The Industrial Organization of Hong Kong's Progression Toward a Cashless Economy (1960s–2000s)

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By examining two episodes in Hong Kong's computing history, this article describes how the industrial organization and knowledge base that structured retail banking technology in Hong Kong transformed between the 1960s and early 2000s. Specifically, the authors compare the adoption of computers at HSBC in the 1960s and 1970s with the Octopus micropayments system's development in the 1990s.

The phrase "cashless society" was originally coined in the United States in the mid-1950s to describe a future in which electronic transactions would replace the exchange of coins, checks, and banknotes.[1] A 1966 newspaper article introduced this concept to people in Hong Kong.[2] In the last half-century, some economies have evolved in this direction, although paper notes and coins are still used in even the most progressive economies, such as Sweden and Iceland.[3] The displacement of cash with other payment solutions is an important topic in the histories of computing and banking: without the digitalization of customer accounts on top of the adoption of mainframe computers by banks in the 1960s and 1970s, the subsequent moves toward cashless economies would not have been possible.

Although historians have published extensively on the adoption of computers by European and North American banks,[4] they have published far less on the computerization of East Asian financial institutions.[5] This article helps to fill this gap by exploring the history of retail banking technology in Hong Kong from the 1960s to the present. Although Hong Kong banks lagged behind their American and British peers in terms of computerization in the 1960s, they rapidly caught up and were early adopters of technologies such as ATMs, telephone banking, and Internet banking. In the early 1970s, the visionary Hong Kong bank executive Roy Victor Munden discussed the possibility that cooperation between banks and other firms might eventually allow the Crown Colony to evolve into a cashless society.[6] Today, Hong Kong's Octopus system is one of the world's most advanced cashless payment systems.[7]

In the early stages of computerization of retail financial markets, although they were already deploying large computer systems on the principle of reducing back-office costs, most higher level managers in banks had limited or no knowledge about computer systems. Computerization was predominantly implemented by people who trained as bankers and within the boundaries of large corporations, particularly Hong Kong's big commercial banks. More recent periods, however, have witnessed a greater diversity of approaches from which to choose when implementing a large application of computer technology in retail finance. This diversity has emerged to the extent that regulatory and technological change together with new financial instruments and trading practices reshaped retail financial markets. Some of these changes have enabled specific instances in which

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nonfinancial intermediaries have taken the lead in the innovative use of computer technology and successfully contested retail bank markets—for instance, the use of cell phones as cash points in Kenya.[8] Here we explore the interfirm networks that enabled Octopus within Hong Kong's retail payment system. To exemplify two stages in the adoption of computer technology in Asian retail banking, this article compares and contrasts the internal deployment of early computers at HSBC in the 1960s and 1970s with the external (nonbank or market) use of computers in micropayments (using the Octopus chip) in the 1990s and 2000s. By documenting these two episodes of technological change, we show not only a dramatic transformation in the nature of the organizations responsible for the transformation of Hong Kong's retail banking technology, but also how that institutional shift reflects changes in the nature of computer-related knowledge.

Large Corporations and Epistemic Communities

To compare and contrast the aforementioned two episodes of technological evolution, we draw on the variant of the knowledge-based theory of the firm developed by Lars Håkanson in his work on the industrial organization of epistemic communities. For readers not familiar with his framework, we will begin by outlining Håkanson's concepts and showing how his views differ from the more established transaction-costs approach to understanding industrial organization pioneered by Oliver Williamson.

Drawing on Ronald Coase's theory of the firm, Williamson used transaction costs to explain why some activities are coordinated by markets, while others take place within firms. In their view, high transaction costs are the primary reason why participants replace the market's invisible hand with managerial hierarchies.[9] Williamson argued that transaction costs, and thus the utility of substituting hierarchies for markets, are likely to be high if one or more of the following conditions is present: high asset specificity, thin markets, difficulties in negotiating and writing enforceable contracts, and asymmetric information between contracting parties.

A Williamsonian approach could help us understand the transition described in this article because the relevant markets—those for computers and the specialized skills needed to operate them—were thin in Hong Kong and elsewhere in the 1960s and 1970s. By *thin,* we mean that there were an insufficient number of specialist vendors to make the market truly competitive. By the 1980s, the markets for computer hardware and skills were much thicker, which contributed to a shift toward the deployment of retail payment technologies in looser, interfirm networks, such as the interfirm network that developed Hong Kong's Octopus system. The increasing thickness of markets often encourages firms to disintegrate vertically and adopt other models for coordinating production, as thick markets make firms less susceptible to the *hold up problem,* which emerges when parties refrain from collaborating in spite of a potentially being better off by cooperating.[10]

Transaction costs are only part of the explanation, however. Thus, instead of using the classical Williamsonsian theory, we draw on Håkanson's newer ideas about epistemic communities. Håkanson synthesizes the knowledge-based view of the firm[11] with Burkart Holzner's work on the sociology of knowledge.[12] In Håkanson's work,[13] *epistemic communities* are systems that allow their members to interpret reality. Because individuals use layered frameworks to make sense of their observed reality, we are all members of many epistemic communities. As individuals progress from infancy through schooling and into an occupation, they join various epistemic communities. Languages structure how their speakers think, and language communities are thus epistemic communities—albeit large ones that comprise everyone living in a community save for very small children. Smaller epistemic communities include learned professions, skilled trades, industrial clusters, and in some cases, as Håkanson documented,[14] individual firms. Through the process of organizational learning, a firm can join an epistemic community. Within the boundaries of each of these more specialized epistemic communities, there is a unifying set of knowledge that includes common terminology; acceptance of other, nonlinguistic conventions; and knowledge of how to perform particular productivity tasks. This shared knowledge permits a more advanced division of labor.

Håkanson discusses *articulation,* the process by which tacit knowledge becomes explicit as standards and other tools (such as operating manuals or blueprints that can be shared with other firms). Articulation encompasses standardization and the development of technical jargon, or a common vocabulary precise enough to permit cooperation across firm boundaries (for example, intrafirm and international consensus about the physical characteristics of a credit card). It is difficult to have extensive outsourcing without some degree of articulation, and articulation facilitates the division of labor. Closely associated with articulation in Håkanson's framework is *replication,* which involves the transfer of knowledge and thus capabilities. In Håkanson's view, articulation and replication facilitate the creation of "well defined, standardized interfaces between epistemic communities," which thereby "increase the feasibility of knowledge combinations through the uncomplicated transfer across epistemic boundaries of physical artifacts, such as blueprints or components."[13]

The boundaries of epistemic communities do not determine industrial organization but they influence it. Håkanson observes that "the cost of governing knowledge processes depends as much on the cognitive background of the exchange partners as on the tacitness of the knowledge."[15] In other words, it is more challenging to trade with an individual who is outside of most of your epistemic communities than with someone who is a member of most or all of the same epistemic communities. Whenever the boundaries of the relevant epistemic communities align perfectly with those of a firm, there will be a strong incentive for productive activity to be coordinated within the boundaries of that company because transaction costs with outsiders are likely to be elevated. In contrast, epistemic communities "that span organization boundaries create and legitimize common codes and cognitive frames" facilitate the exchange of knowledge between organizations.[16] The relative ease with which knowledge flows within epistemic communities changes transaction costs and thus influences decisions about whether productive activities are to be done within the boundaries of a single organization or in looser "networks of practice."[17]

Members of several overlapping epistemic communities have managed the technologies that have facilitated the digitalization of retail banking over the last half-century. Turning back to Hong Kong, when the first computer was installed in 1963, the computer-literate population of the Crown Colony consisted of only a handful of individuals, several small pools of talent, each confined to just a few firms. Within each firm, the information and communication technology (ICT) professionals knew how to operate a single manufacturer's proprietary hardware and software. The managers who supervised these professionals had only the most rudimentary computer literacy. Digital systems for moving money were contained within the boundaries of individual banking firms. This meant, for instance, that teller terminals in bank branches could communicate and exchange information with a mainframe in the head office, but not with computers in other firms. In the 1970s, customers of a given Hong Kong bank could not use the cash dispensers of another bank. Over the next few decades, the epistemic community of ICT professionals would grow rapidly as the proportion of Hong Kong adults who were computer literate increased. As this epistemic community increased in depth (as the number of participants and diversity of specialties increased), the pools of knowledge expanded and extended across the boundaries of firms to include many individuals in a range of firms.

In the 1990s, firms as diverse as banks and public transportation companies worked together to develop the Octopus network, a payment system that has helped the people of Hong Kong reduce their use of cash. This system then grew while working in cooperation with companies such as convenience store and fast food restaurant chains. We believe that the interorganization cooperation represented by the Octopus system was facilitated by the prior emergence of two interfirm epistemic communities in Hong Kong: ICT professionals capable of communicating across firm boundaries and computer-literate managers capable of supervising their professionals and communicating with their counterparts in other firms. The growth of common industrial standards and interoperable systems that contributed to the firms' abilities to cooperate in the implementation of general-purpose computing technologies also enabled further progress in the transition toward a cashless economy in Hong Kong.

Episode 1: Internal Computerization

The first organization in Hong Kong to acquire a computer was China Light and Power (CLP), a local utility. It took delivery of an NCR315 system in late 1963 and then began experimenting with various applications of the technology. By 1965, CLP was sending its customers computer-generated bills.[18] The Crown Colony's second computer arrived at Hong Kong University in 1965.[19] As late as 1965, experience with computers in Hong Kong was confined to just these two organizations. There is no evidence that these two organizations cooperated on solving computer problems or otherwise formed a single epistemic community of knowledge and practice.

Hong Kong's banks became interested in computers largely in response to the rapid expansion of their customer base. In the 1950s and 1960s, the proportion of people in Hong Kong with bank accounts increased dramatically.[20] By the mid-1960s, there was roughly one bank account for every person in Hong Kong.[21] The growth of their retail basis posed major organizational and technological challenges for the colony's banks, which were forced to expand their retail branch networks.[22] The challenges were particularly acute at HSBC, the colony's largest bank. By early 1965, there were 31 HSBC retail branches and sub-branches in Hong Kong.[23] With growing numbers of customers, keeping track of balances became a cumbersome administrative process. Speaking of this period, a retired HSBC executive later recalled that, in some retail branches, the staff were required to stay at work "till ten, eleven o'clock at night a week at a time" to do all of the relevant calculations. He also remembered that these long hours cost the bank significant sums in overtime labor.[24]

To handle its rapidly growing number of transactions, the bank turned to mechanization and later computerization, among other things.[25] In the 1950s, HSBC decided to replace traditional ledgers with the new National Cash Register (NCR) Post-Tronic system for keeping track of customer accounts.[26] HSBC's managers appear to have become aware of the importance of computers to banking at an internal conference in 1958 where they discussed an NCR brochure about bank automation.[27]

HSBC adopted computers under the leadership of Sir John Anthony Holt Saunders (1917–2002), who is shown in Figure 1.[28,29] As chief executive of the bank between 1962 and 1972, Saunders came to regard computerization as vital to the bank's future. Saunders's interest seems to have developed after a visit to the United States in the mid-1960s, where he met with US bank presidents. During his visit, Saunders was repeatedly asked about HSBC's use of computers but was unable to say much in response to these enquiries because HSBC did not yet have any computers. Saunders returned to Hong Kong convinced of the need to keep pace with US banks.[30] It should be noted that HSBC had recently expanded into the US market and was also facing increasing competition in Asia from Chase Manhattan, a US bank.[31]

Figure 1. Sir John Anthony Holt ("Jake") Saunders, 1917–2002. Saunders was chief executive of HSBC between 1962 and 1972 and chairman from 1964 to 1972. (Image was sourced from Wikimedia Commons[29])

Saunders appears to have known little about computers, which he referred to as "bloody things."[32] Nevertheless, he understood that computers were important and was willing to authorize considerable expenditure on them. Given his unfamiliarity with this unpredictable new product, it is not surprising that computerization at HSBC during Saunders's tenure as CEO took place exclusively within the firm's boundaries. In order to learn more about which computer technology to adopt, Saunders set up a Methods & Research (M&R) unit to study the use of computer technologies;[33] this much the same approach as large British banks at the time.[34] In 1964, Saunders assigned the task of supervising computerization to Norman Howard Talbot Bennett (born 1921).

Bennett, who was four years younger than Saunders, knew only slightly more about computers. He had begun his career with Barclays Bank in London and in 1946 joined HSBC, where he then held a number of posts in India, Hong Kong, Singapore, and Thailand over the next two decades. Bennett supervised the M&R team that negotiated the bank's first contract with IBM in December 1965.[35] Bennett had left the United Kingdom before the British banking industry began introducing electronic computers in the late 1950s, so he had been isolated from these developments. It is likely that in 1964, when Bennett was given responsibility for managing HSBC's adoption of computers, he had never seen an actual computer, as he had spent the last two decades living in developing countries in which this technology had yet to arrive. Moreover, Bennett also lacked any formal training in any of the academic disciplines that might have

Figure 2. HSBC advertisement showing a woman and computer (circa 1970). (Image courtesy of HSBC Archives)

Figure 3. Customer at an HSBC ATM, 1975. (Image courtesy of HSBC Archives)

prepared him for work with calculating devices, such as mathematics or engineering. Thus, while some British bankers were acquiring enough knowledge of computers to move into the epistemic community of "the computer literate," Bennett was well outside the admittedly nebulous boundary of this social category.

Bennett's formal title changed several times: in the four years after 1964, he was successively controller with special duties, chief manager's assistant, and then assistant to the chairman. Regardless of the changes in his title, his basic function remained the same; between 1964 and 1970, Bennett's focus was on managing computerization. It appears that Bennett's main source of information about computers was a friend who worked for the National Westminster Bank, a British domestic bank that had already migrated several administrative tasks to computers.[30] Bennett's conversations with his friend, which likely took place during a holiday in the United Kingdom, appear to have represented the extent of his education with computer technology prior to his 1964 appointment.

In Bennett's view, the first major benefits HSBC derived from computerization came from the December 1965 decision to link terminals in each branch to an IBM 360 computer in the headquarters via telephone lines. This important decision permitted real time online account management. HSBC was not the first bank to link computers in branches via telephone lines; a similar system had been adopted in 1961 by the Bowery Savings Bank in New York City. IBM's Robert Osborn, a leading figure in the development of real-time computer systems, visited IBM's Hong Kong office and met with Bennett and other HSBC staff in May 1965.[36] HSBC executives were also aware that a consortium of New Zealand banks called Databank Systems was working on a real-time system. Bennett flew to New Zealand and interviewed Databank CEO Gordon Hogg in the course of planning HSBC's network.[37] The Databank System went live in 1967, the same year the IBM mainframes were installed in HSBC's headquarters and linked to terminals in its branches.[38] Figures 2 and 3 go on to show how the bank displayed its new technological acquisitions while trying to portray an image of a "modern" and innovative financial institution.

During the process of adoption and as it often did with other customers, IBM sent technical advisors to HSBC to help with teething problems during the installation.[39] For instance, IBM's staff helped HSBC select promising clerical employees (many of whom were refugees from mainland China without secondary education) for training as computer programmers. IBM staff then helped to deliver the training needed to convert clerks into programmers. Bennett opined in 1980 that retraining of existing HSBC employees as programmers was important for HSBC's computerization drive.[39,40] Instrumental to its success, however, was also the hiring of three experienced personnel from the UK: the electronic data processing (EDP) manager, chief analyst, and chief programmer who nurtured and led the inexperienced local staff to complete the project.[41]

The Market Thickens in Hong Kong, 1970s–1990s

HSBC adopted computers in the late 1960s and early 1970s primarily as a way to more effectively manage its growing number of savings accounts. Bennett recollected that, while computerization had not deprived any HSBC worker of a livelihood, it had allowed the bank to reduce overtime costs and direct employees' energies toward more profitable activities.[24] At that point, the computer-literate population of Hong Kong consisted primarily, if not exclusively, of workers who had been trained to use a single proprietary system.

Over the course of the next several decades, the level of knowledge about computers within and around Hong Kong's banks rose significantly. By the 1980s, many highly educated people were familiar with both the fundamental principles of computing and a variety of hardware and software products. The markets for computer technology and computer expertise were much thicker, which permitted outsourcing and vertical disintegration. The technology also became less expensive and better understood.

To adopt Håkanson's terminology, an epistemic community that included ICT professionals and managers in many Hong Kong firms had been formed. Higher-education institutions played an important role in the creation of this interfirm epistemic community by training young people with general computer skills. They helped produce large numbers of computer science graduates who could be employed by firms to help them to understand and manage these technologies, which no longer seemed exotic. For instance, the University of Hong Kong (UHK), an English-language institution, offered instruction in computers to students in a variety of disciplines from 1967 onward using an IBM 1620.[42] In 1968, the Chinese University of Hong Kong (CUHK) began offering courses in computer programming. The CUHK established a full-fledged Department of Computer Science in 1973 and began offering a degree in computer science in 1978 (https://www.cse.cuhk.edu.hk/v7/en/about/dept.html). In 1970, UHK and CUHK began interorganization cooperation in computing with the establishment of the Joint Universities Computer Centre (JUCC). Computer lessons became part of the secondary school curriculum in the early 1980s.[43]

Established in 1970 through the cooperative efforts of HSBC, IBM, and other large companies,[44] the Hong Kong Computer Society (HKCS) also helped to create an epistemic community of ICT professionals that extended across firm boundaries. In 1970, two HSBC executives, including J.P. Rastello, the manager of the bank's data-processing center, served on the HKSC board.[44] Many of the HKCS founders were expatriates, although it soon acquired a large number of Chinese members.[45] HKCS took steps to promote greater awareness of computers by the other specialists and the general public. For instance, in 1970, Rastello publicly declared that Hong Kong urgently needed more computer programmers and urged cooperation among various stakeholders to achieve this goal.[46] Echoing Rastello's sentiment and in direct response to increased demand for knowledge about computers in Hong Kong, HKSC began publishing a newsletter. In 1974, HKCS formed a Computer Audit Club with the Hong Kong Society of Accountants.[47] After 1978, HKSC actively facilitated the exchange of knowledge about computers between individuals in different firms and other organizations through an annual convention.

Over the course of the 1970s, a growing number of firms and individuals in a variety of Hong Kong industries began using computers, either by purchasing their own devices or contracting the work out to computer service bureaus. The latter appeared as early as 1970 when HSBC and Standard Chartered began to offer these services to their business customers.[48] The middle years of the decade appear to have been an inflection point for the development of epistemic communities of ICT professionals and computer-literature managers in Hong Kong. A study by Eric Kwong-kay Lo on the number of computers deployed across Hong Kong's industries in the mid-1970s estimated that the number of computers in use in Hong Kong's large businesses increased from 119 at the end of 1975 to 266 at the end of 1977.[49] The same study also suggested that the adoption of computers did not occur at a uniform rate in all sectors of the colony's economy. In banking and public utilities, which had adopted computers in the 1960s, the annual rate of increase in the number of computers was modest compared with that in the ship construction, chemical, and architectural sectors, where firms acquired computers at a much higher rate between 1975 and 1977. Lo's study implies that small retail establishments

Launched in 1997, Octopus rapidly grew to become the preferred micropayments solution in Hong Kong.

and restaurants in Hong Kong did not experience any computerization during this time.

Verifying Lo's estimates of computer penetration levels is difficult because Hong Kong's government generated few statistics about computer sales or usage during this period.[50] As a result, we cannot systematically compare the competitiveness of the colony's ICT markets across time or with those of other jurisdictions. Anecdotal evidence, however, allows us to infer that Hong Kong's market for computer components became highly competitive in the 1980s. For instance, in 1984, Hong Kong had a thriving market for legitimate and pirate computer components for Apple II and IBM PC systems.[50] We know that the number of computer vendors increased dramatically in Hong Kong during the 1980s, when specialized shopping districts for computer components emerged. The most important of these was the area that came to be known as the Mongkok Computer Centre.[51] At the same time, Hong Kong's Golden Arcade emerged as a center for PC-clone distributors and software vendors.[52] In a 1992 article about the Golden Arcade, a *South China Morning Post* reporter noted the intensively competitive nature of the market, which was characterized as a "Darwinian bloodfest… [where] competition is cut-throat and margins razor-thin."[53] This colorful language indicates that markets had become quite thick. By 1990, Hong Kong's Trade Development Council discussed "the increasing commoditization of personal computers, peripherals and even facsimile machines."[54]

All of these developments in Hong Kong were, of course, influenced by global developments in the broader ICT field.[55] During this period, the epistemic communities that worked with computers underwent changes that correspond to the processes of articulation and replication identified by Håkanson. These developments facilitated the shift in the way in which retail banking technology was operationalized in Hong Kong—the entire process was no longer done within the boundaries of a single firm. This new approach is exemplified by the Octopus system.

Episode 2: The Octopus System

By the 1990s, computers were a fact of life in firms in many Hong Kong industries. The interfirm network known as the Octopus system emerged in this context. Launched in 1997, Octopus rapidly grew to become the preferred micropayments solution in Hong Kong. Many consider the Octopus's success a decisive step in the colony's transition to a cashless economy.[56]

The Origins of Octopus

Much like retail banks, public transportation organizations face the problem of dealing with a high volume of standardized transactions. Early computer systems were inadequate for such tasks.[57] This limitation was overcome with the development of Tandem's so-called "nonstop computing" and of fault-resilient systems by other manufacturers during the 1980s. Prior to the advent of such systems, transportation authorities in many countries had attempted to automate fare collection by using cardboard tickets with a magnetic stripe.[58] In Hong Kong, a magnetic-stripe ticketing system was introduced in 1979 on the Mass Transport Railway (MTR) Corporation's subway network.[59] In 1983, the MTR introduced the common stored value ticket (CSVT) to supplement single journey passes. Regular commuters could purchase fixed-value magnetic-stripe cards that could be used until the balance on the card was depleted, thus allowing for multiple journeys with a single ticket. The CSVT both improved customer service and reduced the number of coins the company needed to handle.[60]

By the early 1990s, MTR's CSVT tickets could be also used on the Kowloon-Canton Railway (KCR), a separate company. Bus companies began adopting the system in 1989, giving customers another place to spend the balance stored on their CSVT ticket.[60,61]

Octopus System Development

In 1992, MTR executives began searching for a replacement to the CSVT system, which had technical problems that included a fault rate of one in every 2,500 transactions.[62] These faults were costly in a system handling approximately 2 million transactions a day. Chip-based card technology appeared to be an attractive alternative. France Telecom had pioneered the commercial use of this technology in the 1980s.[63] This near-field technology[64] offered ease of use and speed, fulfilling transactions within 300 ms without having to actually touch readers.[65] Transactions were accurate, and there were safeguards against fraud. End-of-day account settlement also reduced human counting errors and bank settlement time.

The MTR executives decided that it made sense to introduce the new solution across the public transportation systems (ferries, trains, subway, taxis, buses, mini-buses, and trams) operated by different companies.[66] However, this plan required bringing together competing transportation operators to collaborate on a single payment scheme. In other words, a precondition of Octopus was establishing a community that cooperated across firm boundaries to articulate a common payment standard. Octopus was possible because interfirm epistemic communities of ICT professionals and computer-literate managers with a common terminology and references had emerged in Hong Kong by this point.

In 1994, five major public transportation operators—the rail lines MTR and KCRC, the bus companies KMB and Citybus, and the Hongkong and Yaumatei Ferry (HYF)—established a joint venture called Creative Star Limited to oversee the contactless smartcard system's development and implementation.[65] The venture was renamed Octopus Cards Limited in 2002 (henceforth Octopus). This "organizational and governance structure… gave all players (no matter how small) a very significant say" in the development of the payment solution.[66] Professional service provider PricewaterhouseCoopers (PwC) helped to design the governance structure. PwC also acted as intermediary between the banks, who transferred critical technical knowledge to Octopus that allowed the new network to be linked back to the preestablished payment ecosystem. For consumers, this meant that funds could be transferred easily and electronically from bank accounts to Octopus cards.

The Octopus card debuted in 1997 (see Figure 4[67]). The hardware was partially purchased off the shelf and partly developed in house. For instance, while Octopus adopted Sony's smartcard technology, it developed most of its terminals in house.[59] The software also resulted from a combination of in-house

Figure 4. Octopus chip reader used for public transportation. (Image was sourced from Wikimedia Commons[67])

Figure 5. Vending machine activated by Octopus chip. (Image was sourced from Wikimedia Commons[69])

development and ready-made packages. Rail and underground passengers already accustomed to stored-value cards with the CSVT readily accepted the new payment solution.[68] In 2000, the owners of Hong Kong's 6 million Octopus chips acquired the ability to use them on 4,100 buses owned by small and big operators. This extension of the payment network was followed by acceptance by the 600 or so companies running mini-buses.

Figure 6. Access to apartment building activated by Octopus chip. (Image was sourced from Wikimedia Commons[73])

Market Expansion

In yet another sign of articulation across firms, Octopus-compatible readers later began to the connected to machines owned by companies that were not part of the consortium that had created the Octopus system. For example, vending machines inside stations and then shops and restaurants allowed users to spend the balances stored on the Octopus cards on products other than transportation (see Figure 5[69]). In 2002, Octopus payments for nontransport uses amounted to HK$1.1 billion, or 6 percent of all Octopus transactions. By 2010, Octopus payments for nontransport had risen to HK$15 billion, or 61 percent of all Octopus transactions.[70]

By 2011 there were 5,000 readers deployed by 3,000 different merchants accepting payment through Octopus.[70] In that year, there were 23 million Octopus chips in circulation. On average, each card was used 11 times a day, with the average value per transaction of $HK9.00 (approximately US$1.16).[71] Moreover, each card's unique identifier enabled its use as a personal identification device. Designated individuals could thus use their cards to activate elevators in the lobby of the International Financial Centre, book and pay for public tennis courts and swimming pools, and even enter a keyless private residence[72] (see Figure 6[73]).

Conclusion

The introduction of computer technologies in Hong Kong in the 1960s was largely done within the boundaries of firms. That is, executives at firms such as HSBC decided not to develop cooperative networks involving other banks. One benefit of this approach was that it increased a bank's degree of self-reliance. HSBC's approach was influenced by the fact the relevant markets for computer components and ICT skills were then thin in Hong Kong. Moreover, although managers in Hong Kong financial institutions anticipated that computers were important, they were unfamiliar with the technology, which was novel, expensive, and poorly understood by managers, most of whom had grown to adulthood before World War II.

By the 1980s and 1990s, the situation in Hong Kong had changed and now permitted subcontracting and extensive outsourcing. By this point, the local markets for computer technology and computer expertise were much thicker. The storage and processing capacity of computers had grown exponentially while, at the same time, they had become much cheaper (in nominal prices). Moreover, the human capital needed to effect this transition became less scarce, thanks in part of the advent of computer science courses in Hong Kong universities.

By this time, the epistemic community of ICT professionals included individuals working in a range of Hong Kong firms. These developments facilitated the shift in the way in which retail banking technology was operationalized in Hong Kong. The industrial organization of cashless payment technology in Hong Kong changed in part because of the growing size of the relevant epistemic community. By the 1990s, the epistemic community in question had expanded to include individuals in a variety of nonfinancial companies, most notably public transportation operators. The creation of this epistemic community was, as we have shown here, a precondition of the success of the Octopus payment system.

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