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Money, Markets and Microelectronics: Building the Infrastructure for the Global Finance Sector

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ABSTRACT *The rise of a global finance sector is one of the most salient aspects of the whole process of globalisation, and a true phenomenon of our times. Whilst various politico-economic changes were necessary to achieve this change, the simple fact is that it would have been impossible without the prior revolution in information and communications technologies (ICTs). These new technologies—such as semiconductors, computers, computer networks and communications satellites—when combined provided the necessary infrastructure for the emerging global finance system. This paper describes the way various finance markets, mostly American, grew and aggregated to form huge, global markets through the application of increasingly sophisticated and capable ICT systems. In doing so it foregrounds the essential role of sustained development in ICT capability in order to complement the analysis offered by literature written from neo-classical economics or institutionalist perspectives. The developing finance system was the product of many forces, but it was only when the appropriate technological, and particularly systemic, arrangements were in place that the finance sector could become truly global in scale.*

Keywords: globalisation, post-war, finance sector, information technology.

In this age of rampant globalisation,[1] the global economy is now dominated by currency and securities markets, the monetary value of which dwarf the value of the 'real economy' of goods and services.[2] This collection of increasingly interlinked markets can only exist because of the construction of a global infrastructure of information and communications technology (ICT) that allows money to be turned into electronic signals and shifted around the world at a keystroke. This paper outlines the process of construction of the technological infrastructure that enabled the growth of the now all-powerful global finance sector. It proceeds by first introducing the broad trends in modern international financial history, describing the overall development of the electronic global finance markets after the 1960s, and then briefly discussing the technological roots of the essential ICT systems.

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In telling the story of the development of the first truly global finance sector in the decades following World War Two, the paper concentrates on the role of ICT systems in enabling this development. The standard analyses of the rise of this sector focus on various economic issues or institutional transformation,[3] as if these were the only substantial pressures for change. Where it is mentioned at all,[4] technology is seen as merely a means of implementing these otherwise self-generating developments. Some commentary goes further, explaining global finance as a result of 're-regulation' (as opposed to de-regulation) of international economic relations, basically an action of governments.[5] While these are obviously essential factors in the rise of a global finance sector, and thus globalisation proper, the inherent dynamic could not have been realised without the application of new technologies that arose out of the post-war information technology revolution. This paper is intended to describe the role of new ICT technologies in the whole process as the essential material enablers. No matter what other forces were at work, if the appropriate technologies had not been available, the transformation in tempo-spatial relations underpinning global finance could not have occurred. Furthermore, the availability and specific character of these technologies then affect subsequent development.

Thus, it should be clear that the argument put forward in this paper is not a technological determinist one; instead, it sees technology as just one aspect, albeit an important one, of a general and sustained process of development that involved more and more of the geography, population and resources of the planet in a project of technology-based mass industrialisation. Starting with the European breakout in the fifteenth century, this project has led to the increasingly complete subordination of socio-cultural and politico-economic developments to the hyper-project known as globalisation. The paper thus helps meet the need to raise attention to the very specific role of technology, especially ICT, in this long process. In a real sense, the creation of the electronic global finance sector from the mid–1960s onwards was the final stage necessary to enable the current dominance of the entire globalisation project. Global finance markets in effect constitute a highly abstracted control system developed to determine the allocation of resources throughout the world. This is because capital in the form of electronic money is in the end a certain kind of information, and this information requires an appropriate medium to flow through.

As such, it should be noted how the technological dynamic kept pressure on all players—financiers of all kinds, financial mediators (such as stock exchanges) and regulators (including governments)—to constantly expand ICT based trading and to deal with whatever problems arose in terms of more ICT capability. As with core technologies in the past,[6] events in the key country, the US, were then translated outwards to construct international and tendentially global arrangements. This reality reminds us of one of the paradoxes of globalisation: that while globalisation is specifically about the rearrangement of global resources into a new system of production and consumption, the essential characteristics of this new system have been determined by at most a very few nations (such as the Group of Seven or the nations that form the 'triad' of regions) and mostly by one, the US.[7]

But there is a more specific point here as well. Much discourse over the last few decades, and especially that mindful of the rise of the globalisation issue, has focused on the changing relationship between key institutions, most notably states, firms and markets.[8] Particular emphasis has been placed on the supposed decline of the state and the concomitant rise of markets and their main protagonists,

transnational corporations (TNCs). In fact it was the fairly sudden and ever strengthening flood of new ICT capability that transformed all these institutional forms, and all players were kept somewhat off balance by the overall pace of development. The original impetus for this extraordinary phase of technological development was the power of that singular global institution, the US military.[9] It was the military that continually supported the development of globe-spanning ICT systems that comprised one part of the global ICT infrastructure. It was military support for the microprocessor and computer technologies that enabled the extreme abstraction of financial relations into the form of electronic money.[10] All the main players in government, business and elsewhere rushed along pell-mell with this rising tide of innovation, taking their chances where they could and endeavouring to defend their perceived interests as they went. In the pressure-cooker environment generated by the sustained explosive growth of ICT capability, there was hardly time for the main actors to catch their breath and look around at the new world they were creating so rapidly.

Nothing epitomises the whole globalisation project like the finance sector, now operating on a global scale and arising out of the international financial activities that developed along with modern European society.[11] International finance, sometimes called high finance, was once concerned with financing governments, particularly in wartime, or financing international trade.[12] Whether generated by states or markets, the 'real' economy of goods and services was the dog, and finance the tail. In the 1960s international banking was worth about 10% of the value of international trade, whereas by the 1980s the Eurodollar market alone was turning over more than 20 times as much as international trade.[13] Nowadays, with trillions traded per day, there exists a truly massive tail with an apparently tiny dog attached. It is not so much that the dog really is miniature—international trade has continued to grow strongly[14]—but international finance has just exploded in value. This animal seemed to be a very strange and unstable beast to many; in particular, critics have worried about the growing volatility of these finance markets; one shudder of that giant tail and whole economies are disrupted and governments fall.[15]

The rise of high finance is relatively recent. In its modern form it arose out of the era of *Pax Britannica* that followed the defeat at Waterloo of global hegemonic challenger France, and which fell apart in 1914 with the challenge of another potential hegemon, Germany.[16] The century following Waterloo was the golden age of international liberalism, and the most influential element of this time were the international bankers, such as Rothschild, Barings and Morgan.[17] Because of their capacity to move truly huge amounts of capital around with facile rapidity, for some decades international bankers were at least as important as politicians in terms of shaping the emerging industrial world.[18] However, the advent of world war in 1914, the Great Depression after 1929 and world war again in 1939 dealt body blows to high finance.[19] This was because, firstly, war and depression destroyed the transnational links so important to high finance; and secondly because national governments grew more decisive in the underlying processes of development, such as determining basic industrial relations and promoting technological innovation. It was not until the late 1950s that finance again reclaimed its central role in the US[20]—now the undisputed global hegemonic power—and this potency was then spread internationally in the 1960s when it accompanied the US industrial corporations in their breakout from the American heartland.[21] From this time on government control over finance and economics generally began to decline, to be

progressively replaced as key determinant of global economic development by the burgeoning and increasingly international financial interests. The Bretton Woods international financial arrangements, set up by the victorious powers to enable continued governmental control of the global economy, were increasingly strained until eventually they came asunder in the early 1970s.[22] Although governments tried to keep some control over the development of the increasingly global financial system, their power continued to wane in the face of the explosive growth of the sector.[23]

The essential dynamic of the new financial structure that emerged after the 1960s was the utilisation of constantly developing ICT to expand financial transactions in both time and space.[24] Financial interests, usually led by the commercial banks, sought to expand operations in both time and space to tap new sources of capital and to operate more efficiently. The banks set up round-the-clock consumer banking by establishing ATM networks, while banks as well as non-banks established new cash management accounts. The emergent financial structure was progressively integrated into global finance markets centred on the key securities and money markets situated in New York, Chicago, Tokyo, London and Hong Kong. Totally electronic markets like NASDAQ were also created.

The technological core of the whole process was electronic funds transfer (EFT), a version of electronic data interchange (EDI). EFT originated as a strategic response by banks to the new conditions applying in the wider economic context. The central concept was the provision of 24-hour service in both corporate and retail banking. In retail banking the application of EFT technology led to the mass introduction of cash dispensers, automatic teller machines (ATMs), electronic tellers, point of sale equipment (POS), cheque guarantee services, telephone bill payments, home banking and cash management services. The provision of these services necessitated better cooperation between banks, a need mainly met by EFT systems solutions. These measures included the creation of automatic clearing houses (ACHs), public and private national electronic exchange networks—such as Fedwire and Bankwire in the US—and international interbank clearing networks, such as the New York based CHIPS, and SWIFT.[25]

The whole process of payment transactions systematisation into ICT networks first began in the late 1960s. At this time banks concluded that they could successfully translate the back office efficiencies brought about by computerisation into front office operations. ATMs in particular brought about substantial gains in productivity due to greatly increased economies of scale, especially in checking. ATMs, initiated in 1969 by Chemical Bank, had really caught on in the US by the early 1980s,[26] and promised to transform mass banking.[27] The magnetic strip technology used in the ATMs was also adapted for retail transactions in point of sale (POS) systems. These techno-organisational changes brought added convenience for the consumer, additional business for the bank or retailer, and greater economies of scale for both banks and retailers.

The changes also had another effect with serious ramifications for the whole banking industry: they enabled retailers, credit card companies and financial service companies to become more independent of banks, and even to move into areas of business previously the preserve of banks.[28] The credit card companies especially, with their existing experience with 'wired' money, moved quickly to establish themselves in the new ATM networked business. This push was led by some of the largest credit card firms, notably Visa, MasterCard, Plus and Cirrus. Furthermore, businesses not specifically concerned with finance also took

advantage of the new situation to become so. Retailers (like Sears Roebuck, K-Mart and JC Penney), oil companies (most notably Exxon), travel and entertainment companies, brokerage companies, and other firms with a substantial data resource base and developed information technology capability also took an interest.

With this outlet base the next logical step was the integration of separate networks into larger scale systems, and this was soon achieved: by 1983 there were already seven such shared ATM networks operating nation-wide in the US.[29] With this combination of commercially active firms and a growing ICT infrastructure, by the mid–1980s the commercial viability of interlinked electronic money systems was well and truly established.

The banking sector was interconnected by ICT systems which functioned as automated clearing houses for the exchange of cheques, drafts and notes. The first ACH began operating in the US in 1972, run by The Californian Federal Reserve Bank branch from 1972, and in 1974 the National Automated Clearing House Association was established. In all, 32 ACH systems were operational by 1978, most run by the Federal Reserve System (FRS).[30] In the US the FRS's Fedwire, and the private Bankwire network, originally set up in 1952, connected the member banks into national clearing networks. The New York based CHIPS (Clearing House Interbank Payments System) allowed the direct transference of large amounts of money between banks, the balances being settled through the FRS. By 1985 CHIPS and Fedwire between them were carrying over $1.3 trillion daily and the volume was growing at a rate of 25% a year. The global ICT bank clearing system SWIFT (Society for Worldwide Interbank Financial Telecommunications) was founded in 1973. This was a non-profit venture owned by around 100 member banks operating in some 40 different countries.[31] There were also by this time other international payment networks operated by some of the larger banks.[32] Those banks and credit card companies which operated transnational ATM networks were also increasingly integrated internationally.[33]

So the net result of all this frenetic activity was that consumers were now systemically linked into a global financial meta-structure which was connected to the highest levels of finance through electronic networks.[34] EFT systems linked consumers, banks and other financial services operators to make up an ever more tightly integrated electronic funds accumulation and transfer system operating on a global, 24-hour basis. However, as the failure of early home-banking schemes indicated,[35] the real benefits from networking financial operations were not so much, initially at least, at the consumer level but at the level of corporate banking and investment where the edge in information availability was crucial.

The emerging global financial sector included securities markets, currency markets and bond markets. Foreign exchange markets were by definition international in scope, but the other finance markets emerged out of national markets coordinated increasingly by ICT technologies (a notable exception to this national origin being the fast-growing but volatile euromarkets[36]). There is no question that the most important of these national markets were those of the US, both because of the large scale and sustained technological dynamism of the US economy. The main reason for the introduction of new ICT into American stock markets was to improve efficiency as trading volume grew. The US Securities and Exchange Commission (SEC), investigating the May 1962 stock market crash, had recommended the introduction of computers to facilitate the trading process. Accordingly, Burroughs (later part of Unisys) mainframes were installed in 1964 and the process of computerising the stock markets was under way. These

computers were installed to handle the paperwork that derived from trading but it was already foreseen that they could also handle the actual trading as well once the terminals were connected up to each other.[37]

From 1964 more and more computing power was added to American stock markets. This initially occurred in the back office, where the newly installed computers were sometimes almost immediately unable to handle the increased workload, and later they were connected to the actual traders. Both traders and brokers, who could access the exchange's own computer databanks, were electronically connected to the trading floor. Software development reflected the hardware trend. Software packages based on complex mathematical and financial analytical logic were marketed to traders. Such types of trading software were examples of cutting edge software design, dealing as they had to with incredible levels of complexity. In fact, some exchanges introduced automatic program trading, doing away with the human trader altogether.[38]

The application of ICT to stock market operations resulted in greatly increased trading volumes and related economies of scale. Exchanges were more competitive and innovative, and this led them to pressure authorities to deregulate so they could further leverage their advantage. By the 1970s there were a wide variety of new market instruments and contracts available to traders, most importantly options and futures contracts. The first exchange for trading standardised stock options, the Chicago Board Options exchange (CBOE), opened in 1973. The year 1975 saw options trading begin in the American and Philadelphia exchanges and the following year saw the same thing in the Pacific and mid-west exchanges. In 1977 the SEC decided that options trading was getting out of hand and imposed a moratorium on expansion, but trading continued to expand rapidly when the ban was eventually lifted three years later. Before 1974 trading in commodities and related futures contracts had occurred as an unregulated industry centred on the New York Commodity Exchange (COMEX). The Commodity Futures Trading Commission Act established a Federal regulatory body, and this market joined the technology-driven global expansion as well.[39]

In 1972 financial futures trading was initiated at the International Monetary Market (IMM) in Chicago. The free world's major currencies—the pound, the yen, the mark, the lira and later the franc—were all traded. The IMM later merged with the Chicago Board of Trade (CBOT) which then became the world's major trading centre in financial futures. Other financial futures' instruments were introduced, such as interest-rate futures contracts on US Treasury bills, domestic certificates of deposits, and Eurodollar time deposits. Such tradeables gave investors new opportunities to move their money around to benefit from price differences, and this in turn led to further market innovation.[40]

In 1975 the US Congress amended the Securities Act to facilitate the construction of a nationally linked securities market in response to the rapid growth of electronically networked markets. Although this initiative stalled, computerisation continued within the stock exchanges and between them. The Intermarket Trading System (ITS) linked trading in the American, Boston, Cincinnati, Mid-West, New York, Pacific and Philadelphia exchanges from 1978. In 1979 the Cincinnati exchange set up an ICT system that freed members from the trading floor itself. The SEC continued to do what it could to integrate markets, connecting ITS with the NASDAQ system. At this point the pressure for integration was coming from both regulators—the SEC and Congress—and stock exchanges, which were in turn enduring their own pressure to further innovate from traders.[41]

By the mid-1980s, however, it was becoming a moot point whether actual stock exchanges were necessary at all. ICT trading systems like NASDAQ, Instinet and Quotron, which had no spatial 'centre', continued to grow and even began to look to linkages with overseas exchanges. The electronic wave spread to the world's exchanges; the emerging Tokyo exchange was selling fully 80% of its listed stocks by computer by 1985. The electronic exchanges also responded by increasing ICT linkages with other exchanges, beginning in 1984 with the connection of the Montreal and Boston exchanges.[42] Despite these countermoves, the trends to electronic market networking continued to threaten the very survival of smaller exchanges while at the same time centralising activity in the very largest—New York, London and Tokyo. These three giants effectively constituted a 24-hour global trading system.[43]

The intention behind the systematised interlinking of finance markets was to make them operate more efficiently as volume grew, but it also introduced greater levels of instability. Because previously separate markets were increasingly integrated into one huge market, there occurred almost instantaneous communication of trends. In addition, traders increasingly utilised computerised trading systems, an activity known as program trading, which set predetermined limits in response to market movements. Such program trading systems were identified as key factors in the 1987 crash when they exacerbated downward market mobility.[44] In fact, the disastrous crash of October 1987 proved that the stock market electronic control system was still not capable of handling the amount of information that could be generated by the financial system as a whole.[45] The official body (The Brady Commission) that investigated the 1987 crash found that in reality one national stock market had been formed by interconnected electronic systems. The commission's view was that the problem was the same as that which caused the 1962 stock market crash—inefficient matching of buyers and sellers. Its recommendation was, therefore, even better technology. In particular the Brady Commission identified the low carrying capacity of telephone lines as being a major constraint.[46] So again, the ultimate solution to market imperfections was considered to be even greater market integration through even more sophisticated technology.

The London 'Big Bang' of October 1986, when The City was deregulated and new technology was installed all at once, signalled clearly that the effective globalisation of finance markets had reached a new level. The Big Bang began a period of sustained concentration of financial interests around the world. The larger banks and finance houses acquired or merged with brokers and other merchant banks to be better placed to operate optimally in the restructured markets. In a period of sustained activity American, Japanese, European and Canadian companies invaded each other's finance markets, further concentrating financial power as they did so.[47] The pace of computerisation of securities markets did not slacken either. London opted for a system called SEAQ (Stock Exchange Automated Quotations) based on the American NASDAQ system, and other exchanges selected the Toronto Stock Exchange's CATS (Computer Assisted Trading System).[48] Around this time trading in futures and options also moved toward 24-hour global trading, although not without some set backs. Currency trading, continuing its strong expansion, was running at around $150 billion per day by 1986. Of particular significance, the overseas investments of US pension funds, which were ballooning in value, went from nothing in 1981 to $32 billion by 1986. This development showed just how much the essential investments of the

ordinary citizen were being caught up in global finance operations by the mid-1980s as a whole new order of financial activity was generated.

The evolution of the global finance infrastructure from the early 1960s to the mid–1980s was based on the development of a number of core electronic technologies, most notably semiconductors, computers, computer networks and communications satellites. Governments, especially the US government—and within that the US military in particular—played essential roles in getting these technologies to the point of commercial exploitation.[49] The following paragraphs briefly outline the development of these technologies and the developments that together brought about their overall impact.

The invention of the semiconductor grew out of wartime work and the extraordinary research capability of AT&T.[50] The rapid growth and spread of the new technology was largely due to the way AT&T was forced to share the technology, a result of its monopoly agreement with the US government. The US military played a crucial role in sponsoring ongoing research, buying new devices at premium prices, and supporting production innovation.[51] This support for the transistor was continued with the microprocessor, both of which were viewed as essential technologies for the US ballistic missile and space programs. The story with computers was similar. Early computers came out of wartime code-breaking and ballistics calculations work for the military, mainly in the US and Britain. The US government and military provided the first major demand for the early massive, power-hungry and unreliable computers.[52] Eventually computer manufacturers, especially IBM, exploited their work for the military and produced commercially viable machines. IBM leveraged its strong relationship with the US government, which went way back to their early role as calculating machine manufacturers, to eventually dominate the American and global computing industry.[53] Growth in numbers was rapid: in 1951 there were 10 computers in the US, by 1970 there were 75,000 and by 1992 there were 70 million,[54] while, thanks to the level of innovation described by Moore's Law, processing capacity exploded.

The linking of computers into networks through phone lines had begun with the first machines,[55] but computer networks really got going with the invention of packet switching. Again, this was originated by government and military initiative in the US, and particularly important was the role of DARPA.[56] Three significant steps in the development of computer networks were ARPANET, which was set up in 1969 by the US Department of Defence, the introduction of computer time-sharing services in 1970, and IBM's manufacturer standards for data exchange, released in 1974.[57] Once the focus shifted to links, line capacity and coverage became more and more important. Along with optic fibre, communications satellites provided innovative new options in this regard. The origins of communications satellites lie in the work on ballistic missiles began by the Germans in World War Two and continued by the Americans (and others) afterwards to eventually produce launchers capable of putting satellites into space and then into orbit. The first communications satellite was Score, lofted in 1958, and it was mainly for military use; Telstar, launched a couple of years later, was the first operational communications satellite.[58] The first communications satellite operator, Comsat (established in 1963), was basically a private firm set up by Congressional Act, which clearly showed the mix of commercial and political interests associated with the birth of this novel technology.[59] When Intelsat was set up in 1964 to run international satellite communications, Comsat represented the US while all the other 18 signatories were governments or government agencies. Intelsat and the Soviet version,

Intersputnik, were eventually joined by Inmarsat and regional operators like Eutalsat and Arabsat. Meanwhile, national satellite communications operators proliferated.[60] The convergence of these and other new technologies to provide the growing global ICT infrastructure depended on technical, commercial and legislative developments.[61] In particular, the various events that constituted the transformation of the whole American telecommunications system from a monopoly dominated by AT&T to one that stimulated innovation in the US and elsewhere was crucial.[62]

The net result from all these technological advances and their growing interaction was truly extraordinary increases in information storage, processing and communication capacity, along with an equally as impressive decline in costs. This techno-economic project was ideal in relation to the expansion of the emerging finance sector, which was most essentially constituted of information, often in the form of electronic money.[63] The key period was undoubtedly the 1970s when the synergy effect of the new technologies brought truly revolutionary changes in terms of both capacity and cost. For example, in the period 1974–79 computing costs dropped some 95%,[64] in 1973 AT&T's telephone line charges had dropped to about a quarter of what they had been five years earlier, and communication satellite costs dropped about the same amount over the decade while capacity increased tenfold.[65]

In a period lasting only a few decades a diverse range of different financial markets scattered around the world were increasingly integrated into one vast market representing unprecedented wealth. Beginning in the early 1960s finance markets were progressively computerised, and these computers were then linked electronically to construct more and more extensive markets. The volume of world finance activity exploded to unprecedented levels to form what was now an almost non-stop, global finance market.

All along the novel possibilities offered by the new ICT systems encouraged expansion of trading and linked previously separate trading systems to achieve a new scale of operations. Similarly, the increased speed of electronic trading itself generated new trading arrangements. This whole process took on a momentum that dragged institutional structures along with it, and while these developments often seemed to support the basic theoretical position of classical and neo-liberal economists, in that they enabled market expansion, the underlying character of the technological development itself often refuted this particular logic. Markets, especially finance markets, did, under certain conditions, have a tendency to expand, but they could only do so where there existed the necessary physical infrastructure. Furthermore, that infrastructure then imposed its own conditions on the actualisation of the supposed economic logic of market expansion, resulting in certain sustained tensions. The added market volatility caused by computer trading programs is a good example of this tension.[66]

As a final comment, a case can be made that the development of the global finance sector supports the institutionalist argument that market arrangements must always be considered within the wider socio-political and cultural context, as argued by Karl Polanyi[67] and others.[68] The very technologies that enabled the global spread of finance markets were generally not developed under market conditions but mostly due to a military imperative, which in turn involved a whole range of social, cultural, economic, political and other factors. From this perspective, then, it is somewhat ironic that the very phenomena which is often held up as market capitalism at its most advanced actually illustrates the

inextricably complex socio-technological roots of all economic activity. The global finance sector—which seems almost separate from and a step beyond the material world, manifested as it is in electrical signals travelling through space at near light speed—is in reality the product of a vast range of interconnected activities rooted in the ordinary day-to-day activity of billions of human beings. Furthermore, what seems to be quintessentially hyper-modern actually has a history that is centuries if not millennia old.

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