ICT AND PRODUCTIVITY GROWTH – THE PARADOX RESOLVED?

Centre for Business Research, University of Cambridge
Working Paper No. 316

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December 2005

This Working Paper forms part of the CBR Research Programme on Enterprise and Innovation

Abstract
This paper argues that the gains from ICT at the individual business level depend upon the implementation of a range of complementary 'investments' and organisational changes appropriate to the competitive and institutional context of particular sectors. To support our proposition we provide a brief overview of a recently emerging but compelling body of large sample micro-econometric research. We focus in depth, however on a single case study of ICT related organisational transformation in the transportation sector. This case builds upon the conceptual framework developed in the MIT interesting organisations project (Scott Morton (2003)). Taken as a whole we believe there is clear evidence of the conditions that seem to be required before the payoff from ICT can be realised by an organisation and hence diffuse through the economy. Effective use of ICT requires a holistic solution which recognises that there is no single factor, or even just a few, which leads to successful exploitation. Rather success comes from the artful crafting of a series of interrelated and mutually interdependent driving forces. The paradoxical 'gap' between investment in computers and realised performance can be closed if this lesson is absorbed.

JEL Classification: Organisational Behaviour, Industrial Organisation, Business Performance

Keywords: ICT, Complementary Investment, Productivity, Transport Services

1. Context

Nobel prize-winner Robert Solow remarked in 1987 that 'You can see the computer age everywhere but in the productivity statistics' (Solow (1987)). Research on the 'Solow paradox' since then has thrown the contribution of computers, software and telecommunication hardware into sharper relief. There is now persuasive evidence that the information and computer technology (ICT) investment boom of the 1990's has led to significant changes in the absolute and relative productivity performance of firms, sectors and countries. This effect is pervasive and both crosses, and has led to a blurring of, the boundaries between the goods and service sectors of the economy. Its impact has, however, emerged with considerable lags and has been uneven across firms sectors and countries. At the business level controversy remains about its role and the value to a business of ICT investment as a whole and of its components. At the aggregate level views remain divided about three key issues; the degree to which ICT contributed to the post 1995 productivity surge in the US economy; the balance of that contribution between ICT producing and ICT using sectors; and the sustainability of the productivity turnaround.

Our purpose here is to show that the gains from ICT at the individual business level depend upon the implementation of a range of complementary 'investments' and organisational changes appropriate to the competitive and institutional context of particular sectors. To support our proposition we provide a brief overview of a recently emerging but compelling body of large sample micro-econometric research. We focus in depth, however on a single case study of ICT related organisational transformation in the transportation sector. This case builds upon the conceptual framework developed in the MIT interesting organisations project (Scott Morton (2003)). Taken as a whole we believe there is clear evidence of the conditions that seem to be required before the payoff from ICT can be realised by an organisation and hence diffused through the economy. The story as to why this is so is, in many ways, not new – but, judging from the actions of managers in many organisations, and the articles published in leading management and practitioner journals, it has not been fully recognised (Carr (2003) (2005)). True recognition brings the understanding that effective use of ICT requires a holistic solution which recognises that there is no single factor, or even just a few, which leads to successful exploitation. Rather success comes from the artful crafting of a series of interrelated and mutually interdependent driving forces. These forces cross normal organisational boundaries so they require someone with an overall view (normally the CEO) to manage the complex balance that leads to successful change. Maintaining the balance between the forces, whilst moving to achieve fundamental organisational change is a difficult task.

Successful organisations have recognised that computers and communications technology can fundamentally alter the very nature of organisational work; who can do it and where and when it can be done. This in turn often requires the rethinking of the strategy of the organisation with a subsequent remaking of its basic structure and processes. As one CEO of a Fortune 500 company said during the final workshop of the 'Management in the 1990's' research program. 'It is almost like changing the tires on a moving car!'.

Once the impact of ICT is approached from this micro-perspective the nature of the Solow Paradox is more readily revealed and the factors behind the continuing debate about the role of ICT emerge more clearly. The extent to which the computer age shows up in the productivity statistics depends ultimately on the ability of business organisations to match internal structures, processes and culture with an effective strategy for capturing the product market opportunities and production possibilities afforded by changing information and computer technology. The precise form of the organisational change and the opportunities to be seized are contingent upon the extent to which scale, scope and network economies are present, but in all cases success at the corporate level requires costly and time consuming organisational transformation. Although we focus in depth on a single case of ICT-related organisational transformation in the transportation sector, our conclusions are quite general and apply across the manufacturing and services spectrum.

Our analysis is relevant for regional and national policy makers concerned with strategies to promote innovation and productivity growth as much as for organisations concerned with capturing the gains from ICT. At a national policy level OECD governments outside the USA have been keen to emulate what is perceived to have been an ICT-led productivity acceleration in that country. This has led, in particular, to increased interest in productivity growth based on investment in ICT-using industries, services in particular, as opposed to ICT production per se. In the OECD economies services account for around 70% of total employment and value added, and virtually all of employment growth. Yet productivity growth everywhere is perceived as particularly low in these sectors relative to the USA. These governments are urged to deregulate their service sectors open them to trade, liberalise labour markets and improve service-related skills flow and public sector R&D. Important though these conditioning factors may be, they are not the whole story. For instance, in many of the areas identified above, the UK ranks as high or higher than the USA (Card and Freeman (2001)) and yet its services productivity-growth performance, and productivity in IT-using sectors generally, substantially lags that of the USA (Van Ark et al (2003)), Basu et al (2003)). The roots of the difference from our perspective lie in the extent to which organisational transformation has been

brought about by the strategies of key players in the relevant sectors. This suggests the need for a micro-economic sectoral perspective in policy design and evaluation.

Inside the USA a principal policy concern has been whether the productivity acceleration which occurred in the second half of the nineties was sustainable and the extent to which this depends upon ICT production, ICT use and the lags between ICT investment and productivity growth (Jorgensen et.al.(2002), Gordon (2003)). Our emphasis on the need for extensive complementary 'investments' in organisational transformation to reap the gains from ICT, suggests that we should expect to find productivity gains only where this 'investment' takes place; that it may involve considerable lags before it shows through and will be conditioned by particular sector level factors that affect the organisational changes which are required. Our perspective here is in keeping with macro-economic accounts of the US productivity acceleration which point to investment in intangible capital and the movement in residual total factor productivity (once conventional labour and tangible capital inputs have been accounted for) as key features of the US productivity acceleration in the 1990s (David (1991) (2000), Gordon (2003), Baily (2004)).

Our starting reference point is the organisation. This is because a nation's economic wealth is entirely created within organisations. They are the mechanisms by which wealth is created and through which market forces operate. It is certainly important to have facilitating policies and supportive fiscal regimes but ultimately it is the organisation that is the fundamental driver of wealth creation. Moreover it is not just how an organisation performs but importantly, it is how it reacts and performs for its customers and relative to its competition, both locally and internationally, that matters to its survival and growth and to its contribution to national economic performance.

Our starting assumption is that the business environment in which most organisations (both public and private) find themselves is one of continuous change – changes in social and political realities as well as economic and technological ones. The very transparency of the modern world and the impact of the cumulative stock of learning suggest that organisations can continue to expect change into the future and their relative growth must be achieved against this ever changing background.

To achieve this relative growth an organisation must either have human capital which must be smarter, or work longer hours, or be more effectively organised than its competition; or it must have a greater investment in capital assets such as computers, communications, software or other forms of tangible and intangible assets.

ICT is, broadly speaking, available to all organisations. The distinguishing variable is how effectively the organisation exploits its ICT-related investments in human and physical capital. It is the specific execution of their investment and their selective performance against their peers worldwide that results in effective growth.

ICT is of particular relevance to overall productivity growth because it is unique in the sense that it can impact all aspects of every organisation. If one accepts that organisations are collections of people brought together to accomplish a task, it is self-evident that data and information are required to inform, coordinate and execute every aspect of its activities. This information obviously ranges from the implicit and informal to the explicit, and quantitative. As the power and functionality of ICT have increased and the cost decreased, the size of organisation and the breadth of information that can be cost-effectively handled, has changed enormously. ICT is becoming ubiquitous and can have an important impact on almost all organisations.

Prior to, say, 1990 (Scott Morton (1995)), computers and communications were only economically practical for explicit quantitative, local tasks such as payroll records, engineering design, or the analysis of certain medical tasks such as the interpretation of CAT scans. As is well known, the arrival of the Internet and the www, plus powerful personal computers, huge data banks and the embedding of smart chips and Radio Frequency Identification devices (RfiD) into products themselves, has totally altered the economically effective range of tasks and processes that can be effected by ICT. The nature of much of the work in organisations can be considerably altered. This is true both for physical and mental work. Robots do boring repetitive work on the assembly line; powerful three-dimensional work stations let engineers design airplanes or biotechnologists design molecules. There are numerous examples of where a total change is induced in how work is done and indeed what work can be done. (Malone (1991)).

Not only have enough aspects of physical production work changed to challenge the viability of existing organisational structures and processes, but the same thing is happening to ‘mental’ production and coordination work. Brand managers assessing the sales results of experimental price changes on products in the market are one example of this, as are insurance adjusters as they appear at the scene of an accident with their video cameras and live links to the relevant parts of the accident reporting and assessment ‘system’; such ‘work’ is a world removed from the way similar functions were performed in the recent past. There are countless other examples of changes in mental work in every area of work from medicine, finance, to education and social services.

Every sector of services can be or is now being affected by ICT.

It follows that the skills required in the work force and the way work is organised and the organisation structure and incentives that are in place are likely to have to be rethought to gain the full benefits from the changed functionality available. This is particularly true as the changed speed and breadth of information has huge implications for customer satisfaction and the reduction in assets required for a given task. This in turn can change where the work takes place and by whom.

It follows that there is no reason to believe that the way a given organisation has been structured, operated and managed is necessarily effective in this evolving world. In fact, as we will argue, the overall data shows a clear divide between those who are effectively changing their organisations and those who are not. Laggard firms can go on benefiting from their existing momentum and customers for a period of time, but before long a competitor will move in with what the customer will see as a significantly better solution – Dell being a well known example from the ICT industry. The comprehensive nature of the remaking of the 21st century organisation, and the elapsed time that is inevitably involved, will cause significant problems for those firms still unclear about what is happening around them.

The scale, scope and depth of these changes mean that ICT is the latest and possibly most pervasive example of a general purpose technology (GPT) like electricity or steam generation that has economy-wide long-term impacts on the nature of production and consumption (Helpman (1998)). Compared to earlier examples however it is unique in the speed and rapidity with which it has experienced price falls and the rapidity with which it displaced competing technology and created new products. In four decades from the late 1950s the price of computing power fell more than two thousand-fold. As we have seen, ICT rapidly altered not only ways of doing existing things but transformed what things could be done (Triplett (1999)).

The impact of ICT in allowing/requiring the complete remake of firms and industries can be thought of in four different, and largely discrete, pieces. One is the ICT producing industry itself, both manufacturing and software firms as well as consulting services. The revolution in ICT is intimately linked to the persistent decline in the price and increase in power of semi-conductors and computers (Jorgensen and Stiroh (2000), Jorgensen (2005)). The basic point of this paper applies equally to organisations in these sectors, but they are not explicitly addressed here.

Secondly ICT has enabled the growth of whole new firms and industries, firms that simply could not exist without a well developed ICT sector and infrastructure. These depend on situations where 'increasing returns to scale' are the norm, not the classical 'decreasing returns', and where network economies are prevalent. The network economy phenomena of 'more sellers, bring more buyers, bring more sellers', is made particularly easy with information widely available at low cost (Shapiro and Varian (1999)). Thus the existence of the World Wide Web (www) and the Internet coupled with a critical mass of people having electronic access to the web has led to totally new firms such as eBay.

The third and fourth domains of the impact of ICT are on established manufacturing and service firms. As this is where the bulk of a nation's economic and social wealth is created, it is where we have chosen to focus our discussion.

2. Concepts and theories

ICT has changed substantially over the past decade and shows every sign of continuing to do so. The impact of these changes has, as we have seen, been to increase the speed and decrease the cost of communication, data storage and information dissemination. However there has also been a steady increase in our ability to move beyond merely capturing data, to the point where we can effectively capture and process information. There is a considerable array of relevant theories that could inform aspects of our understanding of how these changes will play out in the organisational productivity discussion.

We take as our point of departure the seminal work of Chandler (1970) and Leavit (1967). One of the current authors built on their work to establish the close inter-relatedness of a few major elements of all organisations, namely their strategy, organisation structure, their employees and their technology (Scott Morton (1988)). As a result of further research during the 1990's (Scott Morton (1991)) these elements were put in the context of their external environment of customers and competitors, and the central role of management and operational process made explicit.

Using this lens to view an organisation has made it clear (Scott Morton (1991) (1993)) that organisations that have exploited ICT as part of remaking themselves have done so by changing each of the five elements in the diagram below in a dynamic yet balanced way. There is dynamic interplay between the major driving forces of the changes in customers and the whole external

competitive environment that results in organisations evolving their strategy and using the opportunities presented by technology (particularly ICT). This often requires serious modification to the types, and location, of production (both physical and mental) and coordination processes that should be used. In turn these are mutually interdependent with what will be the most effective organisation structure and related incentive and reward schemes. All of this involves changes in how members of the organisation think and act. As is well known, changes in human behaviour patterns are influenced by the organisation's existing culture and the quality of the organisation's leadership. The dynamic, holistic, nature of the changes demanded by the competitive environment and enabled by ICT require vision and leadership of a very high order, as is illustrated by the data in the following section.

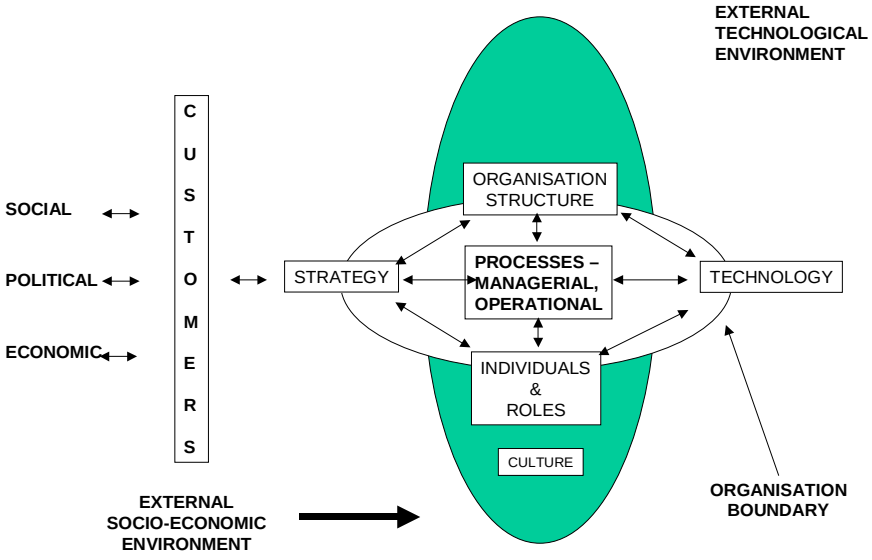

Figure 1 Dynamic Tension between External Forces and Internal Dimensions of the Organisation (Based on Scott Morton (2003))

Figure 1 summarises the findings of the 1990's work and was further supported by research in the 'Inventing the organisations of the 21st century' programme (Malone et al (1993)).

A further powerful set of concepts was raised by Michael Porter in his article on 'What is Strategy' (Porter (1996)). Here he argues, among other points, that the complementary fit of organisational assets among themselves and also with the customer's needs is a major driver of a successful sustainable strategy. This combined with the 'Entrepreneurial edge' (i.e. relative innovation), produces firm growth and profitability. For our purposes here the most important point he makes is the need for 'fit' among the network of complementary organisational assets. He argues for a strong vibrant network that dynamically links the

evolving set of activities that are required to deliver sustainable customer value. He takes as given the need for an organisation to constantly maintain their operational effectiveness in order to stay at their 'productivity frontier'. At best however this maintains the status quo! To create real value for shareholders requires a strategy that is truly innovative relative to competition.

Porter argues that there are three basic strategic positions which will create real value. Each of these requires creating or recombining a set of organisational activities. A point implicit in his argument is that in all of his examples of such combinations, the use of ICT is central to the operation and execution of the strategy. There are, of course, important other elements involved, but without creative systemic use of powerful, innovative, ICT none of the firms he quotes or their strategies could have succeeded.

Porter also argues persuasively that strategy is about combining activities and creating a network, or web, of those activities that fit and reinforce one another.

We would add explicitly to Porter's argument that effective strategy comes not only from positioning and combining activities, but also from being sure that the organisation structure is modified to match the emerging strategy and the technological realities to the new economics of ICT's impact on production and coordination work. ICT makes 'activity systems' into dynamic reconfigurable elements in ways that only a few organisations have begun to take advantage of. As is shown below, building such a network of complementary assets, woven together by information and 'process know-how' can substantially strengthen an organisation's competitive position.

In the in-depth story that follows in Section IV we are able to illustrate with concrete examples some of the reality on the ground that is giving rise to the large sample date that Brynjolfsson (1997, 2002) has been able to collect.

3. Evidence

One way of identifying the interaction between business performance, organisational transformation, and ICT in established firms is to identify statistically significant relationships between the various components captured in Figure 1. This is not straightforward for several reasons. The analysis requires data to be collated from disparate sources on performance (market value, productivity etc); on proxy variables for organisational characteristics and components of ICT investment such as computing power; on a range of other tangible and intangible assets which may impact firm level performance;

and on the contingent effects of culture institutions and the socio-economic environment. There are moreover lags between investments and outcomes, and the simultaneous nature of much the ICT and organisational investments means disentangling causal impacts is complex. Interest in the topic has led to many of these problems being overcome. A clear picture then emerges of the scale of supporting investments required and the need for an integrated approach to ICT investment and organisational change (Applegate et. al. (1988), Barras (1990), Bresnahan et al. (2000) (2002), Bresnahan and Greenstein (1997), Davenport and Short (1990), Huselid (1995), Ichniowsky et al (1997), Kemera and Sosa (1991), Brynjolfsson and Hitt (1995) (1997) (2000) (2003), Brynjolfsson et al (1997) (2002), Black and Lynch (1996) (2001) (2004)).

It is clear from this and related work that the hardware portion of ICT investment programs is small compared to the associated intangible and organisational component. For example less than 20% of the total $20million installation cost of a standard SAP R/3 process integration package in the late 1990s consisted of capitalised hardware and software expense. The rest was customisation design and implementation cost associated with organisational change and staff training (Gormley and others (1998) cited in Brynjolfsson, Hitt and Yang (2002)). Secondly, high investment in ICT goes hand in hand with high investment in related organisational changes, and these in general include a greater emphasis on decentralised structures and individual decision making, team based incentive systems and training programmes to raise skill levels. Finally on average those firms which combine high ICT investment levels with investment in associated organisational transformations do better on a variety of measures than those which are high on one or the other but not both.

Notable contributions have been made at the establishment level in a series of detailed studies focusing on work place innovation and its impact on productivity by Black and Lynch (Black and Lynch (1996) (2001) (2003) 2004)). In their latest work covering 1493 US manufacturing establishments in period 1993-6 they find a positive correlation between the proportion of managers using computers and productivity performance as well as between a variety of high performance workplace practices related to team working incentives and decision taking. They find little evidence of synergies between the two however in the sense that their combined impact is greater than the sum of the parts.

Work focusing at the overall business unit level however reaches stronger conclusions on interactions. The work of Eric Brynjolfsson and colleagues is particularly illuminating here. Early work using a sample of 300 large US firms showed a clear positive relationship between firm level IT investment and their

multifactor productivity. However there were large variations in firm level success with IT and the data was not appropriate to analyse the source of this variation (Brynjolfsson and Hitt (1995)). In later work they test inter alia the following hypothesis which is directly related to our concern in this paper. This hypothesis is that:

'New intangible organisational assets complement IT capital just as new production process and factory redesign complemented the adoption of electric motors over 100 years ago. To realise the potential benefits of computerisation, investments in additional 'assets' such as new organisational processes and structures, worker knowledge and redesigned monitoring, reporting and incentive systems may be needed' (Brynjolfsson, Hitt and Yang (2002) p2).

They relate market valuation to survey-based annual data on computing power and computer stock for a sample of 272 large US goods and service firms in the period 1987-1997, allowing for various control factors such as size and investment in other assets. They specifically include organisational proxies based on survey data which yielding proxies for various dimensions of organisational capital in 1995/6. They define organisational capital as a set of related work practices, investments in training workers, self-management and a set of similar measures designed to indicate a range of complementary assets that match the investment in hardware and software.

Their careful analysis indicates that intangible assets associated with IT in their sample are about 10 times the investment in the IT assets. They also establish a clear link between IT investment, investment in organisational capital and firm performance, at least as measured by its market value. They also show that firms with both a high level of IT investment and high investment in work organisation have relatively high market valuations compared to those which score heavily on only one of these dimensions. It is also clear however that there are many firms which are less successful than others for the same level of organisational and other investments and that successful implementation of integrated strategies is difficult. We use our case study of a successful integrated approach below to tease out the factors that increase the chances of success.

In later work Brynjolfsson and Hitt have extended their work to firm-level performance measures based on productivity performance. They show that their measures of computing investment are more powerful the longer the time period over which they are estimated. Although they do not include organisational variables, they conclude that their findings are consistent with the time taken for organisational investments to work through and with ICT as a general purpose technology (Brynjolfsson and Hitt (2003)).

A second approach to identifying the organisational transformation and interactions brought about by ICT is to examine sector changes. Here given their importance in the aggregate productivity growth story we focus on retailing and wholesaling.

Retailing and wholesaling are major segments of the services sector. In the US and European economies they account for around 10% of GDP and 15% of employment (McGuckin, Spiegelman and van Ark (2005)). These trades have undergone enormous change, in large part due to ICT. Warehouse centralisation and automation were based on 'old' IT, but as scale gains and functional reorganisation were exploited it changed the face of this industry out of all recognition. This was the so-called 'Wal-Mart effect'. Based on an Arkansas family start-up, Wal-Mart's market share in retailing in the US in 1987 was 9%, with a productivity advantage of 40% over its rivals. By the mid-nineties its share was 40%. From 1995 – 1999 competitors raised productivity by 28% but Wal-Mart's productivity advantage rose to 48% (M.Schrage ***Technology Review***, March 2002, p.21) Its retailing productivity growth was based on scale effects in warehousing, electronic data interchange and bar code scanning. Productivity in the sector as a whole was driven by imitation, adaptation and organisational innovations by rivals, and because Wal-Mart competes across many retail categories it impacted upon clothing stores, drug stores, general merchandising and groceries too (McKinsey Global Institute (2001), Foster Haltiwanger and Krizan (2002)). Annual labour productivity growth in retail firms was 7.4% between 1995 and 2002 compared with 2.6% between 1980 and 1995, and it doubled from 4.1% to 8.5% amongst wholesale firms over the same period (McGuckin, Spiegelman and van Ark (2005)). In retailing the productivity growth was almost entirely due to the opening and expansion of new establishments owned by the biggest retailers as they diffused their innovative organisation across the USA (Foster, Haltiwanger and Krizan (2002)). Taken together these changes in performance had a major impact on the aggregate productivity performance of the US economy. Retailing and wholesaling were the top two of the six sectors that accounted for the whole of the US productivity acceleration after 1995. Along with financial services they accounted for three quarters of the aggregate improvement in productivity growth (Solow (2003)). Moreover, the performance of the retailing and wholesaling sectors was responsible for the bulk of the widening of the productivity growth gap between the USA and Europe which took place in this period. Whilst productivity growth accelerated in the USA it languished in Europe (Basu, Fernald, Oulton and Srinivasan (2003), van Ark, Inklaar and McGuckin (2002)).

From this perspective Arkansas made a greater contribution to productivity growth than Silicon Valley. However, this is not really the most important point. It was Wal-Mart's ability to choose new store sites as well as their organisational and management innovation and the competitive response they generated as much as technology change that drove the productivity dynamic. In addition to their investment in the physical assets of their new stores it has been estimated that Wal-Mart invested over $4 billion on its ICT-integrated 'retail link' supply system to serve them. As a consequence they became one of the world's leaders in implementing software systems (Schrage (2002)).

Two key lessons can be drawn from the retailing example. First technology users have a powerful effect in the diffusion process whereby ICT impacts on overall productivity growth at a national level. Wholesaling, retailing and financial trading are all sectors that use information technology in their internal process. These ICT users are more significant than ICT producers in 'accounting' for labour productivity growth but they depend upon the former for their innovative 'product' inputs. The effective use of those inputs requires organisational innovation and embodiment of ICT innovations in the user sector. The demand for, and capacity to absorb the output of high-tech producing sectors by technology users are crucial drivers of overall recent US performance and have capitalised on the increases in efficiency and falling prices in the producing sectors. The ability to absorb and benefit from this investment depended upon the technical competence of management in recognising and implementing appropriate investments in complementary assets. Once achieved the sheer scale of employment in these sectors ensured a huge impact at national level.

The second lesson to be drawn relates to the length of time the process took to work through into the productivity transformation of the late 1990's. Notwithstanding the rapid fall in computer and ICT prices, the interplay between the competitive and regulatory environment and the successful Wal-Mart strategy took decades to emerge. The bar code patent dates from 1949 but the first retail product was not scanned at a checkout until 1975. Serious attention was not paid to its introduction in stores until the 1970's. Then it was seen primarily as a cost saving device at checkout by a consortium of food producers and grocery retailers. The key savings from inventory control took a further 10 years until the 1980s to materialise. Only then was the link with effective ICT made through adopting uniform communications standards and a software system to implement it. It was then not groceries that led the subsequent diffusion but general merchandising where Wal-Mart made the necessary investments and organisational changes to produce the productivity acceleration of the 1990s. This in turn was based as we have seen on the

building of new mega-stores. These matched US consumer shopping patterns, and met little planning resistance given low US land use regulation. They could be serviced by ICT based inventory control systems and a newly deregulated ICT-enhanced trucking and transport system (McGuckin, Spiegelman and van Ark (2005)).

To more clearly articulate the processes by which ICT related transformations interact with strategy structure and people to produce successful corporate outcomes we turn to a detailed case. In the next section we provide an in-depth example from transportation which took place contemporaneously with the retailing changes we have discussed.

4. Firm-level illustration

One line of research providing an in-depth exploration of the impact of ICT on organisational performance was started in 1989 as a result of MIT's 'Management in the 1990's' project (Scott Morton (1991)) Using exploratory in-depth field work in a number of firms, researchers were able to identify a number of factors common to those firms that had successfully exploited ICT. The firms that formed the initial cohort were then all over $5 billion in size but covered a wide spectrum of organisations from manufacturing to services, public to private, as well as firms in the UK and Japan.

This work led, in 2001, to testing of the project's concluding framework in a contrasting setting. The one chosen was in the services sector and was a private, single owner, smaller ($3 billion) firm. The firm in question, Schneider, is in what is usually thought of as a commodity business, that of long distance, full truck load, transportation. Our case study illustrates that any organisation, no matter how apparently prosaic, can alter its growth rate and competitive position if it develops the 'fit' and investment among the key complementary assets of the organisation.

The story that emerges from Schneider provides interesting clues as to the causality driving the phenomena revealed by large sample econometric and sector studies. What follows is a subset of the extensive data collected from the field interviews (Scott Morton and Meyer (2004)). The range of material that is included here is designed to provide a first hand flavour of the rich mosaic of complementary assets that were built to permit the investment in technology to yield the kind of improvements that are visible in the large sample data.

Schneider National and the Transportation Industry

Schneider National Inc. today is the second largest full truckload transportation company in the U.S., with revenues of over $3 billion and 20,000 employees. It's H.Q. and corporate centre remains where it has always been, Green Bay, Wisconsin, the home of its original founder Al Schneider.

The transportation industry has traditionally been thought of as having three modes; land, water, and air. The public carriers in the land mode are categorised as either 'long distance' or 'local' and then 'full truck load' carriers (FTL) or 'less than truck load' (LTL). Companies in the industry tend to operate in just one mode and within one category. Entry barriers are low so competition is fierce; however, Schneider grew organically to be the largest in the industry and despite consolidation by others remains as number two.

Schneider's Beginnings and Technology Trajectory

Schneider has always been a private, family-owned company, and Al Schneider, the founder, started grooming his son Don from age 16 to one day run the company. While in high school and college, Don worked part-time as a 'go-fer', in the machine shop, and as a driver. In 1961, after military service and graduating with an MBA from Wharton, Don Schneider officially joined the company as general manager.

Don's rise to CEO in 1973 coincided with a new period of growth for Schneider. Schneider added a fleet of tank trailers for liquids to create what later became the Schneider Bulk Services division. Schneider also began acquiring other trucking companies, increasing both the depth and range of its operations. With his ascension to CEO, Don Schneider restructured Schneider Transport into a holding company with diverse trucking-related units. The Schneider Corporation is owned by Don Schneider; in 1987 he put in place an interesting and unusual governance structure. He did this because, in his words, 'I want to be sure there is enough 'tension' on me to keep me focusing on what is best for long run interests of the firm and the employees'. In outline form this structure amounted to splitting his shares into 'voting' and 'non-voting' shares. The 'non-voting' shares are owned by Don (and his immediate family) while the voting shares (which have a relatively nominal value) are in a Trust which has a Board of Directors NOT selected by Don Schneider. This Board operates with all the decision authority that is normal for Boards, including the hiring and firing of the CEO, as well as approval of major capital expenditures, performance evaluation, etc. Don Schneider will remain as CEO only as long as the Board feels he is the best qualified person to lead the company for the long term.

(i) Deregulation and Global Competition Bring Changes

In 1980, everything changed in trucking. The passage of the Motor Carrier Act ended the age of regulation, opening new potential opportunities and threats for everyone in the industry. Trucking companies were given much greater leeway in what services they could offer, where they could operate, and how they could price trucking.

In particular, it became much easier for any trucking company to operate in any state. Anyone with the money to buy a truck could become a competitor. The number of trucking companies tripled between 1980 and 1995. The resulting competition was brutal—the decade of the 1980s saw 12,000 trucking companies go bankrupt.

The changes did not end there. In the 1980s and 1990s, American industry was also changing. Global pressure from low-cost producer nations drove manufacturers to improve operations. Concepts like quality and lean production became prevalent, which had unexpected effects on carriers like Schneider. For example, carriers came to be rated on their quality of services (on-time delivery and the like). The use of Just-In-Time manufacturing techniques challenged existing logistical systems. Companies like FedEx arose and conditioned people to expect everything overnight, while companies like Wal-Mart showed everyone the benefits of a well-run distribution system.

Worse, lean manufacturing meant that companies needed fast, reliable deliveries of smaller loads. With little inventory in raw materials, a botched pickup or a late-running truck had a greater detrimental effect on the receiving company. Smaller loads also had an impact on carriers: because the costs to operate an empty truck are almost as much as operating a full truck, the smaller loads added greater expense to carriers (because there were fewer pieces delivered for the same fixed shipping cost). Finally, empty trucks returning from delivery jobs are a constant problem in trucking. These so-called ‘deadhead’ trips (driving an empty truck to a location) can as much as double the cost of a delivery. Manufacturers grudgingly pay the costs of deadhead return trips and LTL (less-than-truckload) service, but constantly look for ways to trim such costs.

In this changed environment, the dimensions of competitive advantage are three-fold. Trucking companies with a low cost-per-mile have an advantage, as do those with a good on-time delivery rate and those with a solution to the deadhead and small-load problem. Any trucking company that could do all three has a clear competitive advantage.

By a fortunate co-incidence Don Schneider had recently taken over as CEO of the company at this time of de-regulation and change when he was visited by the CEO of a then recently established firm, Qualcom. They had just developed a robust geographical position system (GPS). The CEO Irwin Jacobs offered this system, free, for a trial period to Schneider. Don Schneider, although not a technologist, or even particularly interested in technology, sensed the opportunity to use this Qualcom technology as a base to grow ICT systems to improve his performance on three of his critical success factors.; cost/mile, delivery times and reducing deadhead trips.

Schneider then began in 1974 to hire a few carefully selected Information Technology (IT) professionals and to create systems and processes around this technology to improve the firm's performance.

The technology and process solutions created and deployed by Schneider in its efforts to be more effective all contributed to necessary performance improvements either in terms of Schneider's cost of service or quality of service. Schneider’s process for investing in technology was to spend money strategically, looking at long-term technology spending and aligning it with the business. As Chief Information and Logistics Officer Christopher Lofgren explained, ‘We won't go after an IT project unless there is a business leader within Schneider who will take it, fund it, and be accountable for the business outcome’. By 2004 Schneider employed 425 ICT personnel and had earlier formed a steering committee of senior leaders, from business as well as IT, to prioritise the IT projects it works on. ‘We look at IT expenditure as an investment that we can turn into revenue and profit advantage’, Lofgren explained.

Although Schneider chose to invest in technology, the investments represented a means to an end: achieving the operational performance demanded by its customers. The reality that technology was just a means to an end was put best by Don Schneider when he said:

‘When we first put a satellite in, I was telling one of our major customers, an automotive company, how good this communication would be. They said 'Look Schneider, I don't care if you use carrier pigeons to talk to your drivers. All I

care about is that your price does not go up and that you deliver on time, any way that you know how.'

Two of these key technology implementations were:

(ii) Schneider Utility for Managing Integrated Transportation (SUMIT®)

The core of Schneider's shipment planning and management system is an On Line Real Time (OLRT) system called SUMIT (Schneider Utility for Managing Integrated Transportation). SUMIT is a multi-faceted system, providing subsystems for order management, load management, and carrier management. These systems are the base for all Schneider's operational processes.

(iii). Satellite Communications Technology

Traditional IT (computers and software) are only part of Schneider's technology strategy. Schneider National also invests in and spends money on communications between its control centres and its trucks. Schneider National invested some $3,500 per truck to install satellite communications and tracking systems in every truck. Beyond this initial investment, Schneider National spends an additional $7-$10 million per year (about 0.5 cents/mile) on satellite transmission costs.

The key point here is that it was not the technology acquisition that mattered. It was the changed operational processes and the way that the technology became an integral part of the way the company operated that made the difference to performance. Others could (and would) copy the technology; they could not copy Schneider's unique blend of their strategy, technology, work processes and embedded know-how - a truly unique blend of complementary assets.

The new system potentially brought all of Schneider's important physical and human assets into one 'network'.

Before having this communications system, Schneider National barely knew (in common with all FTL firms) where its trucks were. Although drivers would report where they were when they called in, such reports were sporadic. Worse, these reports depended on the driver's ability to determine and report location and Schneider's ability to understand the report and translate it into a map location. With the new system, every communication between truck and centre is automatically tagged with the trucks true location (accurate to within less than 100 meters). Moreover, even in the absence of messages between the centre and the truck, the system automatically polls every truck every two hours to check their locations.

Despite the up-front and recurring costs, the system creates critical improvements in cost, on-time-delivery, and customer service. Because all messages are digital character data, formatted into a set of message templates, detailed logs help Schneider National stay on top of every shipment and analyse the true travel time of shipments.

With routine two-way communications, Schneider National can confidently schedule drivers for pick-ups and deliveries. Tracking information helps Schneider National reliably predict when a driver will be available for the next load and therefore to schedule another pick-up in the immediate area (rather than waiting for the driver to call at some uncertain time in the future). The result is both better asset utilisation (less time spent parked) and fewer empty miles driven.

In 2003 Schneider announced it had begun to install satellite tracking units in its 48,000 trailers in addition to the 14,000 tractors that currently have the system. The new communications and sensor technology embedded in each Schneider trailer detects when a trailer is connected or disconnected from a tractor, if it is loaded or empty, and what its GPS position is. Schneider worked with ORBCOMM for several years, actively participating in the design and development of the system. ‘Our trailer productivity will improve significantly’, said President Don Schneider, ‘which means better service to our customers’.

Schneider invested in QualCom's OmniTRACS system in 1988, being the first in the industry to use such a system. Now, 280,000 trucks in the industry use the system. Schneider is again the industry pioneer in extending the technology to trailers. The system, called Vantage, lets Schneider better manage the productivity and efficiency of its trailer assets by linking critical trailer location and status directly into Schneider's fleet management and logistics systems. Others will follow their lead, re-enforcing the continuous need to innovate, a process that will never end.

(iv). Result: Technology Reduces Costs and Improves Service

A technology-intensive strategy to support customers and operations has worked for Schneider National. Between 1980 and 1998, their cost-per-mile has dropped from $1.00/mile to $0.60/mile (in constant dollars). Internal costs have dropped by 24% through more efficient administration. Satellite-based tracking of truck's locations has lead to a 25% decrease in ‘deadhead’ miles (driving an empty truck to the next location). Decision Support Systems help Schneider know how much to charge and whether it can profitably accept any given shipment.

Schneider's quality of service has also improved. The fraction of late deliveries has dropped by more than a factor of 10, even as delivery deadlines have tightened. Automated information systems have reduced errors and improved responsiveness to customers. EDI (used for more than 35% of all loads and 65% of all invoices) has made Schneider easier to deal with and has accelerated its cycle time.

In addition, Schneider's confidence in its systems and its people have led it to offer guarantees to its customers. For example, Schneider offers guarantees to Chrysler that if Chrysler's line goes down because of Schneider, then Schneider picks up the cost. The cost of a downed line is not trivial – it can cost $100,000 to $200,000 per hour. Chrysler pays a premium to get this guarantee, but they like it because it brings them the level of service they want, needing little inventory on hand. Schneider partners with Chrysler to get that benefit for the supply chain, and Schneider gets some payment for the risks they take in order to guarantee that service.

The overall drop-in costs have more than paid for these investments. The result is that Schneider National has been called 'an information system masquerading as a trucking line'. In that sense it has clear analogies with the development and use of the American Airline 'Sabre' system, the first online computer reservation system for the airline industry.

Schneider's Culture

The description of Schneider thus far has been of its strategy, technology and operations. All of these rest on the employees and the firm culture if they are to be successful. Vision and technology are of little use if there is not a good fit with other key organisational attributes.

Schneider's culture has helped Schneider's investment in technology take hold. First, the company goes through a thorough selection process for each new hire. 'We take a lot of time and effort in our selection process', said Tim Fliss, Vice President of Human Resources. 'We have a detailed selection process, with 12-13 behavioural dimensions. We use a lot of different instruments, with each [non-driver] employee going through 6-7 hours of structured interviews in one day. We look for a rounded skill set and alignment with our values, which include learning throughout your career. We look for people who are comfortable with technology, by asking things like whether they have a PC in their home.'

The selection process tends to weed out candidates who don't connect well with technology. 'They tend to self-select out, Fliss said. 'We do hiring in the

operating centres, so when you come for an interview, you see people with PCs on their desk and headsets -- it's obvious the role technology will play in your job', Fliss said.

Schneider also works intensely to involve the drivers, such as by holding annual banquets for its drivers and their spouses. About 40 banquets are held each year in regions throughout the US. 'It's an opportunity to recognise people for their achievements and tell them how business is going', Fliss said. High attendance rates demonstrate the value of the banquets, which motivates the company to continue hosting them. 'Since they do cost time and money, we've wondered about holding them, but the turnout is great. I went to one in Toronto in February which had 650 people attending.'

Schneider's culture is characterised by its identity statement: '*The Orange On-Time Machine*: Safe, Courteous, Hustling Associates Creating Solutions That Excite Our Customers.'

'Orange isn't just a colour, it's a way of life', said transportation planning leader David Dietrich. As Chairman Don Schneider models hard work and humility and continually praises the efforts of Schneider employees. 'Whilst CEO he talked to every new drivers class, explaining the company's values, and making everyone aware of their importance to the company's goals. Everyone in that operation knows that their job is serving the customer', remarked one satisfied Schneider customer.

Schneider is one of the largest FTL trucking company in the US, but it is agile enough to form strong partnerships with customers. Employees see themselves as innovative, responsible and enthusiastic. Schneider has a fairly flat organisational structure, and Don Schneider makes it clear that everyone in the company is responsible for meeting customer expectations. As a result, one of management's top priorities is pushing information throughout the company so that decisions can be made at the appropriate level, particularly at the driver and customer service representative levels where key interfaces with customers take place.

The company's culture has helped it win new contracts. Ed Root, former Director of Transportation for Libbey-Owens-Ford, interviewed Schneider drivers on the road when he was considering a long-term dedicated carriage partnership with the company. The drivers' genuine regard for their employer was a key factor in his company choosing Schneider for the job.

Schneider's Organisational Fit

The ICT dimensions of Schneider have been introduced organically, driven by a clear business benefit. The systems were designed and built largely internally by the gradual addition of skilled ICT professionals who then spent time working in the business units within Schneider until they had thoroughly absorbed the know-how and skills of the operations and begun to understand the culture and values of Schneider. Employees from the business elements involved (and customers) have been involved as active members of the design and implementation and change processes as well.

The technological advances Schneider made affected all of Schneider's employees. Some of the key traditional trucking people (by job function) that were affected by the advancing line of technology include:

* drivers (who move the loads)
* customer service representatives (who work with customers)
* service team leaders (who support/manage drivers)
* transportation planners (who assign loads to drivers)
* mechanics (who repair and maintain trucks and trailers)
* brokers (who find external carriers to handle particular loads)

Some of the changes experienced by the first four of these are:

(i). How Technology Improves Relations with Drivers

The combined effect of Schneider's technology has helped Schneider improve working conditions for drivers and therefore further improve its relationship with drivers. These effects go well beyond the simple fact that drivers no longer waste time stopping to call for instructions. At the core of the issue is that driving is stressful and takes drivers away from family. Technology helps minimise and ease this problem. For example the system maintains a record of driver preferences and 'blackout dates' such as children's birthdays, and adjusts proposed driver's schedules accordingly.

(ii0. Customer service Representatives

Customer service employees at Schneider sit together in a large open space that takes the entire first floor of the building. Reps sit with others arranged by region of the country they serve or by the large customers (Wal-Mart, P&G, Kimberly Clark) they serve. 'The magnitude of some customers means that a team of people sit together to ensure consistence of service to the customer',

said customer service rep Janice Steffes. There are three customer service roles: the Customer Service Rep, who speaks with customers and takes orders, a Transportation Planner who talks with the drivers and plans the loads, and Leaders who help resolve questions.

Satellite communications have made this job much easier. Customer service reps can now pinpoint the location and status of shipments. If the customer is requesting a change in pickup or delivery, the rep can be confident that the driver will get the message and respond promptly. This confidence in the timely execution of customer requests makes the customers happier as well as the reps.

Customer Service Reps have several tools at their disposal to help take orders for loads efficiently. These tools are typical examples of how Schneider has captured operational processes in software and embedded them in ongoing activities of the firm. The people grow and the software evolves with use in daily practice. One such evolving tool is the 'Capacity and Demand Tool' which displays a map of the U.S., colour-coded by the number of trucks available in that region. Green means that drivers are available and Red indicates that there are fewer drivers than loads, which may man that a load will have to be declined. 'If a key customer calls and needs a load in a red region, we wouldn't say "no", but we'd try to postpone one of the other deliveries for the next day', Steffes said. 'The CSR can ask a Leader at this point, or make the decision on her or his own.' To further ensure smooth planning, teams meet every morning to set the strategy for the day. That sets the understanding, such as if some shipments in a region are critical and there will be no chance to swap orders.

Learning is a key element throughout Schneider. The ICT they use helps with this. CSRs are evaluated on the basis of surveys by customers, which indicate how well they are serving the customer. Team leaders also have a scorecard on which they evaluate a CSR's service to customer. Steffes has been in her role as a CSR for nine years, which is typical of the low turnover at Schneider. 'People like it here because of the strong family feel of the company.'

(iii). Changes for the Service Team Leaders

Schneider's service team leaders provide management and support functions to drivers. Whereas customer service is designed to look out for the best interests of the customers, the service team leaders look out for the interests of the drivers (representing the drivers while they are on the road). They help make sure that drivers get the loads they need and can get home an appropriate amount of time. They also oversee the drivers, keeping track of their performance and working with the drivers personally to help them do a better job.

The biggest change in the jobs of service team leaders is that each one now manages more drivers. In the past, one team leader handled about 25 drivers. Currently, each team leader is responsible for 40 drivers. Although one might think that this has reduced the amount of time that they get to spend with each driver, the opposite is true. With the essential and routine communications handled by technology, team leaders have time to talk to each driver daily, getting a sense for the driver’s health and satisfaction. This daily communication is vital to Schneider, because the major constraint on growth is the ability to hire enough drivers. Ensuring that drivers are getting the miles they need to earn a good living, while getting home on days they want to be home, helps ensure driver loyalty and retention.

(iv). Changes for the Transportation Planner (Dispatchers)

The job of a Transportation Planner is more complicated than it sounds because of all the factors involved in matching loads to drivers. Schneider has developed and continuously evolves a very effective decision support system as a live interactive tool used by the dispatchers to make complex economic fact based trade-offs, balanced with the dispatchers' personal intuitive knowledge of relevant qualitative factors. The system starts with optimisation algorithms, but leaves room for dispatcher judgment. Dispatch decisions include optimising a number of short-term and long-term objectives that include such things as minimising the time a driver has to wait for a load, the distance they must go to collect the next load, and so forth. These factors all have impacts on the financial performance of Schneider, the quality of service that Schneider delivers, and the attitudes of drivers (which affects pay requirements and driver turnover rates). At the same time, Transportation Planners have little control over when customers need loads picked up and delivered and they have no control over weather and road conditions.

The main tool which Transportation Planners use is the Global Scheduling System (GSS), which takes into account all of the drivers and driving teams,

how far they are permitted to drive per day, all the loads set for the day and the drivers' locations and availabilities. The software optimises the load creation, ensuring that the most efficient routes are chosen while ensuring that drivers get the maximum distance to driver per day. ‘GSS divides the US into 100 regions, and looks for the best load with the least deadhead miles and least total miles’.

Despite its powerful heuristics, the software does not replace Transportation Planners, it supports them. Experienced planners can override the software's match-up of drivers and loads to cover complex exceptions related to the special needs of customers, drivers, and the situation. All in all, Transportation Planners accept about 80% of the software's decisions, overriding the system in less than 20% of the cases.

(v). Summary of Schneider Technology Use

The introduction of new technology has caused every job and every function in the organisation to change. These changes have been continuous as customer needs change and the organisation learns how to modify their actions (and the software) to better serve their customers and lower their own costs. In Don Schneider’s view this process will never end, change will be constant, the investment in complementary assets is continuous.

The way ICT was introduced into Schneider is absolutely standard procedure as used by effective firms. That is, it was not the technology that made a competitive difference, it was the technology applied in a very focused way to enhance the organisation’s strategy and this was then combined with major investments in human capital and other complementary assets. This holistic ‘system wide’ thinking was lead by a CEO with a long term vision and a focus on customers as the source of the firm’s well being. As straightforward as this story seems so far it is in fact not at all that common, as many (most) firms seems to treat the technology as an end in itself (Brynjolffson et al (1997) (2002); Carr (2003)) and do not make adequate management or operational process changes.

This first phase clearly had a productivity improvement impact for Schneider and for its customers. However it turned out to be just the beginning. The next phase of organisational change and company evolution has had even more of an impact on the firm and industry’s increase in productivity. It is the ongoing learning and evolution of a well crafted ‘total’ system that is leading to serious change in the competitive landscape and that helps to explain the increase in productivity that can be seen in Eric Brynjolffson’s data (op. cit).

Schneider - Expansion

The transformation of Schneider National from its inception to the present day mirrors the changes that have taken place in the larger economy as a whole. What is interesting is that Schneider has continuously transformed itself while other older companies have risen, fallen, and been replaced by newer companies. Schneider has stayed in front by learning from its customers, from its own experiences and building on the learning to produce better and better processes. In the early years, Schneider was a prime example of a basic trucking company – a unionised blue-collar firm, offering simple, well-delineated, undifferentiated services to its customers. In its present form, Schneider is a much more complex, largely non-union, diversified services company. Beyond trucking, Schneider is now also about the white-collar activity of designing and managing and delivering complex logistics systems that blur traditional provider-customer and provider-competitor boundaries.

(i). The Current Structure of Schneider

Today, Schneider National, Inc. is a $3 billion holding company with a set of 9 internally grown units. . These units can be delineated by the services that they provide. Four of the 9 look like traditional trucking companies and the other 5 represent new knowledge based services that Schneider has created during the 1980s and 1990s. The 9 have been organised internally in various ways as internal skills, and the needs of the market place, changed. Currently there are 4 Divisions and one wholly owned subsidiary. In functional and product terms these can be broken down into their constituent elements as is depicted in Exhibit 1. Here they are shown in competitor/product terms to highlight the degree to which whole new sets of complementary assets have been created by Schneider's single minded focus on providing service(s) their customers need.

* the more traditional shipping companies:
  - Schneider One-Way Van - traditional low-cost trucking with 13,000 drivers, 12,000 tractors, and 35,000 trailers
  - Schneider Bulk - shipment of liquids & chemicals with 700 tanker trailers
  - Schneider Specialised - shipment of overweight, oversize, and fragile items
  - Schneider Expedited – shipment of high value items that are time dependent for their customer.

* the non-traditional service units:
  - Schneider Dedicated - takes over the ownership and operations of private fleets
  - Schneider Finance - full-service truck and trailer dealer (sales and leasing)
  - Schneider Intermodal - manages shipments that combine trucking with rail and water-borne shipping
  - Schneider Brokerage - matches loads to trucks drawn from a network of over 1,000 pre-qualified carriers (competitors to Schneider)
  - Schneider Logistics - analyses, designs, implements, and manages logistics systems for customers

2. Schneider's New Relationships with Customers and Competitors

Schneider's transformation has blurred the traditional boundary separating a service provider from its customers and from its competitors. In the past, most transactions were arm's length – a simple service in which one company handed a load to a carrier company who brought the load to a third receiving company. But now, Schneider is much more than just a trucking company. Complex relationships and combinations of services defy the traditional arms-length arrangement of simple contract shipping. Many of these services would seem to divert revenues from Schneider, giving them either to competitors or forgoing them with customers.

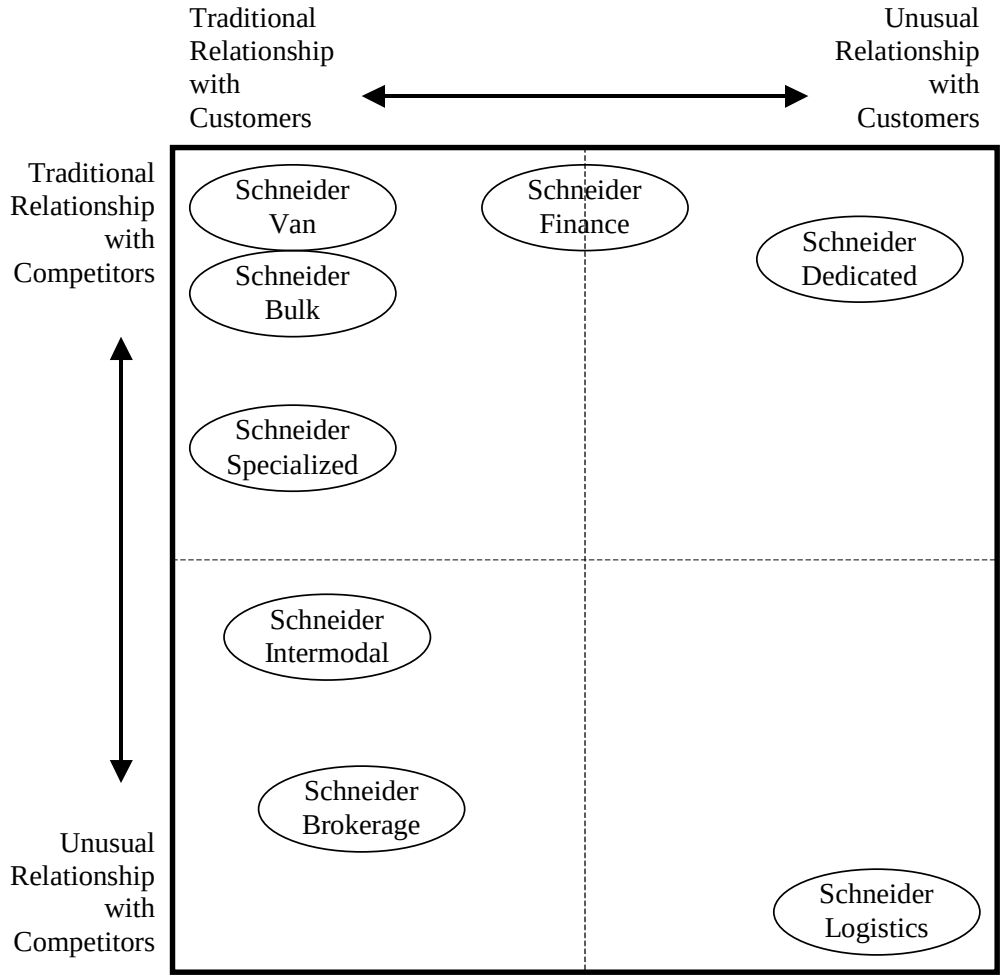

Exhibit 1: Schneider National's Subsidiaries and their Relationships to Customers and Competitors

Exhibit 1 arranges the 9 components of Schneider along two axes. The horizontal axis denotes the nature of the relationship of Schneider to its customers. The left side contains subsidiaries with a more traditional relationship with customers, while the right side contains those with more unusual relationships with customers.

The vertical axis denotes the nature of the relationship of Schneider to its competitors. The top end contains subsidiaries with a more traditional relationship with competitors, while the bottom end contains those with more unusual relationships with competitors. At the extremes are the very traditional Schneider Van (in the top left with more traditional relationships with both customers and competitors) and the most unusual Schneider Logistics (in the bottom right with unusual relationships with both customers and competitors).

Although it has evolved in new ways, Schneider's behaviour is totally consistent with the strategy implicit in founder A.J. Schneider's 60-year-old mission statement: ‘We have only one thing to sell, and that is service.’

To further this strategy of services, Schneider has taken the improvements it made to its traditional trucking operations and repackaged them with embedded know-how to create new services an evolving organisational structure. Two of these are elaborated on below to provide a flavour of the mix of physical and intellectual assets that have enabled such growth.

(iii). Schneider Dedicated: Blurring the Traditional Provider-Customer Line

Schneider Dedicated is an outsourcing service that takes over a customer company's private fleet (typically with contracts that last 3 years). The services offered by Schneider Dedicated cover a wide range that includes:

* logistics engineering and analysis
* carrier management and coordination
* truck/trailer purchasing, maintenance
* driver hiring & training
* mode selection & load scheduling
* cross-dock management
* return container program
* back-haul filling
* warehousing services

Rather than just extending Schneider's shipping services to carry the customer's loads, these arrangements tend to blur the line between Schneider and the customer. For example:

* the trucks are on Schneider's books but are painted in the customer's colours and only used for the customer's loads
* the drivers are Schneider employees but wear the customer's livery and only drive the customer's loads
* the drivers use Schneider's satellite communications system but drive routes designed by the customer

As John Lanigan, the former General Manager of the Dedicated division describes it, ‘We really create a new trucking company for each new customer.’

In many ways this ‘new trucking company’ is both inside the customer company and inside Schneider. Schneider Dedicated spends time to learn the customer's systems and to adapt Schneider's approach to fit with those systems. The outcome is less of a cookie-cutter outsourcing service contract and more like a complex intertwining of Schneider and the customer company.

A good example of the complexity of such relationships is Schneider's relationship with PPG (the largest North American glass maker). Technically, Schneider Dedicated took over PPG's private fleet. In reality, the trailers remain the property of PPG, while the drivers and tractors are now Schneider's. To sweeten the deal, Schneider offered its core freight management software to PPG. PPG took the software written by Schneider, had PPG's IT personnel modify it, and now PPG runs its entire enterprise-wide logistics system with it. In a further twist, only 30% of PPG's loads go to the Schneider-run private fleet. Schneider's software is good at managing a portfolio of third-party carriers, picking appropriate carriers for each load and electronically letting them accept or reject the load. This software lets PPG give loads to some forty other carriers (competitors to Schneider). In short, Schneider gave PPG software that acts in the best interests of PPG, not those of Schneider. Of course, this could be seen as enlightened self interest as the ‘gift’ brought with it further contacts between the two company’s employees, requiring Schneider employees to keep delivering ‘value’ to PPG. Schneider continued to make changes to their own software over time as they continue to capture their broad base of experience.

Schneider leverages its people, processes, and technology from throughout the whole company to provide input to Schneider Dedicated. Employees with Ph.D.s in operations research and experienced ICT personnel work with the customer to determine the customer's logistics needs and to meld customer and Schneider ICT systems together. A well-honed, well-managed project team implements the transition to dedicated service. Tried and true processes for fleet management help Schneider create and maintain each new dedicated fleet. Sophisticated software is easily copied by Schneider’s experienced team for use with each new customer. On top of all of this are the logistical models and experience to competitively, yet profitably, price the offered service.

Schneider Dedicated had supplanted all other Schneider divisions in revenue for the company by the late 1990’s. The division has grown rapidly from 7% of the Schneider's revenue in 1990 to 34% in 1997 to over 38% in 2004. (This growth in the relative revenues is especially large since Schneider's absolute revenues nearly doubled during the same period). Schneider Dedicated currently serves 160 companies, 60 of which use Dedicated only. As a further indicator of

success, Schneider Dedicated's contract renewal rate has averaged 99% between 1984 and 2004.

(iv). Schneider Logistics: Blurring the All Traditional Lines

Schneider Logistics blurs both the lines between Schneider-to-customers and between Schneider-to-competitors. It combines the blurring of roles associated with Schneider Dedicated with those of Schneider Brokerage. A customer company can completely outsource the entire logistics function to Schneider Logistics. In such situations, Schneider Logistics personnel reside at customer sites and often manage carriers that are competitors to Schneider's traditional shipping lines.

Schneider Logistics provides analysis, design, and management services. This includes a wide range of warehousing, distribution, and inventory management solutions. Schneider Logistics builds onto Schneider's core technological base with in-house IT that creates decision support and optimisation tools for logistics. They help clients select from among thousands of third-party carriers in all modes of transportation. Schneider Logistics offers these services as a broad menu of options from providing single in-house logistics engineering to completely taking over enterprise-wide logistics operations.

For example, automaker Mercedes Benz uses Schneider as a third-party logistics provider to coordinate critical freight movement between its Alabama Mercedes plant and its suppliers. Schneider manages daily truckload collection routes from 35 suppliers, delivering 160 loads per day. The task is especially challenging because Mercedes uses a process called In-Time And Sequence (ITAS) to get entire assembly systems completed and delivered in production-run order to its factory floor. (With ITAS, suppliers perform subassembly work, so that instead of Mercedes' receiving head rests and seat cushions and assembling them, it receives fully assembled seats.) No safety stock is held with ITAS, making on-time delivery of the materials essential.

Schneider manages and executes the delivery of in-order and sequence supplier packages for Mercedes. Schneider must set pickup and delivery windows and monitor transit times to ensure they are moving freight into the plant in a manner that supports Mercedes' stringent inventory levels. Schneider also handles the flow of returnable containers from the Mercedes plant back to suppliers.

As a testament to the importance of this service and its success, Schneider Logistics is now larger in revenue terms than Schneider Dedicated. Like Schneider Dedicated, Schneider Logistics has grown rapidly. It was formed in

1993 (although the services date back to a contract with 3M in 1983). The result is that non-traditional divisions (like Schneider Logistics, Schneider Dedicated, Schneider Brokerage, Schneider Intermodal, and Schneider Finance) are, in aggregate, more than twice the size of the more traditional shipping divisions (like Schneider Van, Schneider Bulk, and Schneider Specialised).

(v). Saying Yes to Customers

At the core of Schneider's ability to transform themselves is their willingness to accept and then leverage the challenges that customers lay before them. When 3M wanted to totally outsource logistics in 1983 (a decade before anyone else did), Schneider did it. The result was then offered to other customers and become the foundation for Schneider Logistics Services. When Case Corporation wanted logistics help in Europe in early 1998, Schneider said 'yes' and formed its first international division, Schneider Logistics Europe BV. Accepting new challenges not only ensures that its customers stay with Schneider, but that Schneider stays with its customers as the world changes.

Schneider's acquiescence to customer requests is not as simple as it looks. Schneider's strategy is not a 'satisfy the customer at all costs' approach. Information systems, extensive models, and reams of data on past shipments help Schneider objectively determine what it can and cannot do profitably. If a customer wants an overly aggressive shipping schedule on some route (one that might force drivers to drive too fast), Schneider will negotiate a more feasible schedule or decline it. Indeed, Schneider Logistics actually turns away more RFPs (requests for proposal) than it accepts. The key is that Schneider has cultivated the ability to offer a wide range of services and to understand what it can do profitably for its customers without creating stultifying rules that limit flexibility.

Schneider's strategy of doing more for its customers is not just a matter of selfless devotion nor is it a simple reactive strategy. Schneider could not effectively respond to novel customer requests without its investments in people, processes, and technology. Indeed, Schneider's most important (and most hidden asset) is its ability to learn the customer's situation and create a customised solution in record time. This is especially valuable with Schneider Dedicated and Schneider Logistics where solutions must meld Schneider's technology and processes with those of the client. It is Schneider's seemingly expensive asset base that lets it take on new challenges that create new businesses within Schneider, sustaining growth in an otherwise uncertain environment.

Schneider - Conclusions

The Schneider story is one of several (Allen (1994)) which illustrates the impact that can be enabled by ICT if it is surrounded by the right investments in complementary assets. Wal-Mart is another such story. It illustrates some of what is happening in the retailing sectors by technology users. They are crucial drivers of overall recent US productivity performance. The technology sectors have supplied the products with high and rising efficiency. Thus investment in ICT goods and software is estimated to have accounted for 0.9 percentage points of US GDP growth 1995-2000 (OECD (2003) p. 46). The ability to absorb and benefit from this investment depends upon the competence of management in recognising and implementing appropriate technologies, and building the required complementary assets. A supply push technology transfer policy (focusing on output and business formation in high-tech sectors) that neglects the importance of the management and technical competence of the firms on the demand side (domestic users) will be missing an important lesson. This lesson is that investment in physical and software capital ***and*** investment in human capital and managerial and technical skills are required. It points therefore to a broader educational, curriculum and training side of technology transfer policy for innovative start-ups, and for technology users.

5. Transforming technologies – the next generation?

Given the exponential increase in our knowledge base, and to those adding to it worldwide, we can expect that there will continue to be available technologies that when matched with an appropriate set of complementary organisational assets will transform an organisation. The example of Schneider showed how they used a series of technological innovations: communications, with Qualcom; personal computers, with most employees; graphical work stations, with dispatchers; embedded chips, for truck engine monitoring; and early RfiD, for trailer monitoring.

Each technology was adopted only when the business opportunity was clear to a perceptive business manager. Then the technology was utilised in the context of all of Schneider's complementary assets, skilled employees, industry knowledge, existing work practices, some of them embedded in software, etc.

One next wave of technology as powerful in its influence as were the communications advances exemplified by Qualcom's communications products is Radio Frequency Identification (RfiD). To make effective use of this will require as much vision, persistence and building of complementary assets as we

just saw in the Schneider story. RfiD is deceptive, it is NOT just about smart tags for expensive finished goods inventory, reducing shrinkage and speeding up movements in the value chain. It is that, but it is also about the generic ability to turn passive assets into 'active' living components of the organisation. The range of potential applications is unknown and in some real sense unknowable at this stage. These await the creative imagination of an equivalent business leader to Don Schneider as that person subtly, but inexorably, transforms a firm and in so doing, the industry. The combination of technology, changed processes, organisational structures, behaviours and skills leaves the lead firm in an extremely strong position.

However for any given organisation the results are far from inevitable. The example of Tesco and Sainsbury is instructive in this regard (Tesco, 2004 and Sainsbury, 2004). Tesco has begun trials with RfiD tags. These tags contain a wealth of information about the product and can also be used to track the product's movements. Used cleverly as part of a new organisational process they can have a major impact on productivity in every part of the value chain, and on such aspects of the firm as marketing and pricing. Their initial plan has them using RfiD, and related complementary assets, in a number of their stores in a trial and then to rolling it out nationwide starting in the first quarter of 2005, and so far they appear to be executing to plan. This project began several years ago with a £300,000 support grant to research consortium at MIT that was exploring and developing RfiD technologies.

Initially Tesco is reported to be planning to attach these tags to the trays containing relatively expensive items (e.g. hairdryers). Tesco will be able to develop software, modify their internal processes and embed relevant process know-how to create robust systems that will be very hard for the competition to duplicate.

The prices of the new tags used by Tesco are certainly going to be too high to apply across all products. However the costs are moving lower and will certainly drop as volumes increase. Depending on the specific volume required they already they have moved from several dollars in 1970 to 10 cents in 1990 and 5 cents in 2002. Costs are expected to be low enough that Gillette has announced they expect to use them to identify individual packages of razor blades. Costs will continue to drop and with the expected changes in technology that are currently being experimented with, they will be below 1 cent per tag as volumes rise.

Of course Tesco is using this first product implementation as a way of building the organisational know-how to be sure that the new processes are robust and effective, Thus in such a case the cost of the present Tags is not really the issue,

it the trend and pace of future costs that matters as will be seen in the Sainsbury story below.

As we have seen in the Schneider material above, it is NOT the technology alone that causes the productivity increases. It is the technology plus the set of complementary assets, which includes process changes, that produces the productivity gains. These changes in Tesco's ability to reduce costs and increase responsiveness are the sort of thing it has to do in order to stay among the leaders in their industry. Thus for Tesco it is not just about RfiD but also about related technologies such as 'self scan' check-outs and other innovations, coupled with related organisational process changes. This is a constant process where alert executives maintain a vibrant balance between all the factors laid out in Figure 1 above in order to keep a competitive set of complementary assets.

Tesco's attitude toward change and its holistic approach to embedding technology in the core business processes is in marked contrast to the, not atypical, stumbling of some other firms. Sainsbury Supermarkets (£11 billion turnover) announced in 1978 the first (in the UK) use of a 'hands free' wireless system for operations personnel in their warehouses. The announcement promised major improvements in the whole distribution system. The several American subcontractors involved in developing the initial prototype promised; 'increases in workforce productivity, reduction in operating costs, (and) improvements in operational efficiency…' (Sainsbury).

By March of 2000 Sir Peter Davies was brought in as CEO to reverse a decade long decline in Sainsbury's performance. One of his first acts was to sign a 7 year agreement, for £35 million per year, with Accenture to use ICT to transform Sainsbury's business with a new ICT infrastructure. Although the 'wearable warehouse' system mentioned above had meanwhile been quietly dropped the new team were able to report: '…Sainsbury has been able to migrate from a custom built, centralised, legacy environment that was paper based and used a batch oriented mainframe….. to a new paperless system that operates in real-time through a web browser and has been integrated into key points in the supply chain…….The company has seen an improvement in underlying profit and has achieved a best-in-class cost per case with an in-store availability of 97%. There have been several short-term wins and we have confidence in the long-term strategy' (Sainsbury/Sun Micro Systems).

While this sounds like real progress the announcement 6 months later in October of 2004, tells a different story:

‘Sainsbury plans to write off £260 million in cost associated with flawed ICT and supply chain systems. These have been blamed in part for the chains recent poor performance’ (Miya Knight, *Computing magazine* VNU Publications, Oct 2004). The new Chief Executive Justin King (Sir Peter Davies having stepped down) said they will ‘stop using the automated supply chain system…….and revert to manual processes for stock level management. Our supply chain systems and automated depots are not fully operational…..’ (op cit).

It is interesting that these moves at Sainsbury are at the same time as Tesco is successfully beginning a system-wide roll-out of a focused simple RfiD application. Their learning from this focused application could well lead to a ten year total transformation to how Tesco operates. This learning process lets them embed their ‘know-how’ (a complementary asset) into their ongoing management and operational processes where it will be extremely hard for anyone to copy.

Part of our central thesis is that it is the continuous evolution of the technology that is providing the driver that, when linked to an organisation’s complementary assets, eventually causes the organisation to come to grips with the opportunity to remake itself and thus stay competitive for the longer term. Any single ICT development might be ignored by a successful firm in an industry and its existing momentum could carry them forward adequately. However a whole series of ICT changes over 10 a year period could result in it being too late to regain position.

As with the case of Qualcom and Schneider, we are at a moment in time when the cost and functionality of a technology appears to have crossed a threshold where it has economically effective application.

6. Conclusions

The debate about the impact of ICT on organisations and their effectiveness has gone on in the literature for 20 years or more. A recent, widely misunderstood, example of this is Carr (2003). This appears to say that the end of ICT as a competitive factor has now arrived. Our argument would be that whilst ICT is indeed beginning to become ubiquitous, it will not become strategically significant for an organisation until it is used to creatively enhance the business – in our terminology, until it is embedded in a relevant set of complementary assets. Our examples here are a case in point. They underscore the clear indications from large scale sample studies that the impact is really being felt by

those firms that also invest in complementary assets (and have a sound strategic direction).

As we have shown evidence at the firm level shows why this fact is real and illustrates the sort of holistic effort it takes to have the impact translate to measurable benefits for the firm and society. This investment is important as technology will continue to evolve and global change and competitive pressure will also remain a fact of life. For an organisation to survive and thrive it will have to recognise and respond to the opportunities and threats that the continuing change in ICT provides. Recognising the role of investment in complementary assets and appropriate organisational change would seem to be a useful early step.

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