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Jim J. Quan
Salisbury University, jxquan@salisbury.edu

Ronald Dattero
Southwest Missouri State University, rondattero@smsu.edu

Stuart D. Galup
Florida Atlantic University, sgalup@fau.edu

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INFORMATION TECHNOLOGY WAGES AND THE VALUE OF CERTIFICATIONS: A HUMAN CAPITAL PERSPECTIVE

Jing 'Jim' Quan
Perdue School of Business
Salisbury University
jxquan@salisbury.edu

Ronald Dattero
Department of Computer Information Systems
Missouri State University

Stuart D. Galup
Department of Information Technology & Operations Management
Florida Atlantic University

ABSTRACT

Although the value of Information Technology (IT) certifications has been widely debated in the IT industry, academia has largely ignored the issue. This study intends to bridge such a gap. Anchored on human capital theory and previous literature, we build a comprehensive model to estimate the value of various IT certifications in terms of their contributions to IT professionals' wages. We estimate our model using third-party survey data. The three main findings from the study are: 1) IT certifications are valuable in general; 2) there is a substitution effect between IT certifications and education and between IT certifications and experience; and 3) the value of IT certifications are job and industry specific. In addition, we estimate wage premiums of various IT certifications in the study. From these findings, we draw managerial implications for current and future IT professionals, IT managers, and human resource managers.

KEYWORDS: IT certifications, value of IT certifications, human capital theory, substitution effect, wage premium

I. INTRODUCTION

The accelerated pace of change in the Information Technology (IT) industry and the increase in global competition for IT-related work has intensified during the past decade. This has prompted employers to place an increased premium on employees with high levels of transferable skills. As a result, there is great need for individuals who can manage their own continuing education and career path [Buckley et al. 2004].

Rapidly evolving technology creates a need for highly skilled individuals to apply, support, configure, and adapt IT products and services. Hence, employees need to constantly update existing, and acquire new knowledge and skills. A 2004 Information Technology Association of

America (ITAA) Workforce Development Survey of hiring managers indicates that the best methods for internal advancement include both participation in formal on-the-job training (56 percent) and certification programs (55 percent). Seventy one percent of survey respondents said certification or continuing education is either important or very important for advancement [ITAA 2004].

In spite of the well-established notion that an IT certification is valuable, especially from the popular press [Roberts 2002; Sosbe 2004; Sosbe et al. 2005], the question of how to quantify such value has not been fully addressed in the existing IT Human Resource (HR) literature [Pratt 2005]. A few studies discuss how to incorporate IT certifications into the teaching curriculum in high schools, community colleges, and universities [Adelman 2000; Al-Rawi et al. 2005; Ray et al. 2000; Vedder 2004; Zeng 2004]. Other studies assess the value of IT certification from the HR managers' perspective [Anderson et al. 2002; Cegielski 2004] by gauging how much certifications are valued in relation to hiring decisions.

In this study, we attempt to answer the value proposition of IT certification from a different perspective. Specifically, we investigate the extent to which certain IT certifications contribute to its holder's salary. We believe that the answer to the value question of IT certifications has both theoretical and practical implications. These findings will enlarge the existing knowledge base in the IT human resource management area. In addition, individuals who are pursuing an IT career can use these findings to help manage their continuing education and career path.

To answer the above question, we estimate a human capital model using a cross sectional dataset in different industries and for different job functions. Human capital theorists have long regarded education, experience, and training as determinants that justify the wage an employee receives [Mincer 1962, 1974]. One of the difficulties with operationalizing training in the human capital model is the lack of concrete measurements to determine the effectiveness of IT training. In this study, we use the acquisition of an IT certification as a proxy for the effectiveness of training and incorporate it into a traditional human capital model. IT certifications represent a standard measurement for specific IT skills [Al-Rawi et al. 2005], and IT certification programs are considered by many to be responsive to industry needs and provide up-to-date, relevant training for continuously changing skill sets [Randall et al. 2005].

This paper is organized as follows. First, after reviewing the human capital theory and literature on value of certifications, we propose a general model for assessing the value of IT certifications by job function, industry and specialty. Second, we discuss the survey used in this study and the resulting dataset. Third, we estimate our model using the described data. Finally, we discuss the managerial and personnel implications of our findings.

II. THEORETICAL FRAMEWORK AND RESEARCH QUESTIONS

Human capital theory suggests that education and training are the most important human capital factors, and differences in them lead to wage variance among workers [Becker 1975]. Human capital theorists believe that education represents an investment. By going to school, one has to incur both direct costs in the form of tuition and opportunity costs in the form of foregone earnings. In order to make up for these costs, lifetime earnings for workers who have attained additional education are sufficiently higher [Mincer 1957, 1958, 1962; Schultz 1960, 1961]. A 2004 U.S. Department of Labor 2004 report substantiates this claim. The report states that workers who are at least 18 years old without a high school diploma earn an average wage of $18,734 a year; those with only a high school diploma earn an average of $27,915; those with a bachelor's degree earn an average of $51,206; and those with an advanced degree make an average of $74,602 [U.S. Department of Labor 2004].

Formal education is only one method of investing in human capital. Employers often find that college graduates are not fully prepared when they enter the workforce, requiring the employer to fund formal and informal training programs [Becker 1975]. For example, on-the-job training is

one of the most common training methods. On-the-job training enables a worker to acquire versatile skills, knowledge, and expertise that are usable or salable across firms and industries. Training programs generally aim at increasing an employee's productivity, and the competitive market implies that the more productive employee will be paid accordingly at a higher rate [Mincer 1957, 1958, 1962; Schultz 1960, 1961].

The problem is how to measure the knowledge, skills, and expertise acquired during the training. Traditional human capital theory uses work experience as a proxy, because one accumulates knowledge, skills, and expertise while working. The resulting human capital model states that wages are a function of education and experience [Mincer 1974].

In this paper, we extend the traditional human capital model by incorporating a new form of training, which takes place when one goes through a certification program. Becoming certified allows IT professionals to acquire additional knowledge and skills [Zeng 2004]. This added knowledge and skills can be either firm- or industry-specific. Labor economists [Neal 1995; Parent 2000] have long established that workers should be compensated for their firm-specific and industry-specific skills. Broadly speaking, certifications can be classified into two types, vendor-specific and vendor-neutral. Vendor-specific certifications such as Microsoft, Red Hat and Cisco provide certification examinations for their own products. Normally these types of certifications are narrowly focused and/or driven by commercial motives. Acquiring a certification in one of these areas enhances vendor-specific knowledge and skills. Vendor-neutral certifications, on the other hand, focus on foundational concepts relative to underlying technology and not on a particular vendor's product [Randall et al. 2005]. Some notable generic certification bodies include the National Association of Communication Systems Engineers (NACSE), the Computing Technology Industry Association (CompTIA), and the Institute for Certification of Computing Professionals (ICCP). They provide "vendor-neutral" certifications that cover many products and concepts, are developed by a wide range of experts in a particular field, and encompass a broad range of skills and abilities [Adelman 2000].

The value of IT certifications has been widely debated in the IT industry [Roberts 2002; Pratt 2005]. Academia has largely ignored this topic except for general discussion regarding whether to incorporate vendor-specific certifications in teaching curricula [Adelman 2000; Brookshire 2000; Ray et al. 2000; Zeng 2004]. The proponents for the value of certifications argue that preparation for certifications provides IT professionals with a chance to learn new technology or acquire new knowledge of existing technology leading to increased levels of expertise, productivity, credibility, and marketability, which results in higher compensation [Anderson et al. 2002; Zeng 2004]. This assertion is confirmed by a survey conducted in 2004 by *Certification Magazine*, an IT industry publication. In addition to higher average salaries compared to those who were not certified, a large percentage of certified respondents reported receiving a raise of up to 15 percent in the first year after receiving their primary certification. Almost half of the respondents believed that their primary certification played a significant role in earning the salary increase [Sosbe 2004]. Still, there are some employers and educators who see little value in certifications, since certifications are not accredited, have no single standard, and are not uniformly recognized among employers [Zeng 2004]. Some argue certifications have become "watered-down and diluted" as the number of certifications and third-party centers have grown [Pratt 2005]. This debate leads to our first research question:

Research Question #1: Are IT certifications valuable?

The relationships between certifications and education; and between certifications and experience are also widely debated areas among both academicians and practitioners. Adelman [2000] asserts that, in general, certifications replace neither experience nor degrees obtained via formal education. Bartlett [2002] states that individuals entering the IT workforce lacking formal education may find their employment to be short-lived with limited career opportunities. Some, however, outright question the value of higher education and argue the merits of alternatives, such as professional certifications [Vedder 2004]. Zeng [2004] points out that certified professionals satisfy the identified characteristics and are considered professionals regardless of

whether or not they have a college degree. Realizing the complementary nature of IT certifications to formal education, a number of researchers [Peslak 2005; Randall et al. 2005; Zeng 2004] suggest incorporating IT certifications into both secondary and post-secondary curricula. They argue that education alone is not sufficient to develop full professional capabilities in the IT industry. Due to the rapid changes in technology and associated changes in the knowledge base, technical skills depreciate quickly and technologies have short lifecycles. This makes it difficult for educational institutions to deliver relevant and up-to-date IT education [U.S. Department of Labor 2004].

With respect to the relationship between certifications and experience, the debate centers around which one of the two is more important. Some regard certifications as almost immaterial without proper experience, while others think certifications are a great complement to experience [Roberts 2002].

Although IT certifications do not replace education or experience completely, an ITAA Survey [ITAA 2004] found that hiring managers preferred a combination of relevant experience (46 percent) and a four-year degree (41 percent) in a related field. In contrast, vendor specific certifications were of lesser importance in the hiring process (14 percent). This is consistent with the findings by Anderson, Barrett & Schwager [2002] that indicate that HR managers place a 40-percent hiring weight on education and experience each and 20 percent on IT certification. This accepted business practice suggests that IT certifications have a complementary role to education and experience. As a result, we formulate our next two research questions as follows:

Research Question #2a: Is there a substitution effect between IT certifications and education?

Research Question #2b: Is there a substitution effect between IT certifications and experience?

Anderson, Barrett, and Schwager [2002] suggest a variable called "willing to pay" [WTP] for future research regarding the value of certifications. To operationalize this variable, we use individuals' salaries as a proxy. Anderson, Barrett, and Schwager [2002] also suggest studying the influence of different IT functions and/or specialties on the value of certifications. Labor economists [Neal 1995; Parent 2000] often specify firm-specific and industry-specific skills in their human capital modeling. Because certifications are highly job-specific and industry-specific, we ask our next set of research questions:

Research Question #3a: Is the value of IT certifications job-specific?

Research Question #3b: Is the value of IT certifications industry-specific?

In summary, we formulate our model in which the natural logarithm of earnings is a function of a measure of schooling, a measure of experience, possibly other factors, and a random disturbance term. This is based on Roy's [1950] research in which he related earnings distributions to the distributions of the underlying abilities. Later work by Mincer [1974] showed the regression equation for wages is linear in education but quadratic in experience (The wages function is concave in experience because as experience increases, earnings cannot increase indefinitely). In addition to the formal education and experience factors considered from human capital theory, we add specific certifications to this model. Further, we add some often used control variables, including age, gender, company size, and location, to the model [Ang et al. 2002; Gallivan et al. 2005; Neal 1995; Parent 2000]. Our model is graphically depicted in Figure 1.

And, our model is algebraically represented as

$$\text{Log}[Y] = \alpha + \beta_1[\text{edu}] + \beta_2[\text{exp}] + \beta_3[\text{exp}]^2 + \sum\lambda_i[\text{d\_Cert}_i] + \sum\pi_i[\text{CV}_i] + \varepsilon \qquad [1]$$

where edu = education, exp = experience, CV = control variables, and

$$\text{d\_Cert}_{\text{i}} = \begin{cases} 1, if \text{ a respondent has Certification i} \\ 0, otherwise \end{cases}$$

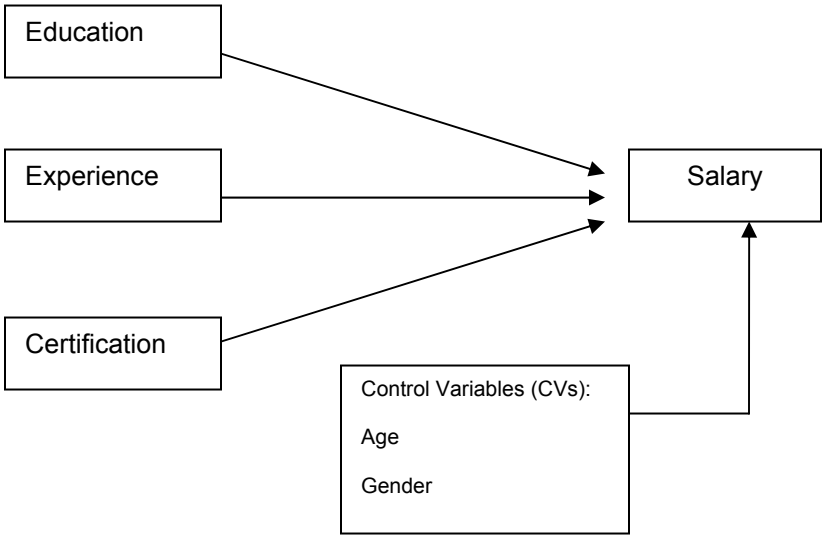

Figure 1. Value of Certifications

Transforming this equation from log[Y] back to Y yields a multiplicative model. So the increased value caused by possessing a specific certification is the exponential constant e raised to the coefficient value λ_i, so the wage premium of possessing the certification is $e^{\lambda i} - 1$.

III. DATA

We obtained our dataset from *Certification Magazine*'s 2004 Salary Survey that was conducted over a six-week period from August 23 to October 3, 2004. This survey collected data for 85 certification programs and general certification categories. The magazine obtained responses from two sources. First, e-mails that contained a link to the online survey were sent to *Certification Magazine* subscribers asking them to participate. Second, IT experts in 27 industry-leading companies, including Apple, Cisco, CompTIA, Hewlett- Packard, IBM, Microsoft, Novell, Oracle, Prometric, Red Hat, Sun Microsystems and VUE, were invited to participate in the same survey. Combining the data from both sources led to a sample of 34,495 IT professionals from 160 countries. About 62 percent of the total responses were from the first source (the subscribers) and 38 percent from the second source (the invited IT experts). The reported margin of error is no more than +/- 1.0% at the 95 percent confidence level. Surveys were data-entered, computer-processed, and tabulated by Litchfield Research, a full-service market-research firm specializing in the publishing industry, [Sosbe 2004].

For greater consistency in reported salary values, we limited this study's focus to a subset of the survey data consisting of IT workers in the U.S. This yielded a sample size of 10,630. Based on the percentages of respondents, we selected the top nine job functions: Computer Systems/Networking, Systems Engineering/Integration/Technical Services, LAN/Network Systems, Support, Software/Application Development, Computer Related Consulting, IS/MIS/DP, Systems Analyst and Data Communications/Telecommunications. Similarly, we selected the top ten industries: Computer/Network Consulting, Federal/State/Local Government, Education, Consulting, Finance/Banking/Accounting, Software/Software Development, Telecommunications, Manufacturing, Health/Medical Services, and Computer Related Retailer/Wholesales/Distributor. The descriptive statistics by job function and industry are given in the following tables.

Table 1a. Descriptive Survey Statistics - Overall

Construct	Measurement scale	Mean value	Range
Salary	in dollars	67,607	10,000 – 204,999
Education	in years	15.46	12.0 – 20.5
Experience[a]	in years	11.61	0.5 – 30.00
Hours worked weekly	in hours	44.93	10.0-60.00
Job Tenure[b]	in years	3.70	0.50 – 15.00
Gender	0, 1	0.83	0-female, 1-male
Age	in years	37.29	17.50 - 65.50
Small Firms	0, 1	0.32	1-small, 0-otherwise
Medium Firms	0, 1	0.24	1-medium, 0-otherwise
West	0, 1	0.20	1-west, 0-otherwise
Mid-West	0, 1	0.21	1-mid-west, 0-otherwise
Northeast	0, 1	0.18	1-northeast, 0-otherwise

[a] years of IT-related work experience.

[b] years in current position.

Table 1b. Descriptive Survey Statistics – Job Functions

Top Job Functions	Percent of respondents[a]
Computer Systems/Operations/Networking	17%
Systems Engineering/Integration/Technical Services	16%
LAN/Network Systems	12%
Support	10%
Software/Applications Development	7%
Computer Related Consulting	6%
IS/MIS/DP	5%
Systems Analyst	4%
Data Communications/Telecommunications	4%

[a] Doesn't add up to 100% because they are the top nine job functions.

Before estimating Equation [1], we need to convert some of the variables in the survey into numerical values. For interval data, the mean value is used. For example, for the salary range of $20,000 to $24,999, it is converted to $22,500, the mean of the range. The detailed conversions are given in Appendix II. One of the difficulties associated with the conversion is that some of the variables have open intervals such as "less than" or "more than." For example, "Under 1 year" and "More than 20" are used for the Experience variable. We exercised extreme caution in choosing a proper value. Further, the percentages for such open interval variables are relatively small. So we are confident that our model results were not significantly impacted.[1]

[1] We also performed "sensitivity" tests. For example, we ran two regressions with "More than 20" being converted to 25 and 30 years, respectively. The regression results with 30 years are

Table 1c. Descriptive Survey Statistics - Industry

Top Industry	Percent of respondents[a]
Computer/Network Consultant	10%
Government: Federal/State/Local	10%
Education	9%
Finance/Banking/Accounting	7%
Consulting	7%
Telecommunications	6%
Software/Software Development	6%
Health/Medical Services	5%
Manufacturing	5%
Computer Related Retailer/Wholesales/Distributor	4%

[a] Doesn't add up to 100% because they are the top 10 industries.

Table 2. Top 10 IT Certifications

Category	Certification	# of Respondents	Percent of Respondents[a]
Security	[ISC]2 Certified Information Systems Security Professional [CISSP]	452	4%
	Microsoft Certified System Engineer- Security [MCSE-S]	122	1%
	Cisco Certified Security Professional [CCSP]	114	1%
Database	Oracle9i DBA Certified Professional [OCP]	900	8%
	Microsoft Certified Database Administrator [MCDBA]	256	2%
Networking	Cisco Certified Internetwork Engineer [CCIE]	156	1%
	Red Hat Certified Engineer [RHCE]	540	5%
	Cisco Certified Network Professional [CCNP]	1077	9%
Programming	Sun Certified Programmer for the Java2 Platform [Java2]	409	5%
Project Management	Project Management Professional [PMP]	80	1%

[a] About 4% of the respondents had earned multiple certifications.

Since there are 84 certifications in the dataset, it is impractical to include all of them in the analysis. We identified in Table 2 the top 10 IT certifications based on various sources [Nagel 2003, 2004; Tittel 2003]. We can broadly classify them into five categories: Security, Database,

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shown in Table 4 and those with 25 years are shown in Table 4a of Appendix III. The two sets of results varied little.

Networking, Programming, and Project Management. We included these 10 certifications in our regression analysis.

It is clear that not all certifications are relevant to the above nine job functions. For example, database related certifications such as Oracle9i DBA Certified Professional [OCP] are not essential for LAN/Network Systems professionals. Based on our best judgment, we matched the job functions with the relevant certifications. The matching is reported in Table 3.

Table 3. Job Functions and Certifications

Top Job Functions	**Certifications**
Computer Systems/Operations/Networking	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP
Systems Engineering/Integration/Technical Services	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP, OCP, MCDBA, Java2, PMP
LAN/Network Systems	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP
Support	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP, OCP, MCDBA
Software/Applications Development	OCP, MCDBA, RHCE, Java2
Computer Related Consulting	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP, OCP, MCDBA
IS/MIS/DP	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP, OCP, MCDBA
Systems Analyst	CISSP, MCSE-S, CCSP, OCP, MCDBA
Data Communications/Telecommunications	CISSP, MCSE-S, CCSP, CCIE, RHCE, CCNP

Note:

CISSP = [ISC]2 Certified Information Systems Security Professional

MCSE-S = Microsoft Certified System Engineer- Security

CCSP = Cisco Certified Security Professional

CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

CCNP = Cisco Certified Network Professional

OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

IV. MODEL ESTIMATION AND RESULTS

We conducted our analysis in two steps. First, we estimated Equation [1], the human capital model, with the control variables only. We then added the relevant certifications based on industry norms of the top 10 certifications by job category (see Table 3) to the regression model for job function. For industries, we added all the top certifications following the same approach. The justification for the inclusions of the additional variables was the increase of the proportion of

variances explained by the new variables, as measured by the adjusted R^2, which, unlike the ordinary R^2, was adjusted to the degree of freedom and may not always increase in value when more variables were added. The results for the job functions and industries were reported in Tables 4 and 5, respectively.

JOB FUNCTIONS

Human Capital Model

We first examined the human capital models with only the control variables. The F-ratios for all regression models were significant at the 1 percent level. Both education and experience were significantly positively associated with salary. Education was significant at the 5 percent or better and experience was significant at the 1 percent level for all job functions. The coefficients of experience were consistently higher than those of education. This underlined the importance of experience in IT jobs. The negative and significant (at the 1 percent level) signs for experience square for all jobs were consistent with human capital theory. Hours worked per week had a strong positive association with salary. It was somewhat surprising that job tenure is only significant for support personnel (β=0.013, p=0.01).

For each job function, gender was not significantly associated with salary because of the insignificant gender coefficients. For eight out of the nine job types, the age coefficient was insignificant, so older IT professionals received similar compensation for their human capital attributes. The exception is in support in which on the average older IT professionals were in lower wage ranges (β=-0.005, p=0.05) than their younger counterparts.

In terms of company size (large companies being the base), IT professionals were paid significantly less in small companies. The job of software/application developers was an exception where the difference was insignificant (β=-0.059, p>0.10). In general, IT professionals were also paid significantly less in medium-sized companies except for computer-related-consulting (β=0.014, p>0.10) and system analyst (β=-0.069, p>0.10). In addition, IT professionals in small firms were consistently worse off in terms of salary than those in medium-sized firms except for software development (β_{small}=-0.059, p>0.10, and β_{medium}=-0.012, p=0.01) and data communications (β_{small}=-0.155, p=0.05, and β_{medium}=-0.166, p=0.01).

Finally, in terms of region (the South being the base), the West and Northeast of the U.S. were consistently the highest paying regions for professionals in all IT jobs. The salary differences between the South and Midwest were insignificant except for computer related consulting (β=0.126, p=0.05), and LAN/Network Systems (β=0.077, p=0.01).

Human Capital Model with Certifications

Based on the matches between the job functions and the certifications in Table 3, we added the relevant certifications to each model. The results are reported in Table 4. The inclusion of the relevant certifications led to increases in the adjusted R^2s for all regressions. This indicated that certifications contributed to explaining more variances, and therefore it was appropriate to be included in the human capital model. The largest increase of 32 percent (from 0.174 to 0.230) was in LAN/Network Systems and the smallest increase of 1 percent (from 0.169 to 0.171) was in Software Application Development[2].

INDUSTRY

The industry-specific results associated with industry in Table 5 were very similar to those with job functions in Table 4. The coefficients for education, experience, and experience squared in most of the industries were consistent with the human capital theory. The only exception was that

[2] Cautions should be exercised here because some of the increases are very small.

education was not significant in manufacturing (β=0.015, p>0.10). Job tenure was not significantly associated with wages in any industry. Gender mattered significantly in only two industries: Education and Finance/Banking/Accounting where males made about 12 percent ($e^{0.117}$-1) and 10 percent ($e^{0.092}$-1) more than their female counterparts did in these two industries, respectively, given their human capital attributes. In the education industry, age also mattered significantly because older workers commanded a premium of 4 percent ($e^{0.004}$-1).

Table 4. Value of IT Certifications by Job Function

	Computer Systems/ Networking		**Systems Engineering/ Integration/ Technical Services**		**LAN/Network Systems**		**Support**		**Software Application Development**	
Intercept	9.053[a]	9.073[a]	9.555[a]	9.625[a]	9.803[a]	9.856[a]	9.375[a]	9.606[a]	10.047[a]	10.032[a]
Edu	0.051[a]	0.048[a]	0.028[a]	0.023[a]	0.024[a]	0.018[a]	0.052[a]	0.037[a]	0.022[a]	0.022[a]
Exp	0.064[a]	0.060[a]	0.057[a]	0.056[a]	0.051[a]	0.046[a]	0.077[a]	0.069[a]	0.085[a]	0.085[a]
Exp2	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.002[a]	-0.002[a]	-0.002[a]	-0.002[a]
Hrs/week	0.011[a]	0.011[a]	0.013[a]	0.012[a]	0.008[a]	0.007[a]	0.008[a]	0.006[a]	0.005[b]	0.005
Jobtenure	0.003	0.005	-0.004	-0.003	-0.005	-0.002	0.013[a]	0.014[a]	-0.008	-0.007
Gender	0.038	0.030	0.033	0.029	0.029	0.036	-0.029	-0.011	-0.008	-0.015
Age	0.003[c]	0.004[a]	0.003[c]	0.004[c]	0.003	0.004[b]	-0.005[b]	-0.004[b]	-0.002	-0.001
Small	-0.145[a]	-0.141[a]	-0.186[a]	-0.174[a]	-0.223[a]	-0.191[a]	-0.264[a]	-0.254[a]	-0.059	-0.066[a]
Medium	-0.068[b]	-0.071[a]	-0.131[a]	-0.134[a]	-0.109[a]	-0.092[a]	-0.153[a]	-0.164[a]	-0.112[a]	-0.116[a]
West	0.106[a]	0.100[a]	0.154[a]	0.148[a]	0.131[a]	0.123[a]	0.115[a]	0.115[a]	0.182[a]	0.185
MW	0.015	0.027	0.010	0.020	0.077[a]	0.089[a]	-0.019	-0.018	0.046	0.052
NE	0.169[a]	0.176[a]	0.122[a]	0.129[a]	0.187[a]	0.191[a]	0.103[a]	0.108[a]	0.093[b]	0.094[a]
CCSP		0.138		-0.055		0.273[a]		0.247		
CISSP		0.237[a]		0.129[b]		0.199[a]		0.197		
MCSE-S		-0.124		-0.181		-0.193[bx]		-0.096		
DBAOCP				0.153[a]				0.384[a]		0.022
MCDBA				-0.066				-0.313[a]		0.039
CCIE		0.447[a]		0.204[a]		0.317[a]		0.398		
CCNP		0.059		0.165[a]		0.151[a]		0.199[a]		
RHCE		0.187[a]		0.097[a]		0.235[a]		0.276[a]		0.201[a]
Java2				0.081						0.044
PMP				0.231						
N	1655		1625		1145		953		749	
Adj R-Sq	0.243	0.262	0.199	0.221	0.174	0.230	0.315	0.358	0.169	0.171
F Value	45.24[a]	33.65[a]	34.56[a]	21.90[a]	21.09[a]	20.01[a]	37.55[a]	27.50[a]	13.70[a]	10.65[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

CISSP = [ISC]2 Certified Information Systems Security Professional

MCSE-S = Microsoft Certified System Engineer- Security

CCSP = Cisco Certified Security Professional

CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

CCNP = Cisco Certified Network Professional

OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

Table 4. Value of IT Certifications by Job Function – cont'd

	Computer Related Consulting		**IS/MIS/DP**		**Systems Analyst**		**Data Communications**	
Intercept	8.763[a]	8.879[a]	9.880[a]	10.020[a]	9.914[a]	10.045[a]	10.350[a]	10.375[a]
Edu	0.058[a]	0.046[a]	0.032[a]	0.017	0.036[a]	0.027[a]	0.007	0.001
Exp	0.080[a]	0.075[a]	0.061[a]	0.058[a]	0.051[a]	0.046[a]	0.040[a]	0.037[a]
Exp2[a]	-0.002[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[b]	-0.001[b]
Hrs/week	0.012[a]	0.012[a]	0.006[c]	0.006	0.006[c]	0.006	0.005	0.005
Jobtenure	0.005	0.007	0.008	0.010	-0.001	0.002	0.006	0.007
Gender	0.001	-0.005	-0.019	0.024	0.028	0.038	-0.011	-0.020
Age	0.006[c]	0.007	-0.001	-0.001	-0.001	-0.001	0.001	0.002
Small	-0.106[b]	-0.100	-0.169[a]	-0.162[a]	-0.193[a]	-0.194[a]	-0.155[b]	-0.148[b]
Medium	0.014	-0.001	-0.110[b]	-0.137[a]	-0.069	-0.070	-0.166[a]	-0.158[b]
West	0.280[a]	0.293[a]	0.104[c]	0.113[b]	0.083	0.060	0.132[c]	0.151
MW	0.126[b]	0.160[b]	0.003	0.022	-0.086	-0.080	0.080	0.087
NE	0.151[b]	0.149[b]	0.135[b]	0.144[b]	0.102[c]	0.100	0.078	0.103
CCSP		-0.042		0.417		-0.195		0.113
CISSP		0.262[a]		0.168[b]		0.262[a]		0.379[a]
MCSE-S		0.074		0.079		0.456		0.013
DBAOCP		0.247[a]		0.341[a]		0.186[a]		
MCDBA		-0.042		-0.102		-0.081		
CCIE		0.223		0.508				0.120
CCNP		0.243		0.097				0.064
RHCE		-0.012		0.037				0.096
Java2								
PMP								
N	563		458		382		408	
Adj R-Sq	0.234	0.257	0.196	0.246	0.145	0.172	0.060	0.077
F Value	15.33[a]	10.74[a]	10.29[a]	8.47[a]	6.36[a]	5.66[a]	3.29[a]	2.89[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

CISSP = [ISC]2 Certified Information Systems Security Professional

MCSE-S = Microsoft Certified System Engineer- Security

CCSP = Cisco Certified Security Professional

CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

CCNP = Cisco Certified Network Professional

OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

Table 5. Value of IT Certifications by Industry

	Computer/ Network Consulting		**Government**		**Education**		**Consulting**		**Finance/ Banking/ Accounting**	
Intercept	9.428[a]	9.621[a]	9.225[a]	9.254[a]	9.148[a]	9.166[a]	9.205[a]	9.302[a]	9.853[a]	9.916[a]
Edu	0.043[a]	0.029[a]	0.056[a]	0.050[a]	0.038[a]	0.033[a]	0.026[a]	0.015	0.029[a]	0.022[b]
Exp	0.091[a]	0.085[a]	0.038[a]	0.036[a]	0.057[a]	0.052[a]	0.069[a]	0.065[a]	0.058[a]	0.054[a]
Exp2	-0.002[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]
Hrs/week	0.009[a]	0.008[a]	0.012[a]	0.012[a]	0.008[a]	0.008[a]	0.015[a]	0.015[a]	0.006[b]	0.005[c]
Jobtenur	-0.005	-0.004	0.002	0.004	0.005	0.005	0.010	0.012[a]	-0.001	0.004
Gender	-0.044	-0.042	0.020	0.019	0.117[a]	0.114[a]	-0.016	-0.011	0.092[c]	0.083
Age	-0.004	-0.002	0.002	0.003[c]	0.004[b]	0.005[a]	0.005	0.005	0.001	0.002
Small	-0.175[a]	-0.181[a]	-0.101[a]	-0.096[a]	-0.132[a]	-0.130[a]	-0.038	-0.033	-0.112[b]	-0.100[b]
Medium	-0.088[c]	-0.108[b]	-0.049	-0.051	-0.127[a]	-0.123[a]	0.106	0.086	-0.060	-0.052
West	0.155[a]	0.150[a]	0.050	0.048	0.148[a]	0.147[a]	0.249[a]	0.231[a]	-0.013	-0.011
MW	0.031	0.060	-0.025	-0.008	0.144[a]	0.164[a]	0.111	0.125[b]	-0.009	-0.005
NE	0.207[a]	0.222[a]	0.079[b]	0.081[b]	0.182[a]	0.178[a]	0.149[a]	0.137[b]	0.117[b]	0.112[b]
CCSP		0.162		0.264		0.503		0.102		-0.051
CISSP		0.283[a]		0.127[a]		0.049		0.136		0.145
MCSE-S		0.149		0.137		0.068		-0.257		-0.021
DBAOCP		0.238[a]		0.172[a]		0.130[b]		0.181[a]		0.174[b]
MCDBA		-0.179[ax]		0.105		-0.081		0.025		-0.191
CCIE		0.371[a]		0.255		0.313		0.551[a]		0.312
CCNP		0.090		0.209[a]		0.100		0.050		0.146[b]
RHCE		0.162		0.122		0.242[a]		0.057		0.176[b]
Java2		0.323[a]		0.098		0.097		0.236[a]		0.171
PMP		0.008		0.130		0.378		0.238		0.155
N	997		921		869		664		644	
Adj R-Sq	0.245	0.284	0.186	0.221	0.253	0.273	0.206	0.239	0.175	0.195
F Value	27.88[a]	18.92[a]	18.50[a]	12.84[a]	25.55[a]	15.79[a]	15.32[a]	10.47[a]	12.40[a]	8.07[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

CISSP = [ISC]2 Certified Information Systems Security Professional

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CCNP = Cisco Certified Network Professional

OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

Table 5. Value of IT Certifications by Industry – cont'd

	Software/Software Development		**Tele-communications**		**Health/Medical Services**		**Manufacturing**		**Computer Related Distributors**	
Intercept	9.914[a]	9.917[a]	9.836[a]	9.911[a]	9.612[a]	9.779[a]	9.748[a]	9.897[a]	9.090[a]	9.180[a]
Edu	0.019[a]	0.015	0.037[a]	0.032[a]	0.041[a]	0.026[a]	0.015	0.007	0.038[a]	0.028[b]
Exp	0.083[a]	0.081[a]	0.045[a]	0.041[a]	0.067[a]	0.061[a]	0.067[a]	0.062[a]	0.060[a]	0.058[a]
Exp2	-0.002[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]
Hrs/week	0.007[b]	0.007[b]	0.009[a]	0.009[a]	0.009[a]	0.008[a]	0.011[a]	0.010[a]	0.018[a]	0.018[a]
Jobtenur	0.005	0.005	0.005	0.007	0.007	0.009[c]	-0.013[bx]	-0.012[bx]	-0.009	-0.006
Gender	-0.043	-0.053	-0.065	-0.057	0.019	0.029	0.072	0.056	0.003	-0.005
Age	-0.001	0.000	-0.001	-0.001	-0.002	0.000	0.001	0.002	0.003	0.002
Small	-0.069	-0.061	-0.154[a]	-0.140[a]	-0.164[a]	-0.159[a]	-0.145[a]	-0.144[a]	-0.346[a]	-0.322[a]
Medium	-0.113[b]	-0.112[b]	-0.093[c]	-0.093[c]	-0.120[a]	-0.134[a]	-0.035	-0.047	-0.138[c]	-0.144[b]
West	0.211[a]	0.184[a]	0.114[b]	0.108[b]	0.047	0.042	0.107	0.111[c]	0.173[b]	0.158[b]
MW	0.034	0.016	-0.022	-0.027	-0.057	-0.041	0.077	0.073	0.167[b]	0.158[b]
NE	0.199[a]	0.195[a]	0.134[b]	0.132[b]	0.058	0.080	0.120[b]	0.124[b]	0.204[a]	0.200[a]
CCSP		0.090		-0.213		0.339		0.000		-0.152
CISSP		0.109		0.218		0.138		0.298[a]		0.381
MCSE-S		-0.189		0.120		0.058		0.130		-0.070
DBAOCP		0.083		0.159		0.328[a]		0.195[a]		0.364[a]
MCDBA		-0.239		-0.136		0.237[b]		-0.017		-0.107
CCIE		0.500		0.378[b]		-0.053		0.317		0.155
CCNP		0.150[c]		0.087		0.098		0.032		0.189
RHCE		0.134[c]		-0.063		0.060		0.101		0.112
Java2		0.094		0.023		0.022		0.166		0.284
PMP		0.089		-0.407		0.185		0.220		0.484
N	617		640		492		488		397	
Adj R-Sq	0.231	0.236	0.115	0.126	0.244	0.286	0.200	0.219	0.315	0.328
F Value	16.43[a]	9.63[a]	7.92[a]	5.17[a]	14.18[a]	9.96[a]	11.13[a]	7.21[a]	16.18[a]	9.80[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

CISSP = [ISC]2 Certified Information Systems Security Professional

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CCSP = Cisco Certified Security Professional

CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

CCNP = Cisco Certified Network Professional

OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

In general, higher pay was associated with firm size -- the larger the firms, the higher the wages for IT professionals. There were four exceptions: 1) in consulting, the distinction did not appear significant (β_{small}=-0.038, p>0.10 and β_{medium}=-0.106, p>0.10); 2) in government, IT professionals in medium-sized were paid similarly to those in the larger ones (β_{medium}=-0.049, p>0.10); 3) in software development, small firms paid IT workers similarly to large ones (β_{small}=-0.069, p>0.10), while medium firms paid less than large ones (β_{medium}=-0.113, p=0.05); and 4) in manufacturing, medium firms paid similarly to larger ones (β_{medium}=-0.035, p>0.10).

Higher wages were consistently associated with IT professionals in the northeast region as opposed to those in the South (the base) for all industries with the health/medical services (β_{NE}=0.058, p>0.10) as an exception. The West was the second best in all industries except for government (β_{west}=0.050, p>0.10), finance (β_{west}=-0.013, p>0.10), manufacturing (β_{west}=0.107, p>0.10), and health/medical services (β_{west}=0.047, p>0.10). When compared to the South, IT professionals in the midwest region were better off in education (β_{MW}=0.144, p=0.01) and computer related distributor (β_{mw}=0.167, p=0.05).

After the block of the top 10 certifications were added to each model, all adjusted R^2s increased for all regressions. The largest increase of 19 percent (from 0.186 to 0.221) was found in the government sector, whereas the smallest increase of 2 percent (from 0.231 to 0.236) was found in software development. This indicated that certifications contributed to explaining the variances and should be included in the human capital model.

VI. DISCUSSION

Before we discuss our results, we reiterate our three research questions:

Research Question #1: Are IT certifications valuable?

Research Question #2a: Is there a substitution effect between IT certifications and education?

Research Question #2b: Is there a substitution effect between IT certifications and experience?

Research Question #3a: Is the value of IT certifications job-specific?

Research Question #3b: Is the value of IT certifications industry-specific?

Tables 4 and 5 indicate that overall at least one certification was significant at the 5 percent level or better for each of the nine job functions and nine out of the ten industries (Software/Software Development was an exception). On the average, 2.8 certifications were valuable for the job functions and 1.9 certifications were valuable for the industries. This is consistent with other studies, [Anderson et al. 2002; Sosbe 2004; Zeng 2004]. Therefore, we concluded that IT certifications were valuable in general.

The inclusion of the certifications lessened the contributions of education and experience to wages for the industries and for the job functions. Nearly all coefficients of experience and

education decreased in the models when the certifications were included. The only exception was for job function software application development, in which the coefficients β_{edu}=0.022 and β_{exp}=0.085 were unchanged. It is worth mentioning that in two industries, consulting and software development, education actually became insignificant after the certification variables were added. This result requires further exploration. The nature of these two industries leads us to believe that experience is valued more highly than education because consultants and software developers learn much of their skills and knowledge from hands-on experience. For example, when a high-ranked government official retires, he or she can easily find a consulting job regardless of education. The big differentials between the coefficients of education and experience for these two industries in Table 5 confirm this. Since certifications reflect, to a large degree, the acquisition of new skills and knowledge, the credential from being certified along with experience marginalizes the effect of education. This is consistent with Vedder's [2004] argument in which he suggests using alternative forms of certification to substitute in part the university degrees to counter the rapid rising of higher education tuition in the U.S.

The above findings provided an affirmative answer to our second research question that a substitution effect between IT certifications and education and between IT certifications and experience existed.

The value of each specific certification varied across job functions. Table 6 shows that 1) the Certified Information System Security Professionals (CISSP) was positively associated with salary for all relevant jobs (with support jobs as an exception); and 2) its premiums were different across jobs. Recall that *premium* is defined as the salary contribution of possessing a certain certification. Mathematically, it equaled (e^{β}-1). Table 6 shows that the largest premium of such a certification (46 percent) was found for data communications/ telecommunications professionals and the smallest premium of 14 percent was found for systems engineering, integration, and technical services.

Table 6. CISSP Premium

Job Function	β	Premium
Data Communications/Telecommunications	0.379	46%
Computer Related Consulting	0.262	30%
Systems Analyst	0.262	30%
Computer Systems/Operations/Networking	0.237	27%
LAN/Network Systems	0.199	22%
IS/MIS/DP	0.168	18%
Systems Engineering/Integration/Technical Services	0.129	14%

It is interesting to see that CISSP carries higher premium for computer related consulting jobs than for networking related ones. At face value, this may appear counterintuitive. One possible explanation is that in the wake of the 9/11 attacks and the widespread concerns for consumer privacy protection and data security in the marketplace, more and more small and medium-sized enterprises (SME) start to take security seriously. Given the fact that demand for security professionals greatly outstrips their supply, SME often do not have adequate in-house professionals to implement security systems. As a result, they will rely heavily on outside consultants for such tasks.

The premiums of the certifications for the various job functions were reported in Table 7. In the area of security, vendor-neutral certifications such as CISSP are more valuable than vendor specific certifications such as Cisco Certified Security Professional (CCSP) and Microsoft

Certified System Engineer-Security (MCSE-S). Specifically, CCSP was significant only for LAN/Network Systems with a premium of 31% ($e^{0.273}$-1) when compared to CISSP that was significant for the seven jobs in Table 6. MCSE-S was found significant for LAN/Network System-related jobs, but with a wrong sign (the negative sign may be due to its relative weakness in comparison to other more established security certification programs). Overall, the nature of security may explain the reason that vendor-neutral security certifications were more valuable than vendor-specific ones. That is, security is an industry-wide issue and knowledge across various security platforms is more desirable than the one related to product lines of a particular vendor.

Table 7. Certification Premiums by Job Function

Job Function	CCSP	OCP	CCIE	CCNP	RHCE
Computer Systems/Operations/Networking			56%		21%
Systems Engineering/Integration/Technical Services		17%	23%	18%	10%
LAN/Network Systems	31%		37%	16%	26%
Support		47%		22%	32%
Software Application Development					22%
Computer Related Consulting		28%			
IS/MIS/DP		41%			
Systems Analyst		20%			
Data Communications/Telecommunications					

Note: MCSE-S, MCDBA, Java2 and PMP were insignificant at the 5% level or better for all jobs.

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CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

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Table 8 provides the wage premiums of the specific certifications in the industries. Both the number of certifications of positive premiums and the magnitudes of the premiums were different across industries. For example, OCP had positive and significant premiums in all industries except software development and telecommunications, while the premium of MCDBA was limited to only the health/medical services sector. The largest premium of 73 percent was found in CCIE for general consulting while the smallest premium of 14 percent was found both in CISSP for government and in OCP for education. Again, the premium of CCIE for consulting is higher than that for networking-related industries. This is consistent with the findings in Table 7. This may be attributed to the consulting industry valuing credentials more than industries. When a

consultant's business card has various certification abbreviations listed, the consultant looks much more impressive and as a result, more likely to get the contract than a person without the various certification abbreviations listed. Thus, the value of certifications varies across industry. The findings in both Tables 7 and 8 provided an affirmative answer to our research questions 3a and 3b that the value of IT certifications is job specific as well as industry specific.

In addition, we found that some certifications, i.e. CISSP, CCIE, OCP, and RHCE, have appeals across jobs and across industries. Among them, only CISSP is vendor neutral. They each address fundamental aspects of information systems: security, networking, database, and open source software. Given that the skills in these four areas are highly transferable, it is not surprising to see that all four certifications are attractive for various jobs and industries. This suggests that employers value certifications that concentrate on technology specific topics and place an increased premium on employees with high levels of transferable skills.

Table 8. Certification Premiums by Industry

Industry	CISSP	OCP	MCDBA	CCIE	CCNP	RHCE	Java2
Computer/Network Consulting	33%	27%		45%			38%
Government	14%	19%			23%		
Education		14%				27%	
Consulting		20%		73%			27%
Finance/Banking/Accounting		19%			16%	19%	
Software Development							
Telecommunications				46%			
Health/Medical Services		39%	27%				
Manufacturing	35%	22%					
Computer Related Distributor		44%					

Note: CCSP, MCSE-S and PMP were insignificant at the 5% level or better for all industries.

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CCSP = Cisco Certified Security Professional

CCIE = Cisco Certified Internetwork Engineer

RHCE = Red Hat Certified Engineer

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OCP = Oracle9i DBA Certified Professional

MCDBA = Microsoft Certified Database Administrator

Java2 = Sun Certified Programmer for the Java2 Platform

PMP = Project Management Professional

It is worth noting that this study did not find that the Project Management Professional (PMP) certification was significantly associated with wage.[3] This is somewhat counterintuitive. As today's IT projects become increasingly complex and costly, project failure rates have been high. A KPMG report shows that 86 percent of respondents from 600 organizations across 22 countries had IT project outcomes that "fell short of planned expectations" [KPMG 2005]. To improve the chances of success with such projects, project management has emerged as an important discipline in organizations, [Beise, Quan, Papke-Shields 2006]. To reflect this industry trend, many universities have introduced project management courses. Unfortunately, in our sample, there were not enough data points (only 80 respondents reported having PMP certification) to discern the impact of PMP certification. This, by no means, implies that PMP is unimportant. To examine the full impact, more awareness of the certification program and more specified data collection method may be warranted.

VII. CONCLUSIONS

This study investigates the contribution of different generic and vendor specific certifications to the overall wages of IT professionals across multiple job functions and industries. We anchor our study on the Human Capital Theory, which states that education, experience, and training independently and collectively contribute to an employee's wages when controlled for firm size and location, and personal characteristics, such as age and gender. The three main findings are: 1) certifications are, in general, valuable; 2) certifications can partially substitute for education and experience; and 3) premiums of certifications are job- and industry-specific.

Based on existing literature and the nature of the data, we selected 9 job functions, 10 industries, and 10 popular IT certifications in the study. We isolated the effects of certifications on wages in the following way. We first estimated our models without certifications. Then we added the block of the relevant certifications to the models. The inclusions of additional certification variables increased the adjusted R^2s for all models. This suggested that adding certifications into the models explained more variances. After adding the certifications into the models, we found that the magnitudes of the coefficients of education and experience in all models decreased. In some cases, education was no longer significant. This suggested that the contributions of education and experience to wages were lessened by certifications. As a result, we concluded that there is a substitution effect between education and certifications, and between experience and certifications.

Our results suggested that at least one certification was positively associated with wages in each of the 9 jobs and 10 industries. For some jobs and industries, multiple certifications carried a wage premium. On the average, 2.8 certifications had significant value for the job functions and 1.9 certifications for the industries. Our results also suggested that the value of certifications was both job specific and industry specific. Not only the number of certifications that had positive premiums, but the magnitudes of the premiums varied across job functions and industries.

The following implications may be drawn from this study. First, current IT professionals should realize that certifications can be valuable. IT professionals who want to advance their career should seriously consider being certified in their area(s) of specialization. The training time needed to acquire a certification may substitute for the foregone experience they may have accumulated otherwise, because of the substitution effect between certification and experience. Second, people who would like to pursue an IT career may want to assess the tradeoffs between getting a formal education and getting an IT certification, because our findings indicated that some certifications have higher premiums than education. Third, both current and future IT professionals should also be mindful that certifications are highly job-specific and industry-specific when deciding on which certifications to pursue. Fourth, when evaluating employees and making

[3] Project Management Professionals (PMP) had a coefficient of 0.238 (27% premium) at the marginally significant level of 10% in the general Consulting industry.

decisions about new hires, employers should have a balanced view of the value of education, experience, and certifications.

Although this research identifies the value of IT certifications, caution should be exercised. IT certifications indicate drive, knowledge, and, to a degree, technical skills, but most of them do not necessarily measure business skills, especially the ones in this study. Numerous studies [Todd 1995; Peslak 2005] suggest that IT professionals who possess both business and technical skills have the highest competitive advantage. Given the trend of IT outsourcing, business skills such as communications and interpersonal skills are more important than ever Margulius [2006]. Executives, hiring managers, and IT professionals at all levels should consider IT certifications as just one part of the overall picture.

Given the rapid changes in technology and associated changes in the knowledge base, technical skills depreciate quickly and technologies have short lifecycles [Randall et al. 2005]. Certifications that have high value today may lose their value in just a few years [Zeng 2004]. As a result, IT professionals should constantly update their knowledge and skill sets. This also suggests that research on the value of certifications should be an ongoing endeavor.

This study has certain limitations. First, the data was provided to us by *Certification Magazine* whose subscribers may not fully represent the general IT professional population. But the fact that the data was collected from both the subscribers as well as IT experts in 27 industry-leading companies moderated some of this concern, given that 38 percent of the total responses were from the latter group. In addition, since the data comes from the survey by *Certification Magazine*, potentially some bias toward responses from those who benefit from certification may be present. Second, using job titles/functions to operationalize the job-type variable may not be the best option. Job titles do not fully convey the nature of the job types, and various organizations use a variety of different job tittles. Therefore, future studies should collect job description data, because it is better at capturing the job type characteristics. Third, the match between job functions and certifications in Table 3 is somewhat arbitrary. Certain relevant certifications may be overlooked while certain relevant certifications may be included. Fourth, the type of degree earned is not considered due to the unavailability of such information in the supplied dataset. This is an important omission. For example, a Bachelor of Science in computer science may carry a different weight than a Ph.D. in chemistry. Fifth, we used mean values for the range items in estimating Equation [1], which can conceal nuance variations among responses. Sixth, the sample size is very large, and even small differences in means will often become statistically significant.

The limitations also suggest possible avenues for future studies. First, job descriptions and degree types should be taken into consideration. Second, education might be better treated as a categorical variable (e.g. with a bachelor degree or not), because years of education may not necessarily be linearly related to income. Third, the timing in acquiring certain degrees and certifications may be significant. For example, certain degrees may be required for specific entry-level positions and then acquiring a certain certification later in one's career may provide significant premiums and advancement opportunities. Finally, the underpinnings of certification value and salary premiums should be investigated. For example, does the value come from the knowledge acquired in studying for the certification, or does the value come mainly from the symbol or credential acquired?

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APPENDIX I: QUESTIONNAIRE

Please tell us which individual certifications you now hold. (Check all that apply.)

3COM

Apple Certified Desktop Technician (ACDT)

Apple Certified Help Desk Specialist (ACHDS)

Apple Certified Portable Technician (ACPT)

Apple Certified System Administrator (ACSA)

Apple Certified Technical Coordinator (ACTC)

Check Point

Cisco CCDA

Cisco CCDP

Cisco CCIE

Cisco CCNA

Cisco CCNP

Cisco CCSP

Cisco Qualified Specialist: IP Telephony

Cisco Qualified Specialist: VPN and Security

Cisco Qualified Specialist: Wireless LAN

Citrix Certified Administrator (CCA)

Citrix Certified Enterprise Administrator (CCEA)

CIW

CompTIA A+

CompTIA CDIA+

CompTIA CTT+

CompTIA e-Biz+

CompTIA HTI+

CompTIA I-Net +

CompTIA Project+

CompTIA Linux+

CompTIA Network+

CompTIA Security+

CompTIA Server+

Computer Associates

Dell

EMC Proven Professional

HDI

HP Master ASE

HP Accredited Systems Engineer (ASE)

HP Certified Systems Engineer (CSE)

HP Accredited Systems Integrator (AIS)

HP Certified Systems Administrator (CSA)

HP Accredited Platform Specialist (APS)

IBM Certified Database Administrator - DB2

IBM Certified Deployment Professional – Tivoli

IBM Certified Application Developer/System Administrator for Lotus Software

IBM Certified Solution Developer/System Administrator – WebSphere

IBM Certified for e-business

IBM Certified Specialist – TotalStorage

IBM eServer Certified Specialist - iSeries

IBM eServer Certified Specialist - pSeries

IBM eServer Certified Specialist – xSeries

(ISC)2 CISSP

(ISC)2 SSCP

Java

Linux Professional Institute (LPI)

Microsoft Certified Application Developer (MCAD)

Microsoft Certified Database Administrator (MCDBA)

Microsoft Certified Desktop Support Technician (MCDST)

Microsoft Certified Professional (MCP)

Microsoft Certified Solution Developer (MCSD)

Microsoft Certified Systems Administrator (MCSA)

Microsoft Certified Systems Engineer (MCSE)

Microsoft Certified Systems Engineer Messaging

Microsoft Certified Systems Engineer Security

Microsoft Certified Trainer (MCT)

Nortel Networks Certified Design Specialist (NNCDS)

Nortel Networks Certified Support Specialist (NNCSS)

Nortel Networks Certified Design Expert (NNCDE)

Nortel Networks Certified Support Expert (NNCSE)

Nortel Networks Certified Architect (NNCA)

Novell CDE

Novell CNA

Novell CNE

Novell CNI

Novell Master CNE

Novell Certified Linux Engineer (CLE)

Novell SUSE Certified Linux Professional (SCLP)

Oracle Application Server Web Administrator

Oracle DBA OCA

Oracle DBA OCM

Oracle DBA OCP

Oracle Developer OCP

Planet3 Wireless CWNA

Planet3 Wireless CWSP

Project Management Institute

Red Hat RHCE

Red Hat RHCT

SANS GIAC

Security Certified Professional

Sun Certified Business Component Developer for the Java 2 Platform

Sun Certified Developer for Java Web Services

Sun Certified Developer for the Java 2 Platform

Sun Certified Enterprise Architect for the Java 2 Platform

Sun Certified Mobile Application Developer for the Java 2 Platform

Sun Certified Network Administrator for the Solaris Operating System

Sun Certified Programmer for the Java 2 Platform

Sun Certified Security Administrator for the Solaris Operating System

Sun Certified System Administrator for the Solaris Operating System

Sun Certified Web Component Developer for the Java 2 Platform

Telephony

TIA CCNT

TIA CTP

UNIX

VERITAS

How many years have you been professionally involved in Information Technology?

Under 1 year

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

More than 20

Which of the following best describes your organization's industry or function at this location?

Aerospace

Business Services/Consulting (non-computer)

Communication Carriers (ISP, Telecomm, dataComm, TV/Cable)

Computer/Network Consultant

Computer Related Retailer/Wholesales/Distributor

Construction/Architecture/Engineering

Consulting

Data Processing

Education

Entertainment/Media

Finance/Banking/Accounting

Government: Federal/State/Local

Health/Medical Services

Hospitality

Insurance/Real Estate/Legal Services

Internet/Web/ISP

Manufacturing

Manufacturing of Computers, Communications or Peripheral Equipment

Non Profit/Religious

Oil and Gas/Utilities/Energy

Pharmaceutical

Publishing

Research/Development

Software/Software Development

Telecommunications

Transportation

Travel

VAR/VAD/Systems or Network Integrator

Wholesale or Retail Trade (non-computer)

Other

How many employees are in your entire company or organization?

Less than 50

50 to 99

100 to 499

500 to 999

1,000 to 2,499

2,500 to 4,999

5,000 to 7,499

7,500 to 9,999

10,000 to 19,999

20,000 to 29,999

30,000 to 39,999

40,000 to 49,999

50,000 or more

Which of the following best describes your primary job function?

Computer Systems/Operations/Networking

Computer Related Consulting

Data Communications/Telecommunications

Engineering

Executive/Management

Financial/Accounting

IS/MIS/DP

LAN/Network Systems

Manufacturing/Production

PC/Micro Systems/Info Center

Project Management

Purchasing

Research/Development

Sales/Marketing

Software/Applications Development

Support

Systems Analyst

Systems Engineering/Integration/Technical Services

Training/Education

Other

How long have you been in your present job?

Less than 1 year

1 year 2 years 3 years 4 years 5 years 6 years 7 years 8 years 9 years 10 years

More than 10 years

How many hours per week do you normally work?

Under 20 20 to 30 30 to 40 40 to 50 Over 50

What is your total 2004 salary including bonuses and other company incentives? (Please indicate using U.S. dollars.)

Under $20,000

$20,000 to $24,999

$25,000 to $29,999

$30,000 to $34,999

$35,000 to $39,999

$40,000 to $44,999

$45,000 to $49,999

$50,000 to $54,999

$55,000 to $59,999

$60,000 to $64,999

$65,000 to $69,999

$70,000 to $74,999

$75,000 to $75,999

$80,000 to $84,999

$85,000 to $89,999

$90,000 to $94,999

$95,000 to $99,999

$100,000 to $109,999

$110,000 to $119,999

$120,000 to $129,999

$130,000 to $139,999

$140,000 to $149,999

$150,000 to $159,999

$160,000 to $169,999

$170,000 to $179,999

$180,000 to $189,999

$190,000 to $199,999

$200,000 or more

Are you?

Male

Female

What age group do you fall into?

18 or under

19 to 24 25 to 29 30 to 34 35 to 39 40 to 44 45 to 49 50 to 54 55 to 59 60 to 64

65 or older

What level of education have you achieved?

High school diploma

2-year associate degree

Technical training (not BA)

BA/BS

Master's degree

Doctorate

Professional degree

APPENDIX II: DATA DEFINITIONS

REGION

Midwest [12]	IL, IA, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI
Northeast [12]	CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
South [14]	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA, WV
West [13]	AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY

SIZE

Small	1-499
Medium	500-2,499
Large	2,5000 or more

HOURS WORKED PER WEEK

10	Under 20
25	20 to 30
35	30 to 40
45	40 to 50
60	Over 50

AGE

17.5	18 or under
21.5	19 to 24
27	25 to 29
32	30 to 34
27	35 to 39

42	40 to 44
47	45 to 49
52	50 to 54
57	55 to 59
62	60 to 64
65.5	65 or older

GENDER

1	Male
0	Female

EDUCATION [YEARS]

12.0	High school diploma
14.0	2-year associates degree
14.0	Technical training [not BA]
16.0	BA/BS
18.5	Master's degree
20.5	Doctorate
20.5	Professional degree

EXPERIENCE [YEARS]

0.5	Under 1 year
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15

16	16
17	17
18	18
19	19
20	20
30	More than 20

SALARY

$10,000	Under $20,000
$22,500	$20,000 to $24,999
$27,500	$25,000 to $29,999
$32,500	$30,000 to $34,999
$37,500	$35,000 to $39,999
$42,500	$40,000 to $44,999
$47,500	$45,000 to $49,999
$52,500	$50,000 to $54,999
$57,500	$55,000 to $59,999
$62,500	$60,000 to $64,999
$67,500	$65,000 to $69,999
$72,500	$70,000 to $74,999
$77,500	$75,000 to $79,999
$82,500	$80,000 to $84,999
$87,500	$85,000 to $89,999
$92,500	$90,000 to $94,999
$97,500	$95,000 to $99,999
$105,000	$100,000 to $109,999
$115,000	$110,000 to $119,999
$125,000	$120,000 to $129,999
$135,000	$130,000 to $139,999
$145,000	$140,000 to $149,999
$155,000	$150,000 to $159,999
$165,000	$160,000 to $169,999
$175,000	$170,000 to $179,999
$185,000	$180,000 to $189,999
$195,000	$190,000 to $199,999
$204,999	$200,000 or more

APPENDIX III: RESULTS WITH EXPERIENCE OF MORE THAN 20 YEARS CONVERTED TO EXP=25

Table 4a. Value of IT Certifications by Job Function

	Computer Systems/ Networking		**Systems Engineering/ Integration/ Technical Services**		**LAN/Network Systems**		**Support**		**Software Application Development**	
Intercept	9.002[a]	9.025[a]	9.514[a]	9.588[a]	9.760[a]	9.817[a]	9.328[a]	9.561[a]	9.988[a]	9.969[a]
Edu	0.051[a]	0.048[a]	0.028[a]	0.022[a]	0.024[a]	0.017[a]	0.052[a]	0.037[a]	0.022[a]	0.022[b]
Exp	0.077[a]	0.072[a]	0.066[a]	0.064[a]	0.062[a]	0.055[a]	0.088[a]	0.079[a]	0.098[a]	0.099[a]
Exp2	-	-0.002[a]	-0.002[a]	-0.002[a]	-0.002[a]	-0.002[a]	-0.002[a]	-0.002[a]	-0.003[a]	-0.003[a]
Hrs/week	0.011[a]	0.011[a]	0.013[a]	0.012[a]	0.008[a]	0.007[a]	0.008[a]	0.006[a]	0.005[b]	0.005
Jobtenure	0.003	0.005	-0.004	-0.003	-0.005	-0.002	0.013[a]	0.014[a]	-0.008	-0.007
Gender	0.042	0.034	0.033	0.028	0.029	0.037	-0.028	-0.009	-0.010	-0.017
Age	0.003[b]	0.005[a]	0.003	0.004[b]	0.003	0.004[b]	-0.004[b]	-0.004[a]	-0.002	-0.001
Small	-	-0.139[a]	-0.186[a]	-0.175[a]	-0.221[a]	-0.189[a]	-0.261[a]	-0.251[a]	-0.056	-0.064
Medium	-	-0.071[b]	-0.131[a]	-0.134[a]	-0.108[a]	-0.092[a]	-0.153[a]	-0.164[a]	-0.113[a]	-0.116[a]
West	0.107[a]	0.101[a]	0.154[a]	0.148[a]	0.130[a]	0.123[a]	0.114[a]	0.114[a]	0.180[a]	0.183[a]
MW	0.015	0.028	0.011	0.021	0.077[b]	0.089[a]	-0.019	-0.018	0.042	0.048
NE	0.169[a]	0.177[a]	0.123[a]	0.130[a]	0.187[a]	0.190[a]	0.107[a]	0.111[a]	0.090[b]	0.091[b]
CCSP		0.138		-0.052		0.272[a]		0.235		
CISSP		0.235[a]		0.129[b]		0.196[a]		0.196		
MCSE-S		-0.123		-0.183		-0.193[b]		-0.096		
DBAOCP				0.153[a]				0.384[a]		0.020
MCDBA				-0.065				-0.315[bx]		0.039
CCIE		0.444[a]		0.201[a]		0.317[a]		0.409		
CCNP		0.060		0.164[a]		0.150[a]		0.196[a]		
RHCE		0.181[a]		0.095[b]		0.231[a]		0.270[a]		0.204[b]
Java2				0.083						0.047
PMP				0.234						
N	1655		1625		1145		953		749	
Adj R-Sq	0.248	0.266	0.200	0.222	0.178	0.233	0.318	0.361	0.175	0.177
F Value	46.37[a]	34.34[a]	34.90[a]	22.06[a]	21.60[a]	20.33[a]	38.06[a]	27.83[a]	14.17[a]	11.03[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

Table 4a. Value of IT Certifications by Job Function – cont'd

	Computer Related Consulting		**IS/MIS/DP**		**Systems Analyst**		**Data Communications**	
Intercept	8.720[a]	8.837[a]	9.863[a]	10.003[a]	9.898[a]	10.032[a]	10.308[a]	10.340[a]
Edu	0.058[a]	0.046[a]	0.032[a]	0.017	0.035[a]	0.027[a]	0.007	0.001
Exp	0.091[a]	0.085[a]	0.065[a]	0.061[a]	0.056[a]	0.050[a]	0.048[a]	0.043[a]
Exp2	-0.002[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[b]
Hrs/week	0.012[a]	0.013[a]	0.006[b]	0.006	0.006[b]	0.006	0.005	0.005
Jobtenure	0.006	0.007	0.008	0.010	-0.001	0.001	0.006	0.007
Gender	-0.002	-0.007	-0.020	0.024	0.027	0.037	-0.009	-0.019
Age	0.007[b]	0.007	-0.001	-0.001	-0.001	-0.001	0.001	0.002
Small	-0.106[b]	-0.101	-0.170[a]	-0.162[a]	-0.192[b]	-0.193[a]	-0.153[b]	-0.146[b]
Medium	0.011[b]	-0.004	-0.111[b]	-0.138[a]	-0.068	-0.070	-0.165[b]	-0.158[b]
West	0.276[a]	0.289[a]	0.104	0.113[b]	0.084	0.060	0.133	0.151
MW	0.124	0.158[b]	0.003	0.022	-0.085	-0.079	0.083	0.089
NE	0.152[b]	0.150[b]	0.134[b]	0.144[b]	0.101	0.099	0.081	0.104
CCSP		-0.036		0.415		-0.195		0.112[a]
CISSP		0.262[a]		0.170[b]		0.262[a]		0.377
MCSE-S		0.071		0.079		0.454		0.012
DBAOCP		0.248[a]		0.340[a]		0.184[a]		
MCDBA		-0.043		-0.101		-0.083		
CCIE		0.219		0.507				0.116
CCNP		0.242		0.098				0.063
RHCE		-0.012		0.036				0.096
Java2								
PMP								
N	563		458		382		408	
Adj R-Sq	0.235	0.258	0.196	0.247	0.145	0.173	0.065	0.078
F Value	15.37[a]	10.77[a]	10.30[a]	8.48[a]	6.39[a]	5.67[a]	3.35[a]	2.92[a]

[a] significant at the 1% level

[b] significant at the 5% level

[x] significant but with a wrong sign

ABOUT THE AUTHORS

Jing "Jim" Quan is an assistant professor in the Department of Information and Decision Sciences in Perdue School of Business at Salisbury University. He holds a Ph.D. from the University of Florida and is an MCT/MCSE and CNI/CNE. His research interests include Information Technology (IT) and Organizations, Knowledge Management, Project Management, and IT Human Resource Management. His work has appeared in such journals as *Journal of Management Information Systems*, *The Communications of the ACM, The Communications of the AIS, Information Resources Management Journal, Journal of Global Information Management, International Journal of Information Management, Journal of Information Technology and Information Management,* and *Journal of Computer Information Systems.* He presented papers at the national and international conferences on information systems and technology.

Ronald Dattero is a professor of Computer Information Systems at Missouri State University. He holds a Ph.D. from Purdue University. His research interests include applications development, knowledge management, database management, IT professional and personnel issues, and applied statistics. His work has appeared in such journals as *Journal of Management Information Systems*, *Information and Management*, *Information Systems*, *Decision Support Systems*, *Communications of the ACM*, *Communications of Association for Information Systems*, and *International Journal of Forecasting*.

Stuart D. Galup is an associate professor of Information Technology at Florida Atlantic University. He holds a DBA from Nova Southeastern University and is a Certified Computing Professional. His professional work in the transformation of information technology organizations was featured in *Computerworld* and *Datamation.* His research appeared in academic journals such *as Communications Research, Communications of the ACM, Information Resource Management Journal*, *ACM Computer Personnel***,** and *Communications of Association for Information Systems*. He is co-author of *Building the New Enterprise: People, Processes, and Technology* and *The IT Organization: Building a World-Class Infrastructure*, both published by Prentice Hall.

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