The outsourcing productivity paradox: total outsourcing, organisational innovation, and long run productivity growth

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Abstract

A growing empirical literature indicates that outsourcing can deliver short term cuts in costs but leads to a long term loss of productivity growth. In order to explain this outsourcing productivity paradox, the paper examines the connection between total outsourcing and organisational innovation, a major contributor to productivity growth. This is done within a model in which managers raise the productive efficiency by identifying organisational architectures that more effectively integrate the value adding activities and administrative routines. As part of this process, managers can internally or externally source an activity. Simulations of the model show that large scale outsourcing restricts the scope for organisational innovation, leading to low productivity growth. The findings accord with the empirical data, and provide a salutary warning for managers and policy-makers about the potential long term implications of total outsourcing.

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1. Introduction

Outsourcing involves the transfer of goods and services production, previously carried out internally, to an external provider (Domberger, 1988). The term 'outsourcing' can cover many areas and activities, in manufacturing as well as services. While much of the media attention has tended to focus on foreign outsourcing by manufacturers and on call centres (so-called 'offshoring'), the vast majority of outsourcing is done 'locally' within the US and within Europe, and the vast majority of outsourcing is by services firms, not manufacturers. (Willcocks and Plant, 2003).

Three key potential benefits of outsourcing have been highlighted in academic literature and in CEO surveys such as the Morgan Chambers study of the top 100 FTSE firms (Morgan Chambers, 2001) and the Outsourcing Institute's study of outsourcing in Japan (Outsourcing Institute, 2005). These are a reduction of direct operating costs, the ability to focus investment on the firm's core competences, and the ability to replaces a set of services with the higher quality services of a specialist provider.

Yet there is a growing amount of empirical data that indicates the existence of an *outsourcing productivity paradox*: outsourcing has a negative impact on firms' long run productivity growth. Particularly notable are the empirical studies of Görzig and Stephan (2002), Bengtsson and von Hartman (2005), Lacity and Willcock (1998), and Gianelle and Tattara (2007). How is this paradox to be explained? The central message of this paper is that it is not ownership, per se, that matters but how activities are *controlled* and *integrated*. Externalities exist between a set of related R&D, design, production, and marketing activities within a firm, and between the activities of firms along the supply chain (Jacobides and Winter, 2005). Organisational innovation is a key source of productivity growth (Chandler, 1980; Harberger, 1998). Over time, firms experiment with different organisational designs that recombine their activities in new and novel ways, thereby raising the total factor productivity of its managerial, labour, and capital inputs. They also experiment with the sourcing of activities. A firm must identify and control core R&D, design, production, and marketing activities for which there are strong externalities. Seen in this light, the make/buy decision is not a question of ownership but of control. What matters is the outsourcing relationship and how this positively or negatively affects the firm's capacity to engage in future organisational change that reorganises activities (held in house or externally) in order to maximise their externalities.

This paper discusses the important differences that exist between total outsourcing relationships and integrated outsourcing relationships, and their differential impact on organisational innovation and long term productivity growth. *Total outsourcing* is by far the most common form of outsourcing relationship. In this relationship the outsourcing firm has *little or no control* over the outsourced

activity for long contractual periods. This severely limits restricts the scope for future organisational innovation and, hence, has a direct impact on the long run productivity growth.

The remainder of the paper proceeds as follows. Section 2 reviews the existing literature on outsourcing. This draws on a number of different sources: transactions cost economics, strategic management, information systems, services innovation, and industrial organisation. These literatures tend to highlight the potential benefits of cost reduction, specialisation, and substitution. Where problems are considered, these focus on the practical problems faced by managers involved in outsourcing. Problems include the effectiveness of monitoring contracts, unforeseen transactions costs, problems identifying core and non-core competences, and the underestimation of externalities that exist between activities.

Section 3 discusses the existing empirical evidence on the relationship between outsourcing and long term productivity of outsourcing firms. Attention is drawn to important differences between integrated and total outsourcing relationships. Key aspects of the theoretical and empirical literature on KIBS outsourcing have focused on the potential advantages of the co-production of knowledge and artefacts by KIBS and their clients. Co-production requires an integrated outsourcing relationship. This is very different to the total outsourcing relationships that the vast majority of outsourcing firms actually engage in.

Section 4 addresses the connection between total outsourcing, organisational innovation, and productivity growth. The literature on outsourcing, discussed in section 2, neglects this important connection. We introduce the key concepts of organisational architecture and organisational innovation, based on a modular theory of the firm (Langlois and Robertson, 1995; Baldwin and Clark, 1997; Langlois, 2002, 2003a; and Marengo and Dosi, 2005). This modular theory of organisational innovation is founded on the twin principles of increasing specialisation and the modularisation of complex organisational structures. Increasing the modularity of an organisational structure leads to improvements in efficiency through specialisation. It also enables a firm to realise system economies. By restricting the ability of a client firm to engage in organisational innovation, total outsourcing reduces its effective search. Increasing the extent of total outsourcing increases the possibility of lock-in to an inefficient organisational architecture, negatively impacting long run productivity.

Section 5 describes a simulation model that is used to investigate the complex relationship between organisational innovation, total outsourcing, and productivity growth. It specifies the alternative strategies for organisational innovation available to the firm, the way in which learning is modelled, the decision rules for IT adoption, and the outsourcing of activities. Section 6 discusses the outputs

generated by the simulation model. Section 7 pulls the findings together and points to new directions for further research.

2. Potential benefits and problems of outsourcing

There has been a rapid increase in the level outsourcing, across a wide range of areas and activities, in manufacturing and services over the last two decades. A notable growth area is the externalisation of information technology (IT) services, and the influence of IT in outsourcing office business services. From 1989 to 2006, the global IT outsourcing market grew from an estimated US$3 billion to just over US$250 billion (Willcocks and Lacity, 2006). A recent Forrester study of US firms (McCarthy, 2002) indicates that computer services account for 26% of all outsourcing (Figure 1). The IT outsourcing revolution has been fuelled by significant developments in countries such as India and China (as new entrant IT providers) but also in respect of the enormous organisational adoption of packaged software; e.g. office based systems and Enterprise Resource Planning (ERP) applications.

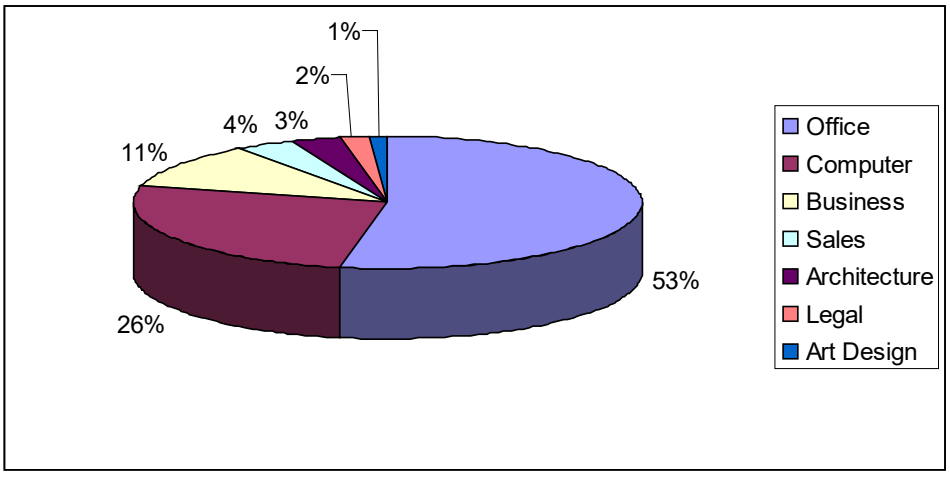

Figure 1. Variety of activities being outsourced

Source: McCarthy, 2002

IT based activities are a significant proportion of office services, accounting for 53% of all outsourcing by US firms. This includes basic back-office activities such as payrolls. The remaining share is made up of advanced, back-office activities such as legal services, and client-facing front-office activities in sales and marketing. Sources such as Indobase and Gartner highlight the present and future growth of Business Process Outsourcing (BPO), including front office systems such as Customer Relationship Management (CRM) applications.

2.1 Potential benefits

Research on outsourcing can be found in four different literatures: transactions cost economics, strategic management, information systems, and services innovation. Three key potential benefits are highlighted in these literatures, and are consistently identified as key drivers in CEO surveys such as the Morgan Chambers study of the top 100 FTSE firms (Morgan Chambers, 2001) and the Outsourcing Institute's study of outsourcing in Japan (Outsourcing Institute, 2005). These are: the reduction of direct operating costs, specialisation in core competences, and substitution of non-core competences with inputs from a specialist provider.

Transactions cost literature, on the firm's decision to produce in-house or outsource through market contracts, dates back to Coase (1937). This literature predominantly focuses on the reduction of direct operating costs, i.e. the wage bill and managerial administrative overheads. Williamson (1985) argues that, ultimately, the sourcing decision depends on the scope for cost reduction and the degree of asset specificity. A firm should outsource activities if to carry them out internally requires excessive investment to get the lowest unit cost.

Where the transactions cost literature focuses on the reduction of direct operating costs, the other literatures additionally discuss potential benefits arising from specialisation and substitution. The outsourcing firm can focus and devote more resources to developing its core competences. A substitution effect arises as the outsourcing firm replaces its non-core competences with inputs from a specialist provider that has greater knowledge depth, invests more in these competences, is more efficient, and is able to offer higher salaries to attract more highly skilled staff.

The nature and potential impact of client-provider interactions has received much attention from services innovation scholars. Of particular interest is the 'co-production thesis'. It is argued that knowledge intensive business service (KIBS) providers do more than provide higher quality inputs; they engage with their clients in the co-production of new knowledge and material artefacts (Gallouj and Weinstein, 1997; Antonelli, 1998; Sundbo, 1998; Preißl, 2000). For the client and the KIBS provider to interact in this way, there must be a semi-permeable boundary between the organisations. Developments in the skills and competences of one will affect a change in the skills and competences of the other (Gallouj and Weinstein, 1997). Potential productivity gains for the client lie in the KIBS provider acting as an interface between the client's tacit knowledge base and the wider knowledge base of the economy, through the provision of high quality information on new business opportunities, market trends, and new technologies, and through new business models (Drejer, 2004).

The co-production thesis raises a most important issue. Co-production is founded on an 'integrated outsourcing' relationship. The integrated outsourcing relationship represents one end of the spectrum

of client-provider relationships. At the opposite end of the spectrum is the 'total outsourcing' relationship. In practice, the vast majority of contracts take the form of total outsourcing relationships. This fact has been neglected by services innovation scholars. Indeed, the issue of control is generally ignored by those researching outsourcing. Yet it is of vital importance to any discussion about the long run impact of outsourcing on long run productivity. Let us consider the problems that have been discussed.

2.2 Problems setting up and managing contracts

The existing literature discusses the practical problems managers face when trying to define core competences, and in drawing up and monitoring contracts. The main focus of transaction cost economists has been the problem of hold-up, which arises due to partners needing to make relationship-specific investments that are of little or no value outside the relationship. Given the problem of writing complete contracts prior to making these investments, there is the possibility of an underinvestment in external sourcing. This has prompted a theoretical debate about the specification of contracts (Grossman and Hart, 1986; Hart and Moore, 1999), contractual protection (Klein *et al.*, 1978), breach of contract (Edlin and Reichelstein, 1996), and renegotiation (Hart and Moore, 1988; Aghion *et al.*, 1994).

The strategic management and IS literatures discuss the practical problems involved in identifying 'core' and 'non-core' competences. They also discuss how managers invariably underestimate the interactions – the *externalities* - that exist between various competences and business activities. In-depth individual case studies, such as McIvor (2003) and Willcocks and Plant (2003), reveal inconsistencies and a lack of clarity in the way managers interpret core competences, and challenge the usefulness of core competence theory as a basis of outsourcing. Activities that were believed to be non-core but later realised are core, or to directly impact on core activities due to the existence of strong externalities.[4]

Willcocks and Plant's study of 78 US, European and Australasian organisations identifies some (all too rare) examples of successful core competence management e.g. Dell, Cisco, Direct Line and Tesco. These detail the mixed development paths that are taken for core competence development. For example, Dell focused on research and development, information management, and the customer buying process while outsourcing input production to suppliers. Tesco's focus on core activities meant it decided to control its online shopping in-house but externalised online banking, which it perceived to be non-core. Direct Line adopted a similar approach regarding the development of

[4] Managers are presumably not helped by fundamental disagreements in the management literature on what constitutes a core competence. Contrast, for example, Prahalad and Hamel's (1980) definition based on enhanced customer value, competitor differentiation, and extendability, with asset specific definitions provided by transaction cost writers such as Reve (1990).

Jamjar.com and Directline.com. Against these success stories, Willcocks and Plant discuss a number of well publicised examples of outsourcing failures. These include the outsourcing of inventory management system sand internet development. Leading firms such as Alamo, J.S.Sainsbury, Cable and Wireless, and J.P. Morgan Chase mistakenly perceived these to be non-core activities and subsequently needed to re-insource.

The management and IS literatures also discuss the unforeseen transaction costs involved in drawing up and managing contracts, and the problems and costs involved in reversing sourcing decisions. IT is an attractive candidate for outsourcing for many small and medium sized firms because it is one of the most expensive parts of the organisation to establish and maintain (Earl, 1996). Unfortunately, the potential cost savings of IT outsourcing can be (and are) eaten away by unforeseen costs that are extremely difficult to quantify at the outset, but which are essential to the make-buy decision. These include initial vendor search and contracting set up costs, transition costs as in-house IT activities are transferred to the vendor, and the costs of managing an ongoing contract - usually the largest cost, as it includes the monitoring of IT vendors, ongoing bargaining and sanctioning (where necessary), and negotiating necessary contract changes (Barthelemy, 2001). Further costs are incurred where the contract is unsuccessful: either in finding a new vendor or in re-insourcing IT.

Barthelemy's survey of 50 IT outsourcing firms found that 14% deemed the outsourcing operation to be a failure (Barthelemy, 2001). Yet, despite this, he identified strong managerial inertia to re-insourcing. When managers initially decide to outsource an IT system, they generally do not consider the possibility of, or mentally prepare themselves for, re-insourcing at a later date. Barthelemy found that managers prefer to search for another vendor rather than consider re-insourcing. Additionally, IT is a lumpy (dis)investment with high sunk costs. It is difficult to rehire skilled IT staff and costly to purchase new IT systems and train general staff. Maintaining external contracts is also expensive, however. Miozzo and Grimshaw (2005) observe that IT suppliers are not turn-key; they are not easily substituted markets are thin. What is more, as the outsourcing firms loses internal IT skills over time, as a consequence of staff turnover and/or the technology frontier continuing to move ahead, monitoring contracts becomes more difficult and expensive.

These issues are raised in research on the outsourcing of non-IT services, such as Hinks and Hanson (2001), Domberger (1998), and Steinmueller (2003). With regards to R&D, Prencipe (1997) highlights the dangers of outsourcing complex production and advanced R&D activities, based on simple notions of core and non-core competences. Outsourcing what today appears to be a non-core competence can seriously impair the development of new (core) technological competences in the future. For this reason, Brusoni *et al*. (2001) emphasise the importance of retaining control over R&D, and the ability to coordinate the R&D, design, and manufacturing activities of suppliers.

2.3 Total outsourcing relationship

Despite its importance, the issue of control has received little or no discussion in the literature on outsourcing. As noted above, total outsourcing is by far the most common form of relationship. This involves a complete hiving-off of activities by the outsourcing firm. Control of the outsourced activities, and their administration, are passed over to the service provider - total outsourcing involves the sourcing of between 80% and 100% of an activity from a client to a supplier (Willcocks and Lacity, 2006). As a consequence of the strict division of labour between client and service provider, there is little or no interaction between provider-client knowledge and competence bases. There is certainly no co-production. The relationship is contractual. The provider undertakes to deliver a pre-specified set of inputs or services to the client at a set price and quality for a number of years.

The nature of the total outsourcing relationship is crucial to the short and long term impact of outsourcing on the client firm. Substituting expensive in-house labour with cheaper provider labour may well deliver a short term cut in the wage bill and in the administration of those (formerly in-house) activities. If loss of client control under total outsourcing restricts its capacity to engage in organisation innovation and restructuring – an important source of TFP improvement – then outsourcing may well have a negative impact on its long run productivity growth. In the next section we consider the empirical evidence on the short and long run impacts of outsourcing.

3. Empirical studies of outsourcing and productivity growth

Given the amount of attention outsourcing has attracted, surprisingly little rigorous empirical research has been done on its economic impacts. Direct investigations of outsourcing and its impact on firm productivity are relatively few in number, as are empirical studies on the link between outsourcing and innovation. What is more, many studies focus on manufacturing rather than services. Given the importance of services in developed economies, and the fact that outsourcing within service sectors accounts for the majority of all outsourcing, this is unfortunate.

In this section we consider key studies that have investigated the short term and long term impacts of outsourcing on costs and productivity. Of particular note are Görzig and Stephan's (2002) panel study of German manufacturing companies, Bengtsson and von Hartman's (2005) study of outsourcing by medium and large size Swedish manufacturing and service firms, Lacity and Willcock's (1998) detailed study of IT outsourcing by US and UK firms, and Gianelle and Tattara's (2007) panel study of outsourcing by textile, clothing and footwear manufacturers in the Veneto region of Italy. In addition, there are a number of individual case studies in the strategic management literature and in the information systems (IS) literature highlighting this problem.

Görzig and Stephan (2002) is one of the earliest attempts to estimate the effects of outsourcing on plant productivity using micro-data, and focuses directly on outsourcing as an explanatory factor of productivity. The study examines a panel data set of 43,000 German manufacturing companies for the period 1992-2000. They estimate firm performance, measured by the returns per employee and the return on sales.[5] The analysis considers material inputs, external contract work, and services outsourcing. Estimates include both a between-firm specification, where all observations are averaged for each firm, and a within-firm specification, where they control for unobserved heterogeneity and exclude all time-invariant variables. The former model is interpreted as the long run model, whereas the latter is interpreted as the short run model.

In the short run, Görzig and Stephan find a statistically significant, positive correlation material outsourcing and productivity but a statistically significant, negative correlation between services outsourcing and productivity. In the long run, they find that increased subcontracting and outsourcing of services reduces firm profitability. They conclude that, on average, the level of subcontracting and outsourcing of services amongst firms in their sample is above the optimal level.

The empirical study conducted by Bengtsson and von Hartman (2005) is based on a survey of 267 medium and large size Swedish manufacturing and service firms.[6] They found that companies successfully achieved short run reductions in costs. Principally this involved reducing the client's wage bill as (relatively) high cost direct labour is through the substituted by the provider's (relatively) lower cost labour. Importantly, they find that management and administrative costs were not reduced overall. Firms report a strongly negative impact of outsourcing on logistics – e.g. manufacturing lead times, delivery times and accuracy. They also report a negative impact on quality and adaptation to customer demands. The findings indicate that outsourcing is accompanied by more complex logistics, increasing the internal administrative overhead. What is more, Bengtsson and von Hartman report that these logistics problems were more common amongst companies that outsource to low-cost countries.

While research into the theoretical and empirical aspects of IT outsourcing services is vast, studies specifically devoted to total outsourcing are still rare. A contributing factor that certainly hinders such research relates to a general reluctance by many clients and suppliers to go public, particularly with specific details of the arrangements. The Lacity and Willcocks (1998) study provides a rare, detailed empirical study of IT outsourcing with findings from 40 US and UK companies. The research includes investigations covering a range of different sourcing arrangements including; total outsourcing, total insourcing, and integrated outsourcing arrangements. Total insourcing is defined as

[5] These are used as indicators of productivity. Each makes use of the gross operating surplus (GOS). The first is GOS divided by employment, the second is GOS divided by gross production.

[6] The analysis is based on a set of written questionnaires collected from 267 firms. All firms have more than 50 employees and are drawn from the ISIC sectors 28-35: metal goods, machinery, office equipment and computers, other electronics, telecoms, instrumentation, and the automotive industry.

at least 80% of activity remaining with a client. Integrated sourcing refers to clients who use external suppliers but retain 20% to 80% of IT activities in-house[7].

The main findings of the research were mostly centred on issues relating to clients' perceptions of success (as defined by financial considerations in favour of clients). In terms of cost measures, total outsourcing arrangements were only successful in 29% of cases, an unfavourable comparison to 67% for total insourcing and 85% for integrated outsourcing. Secondly, those organisations that invited vendor bids and compared them to either existing costs or newly revised internal costs (after external interest) were more successful than those who engaged in no formal bidding process. Thirdly, clients who engaged in short term contracts (shorter than 4 years) achieved significantly greater cost savings than those contracts awarded for longer than 4 years and much greater than deals over 7 years. This is particularly interesting because the overwhelming number of total outsourcing arrangements are based on long terms e.g. between 7 to 10 years. Fourthly, the type of contract also has a significant impact. Detailed 'fee-for-service arrangements' have a 91% success rate; far greater than alternative arrangements. In addition, contracts made towards the end of the decade (1990's) were far more successful than those agreed earlier, perhaps due to the improved performance of many vendors and the lessons learnt by more experienced clients. The final finding discovered that the size of the IT activity or function outsourced seemed to have no impact on clients' perceptions of success or failure.

Another notable study to emerge is the 'CIO's Exclusive Outsourcing and Innovation Survey' (Overby, 2007). There are two main findings from this online survey of 290 senior technology executives. Firstly, only 24% of executives believe that outsourcing contributes to IT innovation (versus 76% for insourcing). Secondly, significantly more executives are dissatisfied with the levels of innovation generated by long distance global outsourcing (off-shoring) when compared to domestic outsourcing. This survey is interesting but highlights the problems with the research in this field - it lacks detailed analysis, rigor in terms of its research method, and focuses on IT sourcing in general (not total outsourcing specifically). Additional empirical research is required in terms of deeper understandings of the relationship between diverse forms of outsourcing and innovation.

The findings of Gianelle and Tattara's (2007) study of total outsourcing by textile, clothing and footwear manufacturers in the Veneto region of Italy is very much in line with the experiences of firms that have committed to the total outsourcing of IT services. Their statistical findings are drawn from a Panel containing 48 joint stock companies, based in the Veneto area. They are mainly medium-size firms that have delocalised important production phases abroad. Gianelle and Tattara identify a one-off short run cost reduction as Italian labour is substituted by cheaper foreign labour. However, long run productivity gains are prevented because the machinery and the production

[7] Another label frequently used in the information systems literature is 'selective outsourcing'.

techniques that are used by clients do not improve over time. Indeed, there are documented cases where the machines previously used in the Veneto area were actually shipped abroad to be used by the new providers. Gianelle and Tattara observe that the reorganisation of production may bring about management innovations (product modularisation, export of knowledge, etc.) in the future, but that these have not happened to date. Only when this occurs will there be long term improvements in productivity.

A significant number of high profile, private and public sector organisations have chosen to outsource their IT activities over the last couple of decades. Prominent examples in the private sector include Eastman Kodak, Caterpillar, Rolls-Royce, MacDonald Douglas, JS Sainsbury, Continental Bank, and Continental Tires. These should provide useful insights into effective and non-effective outsourcing. Yet, while these deals have received much media attention, only the general aims and criteria of the arrangements have ever been disclosed by official parties. Take, for example, the first major total outsourcing deal between Eastman Kodak and IBM. Officially, all that is stated is that this relationship started in 1989, when Eastman Kodak chose IBM to handle the vast majority of its data handling arrangements (Polilli, 1989), and according to an IBM press release (18th October 2005), the relationship continues to evolve with IBM delivering a range of business support functions. Lack of information is also striking in relation to Nestle's US$500 million deal with IBM, and the US$1 billion deal between the British retailer Sainsbury's and the IT vendor Accenture (2000-2005).

Writing in the Financial Times, Alan Cane raised the question of why this lack of information exists when so many IT sourcing projects end in failure. As Cane notes, a frighteningly large percentage are either late, over budget, do not work, or do not meet the client's needs (Cane, 2007). He suggests that both vendor and client have too much at stake, in terms of reputation and customer confidence, to want to publicly air these failures. That is why the current legal action taken by British Sky Broadcasting (BSkyB) against Electronic Data Systems (EDS), for damages in relation to a contract for a call centre and Customer Relationship Management (CRM) system, is the exception that proves the rule.

Despite the general reluctance to go public, many within the IS discipline are sceptical about these sourcing arrangements. Lacity and Hirschheim (1993) are highly critical of Eastman Kodak and others who outsourced large scale, long term projects (e.g. 7-10 years) with single suppliers. Others, such as Weill and Broadbent (1998), highlight the loss of strategic flexibility and effectiveness in such arrangements, while Loh and Venkatraman (1992) highlight the economic issues involved. In addition, there are the potential risks from the potential to alienate the unsuccessful bidding vendors, vendor self interest and complacency once the contract is agreed, requests for additional fees, clients

locked into outdated services or technologies, and clients increasingly incapable of monitoring vendor performance.

Taken together, the body of empirical evidence indicates the existence of an outsourcing productivity paradox. While outsourcing firms enjoy short run savings in labour costs, their productivity growth is lower than that of non-outsourcing firms. How is this to be explained? Clearly, one must look beyond discussions about setting up contracts and the monitoring of contracts. One must look to factors that affect long term productivity growth. A key factor affecting long term productivity growth is innovation. In the next section we examine the connection between total outsourcing, organisational innovation, and productivity growth. If total outsourcing adversely affects the scope of organisational innovation, then this will have a direct impact on long term productivity growth.

4. Optimal search, organisational innovation and outsourcing

Let us consider the connection between organisational innovation, total outsourcing, and productivity growth in depth. The goal of organisational change is the identification of an organisational architecture that more effectively integrates all the administrative activities of the firm. An organisational architecture is a hierarchical structure that solves two key problems faced by managers. The first is the 'fundamental coordination problem': how to most effectively organise the value-adding activities and information flows of the firm in order to maximise profit. The second problem faced by managers is the 'agency problem': to realise and enforce coordination and control in production, both internally and across the boundary of the firm.[8]

Organisational innovation is an important source of firm productivity growth in its own right (Harberger, 1998). It involves new ways of organising internal production and/or external relationships with other producers along the supply chain. This can take the form of new management structures, the development of new internal routines and work practices, new supply chain relationships, strategic alliances, and outsourcing. Chandler (1980) has suggested that organisational innovation, leading to the more efficient use of existing resource inputs, accounts for up to one-third of all firm productivity growth in the US since the 1860s.

Additionally, the interconnection between organisational innovation and product/process innovation has been discussed by Chandler (1962; 1977), and von Tunzelmann (1993). Organisational change is invariably associated with new process technologies when the latter require new internal routines and work practices. In the case of IT, organisational innovation clearly goes hand-in-hand with process innovation and new product innovation. Internet-based IT alters the set of feasible technological

[8] Issues of agency and control in the firm are addressed in detail by Reinstaller (2007).

opportunities in production and the division of labour, and the opportunities for effective coordination and control within and across the boundary of the firm. Depending on its relative impact on internal and external coordination costs, new ITs may either stimulate verticalisation or de-verticalisation.

Organisational innovation, then, is a search process. It involves the search for new organisational architectures that alter the organisational structure of the firm, changes the boundary between the firm and markets (verticalisation / de-verticalisation), and changes the competences of service providers along the supply chain (Jacobidies and Winter, 2005). Clearly, this search process is conducted within a complex search space that contains many dimensions; dimensions that are related to one another in highly non-linear ways. Dealing with this organisational complexity requires managers to engage in ongoing strategic experimentation and learning. It is this ongoing problem-solving activity that drives organisational change and innovation over time.

Scholars working on organisational modularity provide important insights into the nature of organisational innovation, and provide a platform for understanding the connection between total outsourcing relationships, the capacity to engage in organisational innovation, and long term productivity growth. Seen under this perspective, organisational innovation is a search process that involves the creation / destruction of 'modular components' within an organisational hierarchy, or 'architecture'.

Key contributions to this modular theory of the firm include Langlois and Robertson (1995), Baldwin and Clark (1997), Langlois (2002, 2003a), Marengo and Dosi (2005), and Baldwin (2007). The theory brings together Adam Smith's principles of specialisation and the division of labour (Smith, 1776), and Herbert Simon's discussion of complexity and the near-decomposability of complex problems (Simon, 1996; 2002). It is also open to the type of approach used by Altenberg to discuss search within Kauffman NK landscapes (e.g. Altenberg, 1995; Wagner and Altenberg, 1996).[9]

Simon (1996, 2002) addresses the generic issue of problem-solving activity within complex systems. He suggested that complex problems can be made more manageable by breaking them down into a set of constituent parts, or modular components. In this way, the number of distinct elements in a system is reduced by grouping them into a smaller number of sub-systems. The great advantage of modularisation is that improvements can be made to just one sub-component of the system, avoiding the need to change all the other parts of the system (as would be the case if there were no modularisation). There is a cost, however. This cost is the need to establish and maintain organisational interfaces that enable each sub-component (module) to function compatibly with all other sub-components (modules). Interfaces ensure that the organisational structure as a whole

[9] Also see Kauffman *et al*. (2000), and Schilling (2000).

functions in an integrated way, while maintaining a high degree of independence for each sub-component.

Smith's principle of specialisation through the division of labour is a way of dealing with this problem-solving activity. Smith's classic example is the pin factory. Here a range of complex value-adding processes are broken down and divided into a finer set of specialised functions. This specialisation raises the efficiency of production. A necessary prerequisite for this specialisation is cooperation: each activity must be carefully orchestrated. Workers become complements to one another rather than substitutes (Leijonhufvud, 1986). This coordination function must be hardwired to a greater degree into the spatial and temporal interfaces among specialised operations and specialised operatives (Langlois, 2003b). Each operative must make his or her output relatively standardised so that the next operative down the line knows what to expect; and each operative must hand over that output at a predictable time, lest buffer inventories run dry and the entire production process come to a crashing halt.

While Smith's pin factory example is concerned with specialisation in the organisation of production, he made it clear that the principle is generic and holds for specialisation in all aspects of business organisation (Langlois, 2003b). Firms engage in continual, ongoing experimentation in all aspects of the organisation, not just production. This includes decisions about what to produce, the inputs that are required, what should be produced in-house or bought in markets, the geographical location of production, sales etc., the appropriate organisation structure of the firm, and the information and communication requirements of the organisation. By placing Smith's discussion within Simon's framework of decomposable complex problems, we see that the problem that faces managers is how to decompose a set of interrelated, value-adding activities into a set of modular subsystems and, second, how to coordinate these subsystems. Through successful modularisation, a complex system is transformed into a nearly decomposable system[10]. An optimal system is one in which positive externalities are maximised and/or negative externalities are minimised.

Let us consider the relationship between organisational innovation and TFP improvement. There are two sources of TFP improvement. The first is 'system economies' of the type discussed by Nightingale *et al.* (2003). By improving improvement control over interactions between value-adding activities within a *given* set of modules, managers can improve productivity. This is achieved incremental improvement of an existing organisational architecture. This involves the development of more effective managerial service activities to integrate and control a given set of productive activities that are carried out within the firm. Through improved managerial control, the firm approaches a given productivity frontier, improving TFP.

[10] A fully decomposable system is one in which all externalities can be located within subsystems. In a nearly decomposable system externalities exist between subsystems as well as within subsystems.

A second source of TFP improvement is organisational innovation. By changing the organisational structure and increasing modularity, the productivity frontier is pushed outwards. A superior organisational design improves the coordination and control of materials, funds, services, and information, increasing the productive utilisation of the firm's installed productive capacity. Organisational innovation is the process through which new organisational designs are arrived at. This can either involve the splitting of administrative tasks into a greater number of organisational modules or, alternatively, the integrating of organisational modules to increase control over the modular productive elements and their interaction. A superior organisational design improves the coordination and control of materials, funds, services, and information that flows through the complex supply, production and distribution activities of the firm. In this way, better organisational architectures (i.e. more effective modularisation schemas) increase the productive utilisation of the firm's installed productive capacity.

Organisational innovation begets further organisational innovation over time. Managers gain a more specific view of the different activities of the firm, and see the potential creative opportunities that arise, either by breaking down 'departmental silos' or by creating novel synergies between activities (i.e. new organisational combinations). For example, creating stronger interactions between the sales and production departments may lead to new product opportunities being realised. These in turn may lead to economies of scope and, if able to develop new markets, economies of scale. This picks up on the point made by Baldwin and Clark (1997) that the more modular the organisational architecture, the greater the likelihood of stimulating new inventions, i.e. innovation in products/services, distribution, and other key value-adding activities of the firm.

The process of organisational innovation also opens up new possibilities for outsourcing over time. To quote Baldwin, "Modularizations create new thin crossing points where transaction costs are low. *These new module boundaries provide points of entry for competitors and breakpoints where vertically integrated firms and industries may split apart…* Strategies, knowledge and technologies all change over time, and the location of transactions changes as well." (Baldwin, 2007, p.4, italics added).

Hence, the process of organisational innovation is complex. It involves a search for an organisational structure that maximises positive externalities within a nearly decomposable system. This is achieved by creating modules in which the externalities of closely related activities are maximised, and by placing these modules in a structure that maximises externalities between these modules. It is a also a process that must consider whether to source modules internally or externally. Over time, as a consequence of organisational innovation, new opportunities to outsource activities arise and must be

considered. To examine this highly complex, non-linear process, one needs to develop a simulation model. This is the focus of the next section.

5. A model of organisational innovation, IT, and total outsourcing

This section describes an empirically grounded model that is used to explore the impact of total outsourcing on organisational innovation and long run productivity in the more general case where firms engage in both radical organisational change and system economies.

In an empirically grounded model, stylised empirical facts about the micro features of the system being modelled inform the modelling process. Additionally, one or more industry/macro level observations or stylised facts are used as a benchmark to test the validity of the simulated outputs generated by the model.[11] The model of organisational innovation we present here is informed by five key stylised facts, and by empirical evidence on the strategic process of innovation and outsourcing furnished by Tayles and Drury (2001). Four of the five stylised facts already been discussed. These are:

1. organisational innovation is concerned with *control of externalities* between a set of value-adding activities that are either 'core' or strongly influence core competences (Brusoni *et al*., 2001),
2. maximising externalities requires control within the outsourcing relationship,
3. there is an essential connection between the scope of organisational innovation and potential productivity growth, and
4. total outsourcing transfers control of modules to the service provider.

There is an additional stylised fact embodied in the model. This concerns the relationship between internet-based IT and outsourcing. As discussed in section 2., this relationship is well documented. Chandler (1962, 1977) observed that technology directly affects organisational structure. Depending on the particular vintage of IT, technological opportunities and cost reductions will stimulate either verticalisation or de-verticalisation. Reinstaller and Hölzl (2004) observe that the early vintages of IT discussed by Chandler, such as calculators, typewriters, Hollerith electric tabulating machines, and book-keeping machines has limited application to internal administrative activities[12]. Their impact was therefore asymmetric, significantly reducing internal coordination while having little or no impact on external coordination costs. These technologies were essential to the emergence of the modern hierarchical organisation from the 1850s to the 1930s. In turn, large corporations were key purchasers of these IT technologies. Further improvements in these IT further enhanced the ability of

[11] For an in-depth discussion of empirically grounded modelling, the interested reader is referred to the special issue of *Computation Economics* edited by Birchenhall *et al*., (2007).
[12] Also see Yates (2000).

large u-form and m-form businesses to grow in size. The result was a tendency towards vertical integration as more and more activities were brought in-house.

By contrast, internet-based ITs, such as websites, internet-based EDI, and extranets, facilitate new forms of external interaction and significantly lower the cost of external coordination. Their impact on internal administration costs, through applications such as intranets, is more restricted. Internet-based IT therefore alters the set of feasible technological opportunities in production and the division of labour (the fundamental coordination problem), and the opportunities for effective coordination and control within and across the boundary of the firm (the agency problem) in a very different way to the older vintages of IT discussed by Chandler. Internet-based ITs have altered the relative efficacy of outsourcing vis-à-vis performing activities in-house. One would expect a flattening of the hierarchy of the firm, a tendency towards vertical disintegration, and for individual business units to become smaller in size. This stylised fact provides a transmission mechanism between the adoption of new IT, organisational innovation, and outsourcing. The transmission mechanism is important because it enables one to analyse the conditions under the adoption of new IT leads to organisational innovation, de-verticalisation, and outsourcing.

The final input to the model is the Tayles and Drury (2001) study of the decision structure for organisational innovation and sourcing. This was gleaned through an action research project with a major UK engineering company. This decision structure is replicated in the model in a slightly simplified form, as presented in Figure 2.

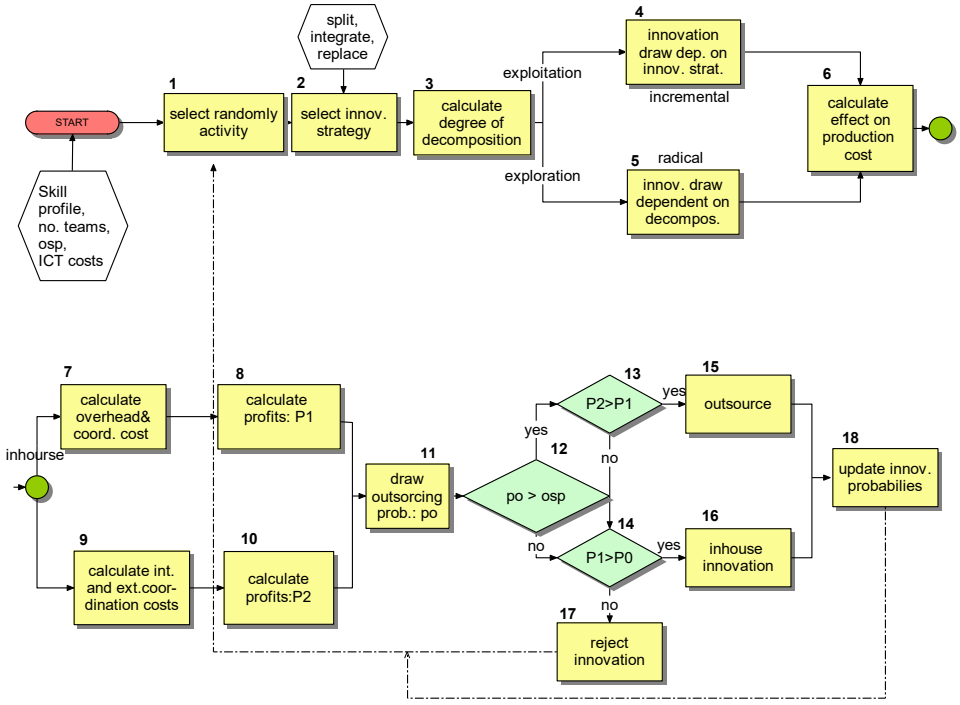

Figure 2. Flowchart of the decision making structure
Based on Tayles and Drury (2001)

Management first consider organisational innovations in order to address coordination problems and/or increase managerial control over productive, value-adding activities (Box 2). A number of different innovation strategies are considered (Box 3). The options are (i) organisational restructuring, taking the form of modular change, or (ii) the incremental improvement of existing modules. The former is an exploration strategy: the firm actively explores the dimensions of the search landscape (i.e. to identify the globally optimum design) by altering the modular structure of the organisation. The latter is an exploitation strategy: it seeks to incrementally improve performance by exploiting the current set of resources contained within the existing modular configuration.

Managers are bounded rational in that they do not know the characteristics of the stochastic process that generates incremental and radical innovations, or the final payoffs to each strategy. They need to estimate the outcome of adopting an exploration or an exploitation strategy[13] on production costs (Box 6), on managerial overheads and coordination costs (Box 7), and on profits, given expectations of price changes and demand elasticity (Box 8).

Following Tayles and Drury, the sourcing decision is the next step of the decision process (Boxes 11 to 18). Two parameters are significant here. The first is the management's outsourcing propensity ('OSP' in Box 12). This is management's risk attitude with respect to outsourcing. For a given outsourcing propensity, we draw a uniformly distributed random variable indicating whether the option to outsource is available (Box 11). We assume KIBS service providers have cost advantages in the delivery of some services. Hence, the optimal design is not a corner solution but a combination of insourced and outsourced services. Again following Tayles and Drury, the process of total outsourcing involves a KIBS-client negotiation of a contract for the delivery of a specific service at a specified price. If the outsourcing firm enters this contract, it shuts down its own productive activity in this area. The second exogenous parameter is the relative impact of IT on external and internal coordination costs. Here we will contrast the case of early IT technologies, discussed by Chandler, that reduce internal coordination costs more than external coordination costs, with that of internet-based ITs that reduce external coordination costs far more than they reduce internal coordination costs.

Following its decision to adopt a particular organisational strategy and, in the case of a modular innovation its sourcing decision, the firm engages in production and sells this on the market. Since the firm is boundedly rational and adaptively leans from its experience, the resulting payoffs provide information that is used to update its expectations regarding the effectiveness of a particular innovation strategy (Box 18). The probability of choosing a particular strategy changes endogenously through reinforcement learning. As described by Arthur (1991), each strategy has a weighted

[13] March (1991) discusses the long term need for firms to have exploitation and exploration strategies.

probability that it will be chosen by the management. This weighted probability increases or decreases over time according to how more or less successful it proves to be in improving performance.

The extent of organisational specialisation ultimately depends on a number of demand and supply side factors. On the demand side, it depends on the extent of the market (i.e. increases in population and income), and the degree of competition (the elasticity of demand) (Young, 1928). On the supply side, it is affected by the availability of IT as this enables activities to be subdivided and coordinated, and enables managers to better deal with the agency problem. Together, the demand and supply side factors determine the extent to which activities can be effectively modularised and technical hierarchies established.

Let's consider the model in greater detail.

Organisational architectures

We assume the administration of a firm delivers θ services to productive routines that generate a firm's value-added. The quality of these services has an impact on the performance of productive routines. These services are produced by organisational routines m_1 and m_2, which produce a subset of all services. These two routines are linked together through a coordination routine m_1^a. More generally, the organisation of a firm consists of a set of n_t organisational modules or routines m_i, grouped by means of n_{t-1} organisational routines m_j^a into an organisational architecture $d_t = \left\langle m_1, m_2, ..., m_{n_t}; m_1^a, m_2^a, ..., m^a_{n_{t-1}} \right\rangle$.[14] Since the division of labour inside the firm can vary over time, n_t carries the time index *t*. The array $d_t \in D$ corresponds to particular organisational architecture of the administrative activities that are in use within the firm at time *t*. It is drawn from a finite space D of possible organisational architectures, which the management explores over time.

Each of the routines used in an architecture consists of λ_i sub-routines or $m_i =< x_h >_{h=1}^{\lambda_i}$; λ_i is allowed to vary across routines. These routines produce a vector θ of k services for the productive routines that are operated by the firm. Together these output characteristics meet well defined customer needs in the market in which the firm operates. In our model, the organisation of a firm is therefore defined through the characteristics of an organisational architecture d_t given by n_t

[14] A routine is the process whereby a vector of inputs is transformed into a vector of outputs through the use of specific knowledge, skills and modes of coordination. See Nelson and Winter (1982, chapter 5). The terms module and routine are used interchangeably in this paper. We assume that routines are somewhat self-contained elements of the production process.

organisational modules m_i, and k service characteristics. The number of modules n_t is therefore a measure of the degree of modularity of the organisational architecture.

Strong externalities exist between the sub-routines x_h in each module m_i, i.e. the performance of each sub-routine $\phi(x_h)_t$ at time step t affects the performance of all other sub-routines in the module, and its performance is in turn influenced by all other sub-routines $\phi(x_{-h})_t$ in the module. Consequently, the performance of all sub-routines $\phi(x_{-h})_t$ change if $\phi(x_h)_t$ changes. It also follows that a sub-set $k^i \subset k$ of output characteristics is directly and indirectly affected by all x_h sub-routines in a module m_i. The overall performance $\phi(m_i)_t$ of a module m_i is therefore the result of negative and positive feedbacks between the sub-routines it contains. These interdependencies reflect a situation that is typical in team production, for example. The skills and activities of the team members are closely complementary and integrated and so, if one member performs under par, the efficiency of all other members is affected.

Externalities between sub-routines mean changing a particular service θ_i in module m_i will alter the performance of connected sub-routines and services. In the simulations we will determine $\phi(m_i)_t$ by drawing λ_i values from a uniform distribution with $\phi(x_h)_t \rightarrow \text{Uniform}[0,1]$ and calculating the average over the λ_i sub-routines. The impact of all n service producing administrative routines on firm performance is then given by, $\Phi_t = \frac{1}{n}\sum_{i=1}^{n} \phi(m_i)_t$.[15]

Strong complementarity is resolved by splitting a routine into two distinct sub-routines, each focused on the producing one service. The coordination problem between the two sub-routines is solved by introducing a coordination mechanism between the two, i.e. the modules m_i are linked through organisational and administrative routines m_1^a that act as interfaces between routines and neutralise strong complementarities. As a consequence, hierarchy increases and the co-ordination overhead increases. This captures Simon's (1996) idea of realising near-decomposable architectures in order to better control complex problems. In this process 'system economies' are realised (see Nightingale *et al*. 2003).

Organisational learning: exploitation vs. exploration

Managers use a set of S strategies to explore the space of organisational architectures D. The strategy space $S = (s_1, s_2, s_3)$ consists of three strategies, each of which is used with probability μ_j

[15] This representation of organisational designs and their impact on the performance of productive activities corresponds to a generalised NK model (Altenberg,1995).

at each time step t. Innovation strategy s_1 corresponds to incremental exploitation, driven by learning by doing. Here all values for $\phi(x_h)_{t+1}$ are redrawn. Performance improves if the average over the λ_i sub-routines increases.

Strategies s_2 and s_3 are exploration strategies. These involve changing the organisational architecture of the firm. A firm identifies and neutralises one or more complementarities that bind sub-routines into a module. It then has one of two options. It can split a more complex activity into a number of less complex routines, and redesign its organisation accordingly. This decomposition strategy s_2 is called 'splitting'. Alternatively, it may reorganise smaller production and organisation routines into larger, more complex modules. In this way the firm can explore the existence of externalities between previously unrelated routines. This integration strategy s_3 we call 'job-enrichment'. Both s_2 and s_3 lead to a change in the organisational architecture as poorly performing routines are replaced by better performing ones[16]. In this case, all performance values $\phi(x_h)_{t+1}$ for the elements in the new module(s) are redrawn. If their joint average increases, this corresponds to a performance improvement. These strategies affect the performance Φ_t of productive routines through system economies. By improving control of productive routines, they push the productivity of a given technology towards its limit.

According to the modular theory of the firm, an increase in the system modularity also leads to an improvement in the innovation rate. Modularity allows a better understanding of the workings of a system, making it easier to recombine routines, increasing the probability of discovering better ways of doing things. We will assume that, depending on the degree of decomposition of the administration of the firm given by the number of routines *n*, the likelihood of discovering better ways of organising the production process increases if the firm invests in this exploration process. This will push ahead the performance Φ_t of productive routines by a factor $(1+\varepsilon_t)$, where $\varepsilon_{t+1} = \varepsilon_t(1+\tau)$. In the simulation, parameter τ has a small positive value as does ε_t at *t=0*. The probability of the firm making an innovation ε_t is determined by a Poisson process with an arrival rate α. Following Silverberg and Verspagen (1994), we assume the firm's investments have first increasing and then decreasing returns. This is captured by a logistic representation of the arrival rate given by

$$\alpha_{t+1} = \frac{\alpha_{\min}\alpha_{\max}}{\alpha_{\min} + \left(\alpha_{\max} - \alpha_{\min}\right)^{-(r^* n_t)}} \qquad (1)$$

[16] Wagner and Altenberg (1996) have discussed decomposition and integration as potential evolutionary mechanisms of change within genetics.

$\alpha_{\min}$ represents a small autonomous probability of making a fortuitous innovation without investing in this type of innovation, $\alpha_{\max}$ corresponds to an asymptotic saturation level of the arrival rate. As can be seen, this process depends on the propensity to invest *r* and on the degree of decomposition. This captures the innovation potential.

The firm maximises profits $\Pi_{d_t}(s_t)$. Its strategic behaviour is given by the probability distribution over the three alternative innovation strategies. This 'policy mix' $s_t = [\mu_{1,t}s_1 \quad \mu_{2,t}s_2 \quad \mu_{3,t}s_3]'$, with $\mu_{1,t} + \mu_{2,t} + \mu_{3,t} = 1$, evolves through reinforcement learning, given some initial probabilities $\mu_{j,t=0}$. This probability should not be interpreted as conscious randomisation. Rather, it indicates (from the perspective of the outside observer) how likely it is that the decision maker will choose each of the three strategies. The reinforcement learning dynamics are those of Arthur (1991); each strategy is allocated a probability based to its past contribution to the performance of the firm.

$$\mu_{j,t+1} = \mu_{j,t} + \frac{\Delta\Pi(s_j)_t - \mu_{j,t}\sum_j \Delta\Pi(s_j)_t}{\sum_j \sum_t \Delta\Pi(s_j)_t}, \qquad (2)$$

where $\Delta\Pi(s_j)_t = \Pi(s_j)_t - \Pi(s_j)_{t-1}$ indicates the change in the performance improvement between two time steps t and $t-1$ where strategy s_j was used. Equation (2) reinforces the strategies that performed best in the past, i.e. those that previously maximised profits.

Costs of production for a given organisational architecture and information technologies

To simplify, we assume that white-collar routines are not productive in themselves but improve the utilisation and development of the firm's productive resources. More precisely, we assume that the services produced by an administrative activity m_i have an impact on the performance of productive routines, $\phi(m_i)_t$. As previously mentioned, the impact on the unit costs of productive routines by all *n* modules is given by Φ_t. In order to run simulations, we choose a simple and well-behaved functional form to represent the effect of performance improvements on the unit costs of productive routines – one that captures the central ideas while ensuring unstable outcomes are avoided. We specify this as

$$vc_{d_t} = w_p l_p e^{-(1+\varepsilon_t)\Phi_t} \qquad (3)$$

where w_p is the average wage bill per unit of output paid for productive routines, and l_p is the unit labour requirement.

Two types of routine govern the administration of the firm. The first type of routine produces managerial services for productive activities contained within a module. The second type of routine coordinates the interaction between these managerial services and modules. Outsourcing involves the outsourcing of the first type of routine as well as the productive activities within a module. We assume the number of services a module produces is proportional to its skill intensity, i.e. the more services an activity produces, the higher are the skills required to carry them out. This implies that the average wage paid to these routines is higher than to routines where only a few services are produced. For simplicity we assume that the unit wage cost of producing one service to productive routines is the same as carrying out one coordination task.

As discussed earlier in the paper, information technologies affect coordination costs. What is more, different vintages of IT have different relative impacts on internal and external coordination costs. Total administrative overhead costs are then defined by

$$oc_{d_t} = \left(z l_a w \overline{\lambda} + (1-z) \sum_{\ell} p_{\ell} \right) + l_c w \left(\nu_{\text{int}} e^{-\theta_{\text{int}}} + \nu_{\text{ext}} e^{-\theta_{\text{ext}}} \right) \quad (4)$$

where l_a and l_c are the unit labour requirements for service and coordination routines, w is the going wage rate paid per 'skill unit', $\overline{\lambda}$ is the average number of services produced in each administrative activity, p_{ℓ} are the prices paid for outsourced routines, v_{int} and v_{ext} are the number of internal and external coordination routines, and θ_{int} and θ_{ext} reflect the impact of IT use on internal and external coordination costs respectively. Variable z ($0 \leq z \leq 1$) weights the unit costs of administrative services produced in-house and those externally produced by their respective share in the total number of services that are produced.

If a specific service producing administrative module m_i is outsourced the unit cost of production of its services by the service firm is then given by

$$cs_{\ell} = l_{a,\ell} w \lambda_{i,\ell} \gamma_{\ell} + l_{c,\ell} w (\nu_{\text{int},\ell} e^{-\theta_{\text{int}}} + \nu_{\text{ext},\ell} e^{-\theta_{\text{ext}}}) \quad (5)$$

where γ reflects the comparative cost advantage service firm ℓ has in producing the services of administrative activity m_i. In the simulations we assume that $\gamma \rightarrow N(1, \sigma^2)$, i.e. the cost advantage is normally distributed around a mean of 1 with some variance σ^2. Variables $l_{a,\ell}$ and $l_{c,\ell}$ reflect the relative unit labour requirements for service producing and coordination routines, and $\nu_{\text{int},\ell}$ and $\nu_{\text{ext},\ell}$ give the number of internal and external coordination routines the service supplier has to manage.

Assuming the supplier has some market power, such that it is able to charge a positive mark-up ξ over costs, the unit price for the services of supplier ℓ to the outsourcing firm is given by

$$p_\ell = (1+\xi)cs_\ell \quad (6)$$

Suppose the firm has a propensity r to invest part of its revenues to organisational exploration, i.e. through the modularity of its administration. These costs are then given by

$$rc_t = rp_t q_t \quad (7)$$

where p_t and q_t are the prices charged and the quantities sold at a time step t.

Profits

The firm faces a downward sloping (inverse) demand given by

$$p_t = \frac{Is}{q_t^{1/\eta}} \quad (8)$$

where p_t is the price the firm charges at time t, Is is the amount of income customers spend on the firm's product, q_t is the firms output and η ($\eta > 1$), is the price elasticity of demand. Following standard theory, the optimum output and price for a given organisational architecture d_t are given by

$$q^*_{d_t} = \left[\frac{Is(1-1/\eta)}{vc_{d_t} + oc_{d_t}}\right]^\eta \quad (9)$$

Therefore, for each organisational architecture d_t, the firm seeks to maximise profits

$$\Pi^*_{d_t}(s_t) = Is\left[\frac{Is(1-1/\eta)}{vc_{d_t} + oc_{d_t}}\right]^{\eta-1} - (vc_{d_t} + oc_{d_t})\left[\frac{Is(1-1/\eta)}{vc_{d_t} + oc_{d_t}}\right]^\eta - rc_t - c_t \quad (10)$$

by reducing unit costs of production. In our model this is achieved by pursuing different strategies s_t of organisational innovation. The term c_t reflects fixed capital cost. Given a constant capital-output ratio, the firm must invest or disinvest as output changes.

The innovation and outsourcing decisions

Decisions to conduct organisational innovation and outsource depend on economic profitability. The management of the firm calculates the expected profits $E[\Pi_{d'_{t+1}}(s_t)]$ that the new organisational architecture d'_{t+1} is likely to generate, and compares this with the profit generated by the current

architecture. The decision rule for adopting a new organisational architecture d'_{t+1} is given by the inequalities:

$$\begin{cases} \Pi_{d_t}(s_t) \geq E[\Pi_{d'_{t+1}}(s_t)] & \text{reject innovation} \\ \Pi_{d_t}(s_t) < E[\Pi_{d'_{t+1}}(s_t)] & \text{accept innovation} \end{cases}$$

Depending on the management strategy, the firm has a certain propensity to pursue outsourcing such that, given strategy parameter *os* ($0 \leq os \leq 1$), it calculates the expected profits of outsourcing services to other firms, leading to an organisational architecture d''_{t+1} with probability pr_{os}

$$\text{if} \qquad pr_{os} > os \quad \begin{cases} E[\Pi_{d''_{t+1}}(s_t)] \leq E[\Pi_{d'_{t+1}}(s_t)] & \text{inhouse} \\ E[\Pi_{d''_{t+1}}(s_t)] > E[\Pi_{d'_{t+1}}(s_t)] & \text{outsource} \end{cases}$$

These are the decision rules the firm follows in order to maximise profitability at each moment in time.

5. Results

Here we report the results of model simulations that examine two, alternative scenarios. In scenario 1, new IT technologies have a large impact on internal transaction costs θ_{int}. This is the scenario for earlier vintages of office technology and IT discussed by Chandler. In scenario 2, new IT technologies have a large impact on the cost of external transactions θ_{ext}. This is the scenario of internet based IT. For each scenario, we examine how the differential impact of alternative vintages of IT on internal and external coordination costs affect organisational innovation, the sourcing of activities, and long run productivity.

In addition to θ_{int} and θ_{ext}, an important variable in our model is the management's propensity to outsource *os*. As discussed in section 4, this is treated as an exogenous variable. The empirical evidence shows that outsourcing is not part of a long run innovation strategy but is driven by consultancy and media promises, and by short run cost cutting goals. In the simulations presented here, the propensity to outsource is fixed at 0.5, with an initial division of labour of 10 administrative activities. This is a conservative value. The decision to outsource is not only condition upon the propensity to outsource but also the probability that a supplier is available that is cheaper than in-house production. At the end of this section we report on sensitivity tests for changes in this parameter and on the initial extent of the division of labour.

The parameter values used in the simulations are reported in Table A.1 of the appendix. The results present averages over 200 differently seeded runs. Each run consists of 400 iterations. This sensitivity analysis tests the robustness of results with regards to initial random seedings (Birchenhall *et al*., 2007). During each iteration, one routine in the technology-characteristics map is drawn randomly, and an innovation strategy is chosen with probability $\mu_{j,t}$. In dependence on the selected strategy performance values for the selected routine were re-drawn.

The results are presented in Figure 3. The bold line provides the mean value for each parameter setting of the 200 runs conducted on scenario 1 and the 200 runs conducted on scenario 2. The thin dashed lines represent the 99% confidence interval around the mean. Note that the dash-dot-dash lines are the results produced for scenario 1 runs, i.e. where there are low internal communication costs θ_{int} for a given outsourcing propensity. The unbroken lines are the results produced for scenario 2 runs, i.e. where there are low external communication costs θ_{ext} for a given outsourcing propensity. Plots for the average productivity, average profits, average unit costs for administrative activities, and the extent of the division of labour in the administration of the firm (the depth of hierarchy) are provided.

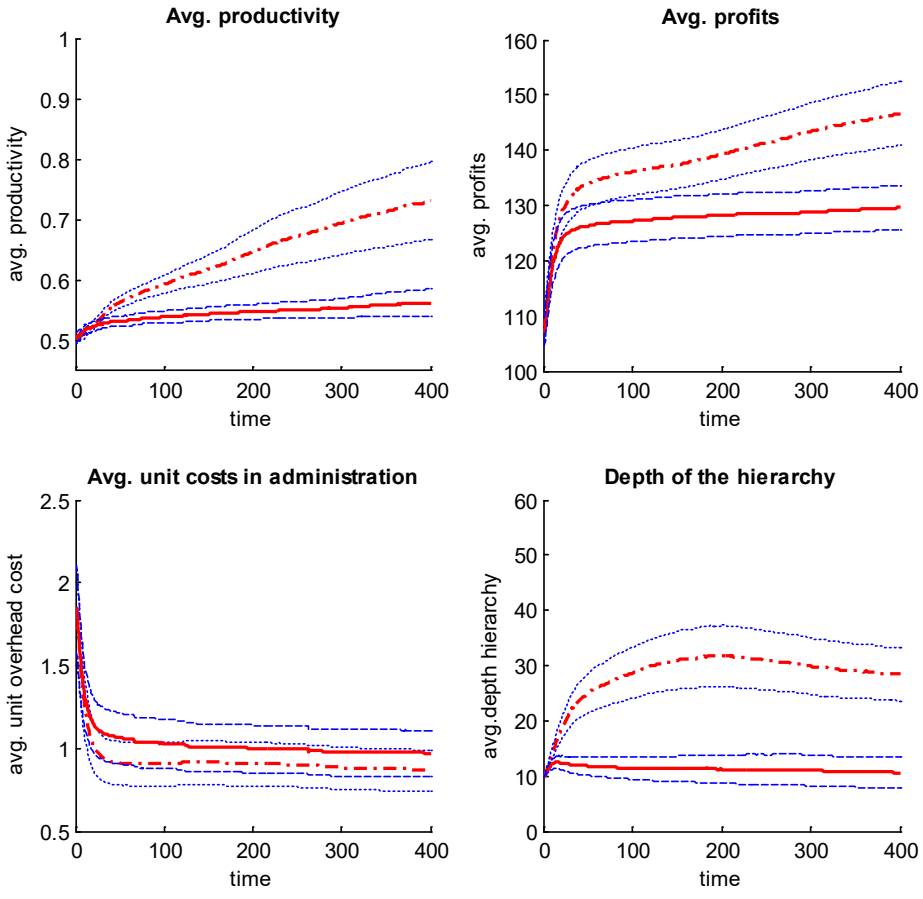

Figure 3: Simulation runs under scenarios 1 and 2.

The simulation results reproduce the outsourcing productivity paradox. The average long term productivity of a firm is lower when it engages heavily in outsourcing, encouraged by an IT technology that reduces external coordination costs. The explanation for the paradox in this model is as follows. The managers of the firm in this model are learning myopically over time, through pure learning-by-doing, i.e. they do not have information on the payoffs of different strategies at the outset but must learn these by observing the payoffs generated by their past decisions. Under these circumstances, the firm's managers perceive there to be a cost-cutting potential if ITs lead to a fall in external coordination costs, and proceed to outsource a high number of service routines. As a consequence, the depth of the hierarchy is reduced and, in the beginning, overhead costs fall. Productivity also grows initially. Reinforcement learning means this initial success, in terms of reducing initial costs and gains in productivity, leads managers to place greater weight on the outsourcing option next time around. If the outsourcing strategy is chosen once gain it will again have a positive impact on cutting costs and on productivity, though with diminishing returns. This further raises the probability of managers choosing to outsource next time. The myopic learning process opens the way opens the way for lock-in to an outsourcing trajectory.

Of course, we know, from the results generated by the model, that long term productivity growth would have been be higher if managers had chosen a non-outsourcing strategy. But the managers cannot 'see' what would happen 'if' they had pursued the alternative strategy. As the firm continues along the outsourcing path, productivity growth continues to fall and can even stagnate. The upshot is that managers focused on the short-run cost cutting effect will indeed succeed in reducing costs, but will unwittingly reduce the long run innovation potential of the firm as well.

This lower potential productivity growth is due to the fact that outsourcing takes the form of a total outsourcing relationship. A decision to outsource places an activity/service beyond the control of the outsourcing firm for the remainder of the simulation run. Reduces the number of modular elements under the firm's control restricts the capacity for future organisational innovation and, hence, the probability of identifying a more efficient organisational hierarchy. This directly affects long term productivity growth. The reorganisation of administrative activities is a significant source of long term cost reduction and productivity growth.

In scenario 2 new IT lowers internal coordination costs. This supports the development of increased modularity in the administration of the firm. As the activities become more specialised, so it is easier to improve the quality of the administrative service to the productive routines. Importantly, the long run potential for radical organisational innovations is exploited successfully. The results indicate that long run productivity under scenario 2 outperforms the alternative scenario, where external coordination costs are lowed by new ICTs and firms engage in outsourcing. The results lend support

to the thesis that an outsourcing strategy that focuses on cost-cutting adversely affects long run performance and firm survival.

The results accord with the empirical studies discussed in section 3. However, it is important to observe that for the runs with low external coordination cost, long run productivity is close to those levels where external coordination costs are high. This outcome depends on the propensity of the firm to invest in radical organisational innovation. It suggests that, if a firm chooses to (moderately) outsource, influenced by the impact of IT in external coordination costs, it should scale up its investment in radical organisational innovations as these will enable it to better exploit the innovation potentials.

Finally, we report the findings of sensitivity analyses conducted on the current set of parameter values (see Table A.1). With regards to the propensity for management to outsource, the sensitivity analysis indicates the reported results hold for an outsourcing probability that is greater than 0.2. When the outsourcing probability is close to zero, the negative effects of total outsourcing, associated with low costs of external coordination become weaker. The results begin to resemble those for simulation runs where internal coordination is cheaper than external coordination. As the outsourcing probability approaches the value 0.2, the difference between the results of the two scenarios vanishes and is no longer statistically significant. This is an expected and rather straightforward property of the model as the outsourcing decision depends on the conditional probability of finding a supplier that is able to produce at lower cost that in-house production, and the probability that the manager decides that the chosen activity should be outsourced captured by the outsourcing probability. Consequently the effective likelihood of having a successful outsourcing draw is very low.

The results are also sensitive with respect to the choice of the initial division of labour in administrative activities. The sensitivity analysis indicates that with a low initial division of labour in administrative activities, the dynamics are rather similar to the runs described in this section but the adjustment process is much slower. If internal coordination costs are lower than external coordination costs, it takes much longer for the minimum division of labour to develop which opens up recombination potentials that drive the innovation process. On the other hand, if external coordination costs are low, firms will quickly outsource and, as very few activities are left, productivity and profits will be rather sluggish from the outset. Overall, the sensitivity analysis confirms the robustness of the results presented in this section.

6. Conclusions and directions for further research

The paper has investigated the outsourcing paradox. Total outsourcing of activities to KIBS business service providers can cut costs in the short run, but has a negative impact on long run productivity growth. This paradox is the striking thesis emerging from recent empirical research. The paper has summarised the empirical findings and identified a set key stylised facts. In order to provide an explanation of the outsourcing paradox, we have addressed the important connection between organisational innovation, total outsourcing, and long term productivity. Added to this is the impact of new IT on the costs of internal and external coordination costs, and the stimulus given by internet based IT to outsourcing.

The discussion has been placed on a more rigorous footing thorough the development a model of organisational innovation. Simulations conducted on this model enabled us to consider the short and long run impacts of outsourcing on administration overheads and on long term productivity growth. The interesting finding is that managers can become locked into a low productivity growth trajectory, associated with the outsourcing of routines, if they are myopic and learn through their own actions. They perceive outsourcing to cut overhead costs in the short run (as expected), and so engage in further outsourcing thereafter. This is to the detriment of long run productivity gains (system economies) generated though organisational innovation. This occurs because the potential for organisational innovation is reduced when modular components are outsourced, placing them beyond the control of the firms' management. The findings accord well with the empirical data, and provide a salutary warning for managers and policy-makers about the potential long term implications of outsourcing.

Looking forward, there is a need to extend the current analysis. The results depend on a number of conditions. First, outsourcing is purely cost driven, and takes the form of a total outsourcing relationship. Important potential interactions between suppliers and service firms, as well as the exchange of competences, are therefore neglected. In future research we will consider the consequences of an integrated outsourcing relationship on the capacity for organisational innovation and long run productivity. We expect this to further strengthen our argument that it is the *control*, not the ownership, of activities that matters. Another simplification in the current version of the model is that the extent of the market (demand) is given. Changing demand, due to a thickening of markets over the course of a life cycle, for example, may lead to a complicated set of results. Finally, different learning environments will affect the results. If managers may, for example, learn from the experiences of other firms, however imperfectly. Future research will examine the extent to which this affects lock-in to a total outsourcing trajectory.

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Appendix

Variable	Range/value
Efficiency of internal and external coordination routines $\{\theta_{\text{int}}, \theta_{\text{ext}}\}$	Scenario with external coordination cost high {2,0} Scenario with external coordination cost lower than internal {2,4}
Outsourcing propensity *os*	*os = 0.5*
Total number of services *F*	*F=100*
Wage bill *w*	*w=1*
Performance improvement τ	*draw from N(0.01,0.0025) to initialise firm parameter, constant over iterations*
Supplier cost advantage γ	*draw from N(1,0.0625) to initialise firm parameter, constant over iterations*
Investment propensity *r*	*for each firm draw from N(0.02,0.0025) , constant over iterations*
$\alpha_{\min}, \alpha_{\max}$	$\alpha_{\min} = 0.01$ $\alpha_{\max} = 1$
l_p	0.8
l_a	$l_a = \frac{F}{F + \upsilon_{\text{int}} + \nu_{\text{ext}}}(1 - l_p)$
l_c	$l_c = \frac{\nu_{\text{int}} + \nu_{\text{ext}}}{F + \nu_{\text{int}} + \nu_{\text{ext}}}(1 - l_p)$
z	$z = \frac{F - Nos}{F}$ *Nos* = number of outsourced services; $\sum_{\ell} \lambda_{i,\ell} = Nos$
$l_{a,\ell}$	$l_{a,\ell} = \frac{\lambda_{i,\ell}}{\lambda_{i,\ell} + \nu_{\text{int},\ell} + \nu_{\text{ext},\ell}}$
$l_{c,\ell}$	$l_{c,\ell} = \frac{\nu_{\text{int},\ell} + \nu_{\text{ext},\ell}}{\lambda_{i,\ell} + \nu_{\text{int},\ell} + \nu_{\text{ext},\ell}}$
Total consumer income allocated to the firm in each period *Is*	*Is* = 100
Elasticity of demand η	draw from uniform [1.05,1.5] *to initialise firm parameter, constant over iterations*
Initial degree of decomposition of the techno-organisational architecture n_0	n_0=10
Average supplier mark-up ξ	draw from uniform [0,0.5] for each outsourcing draw
$\mu_{i,0}, i = 1,2,3;$	$\mu_1 = \mu_2 = \mu_3 = 0.\overline{3}$, at $t = 0$

Table A1: Parameter values used to calibrate the model