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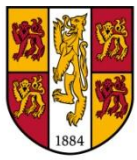

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FROM HIERARCHY TO MARKET: THE CHANGING INDUSTRIAL ORGANIZATION OF EPISTEMIC COMMUNITIES DURING HONG KONG'S TRANSITION TO A CASHLESS SOCIETY (1965-2005)

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Abstract

This paper documents how computer technology modified retail financial markets in Hong Kong in the period from the 1960s to the early 2000s. The forty years after the deployment of Hon Kong's first computer in 1965, saw a dramatic change in retail banking technology as Hong Kong moved towards being a cashless society. Prior to that pivotal year, none of the colony's banks used computers whilst retail customers accessed their liquid balances via cash and cheques and only during banking hours. Over time, the ways in which people spent money became more diverse and transformed with the advent of technologies such as the ATM, point of purchase debit card terminals, the Octopus chip, and mobile phone payments. One could construct a straightforward narrative arc that links the acquisition of HSBC's first computer in 1967 to the proliferation of electronic payment systems in the twenty-first century. Such a narrative, however, would obscure an important discontinuity in the history of retail payment technology. In the early stages of Hong Kong's transition to the cashless society, the relevant technologies were installed and managed within the boundaries of large financial intuitions such as HSBC. The second episode discussed in this paper is the successful launch of a micro-payments solution called "Octopus". Initially designed as a transport payments card, cash balances stored within a smart chip grew outside financial institutions to become the leading payment solution in small value transactions. Over the course of the period covered by this article, the industrial organization of the relevant technologies transformed as the provision of much of the technology for retail payments had been outsourced to non-bank, non-financial institutions. In other words, the industrial organization of the relevant technologies had been transformed. This paper seeks to account for this shift in the organization of payments technology by drawing on literature around the boundaries of the firm as well as the theory of the firm as an epistemic community. It will be suggested that this process of vertical disintegration (i.e., a shift from hierarchy to markets) took place because of changes in the underlying conditions in Hong Kong's economy.

Keywords: cashless, computers, contactless payments, HSBC, Octopus, Hong Kong

JEL codes: E42, L63, N85, N25.

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From Hierarchy to Market: the Changing Industrial Organization of Epistemic Communities During Hong Kong's Transition to a Cashless Society (1965-2005)

1. Introduction

Although historians have published extensively on computerisation in European and North American banks during the late 20th century[1] little has been documented on the computerisation of East Asian financial institutions.[2] This article helps to fill this lacuna by exploring how Hong Kong has remained at the forefront of the worldwide transition to a cashless society. The term "cashless society" was coined in the United States in the mid-1950s to describe a future state of the economy in which a system of electronic transactions replaced the use of coins, cheques, and banknotes as media of exchange.[3] Since that time, the world's advanced economies have all moved in this direction, albeit at different speeds. Although initially Hong Kong banks lagged slightly behind their American and British peers in computerisation 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, visionary bank executives in Hong Kong were discussing the possibility of transition to a cashless society. Today, Hong Kong is not fully a cashless economy. Indeed no jurisdiction has completely forgone cash and coins as means of payment. However, Hong Kong has one of the world's most advanced systems of cashless payments, the chip-based payment scheme known as "Octopus".

This article will discuss the history of retail banking technology in Hong Kong from the 1960s to the present. It will show that the organizations that structured the transition to the cashless society were transformed during this period. During the early phases of transition, the relevant technological innovations took place largely *within the boundaries of*

[1] Bátiz-Lazo, B., 2009. Emergence and Evolution of ATM networks in the UK, 1967-2000. Business History 51, 1-27, McKenney, J.L., A.W. Fisher, 1993. Manufacturing the ERMA Banking System: Lessons from History. IEEE Annals of the History of Computing 15, 7-26, McKenney, J.L., R.O. Mason, D.G. Copeland, 1997. Bank of America: The Crest and Trough of Technological Leadership. MIS Quarterly 21, 321-354.Pardo-Guerra, J.P., 2011. The Automated House: The Digitalization of the London Stock Exchange, 1955-1990, in: Bátiz-Lazo, B., Maixé-Altés, J.C., Thomes, P. (Eds.), Technological Innovation in Retail Finance: International Historical Perspectives. (Routledge, London and New York), pp. 197-220, Stearns, D.L., 2011. Electronic Value Exchange: Origins of the VISA Electronic Payment System. (Springer, London).Bátiz-Lazo, B., P. Wardley, 2007. Banking on Change: Information Systems and Technologies in UK High Street Banking, 1919-1969. Financial History Review 14, 177-205, Booth, A.E., 2001. British Retail Banks, 1955-70: A Case of 'Americanisation'?, in: Kipping, M., Tirasoo, N. (Eds.), Americanisation in Twentieth Century Europe: Business, Culture, Politics. (Université Charles de Gaulle, Lille), pp. 309-323 , Booth, A.E., 2007. The Management of Technical Change: Automation in the U.K. and U.S.A. since 1950. (Palgrave, Basingstoke), Martin, I., 2012. Too Far Ahead of its Time: Barclays, Burroughs and Real-Time Banking. IEEE Annals of the History of Computing 34, 2-16, Wardley, P., 2000. The Commercial Banking Industry and its Part in the Emergence and Consolidation of the Corporate Economy in Britain before 1940. Journal of Industrial History 3, 71-97.

[2] Batiz-Lazo, Bernardo, Joan Carles Maixé Altés, and Paul Thomes, *Technological Innovation in Retail Finance international historical perspectives* (New York: Routledge, 2011).

[3] Bernardo Bátiz-Lazo, Thomas Haigh, and David L. Stearns, "How the Future Shaped the Past: The Case of the Cashless Society," *Enterprise and Society* (2014): 15(1), pp. 103-131.

large, Chandlerian corporations. During the more recent periods, interfirm networks became more important. This article compares and contrasts the "internal" deployment of early computers (at HSBC) in the pursuit of economies of scale in the 1960s and 1970s; with the "external" (i.e. non-bank or market) use of computers in micro-payments (Octopus chip) in the 1990s and 2000s. These two episodes reflect how, initially the adoption of computer technology in retail financial markets involved the deployment of large computer systems and was thus predominantly the remit of large financial intermediaries, such as commercial banks. More recently, non-financial intermediaries have taken the lead in the innovative use of computer technology to enhance the payment system. This dramatic change in the nature of the organisations responsible for Hong Kong's transition towards the ideal of a cashless society reflected broader changes in the nature of business that took place in the late twentieth century, namely, the diminishing importance of "Big Business" in advanced economies. Moreover, the shift in the types of institutions used to structure Hong Kong's payment system reflected changes in the nature of the knowledge related to computers.

In this paper, we draw on both traditional transaction-cost economics and the knowledge-based theory of the firm developed by Lars Håkanson in his work on the firm as an "epistemic community" to frame our discussion. We see the nature of the organizations that supervised Hong Kong's transition towards a cashless society as driven by three major factors. First, the falling costs of the relevant technology allowed firms with less capital and liquid resources to begin participating in the process. Second, bankers and other epistemic communities became more familiar with computers and thus more willing to rely on the market for solutions rather than keeping the process in-house. Third, outsourcing took place because the markets for computer technology and the related types of skilled labour became "thicker" in Hong Kong. The increasing thickness of markets is generally regarded as one reason why firms may wish to dis-integrate vertically and adopt other models for coordinating production because thick markets make firms less susceptible to the so-called "hold up" problem.[4]

In what follows this article's focus on the early phases of the transition to a cashless society are based on materials in the corporate archives of the Hong Kong and Shanghai Bank (HSBC). In preparing this section of the paper, we drew on contemporary secondary sources while looking for the informational, economic and organizational forces that

[4] Yeon-Koo Che and József Sákovics, "Hold-up Problem," *The New Palgrave Dictionary of Economics*. Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan, 2008. http://www.dictionaryofeconomics.com/article?id=pde2008_H000171> doi:10.1057/9780230226203.0743

influenced the adoption of computer technology. The latter sections of the paper deal with more recent historical periods and are based on oral histories of people intimately involved in the construction of the Octopus scheme.

2. The Industrial Economy of Big Business

This paper engages with the debate on the impact of technology and in particular the effects of the appropriation of computers on the structure and nature of "Big Business". The importance of technological change and particularly applications of computer technology to our understanding of the origins and evolution of the capitalist organization is integral to the study of business since the early 1990s.[5] The early phases of Hong Kong's transition to the cashless society in the 1960s and early 1970s coincided with the apogee of "Big Business", that is, the large vertically integrated corporations described by Alfred Chandler that had displaced other forms of economic organization, such as reliance on the market and looser networks.[6] Although much of the literature discussed focuses on the experience of business in the United States, the same basic forces were at work in other capitalist countries as well. However, Chandler's model became less functional after the 1970s corresponds with this paper's account of the technological changes associated with Hong Kong's transition to a cashless society.

Chandler attributed the success of the US economy in the twentieth century to the rise of large, vertically-integrated, managerially directed corporations in that country's most important and technologically advanced industries. The sheer efficiency of this form of enterprise ensured that the U.S. firms that adopted this model were able to out-compete domestic and international rivals that used other models of organization. In other words, substituting the visible hand of managerial hierarchies was superior to relying on looser networks and the invisible hand of the market as a coordinating mechanism.

The interpretative framework advanced by Chandler did an adequate job of accounting for structure of the US and international economies in the 1960s and 1970s. However, in the 1980s and 1990s, the firms described by Chandler were challenged by domestic and overseas competitors that were smaller, more specialized, and, crucially,

[5] Robert R. Locke and Katja E. Schöne, *The Entrepreneurial Shift: Americanization in European High-Technology Management Education*, Cambridge 2004; Howard Cox/Simon Mowatt, *Technological Change and Forms of Innovation in Consumer Magazine Publishing: A UK-Based Study*, in: Technology Analysis & Strategic Management (2008), 503-520; Howard Cox and Simon Mowatt, *Strategy and Innovation: The History of the UK Magazine Publishing Industry, 1750-2010*, Oxford forthcoming; Paul J. Miranti, *Probability Theory and the Challenge of Sustaining Innovation: Traffic Management at the Bell System, 1900-1920* in: Sally H. Clarke et al. (eds.), The Challenge of Remaining Innovative: Insights from Twentieth Century American Business, Palo Alto 2009, 114-131; Richard Coopey, *Information and Technology Policy: An International History*, Oxford 2004; Martin Campbell-Kelly, *ICL - a Business & Technical History*, Oxford 1989; JoAnne Yates, *Structuring the Information Age*, Baltimore 2005; Thomas W. Malone et al., *Electronic Markets and Electronic Hierarchies*, in: Communications of the ACM (1987), 484-497.

[6] Alfred D. Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass: Belknap Press, 1977).

vertically disintegrated. Large "Chandlerian" firms could no longer be regarded as normative by observers of business in the United States and other capitalist economies. The surviving Chandlerian firms in turn sought to improve their competitiveness in this new environment by refocusing resources on their "core" businesses, reversing vertical integration, and reducing significantly the range of economic activity subject to non-market (i.e., managerial coordination).

By the early twenty-first century, many business scholars recognized that a new interpretative framework was needed.[7] Such a framework would have to be able to explain both the rise of "Big Business" and the post-1970s decline of the Chandlerian corporation. In the field of the business history, one major interpretative framework for understanding the rise and (relative) fall of "Big Business" was formulated by Naomi Lamoreaux, Daniel Raff, and Peter Temin, who drew on the transaction-cost approach advanced by Oliver Williamson. Writing in the 1970s, Williamson accounted for the rise of the vertically-integrated Chandlerian firm as an attempt to reduce transaction costs. Following Williamson, economists of Industrial Organization have developed a conceptual explanation for why growing market thickness would encourage vertical disintegration.[8] In tandem with the growth of conceptual explanations, empirical support for transaction-cost economics has been accumulated thanks to systematic studies by scholars studying a wide range of countries, time periods, and industries ranging from road haulage to airlines to manufacturing.[9] Drawing on transaction-cost analysis, Lamoreaux *et al.* regard the Chandlerian company not as the final point of a teleological development but as simply one option out of an array of possible organizational structures. They stress that the frequency with which this form will be used in a given population of companies is subject to change in either direction, and that the equilibrium is unlikely to remain constant for long. They also show that between the polar extremes of "market" and "hierarchy," there are many intermediate or hybrid forms. They suggest that the Chanderlian firm was functional in the period between the late nineteenth century to the 1970s.[10] Since the 1970s, however, a combination of technological, political,

[7] See for instance the discussion (and references therein) about Chandler vs. the resource-based view of the firm in John F. Wilson and Andrew Thomson *The Making of Modern Management* (Oxford: Oxford University Press, 2010).
[8] Oliver E. Williamson, *Markets and Hierarchies, Analysis and Antitrust Implications: A Study in the Economics of Internal Organization* (New York: Free Press, 1975).
[9] Thomas N. Hubbard, "Contractual form and market thickness in trucking," *RAND Journal of Economics* (2001): 369-386; Liza Jabbour,"Market thickness, sunk costs, productivity, and the outsourcing decision: an empirical analysis of manufacturing firms in France," *Canadian Journal of Economics/Revue canadienne d'économique* 46, no. 1 (2013): 103-134.
[10] It is interesting to note that the discussion on "spans of control" reaches a peak around this period. See N-Gram View http://ow.ly/zgDK7 (we appreciate Adrian Tschoegl pointing us in this direction).

legal, and social forces have led to the displacement of the large vertically-integrated firm in many areas of the economy by structures that are closer to the market pole of the spectrum. [11]

Transaction-cost economics provides one way of accounting for the very existence of firms and differences in the extent to which markets and hierarchies are used to coordinate production in capitalist economies. Another perspective, which is now correctly seen as a complement rather than a rival to transaction-cost economics, is the so-called knowledge-based view of the firm. This viewpoint is based on insights present in Edith Penrose[12] and then elaborated by authors such as Nelson and Winter,[13] Bruce Kogut and Udo Zander,[14] Richard Langlois and Paul Robertson, [15] and Nicolai Foss.[16] This viewpoint argues that the superiority of firms to markets in certain contexts stems primarily not from their ability to reduce transaction costs but in the capacity of firms to manage the different types of tacit and codified knowledge. According to this theory, a crucial issue in determining the boundaries of the firm is the degree to which the processes need for the integration and combination of unarticulated and uncodified knowledge. In other words, when the relevant bodies of knowledge are not yet codified and not yet articulated, we can expect to see managers substitute the hierarchical structures characteristic of a firm for arms-length transactions through markets. This state of affairs corresponds to the infancy of a new area of technology, such as the automotive assembly circa 1910 or the application of computers to banking in the 1960s.

Richard Langlois's explanation for the post-1970s decline in the popularity of the Chandlerian model is broadly similar to that of Lamoureaux *et al.* However, Langlois suggests that Lamoureaux *et al.*'s explanation is simplistic in that they believe that one can account for the rise and fall of different organizational forms "largely if not entirely as a response to incentive problems created by asymmetric information."[17] According to Langlois, asymmetrical information is only one of several factors at work. Working with Paul Robertson, Langlois developed an evolutionary theory that encompassed markets,

[11] Naomi R. Lamoreaux, Daniel MG Raff, and Peter Temin, *Beyond markets and hierarchies: toward a new synthesis of American business history*. No. w9029. National Bureau of Economic Research, 2002.
[12] Edith Tilton Penrose, *The Theory of the Growth of the Firm* (New York: Wiley & Sons, 1959).
[13] Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change*. Cambridge, Mass: Belknap Press of Harvard University Press, 1982.
[14] Bruce Kogut and Udo Zander, "Knowledge of the firm, combinative capabilities, and the replication of technology." *Organization science* 3, no. 3 (1992): 383-397
[15] Richard N. Langlois, and Paul L. Robertson, *Firms, markets and economic change: A dynamic theory of business institutions* (London: Routledge, 2002).
[16] Nicolai J. Foss, "The use of knowledge in firms." *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*(1999): 458-486; Nicolai J. Foss, "'Coase vs Hayek': Economic Organization and the Knowledge Economy." *International Journal of the Economics of Business* 9, no. 1 (2002): 9-35..
[17] Richard N. Langlois, "Chandler in a larger frame: markets, transaction costs, and organizational form in history," *Enterprise and Society* 5, no. 3 (2004): 355-375.

hierarchies, and the various intermediate hybrid forms that exist between these two polar opposite styles of economic organization. Their evolutionary theory stresses that in industries characterized by rapid economic change, the individuals who take "make or buy" decisions are themselves often uncertain how to go about performing a given production process.[18] To illustrate how a manager's uncertainty about how to manage an emerging technology might influence decisions about vertical integration and disintegration, Langlois used the example of Henry Ford, who simultaneously integrated backwards into the production of automotive components when he pioneered the assembly line.

According to Langlois, Henry Ford dispensed with his independent suppliers because he "needed to invent fast and cheap ways to make parts." Ford vertically integrated because it cost Ford less "to make the parts himself than to try to manipulate a grossly ill-adapted supplier network... Ford did not request teach his suppliers the techniques of mass production and then buy from them because he could not teach them what he did not yet know."[19] In Langlois's account, the key factor influencing Ford's decision to integrate backwards into the production of parts was not fear that suppliers might hold him to ransom or default on their contracts. Rather, it was that he was working on the technological frontier and did not yet know precisely how he was a going use a novel technology (i.e., the assembly line) that he knew was important.

In confronting the first generations of retail banking computer technology, HSBC's managers were in a situation similar to the predicament of Henry Ford that Langlois describes in the course of explaining why Ford decided to make radiators in-house. By the 1980s and 1990s, markets for computer technology and computer expertise were much thicker, which permitted outsourcing and vertical disintegration. Moreover, the technology was much less expensive and was better understood. Universities in Hong Kong and elsewhere were producing 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. These developments facilitated the shift in the way in which retail banking technology was operationalized in Hong Kong: no longer was the entire process done within the boundaries of a single firm, now looser networks were used. This new approach was exemplified by the Octopus system.

[18] Richard N. Langlois, and Paul L. Robertson, *Firms, markets and economic change: A dynamic theory of business institutions* (London: Routledge, 2002).
[19] Langlois, Richard N. "Chandler in a larger frame: markets, transaction costs, and organizational form in history." *Enterprise and Society* 5, no. 3 (2004): 355-375, p.6

Combining the insights of Langlois and other proponents of the knowledge-based view of the firm with Burkart Holzner's work on the sociology of knowledge,[20] Lars Håkanson has developed a theory of the firm as an "epistemic community." Håkanson's key concepts include *articulation*, the process by which tacit knowledge related to production is converted into explicit standards, theory, and tools (e.g., operating manuals or blueprints that can be shared with other firms). Articulation involved standardization and the development of a common vocabulary precise enough to permit cooperation across the boundaries of organizations (e.g., intra-firm and international consensus about the exact physical characteristics of what precisely constitutes a credit card). Although it is impossible to have extensive outsourcing or vertical disintegration without articulation, the processes that fall into the category of articulation facilitate the division of labour between firms as well as within firms. Linked to articulation in Håkanson's schema is *replication*, which involves the transfer of knowledge and capabilities between firms. For instance, Southwest Airlines adopting the turnaround processes used during pit stops by Formula One racing teams to reduce from 40 to 12 minutes the time to refuel an airplane.[21] In Håkanson 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 artefacts, such as blueprints or components."[22]

The transaction-cost economics and knowledge-based theory of the firm perspectives on the rise and fall of the Chandlerian corporation are largely congruent. It might seem, therefore, that it is pointless for business historians to try to determine which framework does a better job of allowing us to understand the institutions that govern Hong Kong's transition towards cashlessness. However, we believe that Håkanson's perspective is more comprehensive and does a better job of capturing the challenges facing managers tasked with figure out how to use a new technology. As will be evident below, HSBC's managers in the 1960s and 1970s were in a position similar to that of Henry Ford in 1910 in that they knew the novel technology of computers would be very important for the bank's future but they did not know about these devices. HSBC's managers behaved exactly as Langlois's theory would predict: in the 1960s and 1970s, the introduction of the technologies involved in Hong

[20]Holzner Burkart and Leslie Salmon-Cox, "Conceptions of research and development for education in the United States,"*The ANNALS of the American Academy of Political and Social Science* 434, no. 1 (1977): 88-100.
[21] "Lateral Benchmarking", *Management Today*, (01-Nov-1997) http://ow.ly/zaKAD (accessed 15-Jul-2014).
[22] Lars Håkanson,, "The firm as an epistemic community: the knowledge-based view revisited,"," *Industrial and Corporate Change* vol. 19, no. 6 (2010), 1814.

Kong's transition to a cashless society was largely done "in-house" and within the boundaries of a single firm that happened to the colony's largest bank. This approach was dictated by three facts: first, the relevant markets were quite thin in Hong Kong and other markets. By relevant market, we mean the markets for computers and the specialized skills needed to operate them. Second, computer technology in this period was new, very expensive, and only poorly understood by managers in most business organizations. Third, outsourcing took place because the markets for computer technology and the related types of skilled labour became "thicker" in Hong Kong. The increasing thickness of markets is generally regarded as one reason why firms may wish to dis-integrate vertically and adopt other models for coordinating production because thick markets make firms less susceptible to the so-called "hold up" problem.[23] The following section explores the evolution of these factors in greater detail.

3. Systemic Changes in the Field of Information Technology

This paper argues that there three main factors behind the transition in how the payment systems were organized in Hong Kong. These factors were the falling cost of computer technology, growing familiarity with computers within the epistemic communities known as banks, and the thickening of the markets for products and services related to IT. The simultaneous articulation and replication of computer knowledge by higher-education institutions and industrial standards organizations contributed to the transition by making it easier to dispense with the Chanlderian firm in favour of other organisational modes. Market thickness encourages vertical disintegration. In the computerisation of retail banking and payment systems in Hong Kong, the most relevant markets were: the international market for mainframe computer systems; the local market for components; and the local market for computer programming skills. All of these markets thickened in the period from the 1960s to the 1980s.

3.1. Falling Cost of Computer Technology

One of the best documented trends in recent economic history is the dramatic decline in the costs of computing technologies. This decline was evident in the United States and in all other capitalist countries trade with the United States, including Hong Kong. The falling cost of computing technologies has been driven, in part, by the relentless and well-

[23] Yeon-Koo Che and József Sákovics, "Hold-up Problem," *The New Palgrave Dictionary of Economics*. Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan, 2008. http://www.dictionaryofeconomics.com/article?id=pde2008_H000171> doi:10.1057/9780230226203.0743

documented fall in the cost of micro processing power. In 1965 Gordon E. Moore, who then worked for Fairchild Semiconductor, discovered the statistical relationship later dubbed Moore's Law. After reviewing the prices and specifications of memory chips that has been manufactured over the previous decade, he observed that each new chip contained roughly twice as many transistors as the previous generation.[24] Moore's prediction that this trend would continue into the foreseeable future was proved be correct in succeeding decades, thanks in part of the internationalization of chip production and the entry of many non-US firms into the sector.[25] At the same time, the so called "Kryder's Law" proposed that the density in magnetic disc storage was also increasing at an exponential rate. Together with the massification of other computer components, these help to explain how the cost fell in nominal and real terms between the 1960s and 1980s. Another major trend that made computerisation less expensive was the production of an increasing number of module computer parts: the advent of industrial standards agreed by the IEEE meant that it became easier to combine parts made by different manufacturers.

3.2. Growing Familiarity with Computers

Over the period between the 1960s to the 1980s, people in Hong Kong's financial services sector went from being unfamiliar with computers to being extremely familiar with this category of technology. When Tien Chi Chen, an IBM computer programmer, visited Hong Kong in 1962 most of the businesspeople, he met "did not have the faintest idea about what a computer was." In contrast, thousands of computers were already being used by businesses in North America and Asia. [26] The first Hong Kong company to acquire a computer was China Light and Power (CLP), a local utility.[27] In 1963, CLP sent two employees to London for training as programmers.[28] 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 computer-generated bills to its customers.[29] In all likelihood, these bills were the first-computer-generated documents most people in Hong Kong residents had ever seen. Hong Kong University acquired a computer in 1964.[30] Although it had been

[24] Dale W. Jorgenson, "Information technology and the US economy," *American Economic Review* 91, no. 1 (2001): 1-32
[25] E. Mollick, "Establishing Moore's Law," *IEEE Annals of the History of Computing* 28 (2006) no. 3: 62-75.
[26] Tien Chi Chen, "Preface" in Anthony O, *The Computer Age in Hong Kong: Dynamic Past, Hesitant Present, What Next?* (Hong Kong: Commercial Press, 2013), P.ii
[27] *South China Morning Post,* "Computer due on Thursday" 17 September 1963l *South China Morning Post,* "Versatile Computer" 18 August 1963.
[28] *South China Morning Post,* "Giant Computer to Start Work Soon." 14 August1963.
[29] O, *Computer Age in Hong Kong*, 6-7.
[30] *South China Morning Post,* "H.K. University's New Computer in Action." Mar 26, 1964,

purchased with a view to helping students, it was used most frequently by an engineering professor who engaged in private consulting work for architectural firms.[31]

In the 1970s, the Hong Kong business community's ability to understand computers was strengthened by several factors. For instance, until the 1960s, virtually all instruction in computers took place within firms: employees at companies such as IBM were trained to use the products manufactured by their employer. Teaching about computers in general and few universities offered any instruction in computers, notwithstanding the creation of an experimental computer science course at Columbia in 1946. In 1960, IBM was forced to set up the Manhattan Systems Research Institute to train its own employees to use their products. In the 1960s, computer science departments began to be established at American universities, starting with Purdue University in 1962.[32] These departments were then linked together in a full-fledged academic discipline. The decision of the Association for Computing Machinery in 1961 to create a special membership category for university students was connected to the increasing formalization of computer education.[33] Computer science textbooks for use in multiple universities were now published, which promoted to the use of the common vocabulary and concepts that Håkanson's theory suggests is essential for cooperation across the epistemic boundaries of firms. At the same time, computer components were starting to be standardized, a process that later facilitated the adoption of networks that linked multiple firms together. The standardization of computer parts between companies was coordinated by organizations such as the Institute of Electrical and Electronics Engineers. In 1990, Garth Saloner observed that whereas computer manufacturers had traditionally "provided a range of mutually incompatible systems" there had been a recent "trend towards an alternative paradigm in which there are no proprietary boundaries between the product offerings of different vendors. The goal of the proponents of so-called "open systems" is to provide non-proprietary standards specifying how the components at the interfaces interact." He also commented that this change "has potentially far-reaching consequences" for both the computer industry and the industries that use computers.[34] These implications included the decline of the large vertically-integrated company as a coordination mechanism.

[31] O, *Computer Age in Hong Kong*, 8.
[32] John R. Rice and Saul Rosen, "History of the computer sciences department at Purdue University," *Studies in Computer Science*, (1994): 45-72.
[33] Lee Revens, "The first twenty-five years: ACM 1947-1962," *Communications of the ACM* 15, no. 7 (1972): 485-490.
[34] Garth Saloner, "Economic issues in computer interface standardization," *Economics of Innovation and New Technology* 1, no. 1-2 (1990): 135-156.

4. Episode 1: Internal Computerisation of the HSBC Group, 1960-1970

4.1. Background and domestic expansion

In the postwar period, the Hong Kong and Shanghai Banking Corporation (HSBC) was the largest financial institution in Hong Kong and was often referred to by locals as simply "the Bank." In addition to commercial and investment banking, HSBC performed some of the functions of a central bank in the colony. In the absence for other information about market share in this period, examining the role of HSBC in providing the local money supply can help to establish the relative importance of this bank. Although two other banks issued banknotes, the volume of HSBC notes in circulation in 1960, HK$835.8million, was vastly greater than those of the Chartered Bank of India, Australia, and China, HK$74.6 million, or the Mercantile Bank Ltd, HK$3.3 million.[35]

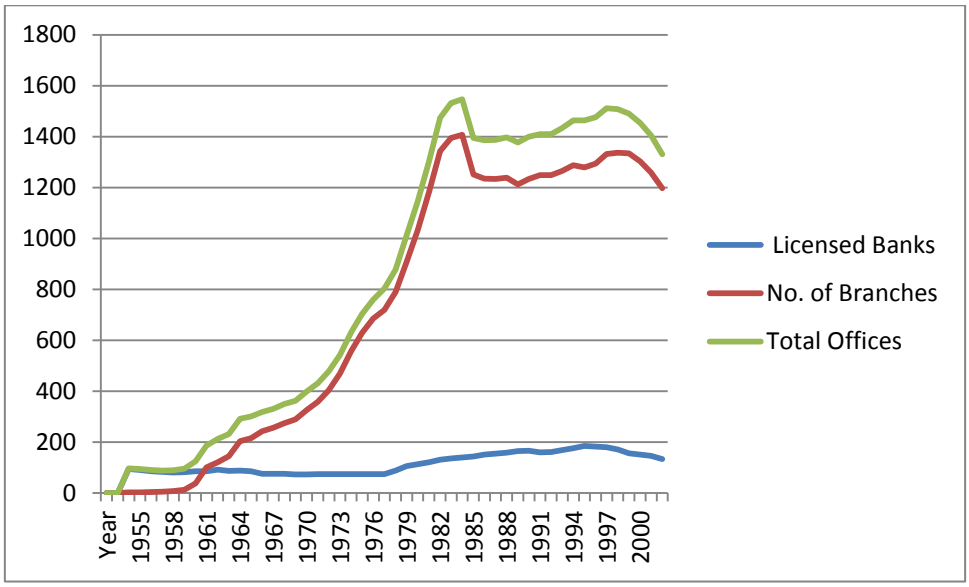
Hong Kong's economy grew rapidly in the late 1950s, thanks in part to a boom in exports of textiles and other labor-intensive goods to the United States.[36] In the 1950s and 1960s, HSBC benefited from the increasing affluence of the ethnic Chinese population of Hong Kong, its most important market. The proportion of Hong Kong residents who used banks grew rapidly in the 1950s, as ethnic Chinese people, who traditionally had been skeptical of banks, now opened accounts.[37] By the 1960s, the typical family in Hong Kong had at least one bank account. By the mid-1960s, there were approximately three to four million savings accounts in Hong Kong, even though the entire population of the colony was just four million.[38] See figure 1.

[35] Hong Kong Economic History Database, Hong Kong Institute for Monetary Research

[37] Y.C. Jao, *Banking and Currency in Hong* Kong, 17.

[38] Interview of Norman Howard Talbot Bennett with Christopher Cook on 11th August 1980 in London, England, p.64, in HSBC Archive, London, HQ 1641/0002. Henceforth referred to as Bennett Interview.

Figure 1. Numbers of Banks, Branches, and Banking Offices in Hong Kong[39]



To accommodate the swelling numbers of customers, HSBC and other banks expanded their retail branch networks, lengthened service hours, and invested in creature comforts such as air conditioning.[40] Mechanization and later computerisation were also among the bank's responses. HSBC's provider of registers, tabulators, and other mechanical calculating devices was National Cash Register (NCR) of Dayton, Ohio.[41] In the 1950s, HSBC decided to replace traditional ledgers with NCR's new Post-Tronic system for keeping track of customer accounts.[42] "Brick and mortar" branching, however, was the key to capture the growing number of balances as deposits. For instance, Hong Kong's government built a massive number of social housing projects in this period responding to the demand of the colony's mushrooming population. HSBC made a point of establishing a retail branch in every development as soon as it was completed.[43]

In 1954, there were 94 banks licensed to do business in Hong Kong and just three bank branches. In this environment, it had been relatively easy for a bank to keep track of all of its accounts through labour-intensive processes. In the next decade, the number of licensed

[39] Source: Hong Kong Economic History Database, Hong Kong Institute for Monetary Research.
[40] Y.C. Jao, *Banking and Currency in Hong Kong*, 20, 25; Catherine R. Schenk, "The Origins of Anti-Competitive Regulation: Was Hong Kong 'Over-Banked' in the 1960s?" Hong Kong Institute for Monetary Research Working Paper No.9 (July 2006); *South China Morning Post*, 2 March 1964, "Banking Problems", 10.
[41] Bennett Interview, p. 65.
[42] Frank H H King, *The History of The Hongkong and Shanghai Banking Corporation*, 4 volumes (Cambridge: Cambridge University Press, 1986-7), Vol. 4, p299. NCR's Class 29 Post-Tronic machine, which was launched in 1956, provided automatic balance pickup from magnetic stripes on a ledger card. This system eliminated the need for the "dual posting" of deposits into account. See further J.F.van Hanswijk Pennink, "NCR Post Tronic 1957-1970 USA" http://www.thocp.net/hardware/ncr_post_tronic.htm. Website viewed: 13 May 2013. The advantages of this system were discussed in J.A. Anderson to Fitzpatrick, 11 May 1971 in HQ HSDAL 0165/0002.
[43] Bennett Interview, p. 61.

unit banks actually fell to 88 while the total number of banking premises (e.g., retail bank branches) increased dramatically to 292.[44] By early 1965, there were thirty-one HSBC retail branches and sub-branches in Hong Kong.[45] With a growing customer base, keeping track of balances started to become a cumbersome administrative process. About this period, a retired HSBC executive 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 had cost the bank significant sums in overtime.[46] In 1967, when HSBC was about to take delivery of its first computer, executive S.J. H. Pughe remarked that if the bank were to continue expanding at the same rate without adopting computers, it would be impossible to find the clerical staff needed to process payments. He also remarked that the introduction of computers would not cause redundancies at HSBC, as displaced workers would be redeployed to other tasks.[47]

4.2. Mechanization and digitalization of customer accounts in Hong Kong

HSBC's managers first appear to have become aware of the importance of computers to banking at an internal conference in 1958 at which a brochure called 'Automation in Every Size Bank' was read and discussed. This document had been prepared by NCR, which had an obvious interest in encouraging bank managers to think that investment in mechanisation was essential. Copies of the document were sent to HSBC branches throughout Asia.[48]

Computers were introduced at HSBC during the leadership of Sir John Anthony Holt Saunders (1917-2002).[49] As chief manager (i.e., CEO) of the bank between 1962 and 1972, Saunders pushed for and came to regard computerisation as vital for the future of the bank. Saunders's interest seems to have developed after a visit to the United States in the mid-1960s, where he met with US banks' chairmen and presidents. Saunders was repeatedly asked about HSBC's use of computers but was unable to say much in response to these enquiries as HSBC did not own a single computer. Saunders thus returned to Hong Kong impressed with the need to keep up to date with US banks.[50] It should be noted that while HSBC was now expanding into the US market, it was also facing increasing competition in Commonwealth countries in Asia from Chase Manhattan, a US bank. [51]

[44] Hong Kong Economic History Database, Hong Kong Institute for Monetary Research.
[45] HSBC *Annual Report* for 1965, p. 27.
[46] Bennett Interview, p.64.
[47] South China Morning Posst, "Hongkong Bank Moving Into the Computer Age," 29 March 1967.
[48] P.A. Sellars in Hong Kong to S.W.P. Perry-Aldworth in London, 13 January 1959 in HSBC Archive, London, HQ HSDAL 0165/0002.
[49] Sara Kinsey, "Saunders".
[50] Bennett Interview, p.61.
[51] John Donald Wilson, *The Chase: The Chase Manhattan Bank, NA, 1945 - 1985* (Boston, Mass.,1986), 168, 169.

Saunders appears to have known little about the actual operation of these devices, which he referred to as "bloody things."[52] Instead, he left the task of supervising computerisation to Norman Howard Talbot Bennett (born 1921). Bennett begun his career with Barclays Bank in London and joined HSBC in 1946 where he then held a number of posts in India, Hong Kong, Singapore, and Thailand over the next two decades. The key point here is that Bennett left the United Kingdom before the British banking industry began introducing electronic computers in the late 1950s. During the period in which computerisation was beginning in computers in Western countries, Bennett was isolated from these developments due to his postings throughout Asia. It is highly likely that when Bennett was promoted to a post in the Hong Kong head office of HSBC in 1966, he had never seen an actual computer, as he had spent the last two decades living in countries in which the technology had yet to arrive. Moreover, Bennett also lacked any formal training in any of the academic disciplines, such as mathematics or engineering, that might have prepared him for work with calculating devices.

As responsible for the bank's computerisation project Bennett's title changed on a number of occasions: in the first four years he was successively Controller with Special Duties, Chief Manager's Assistant, and then Assistant to the Chairman. Regardless of the changes in this title, his basic function remained the same: in the period between 1966 and 1970, Bennett's focus was on managing computerisation.[53]. It appears that Bennett's main source of information about computers was a friend who was then working for the National Westminster Bank, a British domestic bank that had already purchased several computers. [54] Bennett's conversations with his friend, which likely took place during a period of leave in the United Kingdom, appear to have represented the extent of his education with computers prior to his appointment to positions in the bank.

As we have seen, HSBC's senior management knew that computers were important but had little knowledge of the technology. When their ignorance of this technology is seen through Langlois's paradigm, it is not surprising that they decided to have IT functions performed within the boundaries of the firm rather than relying on external providers, as HSBC's managers were in a position analogous to that of Henry Ford in 1911, when he opted to meet his new assembly line's need for components by dispensing with markets and vertically integrating backwards into the production of the components.

[52] Bennett Interview, p. 51

[54] Bennett Interview, p. 61.

In Bennett's view, the first major benefits HSBC derived from computerisation came from the December 1965 decision to link terminals in each branch to an IBM 360 computer via telephone lines. This move permitted "real time" on-line management of accounts. HSBC was not the first bank to link computers in branches via telephone lines, as a similar system had been adopted in 1961 by the Bowery Savings Bank in New York City.[55] HSBC modelled its particular system of "on-line banking" on that created by Databank Systems Limited, a consortium of New Zealand's banks. Bennett flew to New Zealand and interviewed Databank CEO Gordon Hogg in the course of planning HSBC's network.[56] The Databank System in New Zealand went live in 1967, the same year the IBM mainframes were installed in HSBC and linked to the branches.[57]

HSBC's decision to use IBM technology disappointed NCR, which had been attempting to sell HSBC in its own computer system. NCR and IBM had eagerly sought the "prestigious" contract to supply HSBC with computers both because of the size of the contract and because winning HSBC's business was seen as a stepping stone to the potentially massive Asian market for business computer systems.[58] NCR eventually succeeded in selling its computer system to Standard Chartered, a bank with a smaller presence in the Hong Kong market.[59] International Computers and Tabulators (ICT), a struggling British computer company, had also put in a bid for the contract. ICT was regarded by Prime Minister Harold Wilson as a national technological champion, received extensive support from the British state in this period.[60] When British government officials learnt that HSBC had awarded the contract to IBM, Saunders faced pressured to reverse the decision and "buy British". HSBC's chief executive resisted this political pressure, much to the delight of Bennett, [61] who had already developed a rather negative opinion of British-made computer equipment as a result of conversations with a banker in the United Kingdom. This banker had been disappointed with the computers manufactured by Ferranti, a Manchester-based company.[62]

[55] See biography of John Theurer Diebold (1926-2005) at http://www.nndb.com/people/332/000110002/. Biography viewed 13 May 2013.
[56] Interview of Norman Howard Talbot Bennett with Christopher Cook on 11th August 1980 in London, England, in HSBC Archive, London, HQ 1641/0002. Henceforth referred to as Bennett Interview., p.63.
[57] Andrew Cardow and William R. Wilson, "Databank Systems Ltd: Gordon Hogg A Study in Internal Entrepreneurship" (December 13, 2012). Available at SSRN: http://ssrn.com/abstract=2178703 or http://dx.doi.org/10.2139/ssrn.2178703
[58] "Chapter 2: the 1960s: Nail-Biting Times" http://www-07.ibm.com/hk/ibm50th/2/chapter2-8.html from "The IBM Way: Celebrating Fifty Years in Hong Kong"
[59] Danyll Wills, "Revolutionary mainframe turns 40" *South China Morning Post*, 6 April 2004.
[60] Arthur L. C. Humphreys, OH 23. Oral history interview by Erwin Tomash, 28 February 1981, Los Angeles, California. Charles Babbage Institute, University of Minnesota, Minneapolis. http://purl.umn.edu/107365, p.14.
[61] Bennett interview, p.65
[62] Bennett Interview, p.62

IBM sent HSBC a large number of technical advisors to help with the teething problems inherent in installing the new technology. [63] IBM's American employees also helped HSBC to select promising clerical employees for training as computer programmers. Since a market in computer professionals did not yet exist in Hong Kong, HSBC had little choice but to pay for the in-house training needed to turn clerks into programmers. Relative to the other markets in which IBM was active, the average level of education in Hong Kong was extremely low: Hong Kong's population, which consisted mainly of refugees from mainland China, included few people with secondary or university education, let alone training in fields relevant to computer programming. When the IBM employees administered standardized tests to HSBC clerical workers who had expressed an interest in learning how to use computers, they were struck by how high their scores were relative to employees in similar occupations in the United States. They concluded that individuals with native intelligence who might have attended college had they been born in a more fortunate country went to work for HSBC as clerks because that was the best educational opportunity available in the colony. Bennett opined in 1980 that without the retraining of existing HSBC employees as programmers, HSBC's computerisation drive would have been much less successful. [64]

HSBC adopted computers primarily as a way of managing a growing number of savings accounts. Computerisation had helped the bank to manage accounts more effectively. Bennett stressed that computerisation had not resulted in the loss of any worker's actual job. Instead, it had allowed the bank to reduce overtime and direct employees' energies towards more profitable activities. [65] However, once the computers were installed, HSBC executives began to think about other uses of the technology. In an article on computerisation in Hong Kong banks published in the *Far Eastern Economic Review* in 1972, HSBC executive R.V. Munden explained that the colony's banks had initially adopted computers as a way of coping with the tedious task of keeping track of a growing number of transactions, which in the case of HSBC had numbered 3.5 million per month. [66] Once the computers had been installed, the banks had realised their potential use in data analysis. According to Munden, spare time on banks' computers had been sold to outside organizations that needed to do number crunching. Moreover, the banks had begun to use computers to aid their own commercial decision-making processes, or Management Innovation Systems (MIS). Munden did not elaborate on

[63] Bennett Interview, page 62. HQ 1641/0002
[64] Bennett Interview, page 62.
[65] Bennett Interview, p.64.
[66] R.V. Munden, "Computers in Banking: the Decision Makers," *Far Eastern Economic Review*, 1 April 1972, p. 83.

this point beyond saying that the banks had begun to look for patterns in account usage that were connected to the occupations and other characteristics of account holders. [67]

In his article Munden also acknowledged that the credibility of MIS had been badly damaged by the Vietnam War. Here, he was alluding to the much-publicized use of computers in the mid-1960s to plan the American military campaign. Robert S. McNamara, the US Secretary of Defence, had applied statistical techniques he had developed at the Ford Motor Company to planning the military campaign against the North Vietnamese. This approach had been extremely controversial with traditionalist army officers, who regarded warfare as more art than science. Under McNamara's leadership, computer systems had been used to target enemy cities, calculate kill ratios, and, most famously, produce a monthly body count for enemy combatants. During the administration of Lyndon Johnson, the US government had published photographs of the computers involved and had assured the public that the use of such advanced technology would guarantee a swift victory over the primitive enemy.[68] By the time Munden's article was published in 1972, a demoralized United States was in the process withdrawing its troops from Vietnam and was negotiating with the enemy in Paris. This episode damaged the prestige of computerisation. Munden conceded that the theory that war could be managed by computers "died in the jungles of Vietnam," but he stressed that computers could play an important role in managing commercial enterprises. [69]

Munden also discussed the possibility that computerised banking might reduce the use of cash and cheques. Although Munden failed to acknowledge the source of this idea, it was probably influenced by on-going discussions about the elimination of paper money and checks in the USA and the UK. For instance, in the early 1960s John Diebold, whose company built networked computer systems for banks and was well known throughout the industry, was very vocal on public and industry media on issues around automation and particularly the concept of a cashless society.[70] In 1966, George Mitchell, a member of the Board of Governors of the Federal Reserve, had urged American bankers to investigate the possibility of using technology to reduce the use of cash and personal cheques.[71] The first known use of the term "cashless society" in a Hong Kong publication was in an August 1966 article in the *South China Morning Post* about the futuristic ideas of Herbert Blitz, the

[67] R.V. Munden, "Computers in Banking: the Decision Makers," *Far Eastern Economic Review*, 1 April 1972, p. 83.
[68] Donald Fisher Harrison, "Computers, Electronic Data, and the Vietnam War," *Archivaria*, accessed May 24, 2013, http://journals.sfu.ca/archivar/index.php/archivaria/article/view/11490.
[69] R.V. Munden, "Computers in Banking: the Decision Makers," *Far Eastern Economic Review*, 1 April 1972, p.83.
[70] Bernardo Bátiz-Lazo, Thomas Haigh, and David L. Stearns, "How the Future Shaped the Past: The Case of the Cashless Society," *Enterprise and Society* (2014): 15(1), pp. 103-131.
[71] Bernardo Bátiz-Lazo, Thomas Haigh, and David L. Stearns, "How the Future Shaped the Past: The Case of the Cashless Society," *Enterprise and Society* (2014): 15(1), pp. 103-131.

research director at Diebold. Blitz had predicted that the United States would become a cashless society within a decade and that "Europe could follow suit five or ten years later."[72] In the following year, R. Stanley Laing, the President of NCR made similar predictions in a speech delivered in Texas that was also reported in Hong Kong.[73] Although Munden did not refer to these men in his article, he may have been aware of their prophetic statements. Munden opined that as "media of transfer," "cash and cheques" were both inefficient and expensive for banks to handle. Some form of direct debit from a customer's account would be a better way of paying suppliers than the existing system of routing cheques through a clearinghouse. "Taking things a step further, regular monthly payments to such organisations as firms and clubs could be made through this method." Munden also envisioned an even more dramatic use of computers, namely, the installation of "computer terminals… at the point of sale" with "direct access to accounts arranged." The result would be "a cash sale without the cash." Hong Kong, he said, could be at the forefront of the move away from cash because it was geographically compact, had a high velocity of money, and most its banks were already computerised. All that was needed was for the colony's banks to cooperatively develop a common system for linking accounts together. [74]

5. Episode 2: The Market Thickens, 1970s-1990s

5.1. Knowledge creation and widespread deployment of electronic computers

As was stated above, market thickness encourages vertical disintegration. In the computerisation of retail banking and payment systems in Hong Kong, the most relevant forms of this thickening were evident around: the internationalization of US designed and manufactured computer systems; the local market for components; and the local market for computer programming skills. All of these markets thickened in the period from the early 1970s to the mid-1990s.

The thickening of the local market for programming skills effectively meant that the creation of knowledge about computers within and around banks grew significantly. For instance, the University of Hong Kong, an English-language institution, began to offer instruction in computers to student in a variety of disciplines from 1967 onwards, using a mainframe computer than also handled the administrative needs of the university. 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

[72] *South China Morning Post,* "Towards A Cashless Society in America," 5 August 1966.
[73] *South China Morning Post,* "The Cashless Society," Jul 10, 1967.
[74] R.V. Munden, "Computers in Banking: the Decision Makers," *Far Eastern Economic Review,* 1 April 1972, p.84.

1973 and began offering a degree in Computer Science in 1978.[75] In 1970, the Joint Universities Computer Centre (JUCC) was established a coordinated venture of the University of Hong Kong and the Chinese University of Hong Kong. The teaching of computer science at the tertiary level in both English and Chinese began in the early 1970s, while computer instruction became part of the secondary school curriculum in the early 1980s.[76]

Knowledge of computers in Hong Kong's business community also increased after 1970 thanks to the efforts of the Hong Kong Computer Society (HKCS), a non-governmental organization established with the assistance of HSBC, IBM, and other large companies. Many of the founders of the HKCS were expatriates, although it sound acquired a large number of Chinese members.[77] This organisation facilitated the exchange of knowledge about computers between firms in Hong Kong through informal meetings, a newsletter, and, after 1978, an annual convention. In 1971, HSBC was represented on the board of the HKSC by two executives.[78] The computer society published a newsletter. In 1974, the HKCS formed a Computer Audit Club with the Hong Kong Society of Accountants.[79] Over the course of the 1970s, a growing number of firms in a variety of Hong Kong industries began using computers, either by purchasing their own devices or contracting the work out to computer service bureaux. The middle years of the decade appear to have been an inflection point, with the number of computers in use in Hong Kong businesses increasing from 119 at the end of 1975 to 266 at the end of 1977. As Table 1 indicates, use of computer technology did not increase at a uniform rate in all sectors of the 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 to the ship construction, chemical, and architectural sectors, where firms acquired computers at a much higher rate.

[75] "The Department of Computer Science and Engineering at The Chinese University of Hong Kong" https://www.cse.cuhk.edu.hk/v7/en/about/dept.html
[76] A. Fung, "Development of information technology in Hong Kong Education Over the Past Decade," in Mikko Ruohonen and Gail Marshall, *Capacity Building for IT in Education in Developing Countries*(London: Chapman & Hall, 1998), 68-69.
[77] Interview with Anthony O, 3 December 2013.
[78] Hong Kong Computer Society, "Milestones" http://www.hkcs.org.hk/en_hk/intro/milestones.asp
[79] *The Journal of the Global Accounting Alliance*, "Hong Kong Institute of Certified Public Accountants at 40 – Taking On Challenges" 27 June 2013. http://read.gaaaccounting.com/news/hong-kong-institute-of-certified-public-accountants-at-40-taking-on-challenges/#sthash.yDanALFV.dpuf

Table 1. Number of Computer Used in Hong Kong Industries, 1975-1977[80]

Industry	Dec-75	Dec-76	Dec-77	Annual Rate of Increase
Public Utilities and Transport	7	7	7	50%
Oil Industry	4	4	4	50%
Trading (Consumer Goods)	3	3	4	67%
Computer Service Bureaux	8	10	12	75%
Banks	13	19	20	77%
Computer Manufacturing and Sales Agencies	5	8	8	80%
Hotels and Travel Agents	3	4	5	83%
Manufacturing (Garment, Textiles, Spinning, Dyeing)	8	13	14	88%
Shipping	8	14	16	100%
Public Sector	4	8	8	100%
Media	4	6	9	113%
Trading	4	6	9	113%
Real Estate and Property Development	2	5	5	125%
Other	5	10	13	130%
Professionals (Non-Auditors)	14	35	37	132%
Retail	3	5	8	133%
Auditors	1	2	3	150%
Insurance	3	10	10	167%
Trading (Durable Goods)	3	7	10	167%
Electronics	3	9	11	183%
Finance, Securities, and Commodities Trading	3	9	11	183%
Wharfs and Container Terminals	1	4	4	200%
Chemical, Pharmaceuticals, Cosmetics	1	5	5	250%
Dockyards	1	3	5	250%
Construction and Architects Firms	2	14	16	400%
SUM	119	231	266	112%

[80] Source: Eric Kwong-kay Lo, *A study in the use of computer in management information systems in large electronics factories in Hong Kong* (University of Hong Kong Management Studies Department, March 1979), p.14.

These developments in Hong Kong's business community were, of course, influenced by global developments in the field of ICT. During this period, the epistemic communities that worked with computers underwent changes that correspond to the processes of *articulation* and *replication* identified by Håkanson. As was mentioned above, articulation involves standardization and the development of a common vocabulary precise enough to permit cooperation across the boundaries of organizations such as firms. *Replication*, which involves the transfer of knowledge and capabilities between firms, simplifies the transfer across the boundaries of firms of physical objects, such as components. Both of these changes occurred on a global scale.

5.2. Thickening of the local market for computer components

Market thickness encourages vertical disintegration, whereas small numbers of vendors encourages vertical integration. We would expect, therefore, that as the number of vendors in the computer component business increased, this more competitive environment would encourage the outsourcing of IT functions by firms. We lack data on the number of computer component vendors in Hong Kong and are thus unable to compare the competitiveness of the colony's IT markets with those of other jurisdictions. Hong Kong's government generated few statistics about computer sales, usage, and imports in this period. In 1984, Euan Barty, the editor *Asian Computer Monthly*, noted that "government statistics are unreliable. There are no import/export duties, so the government has no stake in keeping records right. Consequently, they lump computers together with other electronic products such as tape recorders, radios and copiers." In addition to the thriving market for legitimate computer components, the colony was also home to "many hundreds of computer shops that are churning out pirate versions of Apple IIs and IBM PCs."[81]

We can infer that Hong Kong's market for computer components became highly competitive in the 1980s. We know that the number of vendors increased dramatically during the PC revolution of the early 1980s, for by this point specialised shopping districts for computer components emerged.[82] The clustering of component suppliers fostered competitor between retailers and wholesalers. Moreover, the property developers who created the second generation of computer-component centres were aware that computer shopping districts were in competition with each other, which is why they offered retailers reasonable rents. [83] The most important of these clusters was the area around the Mongkok Computer

[81] *InfoWorld*, "Hong Kong's Microcomputer Industry," March 12, 1984.
[82] *South China Morning Post,* "Computer Business Hits Fast Forward." 16 October 1983
[83] *South China Morning Post,* "Cheap-Rate Data Base" 28 July 1985.

Centre.[84] At the same time, Hong Kong's Golden Arcade evolved into a centre for software vendors.[85] In a 1992 article about the Golden Arcade, the *South China Morning Post* noted the intensively competitive nature of the market, which was characterised as a "Darwinian bloodfest… competition is cut-throat and margins razor-thin."[86]

In 1990, Hong Kong's Trade Development Council discussed "the increasing commoditization of personal computers, peripherals and even facsimile machines."[87] The development of these highly competitive markets likely encourage the trend towards the outsourcing of IT functions.

6. Episode 3: Octopus as a milestone of the Cashless Society, 1997-2010s

6.1. The big problem of small change

Thirty years after the first deployment of the NCR315 by China Light and Power, computers were a fact of life in Hong Kong. To some degree, issues of standardization, compatibility and inter-operability initially raised by directors still remained, particularly with regards to capturing so called "network externalities" (that is, where new adoption of a particular technological solution, like the telephone, made that solution more valuable to both the new adopter and all previous adopters). However, Munden's ideal of a cashless society did take an important step forward with the birth of a public transit pass that was to be known as the "Octopus chip" in 1997, which grew to become the preferred solution for "micro-payments" in Hong Kong.

Like retail banks, public transport authorities face the problem of dealing with a continuous flow of a very high volume of standardised transactions. Early computer systems were inadequate for such tasks, in the sense of being unable to cope with the full complexity of a banks' retail branch.[88] This was to change with the advent of Tandem's so called "non-stop" computing and other manufacturers of fault resilient systems during the 1980s. Prior to the advent of such systems, the biggest milestone for many transport authorities across the world had been to automate fare collection by using cardboard tickets with a magnetic

[84] Fei Ko, "What is the future of shopping streets in Hong Kong," *Planning* 28 (1991): 585-96Aug.
[85] William R. Swinyard, Heikki Rinne, and A. Keng Kau, "The morality of software piracy: A cross-cultural analysis," *Journal of Business Ethics* 9, no. 8 (1990): 655-664.
[86] *South China Morning Post*, "Price wars bring cheer to PC users," 15 December 1992.
[87] *Computerworld*, "International Briefs" 3 December 1990.
[88] Ian Martin, "Britain's first computer centre for banking: What did this building do?" *Technological Innovation in Retail Finance: International Historical Perspectives*. Bernardo Bátiz-Lazo, Joan Carles Maixé-Altés and Paul Thomes (eds.) (London: Routledge, 2011: 37-70); Ian Martin "Too far ahead of its time: Barclays, Burroughs and real-time banking." *IEEE Annals of the History of Computing* 34(2) (2012): 2-16; Bernardo Bátiz-Lazo, Tobias Karlsson, and Björn Thodeneous, "The origins of the cashless society: cash dispensers, direct to account payments and the development of on-line real-time networks, c. 1965-1985." *Essays in Economic and Business History* 32 (2014): 100-137.

stripe.[89] In the case of Hong Kong, the latter were introduced in 1979 by the Mass Transport Railway (MTR) Corporation for underground transport, based on distances traveled rather than flat rates.[90] In 1983 the MTR introduced the Common Stored Value Ticket (CSVT) to supplement single journey passes. This enabled regular commuters to purchase magnetic strip cards that could be used repeatedly until the value on the card was depleted and thus allowing for single or multiple journeys in a single ticket. The CSVT shortened lines and improved service. It also reduced the number of coins the company collected, transitioning most ticket sales to paper money in HK$100 units.[91]

By the early 1990s, the acceptance of the CSVT had been extended to the Kowloon-Canton Railway (KCR), a longer haul commuter train with service up to the northern Hong Kong/China border; and after 1989, to some bus companies.[92] But at the same time, the magnetic stripe-based system was reporting, on average, a fault every 2,500 transactions (either due to mechanical failure; pollution; humidity; mobile phones demagnetising cards; changing belts, heads and bearings; etc.).[93] This was an expensive proposition for a system handling some two million transactions a day and in geography where around 85% of the total population depended on public transport.

6.2. Do Octopus lay eggs?

In 1992 began an internal effort at MTR to survey available mechanisms that would replace the then existing system within a five to six year timeframe. Chip-based card technology looked as an attractive proposition. Its commercial application had been pioneered by France Telecom in the 1980s.[94] Chip-based cards were attractive as they offered ease of use and speed: fulfilling transactions within 300ms without having to swipe, slide or otherwise physically interact with readers.[95] There was no sacrifice on security or reliability while transactions were accurate with safeguards against fraud. End-of-day account

[89] Tateisi Electronics Company (today Omron Global), a Japanese company, was the first to developed and deployed in 1967 a system using a magnetic stripe that enabled an automated ticket gate that could handle both commuter passes and regular train tickets. See further http://www.omron.com/about/corporate/history/ayumi/innovation.html#history1967 (accessed 18-Jul-2013).
[90] See Ella Chan and Paul Forster "The Octopus smartcard: It came from the subway!", Centre for Business Case Studies, *HKUST Business School*, Hong Kong: Hong Kong University of Science and Technology (2010): 2.
[91] Chan and Forster , p. 3.
[92] Chan and Forster , p. 3.
[93] Interview of Brian Chambers, Managing Director Octopus Ltd., by Bernardo Bátiz-Lazo, 17-Jun-2011, p. 2.
[94] Although attractive as means to reduce fraud, counterfeits and increase security in transactions, this technology remained largely ignored by financial institutions as it was developed early 1980s and shortly after the ISO agreement of 1977 on the physical characteristics of plastic cards. Adding the chip to the card made them too thick for the ISO standard. However, around 1985 France Telecom decided to adopt chips as a way to eliminate small change from public telephones. For the early application of smart cards in banking see Jerome Svigals *Smartcards: The New Bank Cards* (New York, NY: Macmillan, 1987); Bernardo Bátiz-Lazo, Jarunee Wonglimpiyarat, and Douglas Wood, "Barclaycard" in *Exploring Corporate Strategy: Text and Cases (6th ed)*, Gerry Johnson and Kevan Scholes (eds) (London: Pearson Education, 2002**:** 925-940); David L. Stearns. *Electronic Value Exchange: Origins of the VISA Electronic Payment System*. (Springer: London, 2011). Also a dedicated site on the history of Visa Cash and Mondex http://www.mondex.org/main_page.html (accessed 23-Jul-2014).
[95] Chan and Forster , p. 4.

settlement was also simple, reducing human counting errors and bank settlement time. At first the smart card application was considered for a premium service, like a VIP type system for fast access. But the more the team looked at the economics of it, the more sense it made to roll it out across the different public transport systems (ferries, trains, subway, taxi, bus, min-bus, trams). But the proposition was risky for two reasons, first, because the technology had never been implemented in a large scale (except for few trials in London and Manchester).[96] Second, it required bringing together competing transport operators to agree and collaborate on a single payment scheme, an application that everybody could use while changing the nature of competition (from price within the same route, to quality service or alternative routes).

In 1994, five major public transport operators namely, the two rail lines, MTR and KCRC, bus companies KMB and Citybus; and the Hongkong and Yaumatei Ferry (HYF), established a joint venture, "Creative Star Limited" (renamed as "Octopus Cards Limited" in 2002, henceforth Octopus), to oversee the contactless smartcard system's development and implementation.[97] The hardware (chip, card, readers, computers, etc.) were purchased from the market. For instance, Octopus adopted smartcard technology developed by Sony, but developed most of the actual terminals in-house (at cost competitive rates when compared with those used in credit/debit card transactions).[98] The software resulted from a combination of in-house development and ready-made packages.

The Octopus card debuted in 1997. Rail and underground passengers already accustomed to stored value cards with the CSVT readily accepted the new technology.[99] The next milestone came in 2000, when 4,100 buses owned by small and big operators were fully incorporated. Then came the 600 or so companies running mini-buses. By 2011, taxis had yet to be fully integrated. The 15,000 or so taxi licenses represented up to 15% of transport transactions. In other words, within 15 years after its launch 85% or more of daily transport transactions in Hong Kong were cleared through Octopus.

At the same time, reload points began to grow outside stations while the chip's monetary balances became redeemable only after the Hong Kong Monetary Authority granted permission for restricted use of deposit-taking and payment activities in the year 2000. Initially balances became redeemable in vending machines within transport stations. This was followed by fast food restaurants, convenience stores and eventually supermarkets.

[96] Chambers Interview, p. 3.
[97] Chan and Forster , p. 4.
[98] Chan and Forster , p. 2.
[99] Unless otherwise stated this paragraph and the next are based on the Chambers Interview, pp. 7 to 9.

Together all of these offered 24-hour, conveniently located reload points. By 2011 there were over 3,000 different merchants accepting payment through Octopus. Moreover, each card's unique identifier enabled its use to spread while becoming a personal identification device. Such uses included activating lifts in the lobby of the International Financial Centre, booking and payment of public tennis courts and swimming pools, or even a key to enter people's homes.[100]

6.3. What about the banks?

From the outset, Octopus had the goal of creating a common small value electronic payment platform allowing multi-application developments to provide even greater convenience to the public. It was set up with a clear for-profit mandate; this enabled greater freedom to invest in infrastructure but was also an incentive to grow the business out of transport. At the same time, in the mid-1990s there was no other widely accepted solution to solve on the spot, very small value transactions other than coins and bills. Hong Kong banks had no interest to develop their own solution for micro-payments or to join in the setup of Octopus.[101] The daily sorting and transfer of thousands of heavy coins to the bank was a significant cost. The birth of Octopus brought a fundamental shift to Hong Kong's cash culture by opening the door to electronic micropayments.

Octopus was designed to work "off line": with each transaction having a unique serial number, stored both in the chip and the merchant's terminal at the time of the transaction.[102] The main task of the system is synchronization: check, verify and reconcile transactions as well as transfer balances.[103] This enabled to close the actual transaction in milli- or even micro-seconds while reconciliation can take up to seven days later. This gap is explained by, for instance, the time between replenishing a vending machine because only until replenishing an operator's personal digital assistance device downloads and transmits transaction information. The system thus runs outside "normal" banking "pipelines", and it's the back office work at Octopus which makes the link between the monetary balances stored in the chips and the merchants' banks. It also implies that at any one time the maximum exposure to loss for a single card is limited to the maximum replenish value (HK$200.00 in

[100] See further David Birsh and Ed Conway *Identity is the New Money* (London: London Publishing Partnership, 2014).
[101] Chambers Interview, p. 5. The same source states that at the time, Hong Kong banks were hopeful of the Mondex card (on this see http://www.mondex.org/main_page.html, accessed 18-Jul-2014).
[102] All data is encrypted and authenticated by mutual handshaking between the chip and the read/write device. Software encryption is dynamically generated with every transaction to prevent fraud (Chan and Forster, p. 5.)
[103] Transactions are completed between terminals and cards; dialing into a bank network for authorization on every purchase is not required. Each terminal maintains its own records. An Octopus central data clearinghouse consolidates daily transactions and settles accounts with banks and affiliates (Chan and Forster, p. 5.).

2011)[104]; whereas in a credit card the user could be liable to the full amount of the credit limit, which can typically run in the thousands of dollars.

7. Conclusion

In the 1960s, the first computers were installed in Hong Kong's banks. Although the full significance of this new technology was not recognized at the time, computerisation would eventually facilitate Hong Kong's transition to a cashless society.

The first section of this article documented the introduction of new technologies during the initial stages of Hong Kong's transition to a cashless society was largely done "in-house" (i.e., within the boundaries of firms). Faced with a make-or-buy decision, firms such as HSBC decided not to outsource. They did so because the relevant markets, which were for computer components and IT skills, were then quite thin in Hong Kong and other markets. Moreover, while managers in Hong Kong financial institutions understood that computers were important, they were unfamiliar with the technology, which was novel, very expensive, and only poorly understood by managers, most of whom had grown to adulthood before the Second World War. In confronting the first generations of retail banking computer technology, these managers were in a situation similar to that of Henry Ford of Langlois's narrative. Langlois, it will be recalled, attributed Ford's decided to make radiators and other car components in-house to the uncertainty resulting from the sheer novelty of assembly line production.

By the 1980s and 1990s, the situation in Hong Kong had changed and now permitted extensive outsourcing. By this point, the local markets for computer technology and computer expertise were much thicker. ICT was much cheaper in real terms than it had been at the start of Hong Kong's move to the cashless society. Moreover, the forms of human capital needed to effect this transition were more plentiful, now that universities in Hong Kong had programmes dedicated to training future ICT professionals. These developments facilitated the shift in the way in which retail banking technology was operationalized in Hong Kong: no longer was the entire process done within the boundaries of a single firm, now looser networks, such as the Octopus system, were used.

[104] According to Chan and Forster (p. 6.), Octopus first introduced the Automatic Add Value Service (AAVS) in 1999 while developing contracts with over 20 banks and credit card companies in Hong Kong to provide AAVS to their Visa or MasterCard cardholders. The AAVS transfers pre-set amounts (HK$250 or HK$500) automatically to an Octopus Card when its stored value reaches zero or goes negative. Octopus allows cards to go negative because of the HK$50 deposit. For customer protection, the automated top-up reloads only once a day, charging a customer's selected credit card. Even in mid-transaction, the card can reload value if the current purchase exceeds the existing balance on the smartcard. The company reports over 1 million Octopus cardholders use the AAVS, which translates to about 1 out of every 12 credit cards in the territory linked to an Octopus card.

One could attempt to understand this shift by using the framework advanced by Lamoreaux *et al.* However, we believe that Langlois's perspective provides a more powerful and accurate representation of the challenges facing managers confronted with new technologies they know to be important but whose sheer novelty created uncertainty. As~~t~~ the colourful language used by HSBC CEO Saunders in the 1960s about "bloody things" illustrates, banking executives in Hong Kong were frequently perplexed by computer technology. Performing key functions in house was logical response to this conjunction of uncertainty, thin markets, and the high costs of computers. As these three factors changed, the approach represented by the Octopus payment network became optimal.