
Blackboxes, Hostages and Prisoners

Harry Scarbrough

Abstract

Harry
Scarbrough
Warwick
Business School,
The University of
Warwick,
Coventry, U.K.

This paper uses empirical evidence drawn from a sample of IT-based innovation projects to examine theoretical models of the organization of technical knowledge. It suggests that Williamson's transaction cost account is incomplete, in that it fails to take account of the role of social action in communicating technical knowledge and organizing transactions. As an alternative model, it describes the 'strategies of social closure' developed by IT experts to achieve effective knowledge trading and a mutually acceptable division of the economic gains of innovation. Empirical data is used to describe three such strategies: 'blackboxing', 'hostage' and 'prisoner' strategies.

Descriptors: information technology (IT), outsourcing, transaction, expertise

Introduction

This paper outlines evidence on the organization of technical knowledge in the development of major IT-based innovations. Technical knowledge can take various forms in this context, including hardware, packaged software and human expertise. The focus of the paper is upon the strategies by which the buyers and sellers of these multiform knowledge flows exploit a range of organizational mechanisms, including market, network and hierarchical structures, to coordinate and regulate the transfer and application of knowledge.

The importance of viewing knowledge acquisition in the above terms is underlined by recent trends towards the 'marketization' of technical knowledge. Evidence from a range of contexts suggests a surprisingly uniform movement towards the use of market or quasi-market mechanisms for organizing technical knowledge. From the science-based professions and corporate R&D (Pisano 1990; Teece 1988) through to product development, engineering and IT functions, there are unmistakable signs of a shift away from 'professional bureaucracy' (Mintzberg 1979) to some kind of market-type arrangement as the preferred structural means of coordinating the application of knowledge.

One powerful interpretation of this shift is provided by the New Institutional Economics, and in particular by the work of Williamson (1975, 1985, 1986) and Williamson and Ouchi (1981). Other theories, especially those concerned with political factors, tend to equate organization

with hierarchy and consequently find it difficult to accommodate the 'disorganization' (Lash and Urry 1987) implied by marketization. Williamson's work, on the other hand, is a positive celebration of the diversity and mutability of organizational form. It makes changes in organizational form, especially shifts between market and hierarchical structures, the centre-piece of its analysis.

This study compares some of the key tenets of Williamson's model with the complex organization of technical knowledge in the context of innovation. The comparative case-study research described here suggests that Williamson's account, with its emphasis on efficiency of fit between transactions and institutional forms, is an incomplete explanation of the processes involved. This account glosses over the interdependence of economic exchange and social control by defining them as alternative, rather than co-existent, forms of governance. As a result, the Williamson model overstates the determining effect of cost efficiencies on the regulatory means applied to different transactions. In other words, the economics of transaction-institution fit are tendential rather than deterministic, creating a crucial space for social action to shape and organize transactions at the margin. The study of innovation projects described below analyses such social action in terms of micro-level 'strategies of social closure'. Such strategies are seen as having a two-fold purpose. First, actor strategies involve the importation and re-interpretation of institutional rules and resources into under-determined social contexts. Second, social closure in the context of innovation and knowledge trading provides a necessary communicative basis for transactions which economic factors alone cannot secure.

Institutional Structures and Technical Knowledge

In applying Williamson's analysis to the organization of technical knowledge, the key concept is the 'transaction'. Williamson's account focuses on the transaction cost efficiencies of the fit between different institutional forms and the contingencies of technical knowledge, the latter being defined as; organizational specificity ('asset-specificity'); degree of technical interdependency ('technological separability'); and the relative difficulty of assessing its value ('information impactedness'). The risk of a 'small numbers bargaining condition', i.e. dependency on one or two suppliers, is also adduced as an important consideration. In short, Williamson's analysis suggests that the specific features of different forms of technical knowledge make for a more efficient fit with one form of institutional structure than with others.

In this respect, Williamson's work can usefully be seen as a radical extension of the contingency approach to organization. Orthodox contingency theory asked 'how do organizations (meaning hierarchies) survive?'. It found its answer in the 'fit' between hierarchies and their

environments, but in the process made sweeping assumptions about the rationality and integrity of the organization (Wood 1979). In contrast, Williamson re-defines the question; not how do hierarchies survive, but how do they come into existence? By defining the contingencies of the economic transaction as the basic determinant of institutional forms, Williamson avoids many of the weaknesses of the orthodox view. As both the success and the failure of a firm can be explained within the same terms and assumptions of transaction cost theory (a great advantage for a would-be robust general theory), there is no need to reify hierarchies or indulge in political simplicisms about their operation. Moreover, by highlighting the organizational role of markets (and refusing to equate organization with hierarchy) this analysis is better equipped than most to cope with trends towards 'disorganization' (Lash and Urry 1987) and the fragmentation of conventional bureaucratic forms. In the analysis especially of technical knowledge, it offers a powerful explanation of the long-run distribution of technical knowledge between different institutional forms (Francis and Winstanley 1988).

This being said, however, the ambitious claims of this analysis also expose it to criticism. Many writers question whether the efficiency of fit between transaction and institutional form is objectively determined by market forces, or whether it is socially constructed by professional groupings such as accountants (Morgan 1990). A more radical strand of criticism challenges the assumption that transactional exchange is actually the basis of institutional forms at all. 'In the beginning was the market' sayeth Williamson, but many writers suggest that social control is the key principle of capitalist organizational forms (e.g. Marglin 1974). Such writers see the drive towards social control as having a variety of causes and taking many different forms. These include class-domination, the market power of large corporations (Perrow 1981), the discursive effects of disciplinary formations (Foucault 1979), and the monopolistic control exercised by certain professional groups (Johnson 1972). In other words, they counter Williamson's assertion of all-pervasive pressures for economic efficiency, with an equally all-pervasive drive towards social control.

The problem with this line of argument is that counterposing social factors against economic factors simply takes us towards high-level theorizing about the ordinal or ontological primacy of one or the other. In particular, it fails to address the central theoretical challenge posed by Williamson. By defining the transaction as the unit of analysis, Williamson aims to take the debate about organizational forms outside the realm of social relations. At the same time, this micro-level unit of analysis gives Williamson precise analytic tools to explain the boundaries of organizational forms *at the margin*. In a context of industrial and technological change, this bottom-up explanation offers significant analytical advantages. As a native category of socioeconomic interaction, the transaction stands outside existing institutional forms, and offers an

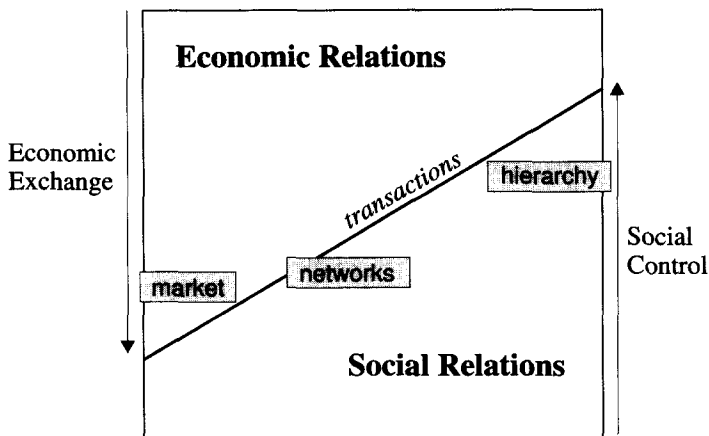
incremental explanation of their emergence and dissolution. This avoids explaining such institutions in their own terms—for example, in terms of dependency avoidance (Pfeffer and Salancik 1978)—or through the invocation of a *deus ex machina* in the form of top-down and diffuse effects of social structure, power and ideology.

This paper will attempt to grasp the theoretical advantages of using the transaction as a unit of analysis, while avoiding the pitfalls, by revising it as a mid-range theoretical concept. There are three major steps in this argument: (i) to argue that transactions are not the timeless *a priori* of economic institutions but are mutually dependent upon social relations: (ii) further, to suggest that the degree of social relations or economic exchange involved in transactions varies in a continuous, not a bi-polar, fashion, and (iii) that, given such a continuum, Williamson's emphasis on the efficiency of fit between transactions and institutional forms is ultimately unconvincing. These points then lead on to a discussion of the role of social action in shaping transactions and mediating their allocation to institutional forms.

To take the first point, however, my argument involves revising the conception of transaction itself. In Williamson's work this concept is remarkably under-defined, boiling down to the following phrase: 'A transaction occurs when a good or service is transferred across a technologically separable interface . . .' (Williamson 1985: 1–2). To see such a transfer as a purely economic exchange, however, is to neglect the social relations which underpin it. Even speaking *de minimis*, for example, we note that transactions not only require the physical exchange noted by Williamson, but also involve a transfer of control (Commons 1970). Furthermore, unless we take property rights to be a natural phenomenon, we have to see this transfer of control as reflecting, however weakly, particular patterns of social relations. Added to questions of control are the relations of interdependence between parties to an exchange (Martin 1993). Such interdependence may lead to direct or indirect forms of exchange, with some exchanges so indirect as to take on the appearance of a gift (Titmuss 1979). These points underline the extent to which transactions not only involve exchange relationships but are equally predicated upon, and embedded in, social relationships. Far from social control being the mirror image of market failure, control and exchange relations seem to operate in tandem as mutually defining forces in shaping transactions.

This point has important implications for the analysis of institutional forms. Williamson sees such forms as effectively bounding the dynamics of exchange and control relations. Thus, social control only emerges through the failure of the market as a governance structure, and is bounded by the development of hierarchical structures. Yet, as Granovetter (1985) notes, pigeonholing exchange and control relations into the competing forms of markets and hierarchies effectively means under-socializing the former and over-socializing the latter. In contrast, defining social control and economic exchange as interdependent and

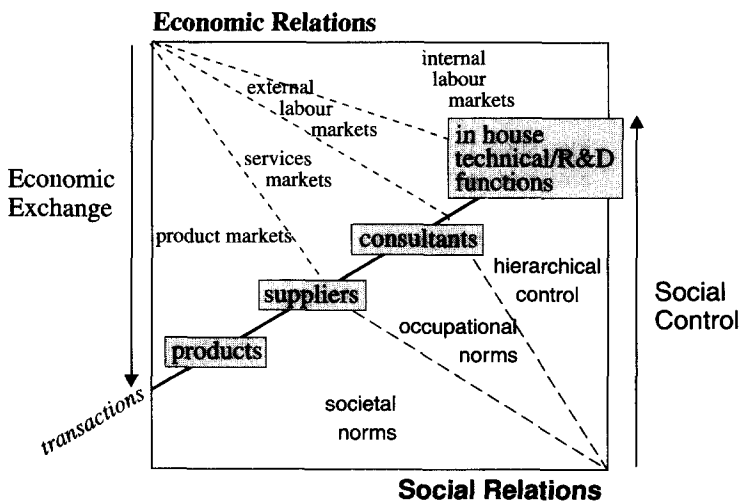
Figure 1
Continuum of Transactions — Between Market and Hierarchy



co-existent aspects of transactions leads us towards the second point in the argument: that relations of economic exchange (i.e. control through material incentives) and social control (control through social relations) are mutually dependent, not mutually exclusive, dimensions of a transactional continuum.

At either end of such a continuum—as outlined in Figure 1—the influence of one form of control or the other is attenuated, but it is not non-existent. Thus, even the simple exchange of commodities involves a minimum quantum of social control (Muetzenfeld 1993). Conversely, even the socially cohesive ‘clan’ forms of organization are not free from the effect of exchange relations, however muted that effect may be. Where many studies of technical knowledge focus on a particular organizational form, applying this analysis (see Figure 2) underscores

Figure 2
Forms of Technical Knowledge



the variability in both content and control of such knowledge. It therefore has special relevance to the fluidity and marginal determination of organizational form which is seen in contexts of disorganization and innovation.

Moreover, the continuous distribution of transactions is not simply a theoretical counterpoint to the polarizing tendency of the markets and hierarchies paradigm. It also helps to account for the tendency of transactions to cluster at the mid-point of the continuum where they are subject to a variety of hybrid organizational forms, such as franchise arrangements and networks. The latter, indeed, assume particular importance in a study of technological innovation, given the crucial role played by occupational and inter-organizational networks (Clark and Staunton 1989; Kreiner and Schultz 1993).

This analysis also makes clear the problematic nature of the presumed relationship between transactions and institutional structures. It clearly challenges the argument that transactions allocate themselves to institutional forms on the basis of efficiency of fit. Except for the extreme ends of the above range, the dependence of most transactions on co-existing social and exchange relations seems to make a perfect fit unlikely. With infinite gradations in the mix of control and exchange relations, the range of transactions is better represented as a continuous gradient than as step-changes in type or form. Along this gradient, the fit between transaction and institutional form seems likely to be approximate and elusive rather than decisive.

This point can be further developed by citing Hennart's (1993) critique of the Williamson thesis. Hennart notes that 'observation shows that most transactions cannot be categorized as either 'pure market' or 'pure hierarchy'' (p. 530). He also argues that the resulting 'swollen middle' of hybrid arrangements reflects the existence of a continuum between markets and firms. Institutional forms, he claims, are the result of a trade-off between the 'shirking costs' associated with behavioural control, and the 'cheating costs' of output control. Although this critique still clings to transaction costs as the basis of institutional forms, Hennart does make a crucial distinction between 'institutions' (markets and firms) and 'organizing methods' (prices and hierarchy). He argues that such methods are applied to the control of transactions, independently of institutional form. Thus the price system might be applied within a firm in the guise of piecework payments, for example, or elements of hierarchy might be applied in a market context. While Hennart does not describe how such methods operate independently of societal institutions—a point I return to later—his account matches empirical evidence on the interdependence of social control and exchange relations. Thus, Macauley's (1963) study of salesmen highlights the functional role of social norms and trust in reducing the need for monitoring and surveillance in market structures. Butler and Carney (1983) suggest that in complex make-buy situations, so-called 'managed markets' are developed, 'augmenting' market structures through the deployment of

mechanisms normally associated with hierarchies, notably 'trust', 'routines' and 'mutual adjustment'. Even in relatively pure market situations we find the operation of market mechanisms resting upon the lubricating effects of social norms and shared meanings (Martin 1993).

Hennart's analysis, together with the other points noted above, provides powerful evidence for the prior role of social 'organizing' over 'organization' in shaping and regulating transactions. The role of such processes, or 'methods', of organizing effectively directs attention away from the immediate contingencies of the transaction towards the scope for social action in shaping such transactions and their allocation to structural forms of governance. As for the character of such action, although there are many different interpretations, a summary analysis highlights the following features. It is *strategic* in that actors' responses are willed and proactive; Child's (1972) notion of 'strategic choice' provides a useful interpretation of such action, providing further rebuttal of contingency theories of organization. It is also *negotiated*, with the construction of shared meanings through the 'negotiation of order' (Strauss et al. 1963). Most importantly, though, social action is not purely voluntaristic, but is informed by the overarching institutional and societal context. Giddens' concept of 'structuration' provides a powerful analysis of this link between action and structural context. In this analysis, 'the rules and resources drawn upon in the production and reproduction of social action are at the same time the means of system reproduction' (Giddens 1994: 81). For our purposes, therefore, structuration highlights the role of social organizing processes in importing shared rules and understandings into structurally underdetermined contexts. Such rules, which are partially reflected in Hennart's 'organizing methods' are informed by the wider social structure, yet are independent of particular institutions. Again, an important and relevant example is provided by the role of social networks in assembling innovations. Here one finds ample evidence of articulated strategies based on extensive constituencies of actors (DeBresson and Clark 1992).

The Organizational Implications of Technical Knowledge

The need to acknowledge the role of social action is highlighted by the problems which the organization of technical knowledge poses for Williamson's 'static and analytic' (Lazonick 1991) account of transaction-institution fit. In Williamson's account, knowledge is effectively equated with human 'asset specificity' which arises from the need for 'learning by doing' and 'team configurations' in the development of human resources (Williamson 1985). This focus on tradeability defines knowledge simply in terms of its effect on transaction costs, crucially disregarding two areas where social action plays an important role. These are, firstly, the role of knowledge in innovation, and, secondly, the importance of communication in the exchange of knowledge.

The distinctive role of knowledge in generating innovations is usefully summarized by Lazonick's telling distinction between 'adaptive' and 'innovative' organizations. The former represents the Williamson model of firm behaviour, in that 'the key decisions are a series of adaptations to 'disturbances', taking as given those factors that constitute the prime elements of the organization's economic environment' (p. 214). Lazonick makes the point that this emphasis on adaptation neglects the dynamic features of innovation processes. In an innovative context, transactional features such as asset-specificity and economic value cannot be taken as given. Rather, the innovation process itself shapes and selects transactions through the creation of new sources of economic value and improved standards of economic efficiency. As Lazonick puts it;

'Asset specificity *results* from an innovative strategy implemented by an appropriate management structure that develops and utilizes the organization's resources. . . . Asset specificity is not a cause of "market failure" . . . but an outcome of "organizational success".' (Lazonick 1991: 218)

In the arena of innovation, therefore, questions of social control — strategic commitments to innovation, for instance — are at least as important as *ex ante* transactional contingencies in shaping the selection of projects and the ultimate division of economic gains. In that sense, the 'innovative organization' actively confronts the contingencies and uncertainties of its environment, creating for itself the kind of transactions to which it must subsequently adapt.

However, the dynamic effect of knowledge on transactional contingencies is not the only cue for social organizing processes. Williamson's analysis highlights certain well-known problems of tradeability — the difficulties of valuing knowledge by observation ('information impactedness'), for example. However, in so doing, his approach defines knowledge as essentially a rather intractable form of information. Without rehearsing long-winded epistemological and semantic arguments, the narrowness of this definition is usefully summarized by the following distinction:

'Information is the answer to a question. Knowledge is the framework that enables the question to be asked.' (Newman and Newman 1985: 499)

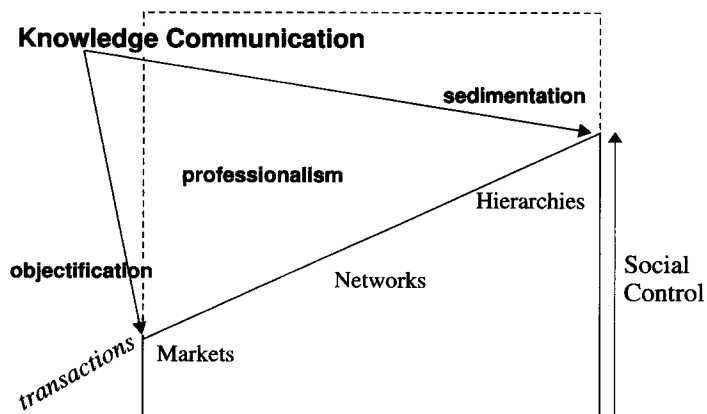
This distinction between knowledge and information helps to account for the inherent problems of equating knowledge-based transactions with discrete physical transfer 'across a technologically separable interface'. In fact, inasmuch as they depend on shared cognitive frameworks and shared meanings, such transactions seem much more akin to social processes of communication. For example, knowledge is typically shared rather than transferred: the seller continues to partake of what he/she has sold. Also, the acquisition of knowledge depends upon the

possession of certain kinds of prior knowledge (Cohen and Levinthal 1990). Moreover, the production of knowledge generally involves 'bootstrapping' (Hofstadter 1980), that is using existing knowledge as a platform for innovation. Given these points, it is hardly surprising (though still significant) that the diffusion of innovations is generally analyzed not in terms of physical transfer, but through broadcasting analogies.

Clearly, knowledge-based transactions depend on social and cultural processes of communication (Boisot 1986) as much as upon economic processes of exchange. The literature suggests three basic modes of knowledge communication, which can be briefly summarized as follows. First, *professionalism*, that is the communication of knowledge through its embodiment in the learning and experience of individuals and groups. Professionalism fosters and transmits knowledge within a particular 'community in practice' (Spender 1992). A second means of communicating knowledge is provided by the dynamic of *objectification*. Here the communication process revolves around the pursuit of portability (Cooper 1992), and universal applicability through standardization. The knowledge needed to use the technology is kept to a bare minimum. Third, there is what can be termed *organizational sedimentation* where knowledge is communicated via rules, standards, routines and structures (Argyris and Schon 1978; Lyles and Schwenk 1992; Whipp and Clark 1986). Adding these parameters of communicability to the differential tradeability of knowledge gives an extra dimension to the continuum outlined earlier, producing (in Figure 3) a useful map of the scope for social action in the organization of technical knowledge.

The importance of addressing the communicability as well as the tradeability of knowledge can be briefly illustrated with reference to the history of technological development in the Computing/IS (Information Systems) field. Were transactional efficiency the primary

Figure 3
Knowledge
Communication
and Tradeability



consideration, one might expect all technical knowledge to be progressively transformed into discretely marketable commodities. Although this is an important trend within information technology as the human crafts of programming have been progressively automated and commodified in hardware and software, it is far from being conclusive or complete. Rather, technological innovation, with its need for social communicability, has meant that the awesome commodification of technology has actually provided a platform for increasing demand for human expertise. The feared deskilling of IS workers (Braverman 1974; Kraft 1977) has been deferred indefinitely by this dynamic tension between the communicative processes involved in knowledge production. Thus, first the 'unbundling' of hardware and software in the 1960s and later the advent of distributed computing in the 1980s actually created a huge demand for a new generation of professional IS specialists. Latterly, indeed, the objectified technological platform provided by commodified IT has even opened up the prospect of competitive innovations in the use of IT at firm level.

In sum, these points highlight the contrasting effects of exchange efficiency and social communication on the organization of technical knowledge. The pursuit of efficiency in transaction costs implies an evolutionary competition between different institutional approaches to organizing knowledge. If we disregarded innovation, this would lead ultimately to pure marketization. In contrast, the social communication of such knowledge creates a potentially symbiotic interaction between institutional forms as different communication processes stimulate innovation. Although I have highlighted the social character of such processes, they are — as Lazonick's account of innovative and adaptive firms reminds us — no less subject to economic pressures, except that such pressures involve the pursuit of the competitive gains of innovation rather than cost reducing efficiencies.

The Study and the Sector

The empirical research reported here was carried out in two sample groups of financial institutions in the period 1988 to 1990.¹ One group, made up of 6 large Scottish-based organizations in the banking, credit card and insurance sectors, encompassing 7 different IT projects, was investigated in depth. A second, smaller group was composed of firms from other parts of the sector, encompassing building societies, fund management services and vehicle finance services. For the second group, the aim was simply to gain a snapshot view of the organization's current use of IT systems. However, for each of the in-depth cases, the focus was on the development process for a major IT-based innovation. The research tracked both

the internal and external deployment of technical knowledge within these processes, including software and hardware acquisition as well as the use of a range of employee and supplier specialists. The in-depth cases were as follows:²

The Bank of Scotland: development of 'CABINET', a large-scale Branch Information Network.

Clydesdale Bank: joint development of 'TELEBANK', a remote banking product for retail and corporate customers.

Royal Bank of Scotland: development of 'ROYLINE', a remote banking product for retail and corporate customers.

Highland Life: development of a customer database.

Home & Auto Ltd.: development of a corporate management information system.

Premier Financial Services: acquisition of a credit card processing package.

Bank of Scotland VISA Centre: acquisition of a credit card processing package.

The methodology of our study contrasts significantly with the dominant approach amongst empirical studies into Williamson's model. This typically seeks to test the *logical* causalities embodied in the argument by comparing outcomes — the actual 'governance structures' employed in different contexts — to the properties of the transaction which they govern. This necessarily neglects the model's *mechanical* causality, i.e. the detailed means by which particular transactional contingencies translate into particular institutional forms. Although this neglect can partly be attributed to the epistemological bias of economics towards large-scale, long run phenomena, some other reasons for such neglect are highlighted by one study which did indeed attempt to examine the mechanics of transaction governance. In this study, Walker and Weber (1984) note that while production costs are explicit and measurable, 'because of the vagueness with which administrative costs associated with a transaction may be measured, transaction costs are not likely to be considered very explicitly in every choice to make or buy' (p. 378). In other words, at a practical level, transaction costs are not a visible component of the calculations around key purchasing and marketing decisions. Although Walker and Weber constructed 'latent variables' as a proxy for transaction cost considerations, it is debateable whether this crucial element of Williamson's model can be usefully correlated with organizational processes as we know them.

The analysis of transactions in the context of innovation poses further methodological problems, many of which are to do with the inappropriateness of the 'make-buy' dichotomy which is at the heart of many empirical studies of the Williamson model (including the Walker and Weber study). Our research shows that make-buy is not a useful conceptualization of the complex interactions involved in acquiring and developing technical knowledge and artefacts.

It follows from these points that our research methodology did not attempt to test Williamson's model in the strictest sense. This was partly on the grounds that notions such as transaction costs and make-buy simply do not operationalize well. More importantly, though, we were less concerned with whether transaction costs were ultimately decisive in the way suggested by Williamson, than with the broad applicability of Williamson's approach, notions of 'asset specificity' and the rest, to the complex and iterative operations involved in technological change. Hence, our research focused not on detailed cost considerations (which in any case did not figure very highly as we will see) but on the unfolding processes of social interaction and flows of technical knowledge involved in each case.

In each case, we tracked the decision-making process on a particular innovation through documentary analysis and interviews with key internal and external actors, sometimes relying on retrospective reconstructions, but more often following the process in longitudinal fashion. This gave us the opportunity to analyze the relationship between the emergent technological innovation, the flows of knowledge around it and embedded within it, and the associated organizational manoeuvres concerned with shaping and controlling the innovation process. In that sense, we were able to address the processual evolution of transactions and organizational forms in a manner which afforded comparability with, but was not wedded to the 'transaction cost' account.

The choice of financial sector IT as the locale for this study reflected its outstanding qualities as a research site for exploring the organization of technical knowledge. IT itself, of course, is an 'enabling' technology which is seen by some (Child 1987; Ciborra 1986) as facilitating the extension of market mechanisms into new areas of economic activity. More specifically, the financial services sector has long been a user of computing and information technologies. Thus IT has been widely applied to rationalizing and commodifying what were once professional or neo-craft skills of banking, actuarialism and service delivery. Its application is reflected in the progressive downgrading of these skills in favour of an increasing emphasis on marketing. As this expanding range of IS applications led to mounting levels of IT expenditure, there were parallel pressures towards a re-alignment in the respective roles of in-house IT functions and external contractors (Price Waterhouse IT Reviews 1989-1993). While in-house IT functions were seeking to claim strategic significance for their role, there was evidence of the increasing involvement of contractors and software houses in both product development and facilities management.

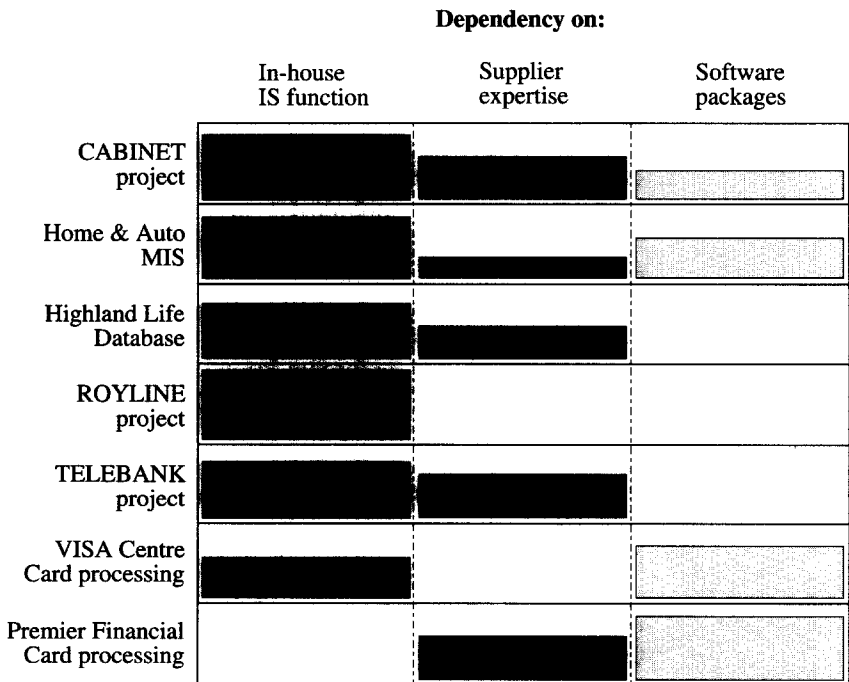
Interpretation of Empirical Data

Our case studies were selected to provide a window into the detailed social processes which lay behind these wider patterns of change. Each case involved a technological project which had been identified as

important and innovatory by senior management. Sometimes these were major projects embodying important technological innovations, but at other times the technology was routine and it was the organizational change around it which merited senior management's close attention. In every case, though, we found developments depending on a complex admixture of in-house and extra-mural technological and human resources. To describe this admixture as the product of make-buy decisions would hardly do justice to the complex processes involved. Moreover, the term might wrongly imply an either/or quality in these processes — either in-house development or external sub-contracting — which was rarely true of the projects we examined. Indeed one of the few commonalities we found between these projects was that the internal and external sourcing of knowledge was typically considered jointly rather than discretely. In other words, projects typically involved not 'make-or-buy' but make *and* buy decisions, with the distinction between one and the other being blurred by long-term contracts and supporting social relationships. Figure 4 provides a graphic representation of this point by highlighting the distributed character of the sources of technical knowledge tapped by each of these projects.

The sourcing of knowledge and technology depended to a great extent on questions of standardization and organization specificity. In broad terms we found that the more standardized and the less organization-specific the knowledge requirements of a particular project, the greater

Figure 4
Sources of
Technical
Knowledge in
Innovation
Projects



the role for sub-contracting and commodification. This is evident in the contrast between a non-standard, highly specific project like CABINET at the top of the table and the acquisition of more routinized card processing technology in the Premier Financial Services case at the bottom. Nevertheless, while these factors give some credence to Williamson's emphasis on technological separability and asset-specificity, there were also important differences in the sourcing of technical knowledge which could not be accounted for in these terms. Thus, the ROYLINE and TELEBANK projects were broadly similar in both technology and target markets, yet were managed quite differently; one being conducted entirely in-house and the other the product of a collaborative development with a technology supplier. Similarly, both the VISA Centre and Premier Financial Services cases involved the acquisition of software packages, but in the former case customization and maintenance was carried out internally, while in the latter such tasks were completely out-sourced.

Such choices were part of a broader picture of blurred institutional demarcations and complex knowledge flows which seemed at odds with the clear-cut categories of the Williamson model. Although certain elements of Williamson's account did seem to be relevant, transaction cost analysis as a whole seemed to lack conceptual force when confronted by delicately poised yet informal governance structures which it could only lump together as 'hybrid' forms. The alternative prospectus, which I have already touched on in outline form, seemed to offer more explanatory power than a focus on transaction-institution fit. Thus, while our research found that the actors in innovation processes were certainly concerned with the transactional contingencies described by Williamson, they took an active role in vesting such transactions in a particular combination of social control and economic exchange, drawing interpretively on the rules and resources which surrounding institutions provided. In other words, transactions did not allocate themselves to institutional forms unambiguously on the basis of cost, but had to be balanced against questions of social control which could not be resolved by an economic calculus.

Moreover, the degree of social control itself was far from being simply the default option to market failure (or an unbounded will to power, for that matter). The emergent knowledge flows involved in innovation posed difficult questions of how much control to seek over a particular technology. Transaction costs were little use as a guide for managerial decisions here, since innovation processes had the effect of defining and selecting transactions and their contingencies against a qualitatively new standard of economic efficiency. A more important consideration it seemed, was the attempt to concert the communication processes involved in knowledge acquisition with the ordering of interests and relationships, and to do so in such a way as to incentivize both through the prospect of shared economic gains. The need for strategic action here was driven by the tensions involved in reconciling knowledge

communication with the orderly negotiation of interests. One implies extensive networks and informality, while the other involves tightly bounded social relations and well-defined outcomes.

Thus, our study found social action being applied in a variety of ways to shape and mediate transactions. Social structuration was certainly present in the ad hoc construction of rules and relationships, but so too was action to elicit and communicate relevant knowledges. Although analytically distinct, we found that in reality these different facets of social organizing operated in tandem; to define rules and relationships meant identifying required knowledges, and vice versa. In that sense, the actors involved in innovation projects had to develop strategies which could usefully balance these tensions between innovation and efficiency, openness and boundaries. Such strategies can usefully be termed 'strategies of social closure', because they involved the progressive de-limiting and fixing of social relations and knowledge flows alike into constellations which could be managed effectively to produce shared economic gains.

This notion of social closure is typically identified with wider occupational groups, and the tying of professional knowledges to the pursuit of exclusionary, credentialist strategies. However, the micro-level strategies which I describe below also involve a degree of interpretive closure of the kind which is normally associated with technological development. As a number of studies have noted (e.g. Pinch and Bijker 1987), such development typically depends upon interpretive closure; the meaning of particular technologies becoming progressively stabilized as users, inventors and producers come to share common frameworks as to the meaning, critical features and purpose of the technology. In the emergent context of innovation, closure was by definition a more localized affair, but the sharing of common frameworks was no less crucial to the effective communication of technical knowledge.

At the level of individual projects, strategies of social closure were crucially important in allowing a useful degree of knowledge-trading within and outside our case-study organizations. Although such projects were often accompanied by the development of a range of formal contractual and organizational arrangements, our study found that these were rarely instrumental in organizing the harmonious interweaving of required relationships and expertise. More often, they were a formalization of patterned relationships and interests which had emerged in the course of the project. Apart from defining the initial locus of innovation, institutional arrangements seemed to be much less important than the strategies painstakingly constructed by the different groups involved. Although our case-studies could not produce an exhaustive taxonomy of such strategies, three major types could be discerned, varying roughly according to the distribution of knowledge, economic interests and social relations involved in each innovation. These have been termed 'blackboxing', 'hostage' and 'prisoner' strategies. Their location in relation to the communication and trading of knowledge is highlighted in

Figure 5
Strategies of
Social Closure in
Organizing
Technical
Knowledge

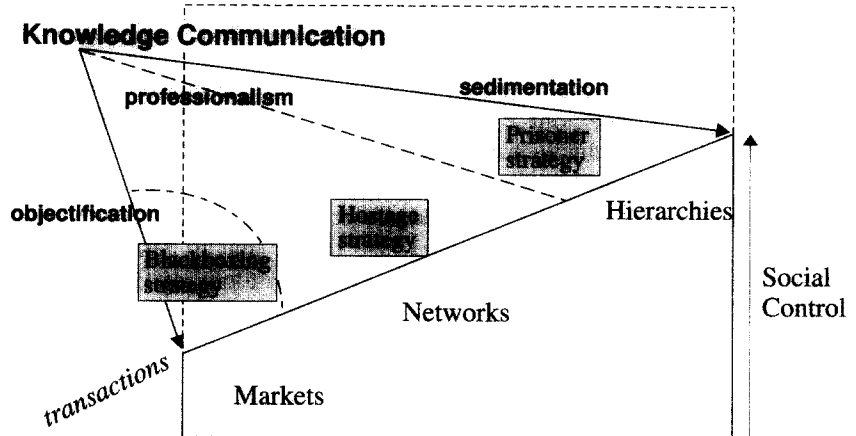


Figure 5. Rather than presenting an exhaustive account of each of our case studies, in the rest of this paper I will use the case-study material to illustrate the way such strategies were worked out in particular contexts.

The Blackboxing Strategy

The blackboxing strategy was developed in a number of our cases as a way of coping with the dilemmas posed by commodified forms of technical knowledge such as software packages. It involves organizing transactions for the economic exchange of objectified artefacts, with minimal dependence on social relations. This seems to be a widely used strategy in the IT area, largely because the technology itself pushes the possibilities of objectification to the extreme. Information processing power makes it easier to objectify knowledge, and this is reinforced by the powerful economic incentives to recoup the costs of labour-intensive software development by exploiting its relatively low cost of reproduction and distribution (Friedman 1989; Pelaez 1990).

Although this strategy seeks to exploit economies of scale in knowledge production (Swann 1990; Brady et al. 1991), it also depends on social processes for communicating that knowledge. It requires that technical knowledge be separated from its original social and technical locale by being progressively stabilized, segmented and made portable (Latour 1987; Cooper 1992). Stabilization involves the establishment of a 'dominant design' for the technology, such that computer hardware, for instance, has become more standardized and more robust (and in the process significantly cheaper). Segmentation, meanwhile, involves separating systems development into different phases, or dividing software into categories such as systems/utilities and applications. Then, portability involves minimizing the knowledge needed to use a technology by

careful design of the user interface, thus allowing elements of a technological system to be removed from one context and applied in another.

In the financial services context especially, blackboxing is a long established strategy for handling technical knowledge. Computing technology was applied originally to 'back office' functions such as accounting and transaction processing. Over time, the hardware component became increasingly black-boxed, reflecting both competition between suppliers to provide complete solutions, and user needs for reliable systems. This allowed first the separation of routine 'operations' tasks from systems development and eventually their complete automation through the use of supplier diagnostic systems. Indeed, by the late 1980s, blackboxing had become almost a literal reality for mainframe hardware, with one of our sample of cases, the Royal Bank of Scotland, making great strides towards the 'dark room' concept for managing mainframe operations. This involved excluding human workers from the machine-room, locking the doors, and 'throwing away the key'. Supplier maintenance and back-up systems would ensure the continuous smooth running of the machines.

While organizational routines colluded in blackboxing mainframe hardware and processing tasks, the product-market developments of the 1980s spawned important new opportunities for blackboxed applications. Deregulation of the U.K. financial services sector encouraged a flurry of product diversification moves, with the vast majority of providers seeking to develop and extend their existing product range. These product-market pressures encouraged providers to look for two types of IT applications; product innovations such as remote banking systems which could augment their existing product range; and customer database applications which would improve the quality of service to customers and at the same time allow a greater degree of cross-selling through the integration of customer information.

As these applications generally involved 'front office' systems — i.e. they affected the interface with the customer rather than the internal operation of existing accounting and processing systems — they were relatively amenable to the discrete functionality of the blackboxing approach. A number of our case-study firms embraced this possibility with enthusiasm. For example, one building society purchased a customer database package ('Baron') which the IS manager described in glowing terms:

'It is an all-singing all-dancing package which will control all our lending portfolios, various products which we hope to put out, such as a checking account, insurance services and so on. "Baron" is very much a customer-based system, as opposed to an account-based system. We're looking to have a customer-based system for the cross-selling opportunities that may exist. For example, if a guy comes in and gets a mortgage, he may need a loan for a car or need insurance or a personal equity plan.' (User Services Manager, Buildsoc)

Here the advantage of the blackboxing approach derived not only from its economic advantages (principally cost and time) over in-house systems development, but also from the building society's willingness to change its organizational routines in the face of changing product market conditions. The software package, in fact, was seen as an important element in shifting to customer- versus account-based procedures for handling records.

The same propitious context obtained in one of our other case studies, which involved the development of a card processing system for Bank of Scotland VISA Centre. The establishment of a credit card operation represented a significant diversification move for the Bank into a market and a technology with which it was relatively unfamiliar. With no pre-existing organizational routines to grapple with, the economic advantages of a software package were overwhelming. There was little or no debate on the make-buy issue, and management early on switched their attention to the choice of a particular package. Once the new package had been selected, management designed the new Centre's organization around it. Much of the basic organizational design was developed by two of the most senior managers drawing up a rough blueprint over a drink in a local hostelry.

These cases clearly demonstrate the advantages of the blackboxing strategy in economic terms. However, such advantages need to be set in context. First, questions of exchange only predominated because social communication and control issues were secondary in these particular cases; the organizational infrastructure within which the technologies were to operate was relatively malleable, either for reasons of strategic choice or because management were designing the organization *ab initio*. Even so, communication and control issues were not entirely absent from these cases. In particular, while blackboxing seeks to instantiate all social relationships and all relevant knowledge in the form of a one-off purchase, it often encounters problems in a complex and dynamic organizational or technological context. Such problems may arise through constraints on surfacing all relevant knowledge, especially where it is organizationally or professionally embedded. Thus Managers at Buildsoc, for instance, were later to acknowledge that the decision to install the system as a complete black-boxed package — without any preparatory customizing to link it into the company's systems and organizational practices — created serious problems.

'Unfortunately, we have had some problems with it. It's an American-based system. There's some anglicisation required to be done and that's led to problems. We've had problems of sizing and unfortunately the whole thing has been beset with problems.' (User Services Manager)

Of course, some managers may be happy to accept marginal mis-alignment between commodified technology and organizational practices. They may see it as a small price to pay for the cheapness and functionality of standardized packages. A longer-term constraint arises, however, where

the black-boxed technology has the potential to act as a platform for future technological innovation. The selection of software packages in our sample, for instance, often revolved around the possibilities and prospects of future supplier 'up-dates' which would enhance the functionality of the package. Such up-dates involve highly specific knowledge of the technology, which again cannot be crystallized out as a one-off exchange. They therefore raise issues of long-term relationships and possible dependency on the supplier. Williamson would term this a 'small numbers bargaining condition' and see it increasing the possibility of supplier opportunism. Our cases certainly provide evidence for such an interpretation. For example, the suppliers of the VISA Centre processing package subsequently went on to establish their own computer bureau in the United Kingdom — effectively setting themselves up as competitors to the Bank of Scotland. At the same time they withdrew support from the package in the United Kingdom. Such decisions apparently validated the Bank of Scotland's decision to carry out the customizing work for the package in-house. However, without denying the importance of opportunism in the exchange of knowledge-based products, it is not a useful explanation on its own — opportunism is probably too open-ended a concept to explain specific outcomes. More importantly, opportunism in this context is only important insofar as it might jeopardize a longer-term commitment to social control of a particular technology. Thus, the VISA Centre decision can be seen less as a negative move to avoid supplier opportunism than as a positive commitment to card-processing technology.

The Hostage Strategy

The more that blackboxing relies on the buttressing of in-house systems development, as in the VISA Centre case, the less powerful its attractions for the user firm. This points the way towards an alternative strategy for organizing technical knowledge. For if dependency on the supplier knowledge-base cannot be avoided, it can be made safer by pursuing a strategy based on mutual dependency and mutual benefits. In broad terms, the 'hostage strategy' involves the use of occupational networks to communicate knowledge, and a mixture of occupational norms and economic incentives to organize transactions. This strategy is uniquely distinguished, however, by its incentive basis, described by Nooteboom as follows:

'A special measure that carries less risk of expropriation is that which takes the logical form of a hostage; something is given in custody which is of value to the giver (who will therefore comply with agreements lest he lose it) but not to the receiver (who will therefore not be tempted to expropriate).'

(Nooteboom 1992: 342)

We can see this strategy clearly in the case study of the Clydesdale Bank's 'TELEBANK' remote banking system. Here we had a collabor-

ative product development involving a bank seeking to develop its product range and a supplier (SoftHouse) which wanted to develop a marketable remote banking product. The development of TELEBANK did not involve the one-sided 'lock in' threatened by package acquisition. Rather, the relationship between Clydesdale Bank and SoftHouse was based on a kind of mutual hostage taking in which each side controlled assets that were more valuable to the other than to itself. Where dependency is usually inimical to the market appropriability of knowledge (threatening opportunistic exploitation of a small numbers bargaining situation), in this case mutual dependency seemed to work effectively for both sides.

However, it would be wrong to present the TELEBANK project as simply the rational calculation of interests around a particular transaction. Many of the reasons for successful knowledge trading here are to do with social relations rather than economic factors alone. Thus, Clydesdale management had initially identified SoftHouse as a likely partner through the occupational grapevine, and the subsequent development relied heavily on the degree of trust which a shared occupational identity helped to engender. Also, the sharing of occupational knowledge meant that each side had the expertise to evaluate the other's work in a complex and uncertain work situation. Such social relations not only served to lubricate the coordination of work, but also extended the sanctions against opportunism: Clydesdale's position within the sectoral networks of the U.K. banking sector gave it reputational leverage over SoftHouse, with a 'high profile' project such as TELEBANK carrying 'enormous embarrassment potential' if it failed.

Factors such as these help to explain the relatively informal organizational arrangements which were applied to this project. Despite its importance to the Bank, there was little attempt to monitor SoftHouse's work. For example, Clydesdale management only needed informal discussions and general information about the development process to feel 'happy' with SoftHouse's programming standards. We can relate this informality to the 'organic' relationships involved in innovation, and to the tacit implications of the social controls noted above. In addition, however, a decisive influence seems to have been the potential economic gains arising out of the project. The benefits of a successful outcome would be both significant and complementary for each side. Once completed, SoftHouse aimed to market TELEBANK as a generic, blackboxed product to other U.K. banks. In return for providing this development opportunity, Clydesdale stood to benefit in a three-fold fashion: by a reduction in development costs, the acquisition of an important new product, and royalties from the sale of that product to other banks.

The achievement of such gains depended not only on the innovation process itself, but also on defining a division of labour within it to allow an acceptable sharing of said gains. The degree of 'technological separability', to use Williamson's term, was important here in that it

allowed the communication, application and proportionate reward of different kinds of knowledge within the same innovation process. To elaborate: TELEBANK could be implemented as a segmented appendage to existing processing systems, without requiring radical changes in them. Moreover, the front-end of TELEBANK could be designed and built by the supplier as virtually a buffer system between various end-user devices and the bank's secure databases. These architectural features of TELEBANK facilitated a broadly segmented division of labour between SoftHouse and Clydesdale's in-house systems development function, with the latter maintaining control over sensitive internal banking systems and data. Equally importantly, it allowed the supplier firm to concentrate upon the development of the stable black-boxed functional architecture as a potentially portable and marketable product.

The advantage of separability lay not simply in allowing subcontracting of work, as Williamson would have it, but also that it permitted more effective communication of different kinds of technical knowledge. The TELEBANK innovation demanded a combination of banking expertise with specific technical skills and a more generalized understanding of the market. As the Director of the software house reflected later:

'Unavoidably we've picked up a lot of expertise and knowledge about what really matters to a bank. I would not for a moment suggest that we are the kind of organization that understands banking as a business to the same level as the people who are responsible in those areas. But what we do understand is what is important. We can make sensible judgements when we assess or incorporate technology. We can tell what really counts and what doesn't. And I think it's the "what doesn't" which is the most important. So that puts us in a position that is very much apart from the standard provider of a package which is not necessarily providing banking functions. We know in any package, including our own, what it is that's attractive to the bank, and what is irrelevant.'

Equally, Clydesdale recognized that, through using this supplier, they could gain access to information about what was happening in the *sector* in relation to out-of-branch banking and thereby obtain a more 'competitive' solution than would have been developed in-house. As one of the Clydesdale managers put it:

'There can be a danger sometimes in doing it in-house. You miss the proper understanding of the market . . . of the options and the technology because you tend then to tailor your cloth to suit your purse too much perhaps.'

Prisoner Strategy

In the TELEBANK case, the involvement of Clydesdale's in-house IS function primarily reflected the need for organization-specific know-

ledge — the Bank had no concerns about the exclusivity of the innovation process. In some of our other cases, though, we found organizations who were concerned to achieve competitive advantage by securing exclusive control of innovation outputs. In these cases, firms were much more likely to deploy a ‘prisoner’ strategy to achieve social closure around the relevant skills and people. This involved knowledge communication through professionalism and an intensively cultivated employment relationship which sought to bind individuals tightly to the organization.

As a form of social control, the employment relationship is open to both optimistic and pessimistic interpretations. Williamson’s view is broadly optimistic, arguing that both employer and employee benefit from a long-term employment relationship. With regard to technical knowledge, however, probably the most important advantage is the incentive that it provides to employer and employee alike to invest in asset-specific skills which might not be readily marketable to other organizations:

‘Continuity of the employment relationship is valued by both employer and employee for tasks that involve the acquisition of significant transaction-specific skills.’ (Williamson 1985: 255)

However, it is possible to take a more pessimistic view by seeing these same features of the employment relationship in terms of employee dependency. The latter would highlight, for instance, the generally unequal bargaining positions of employer and employee (Clegg 1990). Similarly, the informational advantages offered by hierarchy may achieve transactional efficiency by reason of enhanced workforce surveillance as much as by coordination of activities. Even the notion that an employer’s internal labour-market provides a mutually beneficial means of protecting an employee’s asset-specific skills is open to question. Firm-specific skills restrict worker mobility and give the firm a degree of power over its employees. As Littler notes, at the extreme, firm-specific worker skills may produce conformist behaviour:

‘Once a worker accepts that (s)he can no longer move, (s)he is more likely to accept company policies . . . resistance in any form is difficult where no alternative employment opportunities exist.’ (Littler 1982: 43–47)

This more pessimistic view of the employment relationship may be expressed in a number of ways. The ‘prisoner’ metaphor used here evokes Foucault’s (1979) panopticon of surveillance and disciplinary control, Weber’s ‘iron cage’ of bureaucracy and Edwards’ (1979) ‘bureaucratic control’ through internal labour markets and career ladders. Our research suggests, in fact, that employers may apply all of these means quite indiscriminately in attempting to foster employee dependency.

This is not to say, however, that the ‘prisoner strategy’ is based on

coercion or that it has no benefits for the employees at whom it is directed. The freedoms which employees are required to forsake, after all, are the debateable freedoms of hawking their skills around the labour market. Moreover, the groups at whom it is directed are most likely to share in the gains produced by innovation, as Lazonick notes:

‘In the innovative organization, it is not safeguards such as “hostage trading” that attenuate opportunism, but rather the sharing of the gains of innovation that alter “human nature” as we know it and secure cooperation.’ (p. 226)

The prisoner strategy was especially evident in the CABINET case which was the project whose outcomes were most unique to the innovating organization and involving the greatest dependency upon in-house expertise. CABINET involved the development of a customer information network linking all several hundred branches to the Bank’s databases in Edinburgh. This network was designed to replace existing manual records and thereby both speed up responses to customer queries and assist the introduction of new financial services.

This project was both large-scale and long-term. The actual design stage of the project began in 1984 and even at that stage it was understood that implementation through various phases of development (each one adding some new element of functionality to the basic network) was likely to extend well into the 1990s. Significantly, as a strategic infrastructural project, the financial controls applied to the project were less stringent than would have applied to more routine projects. As one of the designers noted:

‘We knew that if we tried to cost justify each application as it came up, we would never be able to do it. . . . We had to take on a longer-term marketing view and accept that we would have to implement one project that was actually not going to be justified.’

The strategic commitment to the CABINET system as a whole did not imply that it was all carried out in-house. Some elements of the system, notably the office automation hardware and routine software elements were black-boxed. Others, including the development of the network management software were sub-contracted to an external supplier. However, the use of outsourcing was heavily constrained by the asset-specificities which arose out of the innovation process itself. The need to restructure existing databases, and the importance of banking knowledge in developing the user presentation software, meant that the greater part of the systems development process had to be performed by the in-house IS function itself.

As CABINET demanded the long-term deployment of people with a combination of banking and IT knowledges, a fairly elaborate strategy was developed to retain this skilled resource. In line with findings from

other studies (Tierney and Wickham 1989; Storey 1985), the elements of this strategy were fairly heterogeneous; some were concerned, for instance, with normative identification, others with effort control. Thus IS employees were recruited to a strong internal labour market, with 9 grades from trainee to senior manager and high levels of job security for IS employees. Career patterns showed a steady pattern of development, with staff joining the organization in junior technical roles and gradually working their way up through the grades. This approach allowed the (selective) invocation of professionalism — both rhetorically and in expectations of personal initiative and team-working. For instance, one manager within the function defined the ‘good’ systems analyst as someone who;

‘defines the thing (system) properly and gets the specification correct the first time and does not have to make lots of changes. Someone who actually thinks ahead of anything that is going to impact on it.’

Ironically, however, normative commitment through elaborate career ladders ran alongside (indeed was facilitated by) the more mechanistic forms of social control built into a detailed division of labour. Work schedules and management monitoring were tight, and sometimes uncomfortable, as one employee noted:

‘... every program you get you are told initially what the completion date is, and then the monitoring every week or two, how you are progressing, and how much work you can do, whether you are going past schedule dates and all this sort of stuff.’

Tight programming standards were enforced and management insisted that programmers ‘sign’ their work — i.e. indicate their accountability.

Conclusions

The study of the organization of technical knowledge is bedevilled by the academic division of labour. Each of the major modes of organizing and appropriating technical knowledge is covered by its own specialist literature; ‘organization’ theorists, whose remit is actually bureaucracy, analyze the management of R&D and technical functions; economists address the commodification of knowledge through product markets; students of innovation examine professional networks, and so on. These disciplinary demarcations pose a major barrier to the analysis of innovation processes, which, as I have noted, draw on technical knowledge in a kaleidoscopic variety of forms and relationships.

This paper has sought to use the notion of the transaction as an analytical standpoint from which to observe these multiform knowledge flows. This has important advantages over institutionally-bounded concepts in

that it exposes the marginal creation of organizational forms and economic value. However, I have also criticized and qualified the view of transactions advanced by Williamson. The latter's model proceeds from an assumedly atomized society in which transactions provide the pre-eminent means of interaction. In attempting to abstract transactions from social relations, Williamson admits social factors into his model only to define them as either universal facts of human nature, such as opportunism, or as contingent features of the transaction itself such as information impactedness. The effect is to condense into the transaction itself many features which are actually variable aspects of the social context (such as opportunism), and which may actually be pre-conditions for, and influences upon such transactions.

In contrast to this narrow view, I have sought to counterpose an analysis which takes greater account both of the mutual dependence of social control and economic exchange, and also of the transformatory effects of knowledge and innovation. Applying this analysis to case-study data produces two important conclusions. First, transactions do not allocate themselves to institutional forms on the basis of efficient fit. This is partly because the presumed economic closure around transaction cost efficiency is frustrated by dependency on more or less diffuse forms of social control. Also, the economic gains of innovation and the social modes of knowledge communication create additional features to knowledge trading which are not reducible to transactional contingencies. Innovation destroys the assumption of a zero sum game in transactions, and posits important benefits of collaboration in sharing its potential rewards. Second, and following on from these points, actors at the micro level develop strategies of social closure which seek a stable interpretive basis through a process of knowledge communication, while proactively fixing the rules and relationships involved in that process.

This account of the organization of technical knowledge seeks to complement the many valuable elements of Williamson's analysis. Acknowledging the micro-level role of social action in organizing technical knowledge qualifies rather than invalidates his account as a macro-level explanation of institutional forms. However, it does lead to a rather different conception of the dynamics of knowledge organization in the context of innovation. This is reflected both in the empirical data of our case studies and in other studies. Apart from Lazonick's work cited above, the new wisdom in, for instance, studies of firm-supplier relationships and corporate strategy, seems to be closer in spirit to the notion of 'social closure' than to the ruthless pursuit of transactional efficiencies which is the Williamson motif. The manifesto for 'lean production' (Womack et al. 1990), for example, rejects the tyranny of cost as the basis for firm-supplier relations. Instead, it highlights the advantages of close relationships with suppliers as a means of sharing knowledge and developing mutually beneficial innovations. Similarly, the idea of 'core competences' (Prahalad and Hamel 1990) in the strategy field is an invitation to the development of collaborative knowledge-

trading networks: firm growth through innovative success rather than market failure. What these ideas promote, and what this paper has illustrated by drawing on the concept of structuration, is the need to acknowledge the proactive role of social actors in organizing transactions and thereby shaping the environment which they inhabit.

Notes

1. This research was carried out by the research team of R. Fincham, J. Fleck, R. Procter, H. Scarbrough, M. Tierney and R. Williams in the period 1988–1990 with the support of a grant from the Joint Committee of the UK ESRC/SERC. Its findings are reported in more detail in *Expertise and Innovation*, Oxford: Oxford University Press, 1994.
2. In some cases, (Highland Life, Home & Auto Ltd., Premier Financial Services) company names have been changed to preserve confidentiality.

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