DURATION OF IT HUMAN CAPITAL EMPLOYMENT

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Introduction

Recent research highlights the role that investments in new information technologies (**ITs**) play in creating business value and executing business strategy (e.g., Brynjolfsson and Hitt 1998; Dewan and Kraemer 1998). Yet in competitive markets, a firm's ability to earn an adequate return on strategic IT investments depends on the capabilities of the human elements present for information systems design, development, deployment and management. In this research, we focus on this other kind of IT asset – one in which individuals and firms can invest – IT human capital.

As organizations scramble to leverage new technologies, the skills and knowledge required by firms employing IT professionals changes. The result is an environment in which firms and individuals must make investment decisions to develop and then apply competencies necessary for success. This creates opportunities for those with relevant skills, but it makes skill set development and retention a critical challenge for individuals and organizations alike. We address these issues in the context of *human capital theory*, a theoretical perspective that views investment in a workforce as a capital investment (Becker 1962, 1995; Becker, Murphy, and Tamura 1990). *IT human capital* is defined as *the productive capacity embedded in an IT professional that results from endowment and relevant investment activities that occur over time*. Economics treats various issues of IT human capital: models of human capital investment (Glomm and Ravikumar 1992, Keane and Wolpin 1997), separation decisions (Johnson 1978; Parsons 1986), and employee mobility (Katz and Ziderman 1990).

Research Questions

How long can the firm expect the IT employment relationship to last? What significant factors impact this "duration"? How influential are these factors in an IT professional's decision making? We attempt to answer these questions in the context of an ongoing study of a large multi-division organization with 700+ IT professionals.

Existing economic literature addresses broad classes of workers as "labor," including it (in an undifferentiated way) as a fundamental input in models of production. As we explore conditions for its separation from the firm, we expect to uncover aspects that make the labor of the IT professional different. In theoretical terms, we view IT professionals' decisions to remain

or separate in utility maximization terms, given a particular skill set, and opportunities within the firm and a market context. This perspective enables us to derive propositions that suggest different impacts of IT skill characteristics and other factors on separation.

Theory

Human capital theory posits that individuals invest time and resources in knowledge and skill development to acquire productivity-enhancing skills. The resulting capital assets give an individual leverage in an employment relationship and help them earn a market wage. Rational agents decide among alternate investment and employment actions and seek optimal levels of productivity consistent with individual goals.

Nevertheless, as firms and individuals pursue relationships, each is constrained by imperfect and asymmetric information. Thus, good skill-to-position matches require some experimentation as firms and individuals test for relationship value. This motivates a theory of job search (Mortensen 1986) in which individuals search for appropriate matches, and lays the groundwork for job matching (Sicherman and Galor 1990) and occupational choice (McCall 1991) theory. They explain job and occupational changes as a search for a more appropriate match between an individual's human capital and her employer or occupation.

These theories offer sound economic reasoning for separation behavior as an individual seeks to maximize return on investment in human capital over the course of her working life. She will do so subject to information and resource constraints. Managerial actions and policy also influence individual employment-related behavior. For example, the nature of a position may constrain the value that an individual can create for the firm. This limits return on capital for anyone employed in that position.

Hypotheses

Asset characteristics and the nature of their application largely determine potential return. Consequently, we expect the dynamic nature of IT human capital – especially in today's market context – to affect IT workforce behavior. For example, as firms adopt new technologies, the nature of work and skills necessary to achieve individual productivity change. Human capital previously valued for its productive capacity depreciates and, absent investment in new skills and knowledge, an individual's value to the firm decreases. The result: a growing mismatch between the individual and the tasks associated with a changing job description. The likelihood for separation increases.

This theory suggests that separation behavior within the IT workforce ought to be consistent with active management of human capital by people who own it. Consequently, we expect to be able to detect their responses *as a population* to changes in observable factors in the business and technology landscape, and in the employment relationship. For example, if compensation begins to fall behind performance, we expect an individual will be more likely to

separate. (Actual separation may not occur immediately, but pressure to separate will build until it reaches some threshold and separation becomes the most attractive alternative.)

Modeling Separation

The Single Period Model. In the exploratory phase of this research, we estimated a binomial logit model that aimed to identify a set of primary drivers in separation decisions for a single period data set:

$$P(Separation = 1) = \frac{\exp(a + bX + gD)}{1 + \exp(a + bX + gD)} + e$$

X is a vector of continuous variables, and *D* is a vector of categorical variables. They include organization and individual level data related to performance, compensation, skill set, age, tenure, position, and other factors. *a* and *b* are estimated parameters, and *e* is an error term.

Maximum likelihood estimation (**MLE**) of the binomial logit model yielded parameter estimates and statistics for separation likelihood. (See Table 1.) Interpreting the signs and significance levels of parameter estimates is similar to linear regression. The partial derivative of the estimated model with respect to any variable equals the change in fitted value associated with a unit change in the variable. However, in the logit model, a problem arises: first partial derivative values depend upon observed values of the other variables (Greene 1997). The *odds ratio* is the solution: it indicates the *change in the odds that an event will occur, given a one-unit change in a single variable with all other variables held constant* (Neter et al. 1996). Goodness of fit is evaluated with the *partial deviance test statistic* or *deviance-* ^{2} (Neter et al. 1996), which indicated our model is appropriately parsimonious.

The Multi-Period Model. This model helps us understand explanatory factors for the duration of employment for IT professionals, as human capital, organizational and market forces all change. A number of considerations arise as a result of moving to multi-period data analysis. One expects that the values of variables that explain an individual's propensity for separation will change over time (e.g., performance may improve or decline, a large salary raise may occur, etc.). Thus, the empirical model, consistent with our human capital theory of a changing job match over time, must allow for such *covariates of duration*. For this, we use a class of econometric models called *duration models* (Kalbfleisch and Prentice 1980; Kiefer 1988). Duration models support time-varying covariates for changing human capital. They also handle data "censoring" associated with individuals who do not separate during the time frame under study (Lawless 1982; Cox and Oakes 1984). Such econometric models are often used in literature on technology adoption (e.g., Sinha and Chandrashekaran 1992).

We model separation over time for the IT professional with a *proportional hazards duration model* (Greene 1992) with time-dependent covariates of the form:

$$h_i(t) = a\,t^{a-1} * e^{-bX_i(t)} h_0(t)$$

$X_i(t)$ is a matrix of explanatory variables for individual *i* at time *t*, and ß is a column vector of coefficients to be estimated for the primary explanatory variables. The mathematical expression for $h_i(t)$ indicates a base hazard rate, $h_0(t)$, for the IT professional population under study, modified by constant effects (via a) and time-varying covariates (via the ß's) . We are in the process of sorting out the appropriate functional form of the model (e.g., log linear, exponential, etc.) and the distributional assumptions that go along with them, as we collect our data.

5. Current Results and Ongoing Work

Empirical results from the Single Period model support the hypothesis that IT human capital is different from human capital in less dynamic and less knowledge-intensive occupations. Furthermore, the separation behavior of IT professionals is consistent with active management of human capital assets by the people who own them. Specifically, we found the following results for the Single Period model:

- IT professionals who are paid less than we would expect, given their performance and position, are twice as likely to separate as those who are not underpaid.
- Those with less investment in the business processes of an organization are more likely to separate: they do not experience a loss of return on valuable firm-specific human capital.
- Poor performance increases observed separation: individuals leave to pursue value-maximizing employment matches.

Data collection work for the multi-period model is under way. We will report preliminary results for the single and multi-period models at WISE '98. Subsequent work will provide insight into optimal approaches to IT human capital management and policy.

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Table 1 -- MLE Results for the Single Period Binomial Logit Model

Variable	Estimated Coefficient	Standard Deviation	P-Value	Odds Ratio
α *(Constant)*	-3.5658***	0.8399	0.000	
Performance Rate	-1.1156***	0.3308	0.001	0.33
Underpaid	0.7526**	0.3617	0.037	2.12
Skill set				
Administration/Strategy	1.2183	0.9900	0.218	3.38
Applications	1.6557**	0.8275	0.045	5.79
Architecture	1.7564**	0.7990	0.028	5.24
Multiple	1.8001**	0.8471	0.034	6.05
System Operations	-0.069	1.072	0.949	0.93
Divisions				
Division 2	0.1030	0.5222	0.844	1.11
Division 3	-0.3879	0.4036	0.337	0.68
Division 4	-1.5855***	0.5911	0.007	0.20

Number of observations in the data set: <474>
*** Significant at .01 level; ** Significant at .05 level

Note: Among the categorical "Skill Set" variables, *Business* is the base case; also parameter estimates for Skill Sets are relative to this base case. Among the "Division" variables, Division 1 is the base case. For the estimated model, *deviance*- ^{2} =218.59 with 257 d.f. and p=0.961. This indicates insufficient evidence to reject h_0. Conclusion: The logistic response model has a good fit. Attempts we made to eliminate variables of secondary importance based on deviance- 2 result in inadequate fit. In addition, adding variables such as Age, Annual Salary, and Tenure individually or as a group had no substantive effect on goodness of fit.
