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Information technology and productivity: Empirical evidence from the Chinese electronics industry

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ABSTRACT

The importance of IT has been increasing in both developing and developed countries over the past three decades. However, almost all findings on IT productivity have been based on data collected in *developed* countries, while research on productivity in *developing* countries has been sparse. We studied the effect of IT investment on firm-level productivity in the Chinese electronics industry using a production function model. We found that the direction and size of the impact of IT investment on productivity in China were generally similar to results of studies for the United States and concluded that Chinese firms should invest more in IT. Finally, contrary to popular belief, labor is still an important factor in the production function of the Chinese electronics industry, despite its status as a high-technology industry.

1. Introduction

The rapid development of IT as well as the declining costs of its deployment has considerably enhanced its diffusion in China as well as the United States. China became the largest IT market in the Asia/Pacific region in 2007, and China's IT market will soon reach US $217 billion with an annual growth rate of 5.9% despite the global financial crisis. Based on the increase in IT investment, Chinese researchers, firm managers, and government policy-makers have become concerned about the question: Does IT investment increase an organization's productivity and profitability?

Many Chinese firms have been enjoying the benefits of IT investment. Lenovo, the world's third-largest PC manufacturer, provides an example of how to achieve considerable efficiency gains and increased productivity through IT in the competitive global market. Using Dell Computer's supply chain management (SCM) system, Lenovo became China's leading PC manufacturer and allowed it to acquire IBM's PC business in December 2004 for $1.8 billion.

Huawei Technologies, one of the largest networking equipment manufacturers in China, recently forged a joint venture with 3Com; Huawei had to invest heavily in IT to make its systems compatible with 3Com's and thus coordinate their common business activities. The upgrade included their SCM, market research, and CRM systems. This helped Huawei's network products gain traction in the relatively established and highly competitive North American market against other network giants such as Cisco Systems and Nortel. In 2007, Huawei and Bain Capital acquired 3Com for $2.2 billion in a bid against Nortel Networks. Moreover, Neway, a leading industrial valve manufacturer in China, also benefited from a real time inventory system and direct cost savings from its integration of ERP and SCM systems [2].

Medium-sized firms in China have also enjoyed benefits from IT investments. Centaline (China), a real estate management firm based in Beijing, is a good example of a medium-sized firm which has effectively used IT. With more than 8200 employees and 380 branches across the country in 22 cities, such as Beijing, Shanghai, and Guangzhou, Centaline recognized that streamlined collaboration and information sharing were a key to its effective completion of transactions and improved customer satisfaction over its widely dispersed operations. To accomplish their goals, Centaline integrated its branch enterprise systems using a single end-to-end office automation solution by using various Microsoft products along with internal IS developed to create workgroup collaboration and workflow applications. Its investments have resulted in streamlined collaboration and information sharing, automated workflow management, new flexible information rights management, while lowering training and integration costs.

These cases demonstrate the benefits of IT investment in China; however, prior empirical studies at the country level (e.g., [7]) did

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not find a substantial IT contribution in developing countries because of an overall lack of IT-enhancing factors such as human capital and experience. In addition, it is still difficult to find firm-level empirical studies on IT investment and productivity in China; only a few studies (e.g., [10]) focused on this topic. Despite the increasing global importance of China, we do not yet have enough empirical analyses to understand the Chinese context. Indeed, some studies (e.g., [29]) pointed out that research on IT investment and productivity within China was important. The research questions of our study were therefore: (1) Is there a significant contribution of IT in increasing business productivity in the Chinese electronics industry? (2) If so, what are the characteristics of this contribution compared to other factors such as non-IT capital and labor?

Our objective was to investigate how IT investment in China has affected firms' productivity. We analyzed firm-level IT investment data using a Cobb–Douglas production function, and estimated the productivity coefficients of firms in the Chinese electronics industry.

2. A review of recent literature

As the amount of investment in IT has increased, managers and researchers' concerns about the effect of IT on performance has also increased. Many studies on the impact of IT investment on business productivity have been conducted to investigate the benefits of IT [6,14]. Over the past several decades there have been arguments not only that IT can help by providing better performance in firms, but also whether IT investment actually results in higher productivity. Studies conducted in the 1980s and early 1990s did not provide consistent results about IT's impact. Some studies even argued that IT investment could have a negative impact on the productivity of an organization due to the increase in coordination costs after the installation of new IS [16].

Many studies adopted new theories (e.g., a resource-based view [1]) or the well-defined framework of the economic theory of production [22], richer data, and more rigorous approaches including a time lag and the information intensity of the industry [13]. These studies found that IT does indeed contribute consistently and significantly to a firm's output. Brynjolfsson and Hitt suggested that computerization made a noticeable contribution to measured productivity and output in both the short- and long-term [3]. Shu and Strassmann reported the positive impact of IT investment on productivity in 12 US banks from 1989 to 1997 [24].

Studies based on the production function model have extended the unit of analysis from the firm to the industry and the country. These studies also found significant IT contributions to industrial or national productivity. A few studies indicated that IT investment had both excess and increasing returns over time [11].

Recent studies found significant contributions of IT on productivity and also added new findings using production theory: the marginal product of IT was higher in less concentrated and more dynamic industries [15]. IT has both a direct impact on industrial productivity and an indirect effect through other production factors such as capital and labor [19]. Supplying industries' IT capital was found to have a measurable contribution to industrial productivity [4]. Similarly, both domestic IT in a country and foreign IT spillover have an effect on national productivity [9].

Although the results of previous studies indicated that IT generates a high ROI, these findings were primarily based on data collected from developed countries, particularly the United States before the dot-com bubble burst (see Table 1 and Appendix A). Empirical studies in developing countries are relatively scarce and have limitations due to data restriction. It remains unclear whether any improvement in productivity in firms residing in developing countries are due to the drastic changes in the IT environment, e.g., the wide adoption of the Internet and enterprise software applications since the mid-1990s.

Table 1
Selected recent studies using the production function model.

Unit of analysis	Sample		
	Developed countries	Developing countries	All countries
Firm	• [3]: *P* • [9]: *P* • [13]: *P* • [14]: *N* • [15]: *P* • [17]: *P* • [20]: *P*	• [21]: *P*	
Industry	• [4]: *P* • [16]: *P*		
Country	• [6]: *P* • [18]: *P*	• [6]: *N* • [18]: *P*	• [6]: *P* • [7]: *P* • [18]: *P*

P and *N* mean that the result of the study shows a positive impact of IT on performance and no impact or a negative impact, respectively.

More data and evidence are necessary to confirm whether findings are robust. The answer to this question has important ramifications for developing countries such as China which is experiencing a rapid growth in IT demand. Despite the increasing global importance of China and its vast population, studies of IT's impact in China are very poorly represented in English-language journals [23]. We therefore investigated how IT investment in China has affected business productivity by applying a production function model with firm-level IT investment data of the electronics industry for the period from 2004 to 2006.

3. Models and data

3.1. Estimation framework

Many empirical studies have employed a neoclassical production theory to assess the value of IT because it has a strong economic foundation and has been widely applied to study the relationship between input factors and a firm's output. It states that input factors, such as capital and labor, can be related to output via a production function:

$$Q = f(C, K, L) \tag{1}$$

where the output is Q = sales (S) or value added (V) and C, K, and L are computer capital, non-computer capital, and labor, respectively.

We used the Cobb–Douglas production function because it facilitates estimation of the elasticity of production inputs by linearizing the equation. Applying this, the base model becomes:

$$\log Q_{it} = \alpha + \beta_C \log C_{it} + \beta_K \log K_{it} + \beta_L \log L_{it} + \varepsilon_{it} \tag{2}$$

where α is the multifactor productivity level capturing those differences in output across firms over time that do not depend on changes in the input use; βs are parameters that denote the elasticity of each of the input factors and t denotes year, with ε_{it} the error term.

Although a simple regression to combine all cross-section and time-series data with ordinary least squares (OLS) is possible despite the pooling of cross-section and time-series data, other procedures may be needed to consider panel data. The first procedure is a covariance model (or fixed effects model) involving