The Economic Effect of Education in an Information Technology–Penetrating Economy: Evidence From Hong Kong

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This article examines the economic effect of education in terms of its impact on the earnings of workers in an information technology (IT)–diffusing economy, based on data from Hong Kong's 2006 by-census and survey on the usage and penetration of IT in industries. Education enhances the productivity of workers and increases their lifetime incomes. However, technological advances, if deskilling, may exert an adverse effect on workers' earnings. The analysis of the economic effect of education is complicated by the increasing application of technologies in the workplace. This study shows that the earnings effect of education and the interaction between education and IT penetration in the workplace are positive and significant, whereas IT by itself brings about a significant negative earnings effect.

Keywords: earnings; education; information technology

Technological changes are often thought to be labor saving and capital intensive and thus tend to be skill biased. New technologies and worker skills are usually considered to be complementary, and skilled workers are perceived to be more able to incorporate new technologies. Technological changes improve the productivity and incomes of workers who can incorporate the innovations in their employment. However, technological changes also bring about changes in demand for workers, which ends in changing their earnings. The effect of technological change on the relative earnings of the various categories of workers is ambiguous. When innovations, particularly process innovations, are introduced, low-skilled workers are usually displaced. For instance, with the introduction and diffusion of information technology (IT), typists and typesetting workers are displaced by word-processing software and computer hardware, telephone operators are displaced by automatic answering devices, bank tellers are displaced by automatic teller machines, and brokers are displaced by online transactions. Technological changes reduce the demand for low-skilled workers. Their wages decrease as a result. But, on the other hand, IT is a skill-biased technological change. Increasing adoption and diffusion of IT will result in up-skilling of skilled laborers, which will in turn engender an increase in their wages. Unskilled laborers will suffer from wage loss, either in relative or absolute terms, if they cannot pick up the new skills related to the adoption of IT. IT then may be either a substitute or a complement for skilled workers (Carnoy, 2000; Parayil, 2005; Rifkin, 1995). Studies by Carnoy (2000) of the skill effect of microelectronics applications show that most of the employment created in microelectronics production is for new kinds of workers, that is, women in production and highly educated men in research and development and in management. This means that technological changes not only create changes in the types of workers employed but also require higher and broader varieties of skills.

Investment in IT hardware and software is increasingly important to individual firms and to the economy. Computers and related equipment have been the most prominent and fastest growing component of tangible investment in Organisation for Economic Co-operation and Development (OECD; 1994) economies. IT has also been the most important and dominant technology adopted by Hong Kong industries since the mid-1990s. As compared with other new technologies, such as new materials and biotechnology, the combination of computer, microelectronics, and telecommunication technologies has had by far the greatest economic impact (OECD, 1994). However, the impact of technological changes on employment will be different depending on the country's level of technological development, its educational development, and its history and institutional structure. Further, it is especially difficult to assess empirically the overall impact of technological changes on employment in the service sector (Evangelista, 2000; Karaömerlioglu & Ansal, 2000; Simonetti, Taylor, & Vivarelli, 2000; Spiezia & Vivarelli, 2000). Although Ang, Slaughter, and Ng (2002) discovered that information intensity[1] does not significantly affect the compensation of IT technical professionals, their study does not address the effect of IT intensity on the compensation of workers other than IT technical professionals. Research examining the economic effects of IT and its interaction with education is still limited. This study aims to examine the economic effect, in terms of earnings, of IT diffusion and its interaction with education in an economy with services production as the dominating economic activity. Hong Kong is a good place to explore the impact of IT diffusion on the economic returns to workers not only because tertiary production accounts

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for 92.3% of the gross domestic product at current prices in 2008 (Census and Statistics Department, 2009) but also because Hong Kong is a world digital city (*Hong Kong Yearbook,* 2007) and has always been regarded as the prime example of a free-market economy. Hong Kong, as noted by Friedman, is an excellent example of a laissez-faire economy (Friedman & Friedman, 1979). The Heritage Foundation (2009) also named Hong Kong the world's freest economy since 1993.

Methodology, Variables, and Data Sets

The Mincerian earnings function approach (Levin, 1984; Mincer, 1974) is adopted in this study to evaluate the effects of education, IT, and their interaction in determining the earnings of a worker. The earnings function approach has been used extensively as an empirical tool for assessing the economic effects of education and training. The general earnings function for the study of wage determinants is as follows:

$$Y = f(E, X_1, X_2, X_3, \ldots X_n),$$

where earnings (Y) is a function of education (E) and other variables ($X_1, X_2, X_3, \ldots X_n$) such as the work experience and gender of workers.

The earnings function provides an estimate of the contribution of the various determinants to earnings. In this study, a regression technique and the natural logarithm of earnings (lnY) are adopted to examine the earnings effect of education. The basic earnings function employed here is as follows:

$$lnY = a + bEd + cWk + dGen + eIT + fEd \quad IT + u,$$

where lnY is the dependent variable, and *Ed, Wk, Gen, IT,* and $Ed \times IT$ are independent variables. *Ed* is the worker's education attainment level, which is proxied by the schooling years equivalent of the individual wage earners; *Wk* is the years of work experience; *IT* is the IT penetration level of the industry sector in which the worker is engaged; and $Ed \times IT$ is the interaction term of education and the level of IT penetration of the individual industry sectors. *Gen* is the gender variable consisting of two dummy variables, *Gen(M)* and *Gen(F)*, for male and female workers, respectively. The values assigned to *Gen(M)* and *Gen(F)* are 1 and 0, respectively, to estimate the effect on earnings of male workers relative to female workers. The parameters *b, c, e,* and *f* reflect the estimated effects of education, work experience, IT penetration, and the interaction of education and IT penetration, respectively, on workers' earnings. The error term, *u*, captures the unobservable individual effects, such as workers' family background and innate ability, on earnings.

Two sets of data are involved in this study. The first set of data is obtained from the 2006 by-census of the Hong Kong population. The other set of data is obtained from the 2006 Annual Survey on Information Technology Usage and Penetration in the Business Sector. Both the by-census and the survey were conducted by the Census and Statistics Department of the Hong Kong SAR government.

The Hong Kong government has been carrying out a full census every 10 years and a by-census in the middle of the intercensus period since 1961, and the data set in this study is obtained from the 2006 by-census of the Hong Kong population. A by-census survey provides information about the education, occupation, and monthly income of Hong Kong's population, as well as some other major demographic characteristics. It also provides information about the industry in which the respondents work. In this study, the data set covers 5% of the population and 342,527 records. Only respondents between the ages of 16 and 65 who are gainfully employed are analyzed in this study. This decision was made because, according to Hong Kong's education and labor ordinances, individuals age 15 or younger have to attend school because of the implementation of 9-year free and compulsory education, and age 65 is the normal retirement age.

Mincer's (1974) approach is adopted in this study to obtain the work experience data of workers, because by-census surveys do not provide any information about the work experience or work history of the respondents. Because the age of children entering the first year of primary education in Hong Kong is 6 years, according to the government's schooling policies, the number of years of work experience is obtained according to the following formula: years of work experience = age – 6 – years of education.

The objective of the 2006 Annual Survey on Information Technology Usage and Penetration in the Business Sector was to collect information relating to IT usage and penetration in various industry sectors. The survey covered all industry sectors except the agriculture and fishing sector and the mining and quarrying sector. The industry sectors covered in the survey were manufacturing, electricity, and gas; construction; wholesale, retail, and import/export trades and restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services. The survey covered a total of 297,286 establishments of all employment sizes.

The 2006 survey shows the percentages of the establishments that have personal computers, Internet connections, and Web pages or websites, and that engage in businesses such as receiving, ordering or purchasing, selling and delivering goods, and providing services or information through electronic means (Table 1, columns b–h). To obtain a proxy percentage of establishments that engaged in business through electronic means, column i of Table 1 is created by averaging the values of columns e, f, g, and h.

The levels of IT penetration for the various industry sectors are proxied by the information technology penetration (ITP) index, which is derived from averaging the percentages of establishments that have personal computers, Internet connections, and Web pages or websites, and their engagement in business through electronic means (i.e., Table 1, columns b, c, d, and i). The ITP indexes of the various industry sectors are shown in Table 2.

The ITP index ranges from 0, which would indicate that none of the establishments in the industry sector adopts information technologies in their business, to 100, which would indicate that all of the establishments in the industry sector adopt information technologies in their business.

Results and Discussion

The results of multiple regression analyses on the data from the 2006 by-census sample are shown in Table 3. The results from regression analyses show that the five variables—level of education attainment, years of work experience, gender of workers, IT

Table 1
Information Technology Penetration by Industry Sector of Hong Kong in 2006

		Among All Establishments, Percentage With							
	a	b	c	d	e	f	g	h	i
Industry Sector	Total Number of Establishments	Personal Computer	Internet Connection	Web Pages/ Websites	Received Goods, Services, or Information Through Electronic Means	Ordered or Purchased Goods, Services, or Information Through Electronic Means	Sold Goods, Services, or Information Through Electronic Means	Delivered Goods, Services, or Information Through Electronic Means	Engaged in Business Through Electronic Means
Manufacturing, electricity, and gas	14,830	47.3	44.0	10.3	40.4	10.5	1.7	10.3	15.7
Construction	19,093	55.2	48.3	2.3	47.9	6.4	0.1	2.5	14.2
Wholesale, retail, and import/ export trades; restaurants and hotels	154,592	60.6	55.6	19.3	53.4	13.0	2.0	19.4	22.0
Transport, storage, and communications	30,026	33.7	30.2	7.1	33.6	4.4	0.6	7.1	11.4
Financing, insurance, real estate, and business services	43,764	88.1	87.1	22.0	85.5	14.3	2.2	25.0	31.8
Community, social, and personal services	34,980	57.3	49.6	24.6	49.9	12.5	0.4	24.6	21.9
Total	297,286	60.5	55.9	17.5	54.7	11.7	1.5	18.0	21.5

Source. Report on 2006 Annual Survey on Information Technology Usage and Penetration in the Business Sector.

Table 2
Information Technology Penetration (ITP) Index

Industry Sector	ITP Index
Manufacturing, electricity, and gas	29.3
Construction	30.0
Wholesale, retail, and import/export trades; restaurants and hotels	39.4
Transport, storage, and communications	20.6
Financing, insurance, real estate, and business services	57.3
Community, social, and personal services	38.4

Source. Report on 2006 Annual Survey on Information Technology Usage and Penetration in the Business Sector.

Table 3
Determinants of Earnings

Variable	Coefficient
Intercept	7.731
Ed (level of education attainment)	0.073*
Wk (years of work experience)	0.020*
Gen(M) (male workers)	0.301*
IT (information technology penetration level)	−1.32*
Ed × *IT* (interaction of education and IT penetration level)	0.147*
R^2	0.303
N	161,540

Note. The dependent variable is the natural logarithm of monthly salary.
*$p < .05$.

penetration level of the industry in which a worker engages, and the interaction between education and IT penetration level of an industry—can explain about 30% of the variance in monthly earnings. The effects of all these variables on workers' earnings are significant at $p < .05$. The positive values of the coefficients of *Ed* and *Wk* support the views of human capital theory. It suggests that differences in earnings reflect differences in workers' human capital endowments that are related to education and work experience (Becker, 1993; Mincer, 1974; Woodhall, 1997).

In addition, this study indicates that men are outearning women. This is consistent with previous findings that there is an earnings gap between male and female employees and that men are usually paid higher (Ferber, 1995; Moreno-Galbis & Wolff, 2008). However, the earnings effect of *IT* is negative, whereas that of *Ed* × *IT* is positive. The negative earnings effect of *IT* reveals that workers' monthly salary varies inversely with the level of IT penetration of the industry in which they work, in terms of installation of personal computers, Internet connections, and use of electronic means in business. The positive interaction effect of *Ed* × *IT* implies that the interaction between education and IT penetration exerts a positive earnings effect on workers' monthly salary. The earnings effect will be enhanced when workers with high education attainment work in an industry with a high level of IT application. On the other hand, the earnings effect will be depressed when workers with low education attainment work in an industry with a low level of IT application.

This study enriches existing understanding about the economic effect of education. Education has to serve as a supplement to the increasing diffusion of IT. Baliamoune-Lutz (2003) claimed that IT diffusion is not associated with enhancement in learning but found that IT, like other general-purpose technological changes, seems to benefit all workers. However, this study reveals that IT's diffusion benefits only the workers with high education attainment. Workers of low education attainment suffer from the increasing penetration of IT. This may be true particularly for those who are IT have-nots. Education serves not only as a means of human capital formation but also as a means of balancing the negative earnings effect of IT usage in an IT-penetrating economy. IT, on one hand, facilitates production and economic growth but, on the other hand, suppresses the earnings of the educationally and information-technologically disadvantaged. It widens the earnings gap between the IT haves and have-nots and between the more educated and less educated workers.

Conclusion

In the new global environment, the primary characteristics of flexible production are new-knowledge intensive, networking intensive, and human-capital intensive. The frontline workers will no longer be the operators, as were those in the industrialization age, but will be required to handle all kinds of information and to deal with day-to-day problems that have not been encountered previously. Diffusion of IT replaces the low-end jobs and results in changes in the types of skills demanded by employers and hence changes in the demand for workers in the labor market. Workers are no longer required to possess only a narrow range of specific skills; they need a wide range of generic skills as well.

Reducing the digital divide has been advocated in almost every country with the increasing application of IT. It is a necessary but not sufficient condition for reducing the earnings gap between the IT haves and have-nots. In addition to alleviating the digital divide, governments should provide retraining to workers to update the skills that are required to deal with the increasing use of IT in the workplace. Furthermore, governments or education authorities should pay attention to upgrading the education attainment of the labor force. The results of this study support Schultz's (1975) argument that education can enhance an individual's ability to deal successfully with economic disequilibria and to cope with changes. The use of IT may imply technological innovation as well as process innovation. For example, banking officers are increasingly required to exercise their discretion to supplement the computerized procedures to cater to the varying needs of their individual customers. Diffusion of IT not only brings about a demand for IT skills but also increases the importance of the human mind in the production process. Carnoy (2000) asserts that the broader and deeper the diffusion of advanced IT, the greater the need for increasingly autonomous and educated workers who are able, willing, and motivated to program and make decisions regarding the entire sequence of their work. Levin (1997) also argued that, in a knowledge-based economy with high-value-added industries, students need to develop their complex reasoning and work-related skills such as exploratory thinking, critical thinking, problem solving, decision making, and the ability to work with others. In addition,

cross-cultural understanding is a competence essential for workers in a cosmopolitan economy such as Hong Kong. In facing the increasing use of IT, the education attainment level of Hong Kong's labor force needs to be raised accordingly to equip employees with all these skills and competencies. Twelve-year free education has been provided since 2008, and the expansion of postsecondary education could become another stage in Hong Kong's education development.

Expansion of postsecondary education is a costly investment in the community's human capital. However, a study of the quality of distance and nondistance education at the first-degree level found that there is no significant difference in quality, in terms of earnings, between these two learning modes. Distance education is an investment in human capital on a par with traditional face-to-face education (Chan, 2009). Distance education can therefore be justified as a less costly alternative (Carbonaro, Dawber, & Arav, 2006) to traditional face-to-face learning in expanding the provision of postsecondary education in Hong Kong. It is suggested that because of the increasing penetration of IT in workplaces and the increasing demand for higher education, the Hong Kong SAR government should subsidize quality distance-learning programs to alleviate the negative economic impact of IT by upgrading the education attainment of school leavers.

This study deals with an investigation only of the general earnings impact of IT and its interaction with education. The earnings effect of IT, education, and their interaction for workers of various occupations such as managers, professionals, and clerks may be different. It would be worthwhile to undertake further multilevel studies to gain more insights into the earnings effect of IT and its interaction with education on different occupational groups.

NOTE

[1]Information-intensive institutions offer products and services that contain high information content and use sophisticated information technology to deliver goods and services (Palmer & Griffith as cited in Ang, Slaughter, & Ng, 2002).

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