection processes. All the three types of training are sponsored by firms. The estimation results are shown in table 2-11.[3]

5.1 Determinants of classroom training

[3] Because there are only two periods of data for workers, this estimation does not correct for unobserved heterogeneity.

Column 2 in table 2-11 shows the estimation results of the intensity regression and selection of incidence of the firm sponsored classroom training. Column 1 contains variable names.

5.1.1 Determinants of Intensity of classroom training

(1) Education level: With no high school graduation as the base, only the coefficient of education level equal to some graduate study is positive and significant (at 1% level) and all other levels of educational attainment are not significant. (2) Sex: Coefficient of sex is not significant. (3) Citizenship represented by birth place: The coefficient of the explanatory variable, born in Canada, is positive and marginally significant (at 10% level), indicating that workers born in Canada may receive on average 3% more classroom training than those not born in Canada. (4) Occupation category: With production workers as the base, conditional on receiving classroom training, professionals and technical/trades are not significantly different from the production workers, and marketing /sales and managers, receive on average 22 % (significant at 1% level) and 8% (significant at 10% level) more classroom training respectively than the production workers, whereas clerical / administrative workers receive 7% (significant at 5% level) less classroom training than production workers. (5) Industry category: With Forestry, mining, oil, and gas extraction industry as the base, Information and cultural industries, Labour intensive tertiary manufacturing, Transportation, warehousing, wholesale, and Real estate, rental and leasing operations have significantly negative effects, while the other industry categories have no significantly different effect on the number of courses in classroom training. (6) Firm Size: The different sizes of the firm

have no significantly different effect on the number of courses in classroom training. (7) Computer usage: workers using computers receive on average 9% more classroom training (at 1% significance level) than those not using computers. (8) Union: Union status has a positive effect on number of courses taken in the classroom training at significance level of 10%. And finally, (9) Job tenure: The coefficient of job tenure is significant and negative; indicating that with each additional year of job tenure , the average number of courses in classroom training may decrease by 0.4%.

5.1.2 Determinants of Incidence of classroom training

(1) Marriage: Married workers are significantly more likely to obtain classroom training than unmarried workers. (2) Dependent child: Have dependent kid(s) is also positive and significant (at 5% level). (3) Education level: With the education level of below high school graduate as the base, except the education level of only high school, which is not significant, all the coefficients of other higher levels of education are significant and positive; observations of those coefficients shows that the higher the education attainment, the higher is the likelihood of receiving classroom training. (4) Sex: Female is significantly less likely to obtain classroom training than male. (5) Citizenship: The workers born in Canada are also significantly more likely to receive classroom training than those not born in Canada. (6) Occupation category: With production workers as the base, all other occupation categories are positive and significant (1% level); in descending order, the professionals are most likely to obtain classroom training, followed by managers, marketing /sales, technical/trades, and then clerical / administrative. (7) Industry category: With Forestry, mining, oil, and gas extraction

industry as the base, Construction is not significantly different, Labour intensive tertiary manufacturing category is the most unlikely to receive classroom training (significant at 1%), and followed by Information and culture. Finance and insurance is the most likely sector in which workers receive classroom training, followed by Communication and other utilities, Education and health services, and Business services. (8) Firm size: With the firm size of 1-19 as the base, all the other firm sizes are significantly more likely to receive classroom training (at 1% significance level), and the larger the firm size is, the more likely are their workers to receive classroom training. (9) Computer usage: The workers using computers are significantly more likely to receive classroom training (at 1% significance level). (10) Union: Union status also makes a significant difference: workers covered by collective bargaining agreement are significantly more likely to receive classroom training than those not covered by collective bargaining (at 1% significance level). (11) Age: With the age group of 24 and below as the base, the age group Between 25 and 39 is more likely to receive classroom training (significant at 5% level), the age group between 40 and 55 is not significantly different from the base group, and the age group above 55 is significantly less likely to receive classroom training (at 1% significance level). Therefore the age profile of selection for classroom training follows an inverse U shape.

Finally, let's look at the coefficient of mills. It is negative and significant (at 5% level) and the correlation coefficient between the disturbance of the regression process and the disturbance of the selection process is estimated to be -0.25. The null hypothesis that the correlation coefficient is zero is rejected.

5.2 Determinants of on-the-job training

With column 1 containing variable names, column 3 in table 2-11 shows the estimation results of the intensity regression and the selection of incidence of the firm sponsored on-the job training.

5.2.1 Determinants of the intensity of on-the-job training

(1) Education level: With below high school graduate as the base, conditional on receiving on-the-job training, the workers with education level of some graduate study will on average receive 25 % more training than the base (at 1% significance level) and those who are high school graduates, 12% more than the base (10% significance level) whereas all other education levels are not significantly different from the base. (2) Sex: Females on average receive 21% less on-the-job training than the male workers with all other factors controlled and the coefficient is significant at 1% level. (3) Citizenship: Workers born in Canada on average receive 8% more on-the-job training than those not born in Canada. (4) Occupation: With production worker as the base, conditional on being selected, managers, the professionals, and technical/trades on average receive 39% (significant at 1% level), 37% (significant at 1% level) and 17% (significant at 5% level) more on-the-job training than the production workers whereas marketing /sales and clerical / administrative workers are not significantly different from the production workers. (5) Industry category: With Forestry, mining, oil, and gas extraction industry as the base, conditional on receiving on-the-job training, workers from Primary product manufacturing receive on average 27% more on-the-job training while workers from

Retail trade and consumer services and Education and health services , receive 28% and 22% less training respectively. All other industry categories are not significantly different from the base industry. (6) Firm size: With firm size of 1-19 employees as the base, workers from firms with size of 20-99 employees and 100-499 employees receive on average 8% and 11% less on-the-job training respectively than workers from the base firm size while the firm size of 500 employees above is not significantly different from the base firm size. (7) Computer usage: Computer use is positive and significant 1%. (8) Union: Union status has no significant effect on the intensity of on-the-job training. And finally, (9) job tenure: Job tenure has a significantly negative effect; with each additional year of job tenure, the time spent in on-the-job decreases by 2% on average and this coefficient is significant at the 1% level.

5.2.2 The Determinants of incidence of on-the-job training

(1) Marriage: The status of marriage is not significant. (2) Dependent kid: Having dependent children is positive and significant at 1% level. (3) Education level: With the education level of below high school graduate as the base, all higher levels of educations are significant and positive and observations of those coefficients shows that by and large a higher education level is associated with a higher likelihood to receive on-the-job training (4) Sex: sex is not significant. (5) Citizenship: workers born in Canada are more likely to receive on-the-job training than workers not born in Canada. (6) Occupation: With production workers as the base, all other occupation categories are positive and significant; professionals are most likely to receive on-the-job training, followed by marketing /sales, managers and technical/trades, and then clerical / administrative. (7)

Industry category: With Forestry, mining, oil, and gas extraction industry as the base, except that workers in Finance and insurance and Transportation, warehousing, wholesale are more likely and in Labour intensive tertiary manufacturing and Construction are less likely to receive on-the-job training, all other industry categories are not significant. (8) Firm size: With the firm size of 1-19 as the base, all other firm sizes are significant (1% level) and positive, and the coefficients reveal an inverse "U" shaped firm size profile. (9) Computer usage: Computer use is also significant (at 1% level) and positive. (10) Union: the presence of a collective bargaining agreement is not significant. And finally, (11) Age: With the age group of 24 and below as the base, all other age groups are significant (at 1% level) and negative, and the higher the age group, the more negative the coefficient, so the age profile of on-the-job training is decreasing, which is a little bit different from the inverse U shape age profile of the classroom training

Finally, let's look at the coefficient of mills. It is negative and significant (at 1% level) and the correlation coefficient between the disturbance of the regression process and the disturbance of selection process is estimated to be -0.33. The null hypothesis that the correlation coefficient is zero is rejected.

5.3 Determinants of career related training

Column 4 in table 2-11 shows the intensity regression and selection of incidence of firm sponsored career related training.

5.3.1 Determinants of the intensity of career related training

Using the same base variables as in previous regressions, there are no significant coefficients for education level, sex, citizen status, tenure, occupation, industry, computer use, or union status. The only factor which seems to influence the intensity of career related training is firm size. With the size of 19 employees and below as the base, conditional on receiving the training, on average the workers receive 10% less (significant at 5% level) and 12% (significant at 5%) training in firms with sizes of 20-99 and 100-499, respectively, while firm size of 500 and above is not significantly different from the base.

5.3.2 Determinants of the incidence of career related training

(1)The status of marriage and (2) dependent children are not significant. (3) Education level: With the education level of below high school graduate as the base, all other higher levels of education except that of high school graduate only, are significant (at 1% level) and positive, and the coefficients show that by and large the higher the level of education, the more likely it is that a worker receives career related training. (4) Sex and (5) citizenship status of the workers are not significant. (6) Occupation: With production workers as the base, except marketing/sales, all other occupation categories are positive and significant (all at 1% level) and the professionals are most likely to receive the career related training, followed by managers, technical/trades, and clerical / administrative . (7) Industry category: With forestry, mining, oil, and gas extraction industry as the base, finance/insurance is the only industry with a significant (at 1% level) and positive coefficient. All other industry categories are either not significant or negative with workers in retail trade and consumer services and labour intensive tertiary manufacturing

associated with lowest likelihood to receive of career related training. (8) Firm size: With the firm size of 1-19 as the base, firm size of 20-99 employees is not significant while other firm sizes are positive and significant (at 1% level). (9) Computer usage: Computer use is also significant (at 1% level) and positive. (10) Union: The collective bargaining agreement is not significant. (11) Age. With the age group of 24 and below as base, the age group of between 25 and 39 is not significant, the age group between 40 and 55 is negative and significant at 10% level, and the age group of above 55 is more negative and significant (at 1% level), revealing that the age profile of career related training is decreasing, which is similar to that of on-the-job training and of the classroom training.

Finally, let's look at the coefficient of mills, which is not significant, suggesting that the null hypothesis that the correlation coefficient is zero also cannot be rejected.

Table 2-11: Estimation Results, determinants of firm-sponsored training

Regression variables	log(Number of courses in class room training)	log(time spent on-the-job training)	log(number of courses taken on the career related training)
Intensity			
Highest Education (No high school as base)			
High school Graduate Only	0.01(0.02)	0.12(0.06)*	-0.04(0.07)
Some college only	0.01(0.03)	-0.02(0.07)	0.03(0.09)
College Degree	0.02(0.03)	0.10(0.07)	0.04(0.08)
Some University	-0.01(0.03)	0.10(0.07)	0.12(0.10)
University degree	0.03(0.03)	0.04(0.07)	0.08(0.09)
Some graduate Study	0.10(0.04)***	0.25(0.10)***	0.00(0.10)
Master's degree	0.04(0.04)	0.12(0.09)	0.10(0.12)
Other education	0.03(0.03)	0.12(0.08)	0.03(0.10)
Female	-0.01(0.01)	-0.21(0.03)***	0.00(0.03)
Born in Canada	0.03(0.02)*	0.08(0.04)**	-0.05(0.04)
Occupation categories (Production workers as			

base)			
Managers	0.08(0.04)*	0.39(0.09)***	-0.15(0.10)
Professionals	0.06(0.05)	0.31(0.10)***	-0.12(0.10)
Technical/Trades	0.03(0.04)	0.17(0.08)**	-0.05(0.09)
Marketing/Sales	0.22(0.05)***	-0.02(0.11)	0.19(0.13)
Clerical/Administrative	-0.07(0.03)**	-0.02(0.09)	-0.10(0.10)
Industry categories(Forestry, mining, oil, and gas extraction as base)			
Labour intensive tertiary manufacturing	-0.09(0.04)**	-0.02(0.10)	-0.02(0.11)
Primary product manufacturing	-0.04(0.04)	0.27(0.09)***	0.03(0.10)
Secondary product manufacturing	-0.03(0.04)	0.06(0.10)	-0.02(0.10)
Capital intensive tertiary manufacturing	-0.07(0.04)*	-0.01(0.09)	-0.04(0.10)
Construction	-0.04(0.03)	0.12(0.09)	-0.02(0.09)
Transportation, warehousing, wholesale	-0.07(0.03)**	-0.01(0.08)	0.02(0.09)
Communication and other utilities	0.05(0.03)	0.02(0.09)	-0.01(0.09)
Retail trade and consumer services	-0.06(0.04)	-0.28(0.09)***	-0.03(0.10)
Finance and insurance	0.04(0.03)	-0.06(0.08)	0.01(0.09)
Real estate, rental and leasing operations	-0.07(0.04)**	-0.16(0.10)	0.02(0.10)
Business services	-0.01(0.03)	-0.3(0.08)	-0.01(0.08)
Education and health services	-0.03(0.03)	-0.22(0.08)***	0.07(0.09)
Information and cultural industries	-0.14(0.04)***	-0.09(0.09)	0.05(0.10)
Firm size(1-19 employees as base)			
20-99 employees	0.01(0.02)	-0.08(0.04)*	-0.10(0.04)**
100-499 employees	0.02(0.03)	-0.11(0.05)**	-0.12(0.05)**
500 employees or more	0.03(0.04)	-0.02(0.05)	-0.05(0.05)
Use computers	0.09(0.02)***	0.15(0.06)***	0.02(0.06)
covered by collective bargaining agreement	0.03(0.02)*	-0.03(0.04)	-0.02(0.04)
Tenure of job	-0.004(0.001)***	-0.02(0.00)***	0.00(0.00)
Selection			
Married	0.07(0.02)***	0.01(0.02)	-0.03(0.03)
Have dependent kids	0.003(0.02)**	0.04(0.02)***	0.00(0.03)
Education (No high school as base)			
High school Graduate Only	0.04(0.03)	0.06(0.03)**	0.03(0.06)
Some college only	0.08(0.03)***	0.12(0.03)***	0.18(0.06)***
College Degree	0.13(0.03)***	0.15(0.03)***	0.18(0.06)***
Some University	0.14(0.03)***	0.21(0.03)***	0.37(0.06)***
University degree	0.14(0.03)***	0.23(0.03)***	0.26(0.06)***
Some graduate Study	0.18(0.05)***	0.16(0.05)***	0.24(0.08)***
Master's degree	0.18(0.04)***	0.25(0.05)***	0.43(0.07)***
Other education	0.15(0.03)***	0.23(0.03)***	0.30(0.06)***
Female	-0.09(0.02)***	-0.02(0.02)	0.01(0.03)

Born in Canada	0.11(0.02)***	0.05(0.02)***	0.03(0.03)
Occupation categories (Production workers as base)			
Managers	0.49(0.04)***	0.35(0.04)***	0.27(0.07)***
Professionals	0.52(0.04)***	0.44(0.04)***	0.29(0.07)***
Technical/Trades	0.43(0.03)***	0.35(0.03)***	0.22(0.07)***
Marketing/Sales	0.45(0.05)***	0.38(0.05)***	0.05(0.47)
Clerical/Administrative	0.16(0.04)***	0.29(0.04)***	0.16(0.07)**
Industry categories(Forestry, mining, oil, and gas extraction as base)			
Labour intensive tertiary manufacturing	-0.39(0.05)***	-0.15(0.05)***	-0.20(0.09)**
Primary product manufacturing	-0.30(0.04)***	-0.02(0.05)	-0.04(0.08)
Secondary product manufacturing	-0.26(0.05)***	0.02(0.05)	-0.09(0.08)
Capital intensive tertiary manufacturing	-0.34(0.04)***	0.01(0.05)	-0.14(0.08)*
Construction	0.05(0.04)	-0.09(0.04)**	-0.07(0.07)
Transportation, warehousing, wholesale	-0.08(0.04)**	0.12(0.04)***	-0.14(0.07)**
Communication and other utilities	0.15(0.04)***	0.08(0.05)*	-0.03(0.08)
Retail trade and consumer services	-0.30(0.04)***	-0.08(0.04)*	-0.20(0.08)***
Finance and insurance	0.20(0.04)***	0.15(0.04)***	0.24(0.07)***
Real estate, rental and leasing operations	-0.13(0.05)***	-0.06(0.05)	-0.04(0.08)
Business services	0.07(0.04)*	0.02(0.04)	0.02(0.07)
Education and health services	0.10(0.04)**	0.04(0.04)	-0.12(0.07)*
Information and cultural industries	-0.35(0.04)***	0.03(0.05)	-0.18(0.08)**
Firm size(1-19 employees as base)			
20-99 employees	0.29(0.02)***	0.15(0.02)***	0.05(0.04)
100-499 employees	0.48(0.02)***	0.24(0.02)***	0.13(0.04)***
500 employees or more	0.50(0.02)***	0.19(0.02)***	0.13(0.04)***
Use computer	0.30(0.02)***	0.34(0.02)***	0.25(0.04)***
covered by collective bargaining agreement	0.17(0.02)***	0.01(0.02)	0.05(0.03)
Age group (24 and below as base)			
Between 25 and 39	0.04(0.02)**	-0.35(0.03)***	0.04(0.06)
Between 40 and 55	-0.05(0.03)	-0.46(0.03)***	-0.11(0.06)*
Above 55	-0.26(0.04)***	-0.58(0.04)***	-0.30(0.07)***
mills			
lambda	-0.16(0.09)**	-0.48(0.16)***	-0.11(0.19)
rho	-0.25	-0.33	-0.19

(Note: *** indicate significance at the 1% level, **, at the 5% level and *, at the 10% level)

6. Conclusions

How likely a worker is to receive firm-sponsored training and if so how much training a worker receives depends on many worker characteristics, firm characteristics and job characteristics and the types of the training. Our results show that for the more specific training such as on-the-job training, intensity and incidence processes tend to be significantly related, in which case the sample selection model is warranted in the estimation, whereas for the more general training, such as career related training, the two processes tend not to be significantly related. Both descriptive statistic results and estimation results for all three types of training show that incidence of training tend to vary significantly across education and some job characteristics. Empirical evidence all point to the more educated workers in larger firms being more likely to receive firm-sponsored training. It also shows that in the current knowledge economy technology use especially computer use on the job plays a significantly positive role in determining the selection of firm sponsored training.

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Chapter 3: Estimating the Effect of Firm-Sponsored Training on worker's earnings and Firm's Productivity: Evidence from Workplace-Employee Survey (WES)

Abstract

Utilizing the longitudinal property of Canadian linked employee-employer data, that is, Workplace-Employee Survey (WES), of 2003-2004 panel, we try in this paper to consistently estimate the impact of three types of firm-sponsored training, classroom training, on-the-job training and career related training on both firm-level labour productivity and worker's earnings controlling for firm and worker fixed heterogeneities. Our results show, on average, on the worker side, classroom training increases worker's wage in the current year by 1.9%, on-the-job training increases worker's wage in the current year and next year by 0.6%, and career related training has no significant impact on worker's wage whereas; on the firm side, classroom training increases firm's labour productivity in the next year by 12%, on-the-job training increases firm's labour productivity in the current year and next year by 7%, and career related training increases firm's labour productivity in next year by 12%. All these results are consistent with firm-sponsored training theory.

1. Introduction

From Workplace-Employee Survey data, every year in Canada, about 30% percent of Canadian workers receive firm-sponsored classroom training and on-the-job training, and about 4% receive career related training. What is the effect of this training on firms'

productivity and workers' earnings? This is one of the major empirical questions that needs to be answered besides who gets the training and who provides the training.

One of the major problems in estimating the effect of training either on workers or firms is selection bias or endogeneity: both the earnings or productivity and the selection of training are correlated with the unobservable ability of workers or/and profitability of firms; thus a simple regression of wage or earnings on training will not produce unbiased estimates of the training effect, and may suffer heterogeneity bias.

There are three methods to correct the bias. The first one is to use Heckman's two step approach (Heckman, 1979). The problem with this method is that it is extremely difficult to find instrumental variables that are correlated with training selection but not correlated with wage. The second one is to use a randomized experiment or a natural experiment to generate a treatment group and control group. In this case, selection is exogenous so there is no selection bias or endogeneity. However, the limitation of this method is that almost all the relevant data is observational data and not experimental data. The third method is to exploit the longitudinal structure of the data. Fixed effect method or difference in difference method belongs to this category. Fixed effect regression can control for the fixed heterogeneity, and produces consistent estimates. Heckman et al (2005) provides an extensive and detailed review on estimating the treatment effect and related problems.

The increasing availability and use of linked longitudinal employer-employee data creates the potential for answering some fundamental questions and solving important

controversies because they allow us to observe the data on both sides of the market, and create the potential for controlling "unobservables" (Abowd and Kramarz, 1999; Andrews et al. 2004). The Canadian linked employer-employee data is the Workplace-Employee Survey (WES) starting from 1999. The Canadian linked WES data of 2003/2004 panel is employed in this paper to study the impact of firm-sponsored training both on workers as well as firms.

There is a vast literature studying the impact of human capital investment such as education and firm-sponsored training on productivity (Jorgenson et al, 1967; Bartel, 1994; Dearden et al, 2006; Ichinowski et al, 1997; Zwick, 2006; Black and Lynch, 1996 and 2001), and on employees (Ashenfelter, 1978 ; Ashenfelter and David Card, 1985; Lynch, 1992; Frazis and Loewenstein 2005). There are also a few studies utilizing the Canadian Workplace and Employee Survey to examine the relevant issues. For example, Dostie (2008, 2010) uses the linked WES data from 1999 to 2005 to estimate returns to firm-sponsored on-the-job and classroom training and finds that workers who receive classroom training are 10% more productive than other workers, but that there is no effect for on-the-job training. There are also positive impacts of both on-the-job-training and classroom training on product quality, customer satisfaction, profitability and innovation. Zoghi (2004) uses the 1999-2000 panel of the WES to examine the impact of computer use on the earnings of workers, and shows that after controlling for unobserved worker heterogeneity, the wage impact for the first year computer use is a statistically significant increase of 3.8%.

However, most of the literature only estimates the impact of training either on firm level productivity or on the earnings of workers. From the firm-sponsored training theory developed in the first paper based on new training theory (Acemoglu, 1998), firms have an incentive to sponsor training, specific as well general, because training can increase workers' productivity in the future and firms can appropriate at least part of the increased productivity because of the market power that firms have over their workers. That market power comes from the complementarities of general training and specific training or the specificity of the training. On the other hand, if firms only appropriate part of the increased productivity from firm-sponsored training, workers' wages would increase though they may increase less than the growth of productivity in the future period. With a competitive labour market, competition for the workers and provision of training may imply that the worker's wage may increase even in the period of training. Thus firm-sponsored training impacts both the productivity of firms and the earnings of workers. The contribution of this paper is to estimate the effect of firm sponsored training on both firm level productivity and employees' earnings using the same panel of 2003/2004 WES data, controlling for both workers' and firms' characteristics, and especially for the individual i.e. worker-specific and firm-specific, heterogeneity by exploiting the longitudinal feature of the WES data on both worker side and firm side.

Our results show classroom training would increase the earnings of workers in the current period on average by 1.9% and firm level productivity on average by 12%. On-the-job training would increase the earnings of workers in the current year by 0.6% and in the next year by 0.6%. And from on-the-job training, a firm's productivity increases by 7% per

year in both the current year and the next year. Firm sponsored career related training has no significant impact on both worker's current earnings and worker's earnings in the next year, but increases the firm's productivity in the next year by 12%. Our findings by and large are consistent with the theory developed in the first paper and the new firm-sponsored training theory.

The rest of the paper is arranged as follows, section 2 will outline the theoretical and empirical estimation strategy, section 3 will discuss the data and the estimation results, and section 4 will conclude the paper.

2. Theoretical and Empirical Estimation strategy

2.1 Theoretical basis

Let the production function of a firm be of the Cobb-Douglas form,

$$Y = K^{\alpha}(LH)^{1-\alpha} \quad (1)$$

where H is some measure of average human capital of workers in the firm. Let,

$$H = \exp(\beta E + \gamma G + \delta S) \quad (2)$$

where E is a measure of formal education, G is a measure of general skill and S is a measure of specific skill.

Then, the average labour productivity of the firm can be written as,

$$\frac{Y}{L} = (\frac{K}{L})^{\alpha}(\exp(\beta E + \gamma G + \delta S))^{1-\alpha} \quad (3)$$

Taking the log of both sides and letting *y* be average labour productivity, we obtain,

$$\ln y = \alpha \ln k + \beta(1-\alpha)E + (1-\alpha)\gamma G + (1-\alpha)\delta S . \quad (4)$$

Taking the difference yields

$$\Delta \ln y = \alpha \Delta \ln k + \beta(1-\alpha)\Delta E + (1-\alpha)\gamma \Delta G + (1-\alpha)\delta \Delta S \qquad (5)$$

The marginal product of labour is equal to the derivative of *Y* with respect to *L* from equation (1). We have,

$$\frac{\partial Y}{\partial L} = (1-\alpha)(\frac{K}{L})^{\alpha}(\exp(\beta E + \gamma G + \delta S))^{1-\alpha} \qquad (6)$$

Log both sides of the above equation, then,

$$\ln(\frac{\partial Y}{\partial L}) = \alpha \ln k + (1-\alpha)\beta E + (1-\alpha)\gamma G + (1-\alpha)\delta S + \ln(1-\alpha) \qquad (7)$$

Ideally, in a perfectly competitive labour market, the wage rate is equal to the marginal product of labour. However in an actual frictional labour market involving firm-sponsored training, specific as well as general, workers can only obtain part of the marginal productivity increase coming from firm-sponsored training based on bargaining power and complementarity between general and specific training. So let the wage rate be *w*. In a frictional labour market, wage rate determination can be written as follows,

$$\ln w = \alpha \ln k + (1-\alpha)\beta E + \lambda_G(1-\alpha)\alpha G + \lambda_S(1-\alpha)\delta S + \ln(1-\alpha) \qquad (8)$$

where $\lambda_G <$ 1and $\lambda_S <$ 1 are the proportions of the earnings that workers get from increasing marginal productivity originating from firm-sponsored general and specific training.

Taking the difference of the above equation, we find,

$$\Delta \ln w = \alpha \Delta \ln k + \beta(1-\alpha)\Delta E + \lambda_G(1-\alpha)\gamma \Delta G + \lambda_S(1-\alpha)\delta \Delta S \qquad (9)$$

Equations (4) and (8) or (5) and (9) form the theoretical basis of the empirical estimation.

2.2 Empirical estimation strategy

Empirically, the productivity and wage may depend on other firm characteristics, employee characteristics, unobserved firm heterogeneity and worker heterogeneity.

$$\ln y_{it} = \alpha_1 \ln k + \alpha_2 E + \alpha_3 G + \alpha_4 S + \alpha_5 (E*T) + \phi X + u_i + \varepsilon_{it} \quad (10)$$

$$\ln w_{jt} = \beta_1 \ln k + \beta_2 E + \beta_3 G + \beta_4 S + \beta_5 (E*T) + \varphi Z + \eta_j + \omega_{jt} \quad (11)$$

Where *E*T* is the cross term between education attainment and employment tenure or job tenure (Altonji, 2005; Altonji et al, 2008).

Fitting the above two equations, we face several problems,

(1) The data on the two unobserved heterogeneities do not exist and the two unobserved heterogeneities may be correlated with both the explained variables and explanatory variables of interest, so a pooled model and random effect regression may lead to biased estimates.

(2) The data on the stock variables *G* and *S* is missing although the data on *E* can be approximately represented by the number of years of formal education. Simple fixed effect models, though warranted, are not obtainable.

(3) For some explanatory variables in the wage equation, such as the cross term between education and employment tenure or job tenure, it is difficult to find the meaning of a deviation from mean value, even though it is easy to calculate the difference.

Differencing the above two equations, we get,

$$\Delta \ln y_{it} = \alpha_1 \Delta \ln k + \alpha_3 \Delta G + \alpha_4 \Delta S + \alpha_5 E + \phi \Delta X + \varepsilon_{it} - \varepsilon_{it-1} \quad (12)$$

$$\Delta \ln w_{jt} = \beta_1 \Delta \ln k + \beta_2 \Delta E + \beta_3 \Delta G + \beta_4 \Delta S + \beta_5 E + \varphi \Delta Z_j + \omega_{jt} - \omega_{jt-1} \quad (13)$$

The increase in general skill and specific skill can be represented by the training time workers receive. Considering the dynamics of the impacts of training on worker's earnings and firm's productivity, a term representing lagged training is also introduced in (12) and (13). In addition, there is no capital data in the WES data, but because there are many firm characteristics and worker characteristics variables, these are introduced into the estimation to attempt to capture the variation in this term. All the explanatory variables are not correlated with the error terms by assumption. Thus regression of the above two equations will lead to consistent estimates.

3. Data and empirical results

Canada's linked employee-employer data is the workplace-employee survey (WES) supplied by Statistics Canada. WES is an annual survey starting from 1999. It is longitudinal for workplaces, and is re-sampled for employees every two years, so it is a longitudinal two-year panel for employees. WES is longitudinal and documents both the characteristics of workplaces and characteristics of employees in a linked way (Hidiroglou et al, 1998. Patak et al, 1998). The advantages of using WES are, (1) WES data contains both firm characteristics and worker characteristics, thus allows for controlling more variables in the estimation and avoids omitted variable bias. (2) WES data is longitudinal for firms and workers for two years and allows for controlling both firms' and workers' heterogeneity. (3) WES allows for estimating the effect of training on both firm level productivity and worker earnings.

The recent panel 2003-2004 will be used for this study. The sample size for the workplace is 6565 and 6155, and 20834 and 16804 for the employee in 2003 and 2004 respectively (Statistics Canada, 4 Feb 2009)

The explained variables are the earnings on the worker side and average labour productivity on the firm side respectively. We measure the worker's earnings by the hourly wage and firm level productivity by the sales per worker.

3.1 Sample statistics

The basic statistics of worker's wage are shown in table 3-1. In 2003, the mean and median hourly wage is 20.6 and 17.8 Canadian dollars per hour respectively. In 2004, those numbers are 21.9 and 19.0 Canadian dollars, representing increases of 6.2% and 6.9% respectively.

Table 3-1: Basic statistics of hourly wage

Year	Mean	Std. Dev.	Median
2003	20.6	12.7	17.8
2004	21.9	13.0	19.0

The sample means of wage by age group are shown in table 3-2. The mean wage first increases from the youngest age group to the age group between 40 and 55 then decreases for the group above 55 years of age.. Thus the age profile follows an inverse U shape.

The sample means by education levels are shown in table 3-3. By and large, the education profile of wage is increasing. The only exception is a slight dip from high school only to some college.

Table 3-2: Age and mean hourly wage

Age group	Mean Wage (C$/hour)
24 and below	11.3
Between 25 and 39	20.8
Between 40 and 55	23.2
Above 55	22.6

Table 3-3: Education level and mean hourly wage

Education level	Hourly Wage (C$/hour)
Below high school	16.3
High school only	18.1
Some college	17.5
College degree	21.3
Some university	22.0
University degree	28.0
Some graduate	31.3
Master degree	35.6
Other education	23.4

There is also a union premium as is shown in table 3-4. The mean wage of workers who have a collective bargaining agreement is 22.4 dollars per hour whereas the mean wage of workers who have no collective bargaining agreement is 20.8 per hour. The sample unconditional union premium is 7.7%.

Workers in larger firms have higher mean wages as shown in table 3-5. The mean wage in large firms of 500 employees and above is 56.6% more than that of the small firms of 1-19 employees.

Table 3-4: Union status and mean hourly wage

Union status	Hourly Wage (C$/hour)
Have collective bargaining agreement	22.4
No collective bargaining agreement	20.8

Table 3-5: Firm size and mean hourly wage

Firm size	Hourly Wage (C$/hour)
1-19 employees	17.5
20-99 employees	19.5
100-499 employees	23.1
500 employees and above	27.3

There are 3 major explanatory variables, that is, firm sponsored classroom training, firm sponsored on-the-job-training and firm sponsored career related training. And as a contrast with the firm sponsored training, we add another explanatory variable, career-related training not sponsored by the employer. Those four explanatory variables are used as dummy variables in the estimation on the worker side, whereas in the estimation on the firm side, the key variables are the proportions of workers who obtain the relevant training in each firm. As is shown in table 3-6, in 2003-2004, 35.3% of workers received classroom room training, 28.4%, on the-the-job training, and 3.8%, career related training sponsored by employer, whereas 7.6% of workers engaged career-related training not sponsored by their employer.

Table 3-6: Statistics of main explanatory variables

Type of training	Proportion	Std. Err
Received classroom training	0.353	0.006
Received on-the-job training	0.284	0.005
Career-related training	0.038	0.002
Career-related training not sponsored by employer	0.076	0.003

3.2 Choices of explained variables, explanatory variables and null hypotheses

On the worker side estimation, the dependent variable is the first difference of log hourly wage. The core explanatory variables are four dummy training variables: received firm-sponsored classroom training, received firm-sponsored on-the-job training, received firm-sponsored career related training, received career-related training not sponsored by employer, these four dummy variables' lags, and other explanatory variables including worker characteristics and characteristics of the firm where the worker is employed. According to the firm sponsored training theory developed in the first paper, firm-sponsored training would have a positive impact on current earnings and future earnings. Since our explanatory variable is the difference in log earnings, we would expect the coefficients for the 3 dummy firm-sponsored training variables to be positive. Coefficients for the 3 lag dummy firm sponsored training variables are indeterminate but the sum of the coefficients of the each dummy firm sponsored training variable and its lag is positive. The inclusion of the dummy variable, received career-related training not sponsored by employer, and its lag is for the purpose of comparison.

On the firm side of the estimation, the dependent variable is the first difference of log firm-level productivity measured by per worker sales. The core explanatory variables are four average training participation ratios, that is, the ratio of workers in each firm receiving

classroom training, the ratio of workers receiving on-the-job training, the ratio of workers receiving career-related training sponsored by the employer, and the ratio of career-related training not sponsored by employer, as well as their respective lags. Other explanatory variables include worker characteristics in employee survey averaged by firm and characteristics of the firm that the employee works for. According to the firm sponsored training theory developed in the first paper, firm sponsored training would have a negative or non-positive effect on current productivity because of the training cost incurred, and a positive effect on future productivity. Considering that our explanatory variable is the difference in log productivity, we would expect the coefficients for the 3 firm-sponsored training variables to be negative or not significant but the coefficients for the 3 lagged firm-sponsored training variables to be positive. The ratio of workers receiving career-related training not sponsored by employer and its lag are included for the purpose of comparison.

We should note that for the four training types considered here, actual training courses may be different in quality, duration and content, and that the effects of the training on both worker earnings and firm labour productivity would vary with the characteristics of workers who obtain training and the firms who provide the training. We here evaluate the average effect on all participants in the WES 2003-2004 sample instead of the effect of a specific course on a specific worker in a specific firm.

3.3 Worker side estimation

Worker side estimation results are shown in table 3-7. Here we focus on the coefficients of participation in training. It is reasonable to assume that current training has no effect on previous earnings. Since the dependent variable is the growth rate of hourly wage, the coefficient of the training in the current year is the effect of current training on the current earnings level, and the sum of the coefficients of training in current and previous year is the effect of the training in current year on next year's earnings level. Observations of table 3-7 show,

(1) The coefficient of participation of classroom training is 1.9% (significant at level 1%), which means that participation in classroom training in the current year increases worker's earnings growth by 1.9%, indicating that participation in classroom training would increase a worker's earnings in the current year by 1.9% on average. However, the coefficient of participation in classroom training last year is -1.9% (significant at level 1%), suggesting that the impact of participation in classroom training on the next year's earnings is not significantly different from 0. This implies that the firm compensates the worker for training in the year of the training, but allows the worker's wage to return to its previous path following the training.

(2) The coefficient of participation in on-the-job training in the current year is 0.6% (significant at level 1%), indicating that participation in on-the-job training would increase a worker's earnings in the current year by 0.6% on average. Also, since the coefficient of participation in on-the-job training last year is not significantly different from zero, then the impact of participation in on-the-job training on the next year's earnings is also 0.6%.

(3) The coefficient of participation in career related training sponsored by the firm in the current year is not significantly different from zero, thus participation in career related

training sponsored by the firm has no significant impact on a worker' earnings in the current year on average. The coefficient of participation in career related training sponsored by the firm in last year is not significant either, suggesting that the impact of participation in career related training sponsored by the firm has no significant impact on next year's earnings either. Since the estimation corrects for unobserved heterogeneity, this cannot explain the results. However, only a small proportion of workers receive career related training. If this training is concentrated in larger firms, and the wage structure is more compressed in those firms, this may account for the lack of significance of these coefficients.

(4) The coefficient of participation in career related training not sponsored by the firm in the current year is 0.9% (significant at level 1%), indicating that participation in career related training not sponsored by the firm would increase a worker's earnings in the current year by 0.9% on average. And, since the coefficient of participation in career related training not sponsored by the firm is not significant, the impact of participation in career related training not sponsored by firm on the next year's earnings is also 0.9%.

Furthermore, we can find other important observations from table 3-7. For example, computer use on the job would increase a worker's earnings by 2.0%, and both industry and occupation categories are important in determining wage growth.

Table 3-7: Estimation on the worker side: Growth rate of hourly wage as dependent variable

Regression variables	Coefficient	Std. Err.	Significance
Receive classroom training			
current year	0.0192	0.0028	***
last year	-0.0195	0.0027	***
Career-related training sponsored by employer			
current year	0.0052	0.0062	

last year	-0.0004	0.0062	
Received on-the-job training			
current year	0.0061	0.0027	**
last year	-0.0037	0.0027	
Career-related training not sponsored by employer			
current year	0.0095	0.0049	**
last year	-0.0060	0.0044	
Education (No high school as base)			
High school Graduate Only	-0.0171	0.0045	**
Some college only	-0.0149	0.0053	**
College Degree	-0.0192	0.0048	***
Some University	-0.0173	0.0057	***
University degree	-0.0123	0.0055	**
Some graduate Study	0.0319	0.0086	***
Master's degree	-0.0251	-3.1000	***
Other education	-0.0055	0.0056	
Female	-0.0044	0.0027	*
Born in Canada	-0.0177	0.0032	***
Have dependent kids	0.0036	0.0027	
Married	0.0011	0.0029	
Occupation categories (Production workers as base)			
Managers	0.0382	0.0046	***
Professionals	0.0173	0.0040	***
Technical/Trades	0.0182	0.0061	***
Marketing/Sales	0.0134	0.0048	***
Clerical/Administrative	0.0423	0.0064	***
Industry categories(Forestry, mining, oil, and gas extraction as base)			
Labour intensive tertiary manufacturing	-0.0469	0.0114	***
Primary product manufacturing	-0.0445	0.0121	***
Secondary product manufacturing	-0.0259	0.0114	***
Capital intensive tertiary manufacturing	-0.0411	0.0113	***
Construction	-0.0190	0.0114	*
Transportation, warehousing, wholesale	-0.0389	0.0106	***
Communication and other utilities	-0.0326	0.0129	**
Retail trade and consumer services	-0.0191	0.0104	*
Finance and insurance	-0.0209	0.0115	*
Real estate, rental and leasing operations	-0.0732	0.0135	***
Business services	-0.0473	0.0108	***
Education and health services	-0.0404	0.0105	***
Information and cultural industries	-0.0311	0.0119	***
Firm size(1-19 employees as base)			

20-99 employees	-0.0011	0.0032	
100-499 employees	-0.0061	0.0037	*
500 employees or more	-0.0014	0.0039	
Use computer	0.0204	0.0031	***
covered by collective bargaining agreement	0.0033	0.0032	
Age group (24 and below as base)			
Between 25 and 39	-0.0367	0.0051	***
Between 40 and 55	-0.0568	0.0053	***
Above 55	-0.0584	0.0062	***
Tenure of job	-0.0007	0.0002	***
Constant	0.1280	0.0130	***

(Note: *** indicate significance at he 1%, ** at the 5% level and *at the 10% level)

3.4 Firm side estimation

The firm side estimation results are shown in table 3-8. Here we also focus on the coefficients of major explanatory variables. It is also reasonable to assume that current training has no effect on previous firm level productivity. Since the dependent variable is the growth rate of firm level productivity, the coefficient of the training in the current year is the effect of current training on the current firm level productivity, and the sum of the coefficients of training in current and previous year show the effect of training in the current year on next year's productivity level. Observations of table 8 show,

(1) The impact of workers receiving classroom training in the current year on current labour productivity is not significant. And the impact of current ratio of workers receiving classroom training on next year's productivity is 10% (significant at level 1%).

(2) Workers receiving on-the-job training in the current year would increase the firm level labour productivity by 7% on average (significant at level 1%). And the impact of the current ratio of workers receiving on-the-job training on next year's productivity is also 7%.

(3) The impact of workers receiving career related training sponsored by the employer in the current year on current firm-level labour productivity is not significantly different from zero. And the impact of the current ratio of workers receiving career related training sponsored by the employer on next year's productivity is 12% with a significance level of 5%.

(4) The impact of workers receiving career related training not sponsored by the employer in the current year on current labour productivity is not significantly different from zero. And the impact of the current ratio of workers receiving career related training not sponsored by the employer on next year's productivity is not significantly different from zero either.

Table 3-8: Estimation on the firm side: growth rate of productivity as dependent variable

Regression variables	Coefficient	Std. Err.	Significance
Industry categories(Forestry, mining, oil, and gas extraction as base)			
Labour intensive tertiary manufacturing	0.158	0.079	**
Primary product manufacturing	0.030	0.095	
Secondary product manufacturing	0.091	0.081	
Capital intensive tertiary manufacturing	0.078	0.080	
Construction	0.045	0.071	
Transportation, warehousing, wholesale	0.103	0.070	
Communication and other utilities	0.109	0.091	
Retail trade and consumer services	0.053	0.069	
Finance and insurance	0.093	0.074	
Real estate, rental and leasing operations	0.077	0.076	
Business services	0.087	0.071	
Education and health services	0.056	0.072	
Information and cultural industries	0.135	0.086	
Firm size(1-19 employees as base)			
20-99 employees	-0.044	0.020	**
100-499 employees	0.011	0.049	

500 employees or more	-0.005	0.161	
Fraction of foreign ownership	0.000	0.000	
Market focus (national market as base)			
local	0.000	0.000	
USA	-0.002	0.001	***
World market	0.001	0.001	
improvement of process	0.058	0.028	**
improvement of product	-0.086	0.021	***
Have new hiring	0.024	0.015	*
implement new soft ware	-0.016	0.022	
New process	-0.019	0.030	
New product	0.053	0.021	***
Fraction of collective bargain arrangement	-0.118	0.037	***
Fraction of workers receive classroom training			
current year	-0.009	0.024	
last year	0.101	0.024	***
Fraction of workers receive career related training			
current year	-0.016	0.061	
last year	0.120	0.061	**
Fraction of workers receive on-the-job training			
current year	0.070	0.023	***
last year	-0.022	0.023	
Fraction of worker obtain career related training not paid by the employer			
current year	0.009	0.046	
last year	0.028	0.038	
Proportion of Education level for workers			
High school Graduate Only	-0.063	0.029	**
Some college only	-0.035	0.036	
College Degree	-0.047	0.031	
Some University	-0.176	0.039	***
University degree	-0.065	0.038	*
Some graduate Study	-0.151	0.070	**
Master's degree	-0.003	0.094	
Other education	-0.054	0.041	
Born in Canada	0.041	0.023	*
Female	-0.062	0.019	***
proportion of workers using computer	-0.047	0.020	**
Proportion of age group of workers			
Between 25 and 39	0.047	0.032	
Between 40 and 55	-0.026	0.031	

Above 55	0.011	0.037	
Constant	0.019	0.085	
(Note: *** indicate significance at he 1%, ** at the 5% level and *at the 10% level)			

3.5 Comparison of worker side estimation and firm side estimation results

(1) Classroom training increases worker's current earnings by 1.9% but has no significant impact on worker's earnings next year. Classroom training has no significant impact on firm's current productivity level, but increases firm's productivity in the next year by 12%.

(2) On-the-job training increases a worker's current earnings by 0.6% and next year's earnings by 0.6%. On-the-job training increases a firm's current productivity by 7% and a firm's productivity in the next year by 7.0%.

(3) Career related training sponsored by the employer has no significant impact on both workers' current earnings and worker's earnings next year. Career related training sponsored by the employer has no significant impact on a firm's current productivity, but increases firm's productivity in the next year by 12%.

(4) Career related training not sponsored by the employer increases a worker's current earnings and a worker's earnings next year by 0.9%. Career related training not sponsored by the employer has no significant impact on a firm's current productivity or on a firm's productivity in the next year.

In sum, firm-sponsored training increases firm productivity in the next year and a worker's current and next year earnings, and the productivity impact is larger than the earnings impact, which may provide an incentive for a firm to sponsor training.

4. Conclusion

Using Canadian linked employee-employer data, that is, Workplace-Employee Survey (WES), of 2003-2004 panel, this paper tries to estimate the impact of three types of firm-sponsored training, classroom training, on-the-job training and career related training on both the firm-level labour productivity and worker earnings controlling for the firm's and worker' fixed heterogeneities.

Our results show, on average, (1) classroom training increases a worker's wage in the current year by 1.9%, and firm labour productivity in the next year by 12%; (2) on-the-job training increases a worker's wage in the current year and next year by 0.6% , and firm's labour productivity in the current year and next year by 7.%; (3) career related training has no significant impact on worker's wage, but increases the firm's productivity in the next year by 12%. All these results are consistent with firm-sponsored training theory.

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General Conclusions

The above three papers discuss firm-sponsored training from different perspectives. Chapter 1 develops a general theoretical framework to attempt to analyze how much and what kinds of training firms would provide for workers of different education levels in a competitive market based on the following plausible assumptions: 1) Labour market is competitive and information is perfect; 2) The future wage and training is non-contractible; 3) Wages are determined through simple Nash bargaining; and 4) education, specific skill and general skill are complementary each other. Chapter 2 and chapter 3, using Workplace and Employee Survey (WES) data of 2003/2004 and identifying three firm sponsored training variables in the data, that is, class-room training, on-the-job training, and career related training, provide empirical evidence to the theory developed in chapter 1 from two different perspectives. Chapter 2 focuses on estimating the determinants of the intensity and incidence of each of the three types of firm-sponsored training by applying, in an integrated way, the sample selection model while chapter 3 estimates the effects of three types of firm sponsored training on the earnings of workers and productivity of firms controlling for worker's, firm's and job characteristics as well as both worker's heterogeneity and firm's heterogeneity employing the longitudinal feature in the WES data of 2003/2004 batch. The general findings arising from the three papers can be summarized as follows.

(1) In a frictional labour market, firms have incentive to sponsor general as well specific training, because the firms can harvest benefit from the productivity growth from general as well as specific training as long as the firm has some bargaining power and specific skill and general skill are complementary to each other.

(2) If education and training, and general skill and specific skill, are complementary to each other, firms have incentive to sponsor more training, specific and general, to the more educated workers. Firm sponsored training is also closely related to other labour market characteristics such as firm's wage bargaining power and worker's job destruction rate. The more bargaining power the firm has, the more benefit the firm can derive from the productivity increase resulting from the training, thus there is more incentive to sponsor the training, other conditions being equal. And, the higher job destruction rate, the lower is the incentive firms have to sponsor training.

(4)There is virtual reinforcement among education, firm sponsored training, and job retention rate. The firm has more incentive to sponsor training for the more educated worker. The more educated worker plus more training would increase the job matching quality between the firm and the worker, and thus decrease the job separation rate and increase the job retention. The increase of job retention rate would provide further incentive for the firm to provide the incentive to the worker.

(5) In a worker's life cycle, firm-sponsored training would decline because the working time remaining would shrink and eventually would end when the worker retires. The worker's life cycle profile of firm sponsored training would be either inversely U shaped or decreasing.

(6) Since generally firms do not appropriate all the benefit resulting from the productivity increase brought about by firm-sponsored training, firm-sponsored training is inefficiently lower; also, before entering the labour market, the worker's choice of education is inefficiently lower because the firm sponsored training is inefficiently low later. The policy implication is that government can subsidize not only education but also firm sponsored training, especially for the small and middle firms to improve efficiency.

(7) The estimation results from the sample section model based on 2003-2004 WES data show that, for all three types of firm-sponsored training, that is, classroom training, on-the-job training, and career related training, higher education levels mean higher incidence of training. On the other hand, conditional on obtaining training, only workers with education attainment of some graduate study seem to get significantly more on-the-job training and classroom training; for the intensity of career related training, different education levels have no significantly different effect. Both occupations and industries are important determinants of firm sponsored training. Professionals, managers and technical /trades are more likely to obtain all three kinds of training. On the intensity, conditional on obtaining training, professionals, managers and technical /trades tend to obtain more on-the-job training, marketing/sales tend to obtain more classroom training, while occupations seem to make no significant difference to career related training. For the industries, workers in finance and insurance seem more likely to obtain all three types of training.

(7) Firm sizes are significant for the incidence of all three types of training: Larger firm sizes usually mean significantly higher incidences of training. On the intensity, firm size makes no significant difference for on-the-job training but is significant for the intensity of classroom training and of career related training:. The firm size profile of the intensity by and large is U shaped.

(8) The tenure of job is significant and negative for the intensity of class room training or on-the-job training, but not significant for the career related training. The age profile is decreasing for all three types of training.

(9) Collective bargaining agreement is only significant and positive for the incidence and intensity of classroom training, not significant in all other cases.

(10) Technology use, especially computer usage, on jobs is a very important determinant of firm sponsored training. Computer users are more likely to obtain all three types of training, and computer usage is significant and positive for the intensity of classroom training and on-the-job training.

(11) Workers born in Canada seem more likely to obtain, and conditional on obtaining training, obtain more classroom and on-the-job training.

(12) There is evidence of selection bias for on-the-job training and classroom training, for those types of training, the two models (incidence and intensity) cannot be estimated separately; however for career related training, there is no evidence of selection bias, the two models (incidence and intensity) can be estimated separately.

(13) The estimating results on the effects of firm-sponsored training on film's productivity and worker's earning show that classroom training increases the worker's wage in the current year by 1.9%, and the firm's labour productivity in the next year by 12%; on-the-job training increases the worker' wage in the current year and next year by 0.6% , and the firm's labour productivity in the current year and next year by 7%; career related training has no significant impact on the worker's wage, but increases firm's productivity in the next year by 12%.

(14) Empirical evidence is consistent with firm-sponsored theory based on a frictional labour market.

(15) The policy implication is that a subsidy to education and firm sponsored training will improve efficiency.