OPEN
DISCUSSION PAPERS IN
ECONOMICS

Evolution of Markets in the Software Industry

Suma Athreye

January 2001

NUMBER 32

***Copies may be obtained from**:*
Economics Department
Faculty of Social Sciences
The Open University
Walton Hall Milton Keynes MK7 6AA
Telephone: 01908 654437
Email: Socsci-economics-support-list@open.ac.uk
Fax: 01908 654488

This series is registered under
ISSN 1753-2590 (Print)
ISSN 1753-2604 (Online)

Economics Research at The Open University

Throughout the 1990s, The Open University has been developing its research capacity in economics. Economists at the OU comprise a lively and expanding group with a wide set of interests ranging from development policy to decision theory, from Marxist theories of profit to libertarian foundations of environmental policy and from econometric analysis of large data sets through institutional economics to the use of case-studies in policy formation. Nearly a 1000 students from around the world register each year to study economics courses and their needs, together with the multi-disciplinary nature of social science at the university, shape out research. Through a variety of personal and group research projects, our work makes a strong contribution to areas like business, public policy and even philosophy where sharply focused analysis can inform decision-making as well as contribute to scientific progress.

In 1999, approximately £250,000 million worth of externally funded grants (3 from the ESRC) were held by discipline members, some of whom also act as consultants to national and international bodies. Approximately half a dozen students are currently reading for doctorates with members of the discipline and we are always interested in proposals from colleagues or potential students who would like to do research with us.

Some of the journals in which discipline members have published include: *Annals of Operations Research, Economic Journal, Economica, Economics and Philosophy, Feminist Economics, Feminist Review, International Journal of the Economics of Business, International Journal of Industrial Organisation, Journal of Economic Issues, Journal of Economic Psychology, Journal of the History of Ideas, Journal of Social Policy, Local Government Studies, The Locke Newsletter, Open Learning, Oxford Economic Papers, Public Policy and Administration, Radical Statistics, Revue d' Économie Politique, Risk Decision and Policy, Structural Change and Economic Dynamics, Technovation* and *Theory and Decision.*

The papers contain results of economic research which are the sole responsibility of the authors. Opinions expressed in these papers are hence those of the authors and do not necessarily reflect views of the University.

Evolution of Markets in the Software Industry

Suma S Athreye

The Economics Discipline
The Faculty of Social Sciences
The Open University
Walton Hall
MK7 6AA
Email: Suma Athreye@umist.ac.uk

This chapter analyses the evolution of the software industry into a market for technology and concentrates particularly on the evolution of segmentation within the software industry. The software industry is a good example of technology markets because it encompasses the two forms that a technology market may take. The first is that of a technology market that comprises outsourced demand, as is the case in its customised segment. The second is the possibility of a technology market that is arms-length and independent of particular consumers, as is the case in its product segment.

Analysts working on technology have often seen the context-dependence of technology as an important impediment constraining the emergence of anonymous, arms-length markets. Context-dependence of technological information imposes severe costs on the supply side for the buying firm making arms-length markets difficult to emerge. In this chapter, however, we have emphasised the role of the scale of homogenous demand. This is usually small for intermediate markets such as the markets for technology, and consequently it exercises an important influence upon market segmentation.

Favourable factors on the demand side encourage an idealised arms-length market to develop. Of particular importance here is the scale of homogenous demand which if large can encourage an independent market to develop around those attributes of the technology that are widely demanded. A small-scale heterogeneous demand can however, emphasise supply-side constraints, such as context-dependence. This encourages specialisation around a narrow context of use and results in the emergence of niche markets, rather than arms-length markets. Such niche markets tend to characterise technology markets that are due to outsourcing. Demand and supply side factors can also be interrelated. Thus, heterogeneity of demand makes technology context specific but adequate standards can transform some kinds of heterogeneity into a manageable homogeneity.

In this chapter we try to illustrate all of these arguments through the history of software evolution. The evolution of the software market into 'product' and 'customised software' segments, we argue, reveals much about the way in which demand and supply-side factors influence market evolution and the subsequent segmentation of industry. Product markets are akin to arms-length markets for software technology, while customised markets represent a demand for software that is outsourced by particular firms. We draw particular attention to differences in the importance of the two segments of the software market across countries. These differences reflect, we argue, differences in the evolution of a homogenous demand for software. Furthermore, heterogeneous demand has often been managed by the creation of common standards.

The remainder of this chapter is organised in the following way. Section 1 briefly outlines the role demand and supply side factors in the emergence of technology markets. Section 2 describes what we include in our definition of the software industry and also contains a brief history of the evolution of the software industry. Section 3 outlines the demand side influences in the growth of the software industry and the (supply) constraints imposed by the needs of compatibility between different types of software. It also discusses the reasons for the segmentation of the software market into 'product' and 'customised' and the very different nature of competition in the two market segments. Section 4 concludes.

1 Demand and Supply Side Constraints on the Emergence of Technology Markets[1]

For a subject preoccupied with markets and their functioning, economic writing on the issue of when markets emerge has been surprisingly sparse. At the same time, writing on technology markets has been preoccupied with the public good nature of technology, which it is argued may cause arms length markets to fail. In this section, we will set out some arguments for the emergence of markets generally and relate these to the emergence of technology markets in particular.

1.1 Existence of exchangeable commodities

Among economists in the classical tradition, Marx stressed that the most important aspect of capitalism and a market form of organisation is commodity production. He additionally outlined the minimum characteristics of a commodity. Commodity production takes place when production is not for the direct use of the producer but for sale on the market, i.e. for exchange. Thus when baker bakes bread for his own consumption it is a product but when he bakes bread to sell in the market it assumes the form of a commodity. (Bhaduri 1986: 4–6).

A product thus becomes a commodity when it can possess an exchange value, which is independent of its use-value. This defining feature of a commodity is important in the context of a market. This is because in a market products are traded at their exchange values in order to satisfy the use-values that the final consumer of product derives from the product. However, the fact that the use value of the product has nothing to do with the exchange value (prices) that it commands in the market is an important feature of both markets and commodities. Indeed there would be no production for a market if use values (for the consumer) did not exceed exchange values received by the producer.

Possessing this essential duality of exchange value in a market and use value for a consumer requires the alienation of the commodity as a prerequisite. Property rights are an important institutional necessity for such an occurrence.[2] It is only in the transfer of ownership involved in an act of market exchange, that both the exchange and use values are realised for the seller and the buyer respectively. Thus, the existence of property rights is sufficient to the condition of alienation.

Firms through their experience of production generate technology. For a market to develop in the technology it has to be more than the result of a firm's previous experience in production. Technology must acquire the status of a commodity. In other words, firms must to produce this technology for the use of other firms and with a view to selling it for a profit. It is also necessary that the use value (to the buying firm) of these technology goods must be larger than what the firm pays to acquire it from another firm.

1.2 Scale of demand: static and dynamic factors

Commodities exist with generalised exchange and generalised exchange already presumes markets have emerged. However, the continuous or frequent nature of such exchanges is also a pre-requisite for commodity production. If a producer is to be induced to produce for a market and in the expectation of a profit, then some frequency of transaction in the commodity must already be established. Put in another way, the 'expectation' of the

producer may be about how many units of a good he may sell, but usually it is not about whether he will find any customers at all.

Adam Smith gave the other important explanation for when markets emerge. Smith saw specialised markets emerging as a consequence of increased inter-firm division of labour due to the expansion of markets for exchange of final products. The extent of the exchange market for final goods in turn was positively related to population size and density, amount of natural resources and accumulated capital available (Book 1, chapter 3) the ease of transportation (Book 2, pp.259–61), extent of trade, and lastly the stability of the market. Smithian division of labour has usually been discussed in the context of scale of market demand and both Young (1929) and Stigler (1951) had recognised the scale of the market as the one factor, which ultimately determines the emergence of new industries through vertical disintegration.

It is also worth noting that the size of the exchange market is actually subject to two separate sorts of influences. At any point of time, the size of the exchange market is defined by the number of participants in the market multiplied by the frequency of exchange to any one participant. However, it is easy to see that an increased frequency of exchange transaction would in fact be the result of all the factors considered by Smith as the factors increasing the extent of the market positively, so that what lies behind the extent of the market is in fact an increased frequency of exchange.

At the start of a market emergence process, one may expect the number of participants to be small and unchanging. At this stage it is the frequency of exchange transactions that determines the emergence of a market. Once an exchange market has been established in one period, however, its continuance could come about by an increasing frequency of exchange or by an increase in the number of participants, or both.[3]

Once a market has emerged in a commodity, institutions may emerge to support the continuance of this market. These are likely to differ according to the volume of exchanges and also according to the differing social norms in different environments. They may also give rise to increasing returns in the process of exchange (North 1990). The emergence of standards in several industries is a good example of the role of institutions. Quality standards cut down the buyer risks associated with exchange and facilitate the continuation of the exchange process. Simultaneously by making for compatibility across different users and manufacturers they also facilitate the increase in the size of the market making seller risks low.[4] Thus, the emergence and existence of institutions is sufficient to the second condition viz. the maintenance of the reasonably frequent and continuing exchanges.

The above discussion suggests that the defining features of a market are both the existence of an exchangeable product and the existence of reasonably frequent and continuing exchange transactions in that product. On reflection it is also clear that theoretical conceptions of what a market is also implicitly assume these two characteristics. A ‘commoditisable product’ alone is sufficient to define sporadic exchange and trading behaviour. Routine exchange is capable of giving rise to regular markets with stable behavioural regularities and the possibility that market prices reflect differences in quality or costs of production.[5]

Once markets have emerged they may be regular and irregular. Textbook representations of perfect and imperfect market distinguish between the spread of transactions on both sides of the market (in the case of competitive markets) or concentration of transactions on one side of the market (as in the cases of monopoly oligopoly, or monopsony), as a source of market irregularity. The effect of this irregularity is that make prices diverge from the costs of production.

The scale of market demand at a point of time and its growth overtime are both factors that may particularly constrain the emergence of technology markets. This is because the demand for technology goods is a derived demand from the demand for final goods. Derived demands are typically small. Thus, Athreye (1998) and Breshnehan and Gamberdella (1999) argue that technology markets develop mostly on the basis of cross-sectoral demand – a possibility encouraged by the presence of technological convergence. Rosenberg (1963) argued that this was the most important factor facilitating the development of the US machine tool industry. In addition, the interchangeability of component parts ensured that an arms length market could emerge in some parts of the machine tool sector. The use of common standards has played the same role in the development of the software industry.

1.3 Boundaries of the market, bundling and unbundling

In the discussion so far the term market has not been defined except as an organisational mode that facilitates production through exchange and the incentive for which is the profit from such exchange. In particular I have tried to avoid a product based definition of the market because if we think of the emergence of regular markets in more dynamic terms or over several time periods, it should be clear that the consolidation of the process of exchange and the considerations of profitability of the producers will also define the product which is being sold. What is exchanged between buyers and sellers in a market gets determined simultaneously with what can or cannot be alienated as a commodity and with what combination of products a reasonable frequency of exchange transactions might emerge to make it profitable for the producer to sell his product.

Two examples may clarify this last point. In several economies consumer durables are sold along with a guarantee of after sales service. This is a composite product with a product element and a service element. There is no reason why the two should not exist as separate markets by a product definition of a market. In several developing countries markets for repair often act as guarantors for consumer durables, or sometimes no guarantees are sold. Another example is that several developing country firms diversify into several lines of production because often markets do not exist in complementary products such as machinery. Here again is the case of a market that gets established in a composite rather than a single product. Excessive preoccupation with product-based definitions of the market could obscure the process and function of exchange which lies at the heart of the regular market abstraction and the organisational mode of the market.

Technology markets often emerge in composite or ‘bundled’ products. An example here is the case of IBM, which initially provided both hardware and software till the threat of anti-trust legislation forced the firm to unbundle hardware from software. Partly this kind of bundling is a consequence of the natural evolution of demand. If demand grows in an

unfettered way, the composite product is subject to specialisation and a greater division of labour.

Partly however, bundling also reflects the difficulties of 'alienating' technologies from their context. Alienating technologies from their context, imposes costs of codification and standardisation upon firms. We turn now to a discussion of these cost considerations that prevent a market for technologies from developing.

1.4 Supply side views on market emergence

The question of when markets in technology develop maybe viewed from the point of view of a firm who decides when it will be profitable to make or to buy technology that it needs. Viewed in this way, the costs of buying the technology become the important determinant of when a firm will decided to buy the technology. If these costs are lower than what the firm would pay to produce the technology in-house, then a market for technology could emerge. Posing the question in this way should of course not blind us to the fact that buying a piece of knowledge is not the same thing as buying a component of production. Furthermore, the make-buy tradition is unduly static in its assessment of the costs of technology. It does not, for instance, consider what costs are incurred by the firm in using the market, nor does it consider the time that it takes for firms to produce the same technologies in-house.

Nevertheless there are some insights worth noting. In a through review of the existing literature in this tradition, Arora *et al* (1999)[6] point to two important supply side constraints to the emergence of technology markets: the context dependence or 'stickiness' of knowledge and the problems of writing contracts for knowledge type goods. Both these constraints impose large costs upon firms that in turn predispose them to produce technology in-house.

Arora and Gamberdella (1994) argued that such context dependence affects the cost of information exchange, but that the new advances in information technology had reduced the impact of this constraint. This is because advances in computing capability have allowed the codification of previously context specific knowledge by the use of abstract and general principles. The costs of information exchange due to context dependence can be reduced thus leading to a growth in markets for technology.

However, they also point out that if these costs were like a fixed cost then supply side constraints would dissolve in the face of growing demand. Growing demand would ensure that the fixed costs imposed by say codification/standardisation, would be lower in unit cost terms reducing the price of technology.

Another problem that is often raised is the difficulties of writing contracts in technology because of uncertainty, small numbers of participants and the ease of imitation. Arora (1995) argues that under some circumstances it may be possible to write contracts in technology, even if technology is largely tacit. The particular circumstance that he draws attention to is the complementarity of tacit and codified components and the possibility of the codified component being protected by intellectual property rights. In this circumstance, technology would be sold as a package. The licensor would always be able to withdraw the license on the codified part of the package and so control opportunistic behaviour on the

part of the buyer. This analysis again points to the importance of bundling in technology markets.

2 The Software Sector and its Evolution Overtime

Computer software is the stored, machine-readable code that instructs a microchip to carry out specific tasks[7]. Over thirty years of its evolution the software market has encompassed this basic functionality, across a differentiated range of uses. There are at least two ways in which data on the industry describe the different activities that constitute the software sector.

2.1 Classification of software

One classification is based upon the function of the software and what sort of tasks it instructs the microchip to carry out. Here there are three broad categories: operating systems, tools and applications. Conceiving the software sector in this way defines the importance of particular computer science skills that are required to write those kinds of software.

A second classification is in terms of how software and its associated services are provided by producers. Thus there are 'product providers' or 'customised software/service providers'. Each of these two kinds of producers may provide operating systems, tools or applications. Such a classification is useful because it emphasises the associated differences in the nature of markets and competition between the two segments (Mowery 1996, Hoch *et al* 1999). We use this second classification in this paper as it corresponds more closely to the two forms that technology markets can take.

Table 1 Domestic consumption of software and computer services in the United States, Japan, and Western Europe ($ billion)

	Package software		Custom software		Processing services
	1985	1992	1985	1994	1985
United States	12.60	28.46	4.17	35.60	11.1
Japan	0.27	5.96	2.74	5.95	3.77
Western Europe	5.21	23.85	4.72	26.57	5.33

Source: Mowery 1996: page 7.[8]

This current segmentation of the industry however, masks the fact that the software industry evolved overtime from being a professional services provider to providing software products. The evolution of the market segments we will argue is largely a consequence of the evolution of a homogenous or heterogeneous demand for software. Standardisation played an important role in eliminating some sources of heterogeneity.

2.2 Stages of software evolution

Hoch, *et al* (1999) argues that the software business unfolded in five stages. The first stage (1949–59) comprised the development of professional service firms in the US, who developed tailor-made solutions for several big software projects underwritten by the US government and later by large corporations. The SAGE and the SABRE systems were both

products developed in this period. Nevertheless in the 1960s the demand for software came from a few large firms and the conventional wisdom was that software couldn't, by itself, make money.

1959–69 saw the emergence of the first two software product companies. Mark IV written by Informatics was one of the most successful software products. The other software product came about due to a failed contract. ADR produced the product *Autoflow* for another firm (RCA) who decided they didn't want it after all. ADR reacted by trying to recover its costs by selling the same product to other buyer. Eventually they rewrote the product slightly for IBM 1401 and later for IBM/ 360 series.

The decade of the 70s started with the unbundling decision of IBM. The immediate consequence was that a number of software product companies emerged, providing database applications across a range of business operations, for finance and insurance companies. These companies also called independent enterprise solution providers included firms like SAP, BAAN and Oracle– all established during this period.

The decade of the 1980s saw the rapid spread of the personal computer and the associated need for a different kind of software – mass packaged software that could be installed on small systems. The software market splintered into more areas of application. Even before the 80s there were two competing platforms for operating systems on personal computers, viz. the DOS system and the Mackintosh. In the 80s, Windows emerged as the standard operating system. Applications software for the personal computer were written based on the operating system it was to run upon, and this grew as a distinct area of software.

The spread of the PC created the possibility of replacing mainframe systems with networked PCs. This created a new kind of software market where PCs on different operating systems and on the same operating systems could 'talk' to each other. The Internet is an extension of this same basic idea. The possibility of writing software that enables different microchips communicate to each other also opens up whole new areas of application – in telecommunications, in media and in 'intelligent' consumer durables. These are also the important growth areas for the future of the software industry.

Figure 1, reproduced from Hoch *et al* (1999) shows the above history of software in terms of significant players and events. Two aspects of the figure are remarkable. The first is that the different developments described were periods in which new technological advances created opportunities for the entry of completely new firms. This is also a feature observed for the evolution of other industries, notably automobiles.

Second the figure shows the gradual development of new software languages as software applications developed. This aspect of software industry evolution is similar to that observed for the capital goods industry where the growth of the machinery sector in economic production was accompanied by the development of engineering and its sub-disciplines.

3 Demand and the Evolution of the Software Industry

The demand for software is a derived demand that has emerged as a consequence of increasing computerisation of several administrative and production activities, and more recently the increasing digitisation of different forms of data (numeric, graphic, musical). The factors that influenced the scale of computerisation and digitisation also had an impact on determining the scale of homogenous demand for software. In this section we will argue that the scale of homogenous demand, where large encouraged the emergence of product software. Where the scale of demand was large but heterogeneous, niche markets and customised software prevailed.

In the early fifties when the first computers were made, computer software was wired into the hardware. Software programs were very specific to the use to which they would be put to. In this early period of the software industry demand was heterogeneous and infrequent. Whatever software was written was sold with the hardware and was free. This is still the case in several other areas such as mobile phones and telecom switches to name just two examples.

For all of this early period, service firms that wrote one-off programs for large users populated the software industry. In the forties and fifties these large users were US Government departments. As big firms adopted computer mainframes to store their business data and files they became the big users that demanded software. The lack of standardisation in hardware meant that the demand for software though similar remained fairly heterogeneous. The cost incurred was usually that of employing programmers and firms tried to maximise the use of these programmers by actively looking for new orders.

The idea that the same software program could be sold again and again to different users took some time to take hold. The repeated sale of the same software program was a relatively new way of doing business in the software industry. First the firm would undertake the fixed developmental costs of creating the program and de-bugging it. The use of the program would then be sold to recover the costs of writing it, rendering software production very similar to commodity production.

The early strategy of service provision was very different to the strategy of product providers. In terms of our discussion in Section 1, product provision in software is akin to the commodification of software, and as we explained commodification requires investment in anticipation of demand. In microeconomics terminology, the balance of fixed and variable costs changes for the producing firms. Service providers have very few fixed costs and can recover all their variable costs through utilising their resources fully. Software product providers however, have mostly fixed costs. The only variable cost that they incur is the cost of additional units, which for software is the cost of reproduction. When there is the large dominance of fixed costs standard economies of scale accrue to the producer. Total profits increase as market share grows.

3.1 Homogenous demands and the emergence of software products

The software product strategy could not have worked without a large enough scale of homogenous demand. A large-scale of demand was created by the continual introduction of cheaper and cheaper machines. In 1960, IBM introduced the IBM1401, a cheaper general-purpose machine meant for medium sized users. This was followed up by the successful introduction within a few years of the System/360 around a standardised

operating system. The installed base of computers grew and so did the market in software services. The first software 'products' were written to run on these IBM machines. Indeed the spread of computer usage and the growth of software markets is the best modern day example of the advantages of the increasing division of labour. Cheaper machines increased the usage of computers and created a demand for separate software. This trend was accelerated and replicated with the spread of the personal computer in the 1980s. The installed base of computers has grown ever more and for the first time a mass market for PC software products emerged.

Though software products needed a large scale of demand to which they could sell repeatedly, the areas of use in which software products emerged is also instructive. The package software industry emerged and grew around various applications that were usually cross-sectoral in application. Brady *et al*. (1992) argue that the commodification of software occurred when many of the smaller emerging software firms began to offer packages that reflected primarily *'the converging needs of large numbers of computer users across many sectors. With respect to application software specialisation developed along two lines. Some software firms developed products for general purpose applications such as payroll or accounts where there was a commonality in the requirements of users across many sectors. Other firms evolved to sell to particular large vertical markets such as banking or insurance or the military'*. However, where such cross-sectoral convergence of application needs did not take place, such as in the case of firm specific applications designed to achieve competitive advantage computerised systems were more likely to be produced internally, or be developed as bespoke software by software houses, as had been common during the earlier growth of the industry.

The growth of software products around particular applications was greatly helped by the emergence of common platforms. This in turn was caused by the early actions of IBM. Common platforms mean that one basic software language is adopted on a number of machines and programs. The IBM 1401 machine was sold with a new software language RPG that was available free with the machine. Software product companies could build their applications around this common and freely available language. IBM's motives in providing a common platform was to increased hardware sales, and create fresh demand by reducing the costs of switching for users. This increase in hardware demand of course had a dramatic influence on the potential demand for software.

3.2 Heterogeneity of software demand and the dominance of customised markets

Though there was a dramatic growth of demand for software – this demand was not all identical or homogenous. There were areas where software needs were fairly heterogeneous, and this heterogeneity could be usefully exploited to both blunt competition and make money. The growth of the customised software and services sector, both globally and within particular countries, can be best understood as a response to the common factors that underlay heterogeneous demand. These factors also varied from country to country.

There were many sources of heterogeneity in the demand for software. An important source of heterogeneity was linguistic and legal diversity across nations. This was particularly relevant to the spread of computerisation for administrative uses in companies. Payroll

software developed for one country could not very simply be used for another. Thus, localised software development was the first large source of software demand in every nation. The different waves of hardware installations created a need for software that was written differently but for the same vintage of the operating system installed. Software for mainframe computers could not run on minicomputers and software for minicomputer had to be rewritten for the personal computer and for PC networks. Again this created a need for bespoke software in niche markets. Lastly, industrial sectors were different in their administrative and production needs and procedures. Some firms specialised by sectors, such as finance, oil, or retail trading. Their aim was to provide all the software needs of their chosen sector.

All these different sources of heterogeneity are associated with segmentation of the market into smaller local or special markets where competition is low. The types of abilities and management practices that firms required to succeed in these markets are also different. Thus, in their survey of Western European software firms Malerba and Torrisi (1996) found that reputation and knowledge of user needs usually acquired through long term relationships with the customer were the important barriers to entry in the customised market. In contrast, the package software market demonstrated barriers to entry on account of marketing and distribution networks as well. The balance of skills needed and their variety is clearly evident in Table 2 below reproduced from Malerba and Torrisi (1996).

Similarly, Hoch *et al* (1999: 46) on the basis of their survey of 100 leading software firms around the world argue that the ranking of management practices in the customised and product segments of the software market are quite different. They found that customised software and services firms tend to place the highest priority upon human resources management, followed by software development strategies, marketing and sales and strategy. In contrast, software product firms ranked Strategy as most important, followed by marketing and sales, human resources and placed software development as the least important.

One implication of the different skills and management practices needed in the different market segments is that the transition of firms that serve niche markets into product market players though theoretically possible, is empirically less observed. The effect of initial heterogeneity in demand upon market segmentation is difficult to overcome, because the skills and management required to deal with mass marketing and the creation of homogenous demands through skilful marketing is less abundant in the economic system.

Table 2 Entry barriers for different types of European software producers (average scores)

Firm type	Financial resources	Marketing and sales network	Knowledge of user's environment	Technological skills and capabilities	Image and reputation	Corporate culture
Software and services	2.83	3.25	3.64	3.20	3.68	2.69
System software and utilities	1.50	2.00	3.50	5.00	4.00	4.00
Packaged software	3.50	3.36	3.73	3.00	3.45	3.50
Services (EDP, Consulting/ training)	2.23	3.36	3.73	3.14	4.36	2.50
Technical services (software development tools, expert systems)	3.50	3.25	3.25	3.00	2.25	1.00

Notes: Scores are from 1 'not relevant' to 5 'very relevant'.
Source: Malerba and Torrisi (1996), Table 7–9; page 178.

The evolution of the software industry certainly demonstrates this kind of persistence in the aggregate. Thus, Table 1 showed us that American firms faced a larger demand for software products in the early stages of the industry. This early lead was a consequence of the larger scale of homogenous demand faced by American firms. Table 1 also shows that the pattern changes and package software consumption grows in Europe. This growth in demand for package software in Europe is however, served largely by US firms. Mowery (1996: 7–9) estimates that US firms account for more than 80% of the US package software market and over 60% of the non-US software market.

3.3 Standards and the reduction of heterogeneity in demands

An important element in the growth of the demand for software and its diversity has been the emergence of platforms and standards that has had many implications for the future development of the industry. Breshnehan and Greenstein (2000) argue that the emergence of standards and platforms have helped groups of firms compete with each other while helping them to avoid ruinous direct competition. However, the rise of a dominant standard is also akin to the emergence of sunk costs, albeit over a group of firms. This is because the emergence of platforms and standards is associated with other network effects that have important implications for demand for the standard, so that the expenditure on the standard affects both profitability and raises demand making it an endogenous sunk cost.

Our interest in this sub-section is to stress the demand-side implications of standards and their role in directing the evolution of the industry. As computerisation proceeded in

different waves and with different vintages of computers and operating systems, an important source of heterogeneity in demand was introduced. As long as the market was expanding with new participants entering the market this was not a serious problem. But when computerisation was reasonably widespread further increases in the demand for computers could only come about by new buys from old users. In this situation the incompatibility of different systems introduced a new cost for the buyer- the cost of switching. A machine and operating system that was compatible with the older model reduced switching costs for the buyer and allowed them to transfer their data and files from the old machine to the new one.

For software producers who wrote applications around a particular operating system the existence of standards became even more important for similar reasons. Firstly, successful platforms defined their potential market in an important way. Secondly, upgrades of application software with new features or additional tasks, depended upon a compatibility with past software. For the buyer of software a common standard allowed her to have a variety of applications, which was desirable.

For all these reasons the importance of standards in software is similar to the importance of interchangeable parts in the growth of the machine tools industry. Interchangeable parts allowed heterogeneous production to proceed with the benefits of a homogenous demand. In software, standards achieve the same objective. The creation of standards however, requires coordinated costs to be maintained across a group of firms.

4 Summary and Implications

In this chapter we have tried to emphasise the role of demand and supply side factors in the evolution of the software industry and its important segments. Undoubtedly this is not the only way to read the evolution of the industry. However, it is an approach that usefully delineates the evolution of the two forms that technology markets can take. We argued that the evolution of these segments has implications for the nature of competition in the market segments, and also the potential benefits of technology markets.

Thus we have tried to show that the extent of homogenous demand has defined the existence of mass market commodities in software while heterogeneous demand has given rise to niche (outsourced) markets. The nature of competition in the two markets is quite different as is the nature of skills that firms require to succeed. Furthermore, these skills have shown remarkable persistence overtime. Software standards and platforms have played an important role in reducing the impact of some kinds of heterogeneity.

In many respects we have tried to emphasise the similarity between the evolution of software and the emergence of the machine tool sector in the latter part of the last century. Such a comparison also serves to highlight the nature of the advantages and externalities that accrue to the economy due to ‘economies of specialisation’ in software.

By virtue of being intermediate sector efficiencies in software design and improvements in productivity that result from such developments in software are likely to be transmitted to a number of sectors. The scope of this transmission depends both on the extent to which software is used in the economy and the development of key user sectors for software. Two sorts of effects are evident. In the financial and information based sectors (newspapers, entertainment) and functions (administration in offices) the effect of software

development has been in speeding up the production time and thus resulting in improvements in productivity. In sectors like manufacturing the development and use of software has given firms the ability to be consistent in quality and increase variety within arrange of products, as was noted by the flexible specialisation arguments. As software expands in scope to include all kinds of digitisation and communication, the improvements in software programming and development maybe expected to do the same kinds of things for other sectors – increase productivity by reducing production time, and keep quality consistent.

References:

Arora, A. (1995) Licensing tacit knowledge:intellectual property rights and the market for know-how. *Economics of Innovation and New Technology, Vol. 5.*

Arora, A., and Gambardella A. (1994) The changing technology of technological change: general and abstract knowledge and the division of innovative labour. *Research Policy 23, 523–532.*

Arora, A., Fosfuri, A. and Gambardella, A. (1999*)* Markets for technology. *Mimeo. Carnegie Mellon University. Pittsburgh, USA.*

Athreye, S. (1998) On markets in knowledge. *Journal of Management and Governance*, Vol. 1(2): 231–253.

Bhaduri, A. (1986*)* Macroeconomics: the dynamics of commodity production. *New Delhi: Oxford University Press.*

Brady, T., M. Tierney and R. Williams (1992*)* The commodification of industry applications software. *Industrial and Corporate Change 1, 489–513.*

Bresnahan, T., and Gambardella, A. (1998) The division of inventive labour and the extent of the market. *In Helpman, E. (ed.)* General purpose technologies and economic growth. *MIT Press.*

Bresnahan, T., and Greenstein, S. (1999) Technological competition and the structure of the computer industry. *Journal of Industrial Economics, Vol. 67(3): 1–40.*

Hoch, D.J., Roeding, C.R., Purkert, G., and Lindner, S.K. (1999) Secrets of software success. *Boston: Harvard Business School Press.*

Malerba, F. and Torrisi, S. (1996) The dynamics of market structure and innovation in the Western European software industry. *In Mowery, D.C* (1996) (ed.): The international software industry: A comparative study of industry evolution and structure. *New York and Oxford: Oxford University Press.*

Marx, K. (1857/58: 1973) Grundrisse*:* foundations of the critique of political economy, *English edition, ed. N.I. Stone, Chicago 1904; (translation M. Nicolaus). Harmondsworth Middsx: Penguin Books.*

Mowery, D.C (1996) (ed.) The international software industry: A comparative study of industry evolution and structure. *New York and Oxford: Oxford University Press.*

North, D.C. (1990) Institutions, institutional change and economic performance. *Cambridge: Cambridge University Press.*

Roncaglia, A. (1985) Petty: The origins of political economy. *Cardiff: University College Cardiff Press.*

Rosenberg (ed.) (1976) Perspectives on technology. *Cambridge: Cambridge University Press.*

Rosenberg, N. (1963*)* Capital goods, technology and economic growth. *Reprinted in Rosenberg (ed.)* (1976) Perspectives on technology. *Cambridge: Cambridge University Press.*

Smith, A. (1776: 1986*)* An enquiry into the nature and causes of the wealth of nations. *Reprinted in Penguin classics, Penguin Books.*

Stigler, G.J. (1951*)* The division of labour is limited by the extent of the market. *The Journal of Political Economy, 59(3): 185–193.*

Yamin, M. (1997): The dual risks of market exchange: the roles of marketing institutions and activity in the transition process. *International Journal of Entrepreneurial Behaviour and Research 3(1):1355–2554.*

Young, A. (1929): Increasing returns and economic progress. *Economic Journal 38: 527–542.*

Notes:

[1] This section draws upon Athreye (1998).

[2] This is explained in the following passage about commodities, exchange and circulation, from Grundrisse: *'To have circulation, what is essential is that exchange appears as a process, a fluid whole of purchases and sales. Its first presupposition is the circulation of commodities themselves, as a natural many-sided circulation of commodities. The precondition of commodity circulation is that they be produced as exchange values not as immediate use values, but as mediated through exchange value. Appropriation through and means of divestiture (Entäusserung) and alienation (Veräusserung) is the fundamental condition. Circulation as the realisation of exchange values implies: (1) that my product is a product only insofar it is for others; hence suspended singularity, generality; (2) that it is a product for me only insofar as it has been alienated, become for others; (3) that it is for the other only in so far as he himself alienates his product; which already implies (4) that production is not an end in itself for me but a means.'* Marx , K. (1857:1973) page 196. Alienation is usually discussed in a specific context popularised by existentialist philosophers, viz. the lack of control over the end use of its product by labour. However, Marx's discussion of the historical development of labour power as a commodity makes clear that the alienation of labour from the means of production was an important historical necessity in the transforming labour power into a commodity.

[3] The division of labour process is cumulative. The efficiency gains due to the division of labour ultimately lower prices, which should induce more consumption. Because this decrease in price does not happen at the expense of profitability but by cutting down costs, it also allows induces more production by existing firms or by new entrants.

[4] Yamin, M. (1997).

[5]Roncaglia (1985) discusses this point in the context of evaluating Petty's conceptualisation of the market as evidenced in The Dialogue of Diamonds.

[6] This brief sub-section draws upon their review.

[7] From Mowery (1996)

[8] Western Europe is defined as the seventeen countries of Austria, Belgium, Finalnd, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and the UK.

Titles available in the series:

Number 1	Valuing the environmental impacts of open cast coalmining: the case of the Trent Valley in North Staffordshire *Andrew B Trigg and W Richard Dubourg, June 1993*
Number 2	Scarcity and stability in a very simple general equilibrium model *Vivienne Brown, February 1994*
Number 3	A conflict model, with rational expectations, of the disinflation of the early 1980s *Graham Dawson, February 1994*
Number 4	Foreign Investment, Globalisation and International Economic Governance *Grahame Thompson, May 1994*
Number 5	Testing the Small Country Hypothesis for Developing Countries *Jonathan Perraton, December 1994*
Number 6	The Discovery of 'Unpaid Work': the social consequences of the expansion of 'work' *Susan Himmelweit, June 1995*
Number 7	Exit, Voice and Values in Economic Institutions *Graham Dawson, June 1995*
Number 8	Residential Summer Schools Attendance and Students' Assessed Performances on Open University Foundation Courses *Alan Gillie and Alan Woodley, June 1995*
Number 9	Putting Words into People's Mouths? Economic Culture and its Implications for Local Government *Maureen Mackintosh, December 1995*
Number 10	What is a Fair Wage? A Critique of the Concept of the Value of Labour-Power *Susan Himmelweit, December 1995*
Number 11	The Origin of the Poverty Line *Alan Gillie, December 1995*
Number 12	The Determinants of Product and Process Innovations *Roberto Simonetti, Daniele Archibugi, Rinaldo Evangelista, February 1996*
Number 13	Technical Change and Firm Growth: 'Creative Destruction' in the Fortune List, 1963-1987 *Roberto Simonetti, February 1996*
Number 14	Utilities vs. Rights to Publicly Provided Goods: Arguments and Evidence from Health-Care Rationing *Paul Anand and Allan Wailoo, January 2000*
Number 15	Proceeding to the Paddling Pool: The Selection and Shaping of Call Centre Labour *George Callaghan and Paul Thompson, January 2000*
Number 16	Doing 'Qualitative Research' in Economics: Two Examples and Some Reflections *Elizabeth Hill and Gabrielle Meagher, November 1999*
Number 17	Veblen, Bourdieu and Conspicuous Consumption *Andrew B Trigg, January 2000*

Number 18	The Effect of Idiosyncratic Events on the Feedback between Firm Size and Innovation *Mariana Mazzucato, January 2000*
Number 19	Non-market relationships in health care *Maureen Mackintosh and Lucy Gilson, January 2000*
Number 20	Selling pollution and safeguarding lives: international justice, emissions trading and the Kyoto Protocol *Graham Dawson, October 2000*
Number 21	Entrepreneurship by Alliance *Judith Mehta and Barbara Krug, September 2000*
Number 22	A disorderly household - voicing the noise *Judith Mehta, October 2000*
Number 23	Sustainable redistribution with health care markets? Rethinking regulatory intervention in the Tanzanian context *Maureen Mackintosh and Paula Tibandebage, November 2000*
Number 24	Surplus Value and the Keynesian Multiplier *Andrew B Trigg, October 2000*
Number 25	Edwards Revised: Technical Control and Call Centres *George Callaghan and Paul Thompson, November 2000*
Number 26	Social Norms, Occupational Groups and Income Tax Evasion: A Survey In The UK Construction Industry *Maria Sigala, November 2000*
Number 27	Procedural Fairness in Economic and Social Choice: Evidence from a Survey of Voters *Paul Anand, December 2000*
Number 28	Alternative rationalities, or why do economists become parents? *Susan Himmelweit, December 2000*
Number 29	Agglomeration and Growth: A Study of the Cambridge Hi-Tech Cluster *Suma Athreye, December 2000*
Number 30	Sources of Increasing Returns and Regional Innovation in the UK *Suma Athreye and David Keeble, January 2001*
Number 31	The Evolution of the UK software market: scale of demand and the role of competencies *Suma Athreye, September 2000*