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Research on why firms should outsource and how they should do it has proliferated in the past two decades, but few consistent findings have emerged concerning the benefits of outsourcing. We argue that this is in part due to the lack of an adequate framework for measuring the effects of outsourcing. To address this, we present such a framework based upon the Cobb–Douglas productivity function. We explain how our framework can be used to unpack one component of the Cobb–Douglas productivity function, the 'total factor productivity', which represents the other numerous sub-variables that affect outsourcing productivity, beyond the capital and labour expenditures. We also demonstrate the framework using a simple illustrative example.

Keywords: outsourcing; Cobb–Douglas; total factor productivity; aerospace; manufacturing; Ishikawa diagram

1. Introduction

The practice of outsourcing is when one company contracts out a part of its existing internal activity to another company (Lei and Hitt 1995, McCarthy and Anagnostou 2004). It is an activity that has gained prominence both in management practice and in the research literature. Particular attention has been paid by researchers to the labour market and the productivity effects of outsourcing practices, where empirical evidence is often employed to examine the effects of outsourcing. However, these and other studies present conflicting findings and arguments over the effectiveness of outsourcing practices (Dabhilkar and Bengtsson 2007). We suggest that these contradictory results can be explained in part due to the method used to measure the effects of outsourcing (Horgos 2009).

To help researchers and managers better understand the productivity (i.e. efficiency of production) implications arising from a decision to outsource, we present and illustrate a framework that relates business inputs (capital and labour) to useful outputs (goods or services). Central to our framework is the Cobb–Douglas (1928) productivity function, a simple and seminal algebraic expression relating production output to production inputs. The function also employs a third variable or factor, total factor productivity (TFP), to crudely account for the other innumerate impacting variables (beyond labour and capital) that also affect productivity. The Cobb–Douglas function was primarily developed to describe productivity effects arising from the alteration of labour and capital, the two endogenous variables that can be controlled to some extent by managers. However, the Cobb–Douglas function has been extensively employed to gain a retrospective insight as to whether an outsourcing decision has made a positive impact upon the productivity of the firm by evaluating the amalgamated exogenous variables in the form of TFP (e.g. Girma and Görg 2004, Olsen 2006, Gorg *et al*. 2008). The outcomes of these investigations suggest there is only a tenuous trend between outsourcing intensity and productivity. Thus, we assert that it is important to be able determine the TFP for different outsourcing decisions *ex ante* by identifying and evaluating the pertinent factors affecting the potential TFP change.

To this end, we present a framework that can be used to unpack the TFP variable into a number of specific sub-variables or categories. This follows other studies that closely examined the make-up of other contingent factors such as industry uncertainty (Milliken 1987) and industry velocity (McCarthy *et al*. 2010). Our framework also complements other outsourcing frameworks (e.g. Fixler and Siegel 1998, Vining and Globerman 1999) and make-versus-buy frameworks (Platts *et al*. 2002), in that we argue that outsourcing performance is contingently dependent on how TFP indicators combine with labour and capital variables to influence the success or failure of an outsourcing decision.

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We present our arguments in three sections. In Section 2, we review the research on the impact of outsourcing in the operations management and strategy literature focusing on the opportunities that this study presents for developing the TFP framework. In Section 3, we present our framework by introducing the TFP concept and then defining some categories of sub-variables that could affect an outsourcing decision. Then, we illustrate the framework and method. We do this by presenting a simple illustrative to show how potential relationships among the TFP variable and outsourcing performance categories can be unpacked. In Section 4, we explore the implications of our framework for managers and scholars interested in understanding and measuring the impact of outsourcing.

2. Research on the impact of outsourcing

There has been a profusion of management and economic research on outsourcing ever since the practice gained prominence during the latter half of the twentieth century. Generally, much of this research focuses on two broad themes: labour market effects (Feenstra and Hanson 1999) and aggregate- and firm-level productivity and efficiency (Gilley and Rasheed 2000, Raa and Wolff 2001). In terms of operations management, such effects have prompted researchers to examine the sourcing strategies of Belgian firms (Everaert *et al*. 2007) and how supply chains should be designed to operate in developing regions (Taps and Steger-Jensen 2007). Furthermore, McCarthy and Anagnostou (2004) show how outsourcing in the UK manufacturing industry reduces the value of a manufacturing firm, which in turn represents a decline in the gross domestic product of the industry, as services and other non-manufacturing activities are outsourced.

In a review of the outsourcing literature, Jiang and Qureshi (2006) argued that outsourcing research focuses on three themes. Two of the themes that dominate the literature are understanding the determinant factors that prompt the decision to outsource and exploring the methods by which a company implements outsourcing. The third, less developed theme (accounting for less than 20% of papers reviewed) is those studies that focus on the impact or results of an outsourcing activity. One reason we suggest for the limited attention to studying outsourcing results is the lack of a framework that guides researchers on how to contingently measure the relationship between different outsourcing decisions and corresponding outputs. To address this and respond to Jiang and Qureshi's (2006) call for researchers to pursue result-based research on outsourcing, we present and illustrate a framework that focuses on unpacking the TFP variable. This allows researchers and managers to determine and quantify some of the categories of TFP sub-variables that affect outsourcing performance and to identify some of the outsourcing opportunities which best represent productivity growth opportunities. We are motivated to develop this framework, because we believe the link between outsourcing intensity and productivity is too simplistic, i.e. a single dimension is insufficient to account for the array of influencing factors on TFP magnitude.

Table 1 lists some of the major studies in management and economics that have used TFP to examine outsourcing results. They were selected using the terms TFP, outsourcing and 'Total Factor Productivity'. Looking across these studies, we identify three themes that support and motivate our study. First, as all the studies listed in Table 1 employed TFP to justify a link between productivity change and outsourcing, they provide arguments that support the need to better estimate the impact of outsourcing on productivity. For example, Olsen (2006) provides a comprehensive review of the prior research that used the Cobb–Douglas function to identify a trend between outsourcing intensity (i.e. ratio of purchased and created goods and/or services) and the productivity of the firm or industry. He argues that such studies are needed because the impacts of outsourcing on productivity have received only little attention. Similarly, Girma and Görg (2004) focus on three separate UK manufacturing industries over the period 1982–1992 and use TFP to examine whether outsourcing has a positive effect on productivity.

Second, in no instance is an unequivocal link between outsourcing intensity and productivity increase proven. While a link is plausible based upon the findings of the literature identified, the mechanisms by which this would operate have not been considered. Olsen (2006) concludes that using TFP growth or magnitude as a measure, the reports studied indicate that in 59% of cases an improvement in productivity has been noticed and that in 41% of studies no improvement is seen. He concludes that 'there are no clear patterns as to how outsourcing affects productivity'; moreover, productivity growth 'much seems to depend on sector- and firm-specific characteristics' (Olsen 2006, p. 28). From this it seems that a weak relationship between outsourcing intensity and improved productivity exists; however, it also suggests that the act of outsourcing itself might not directly lead to increased productivity, reduced costs or improved resource efficiency.

Table 1. Research on outsourcing and TFP.

Authors	Approach	Industries	Key findings
Olsen (2006)	Survey of literature relating to productivity effects of outsourcing, using TFP growth as a benchmark indicator	Various manufacturing, both firm and aggregate level	The link between outsourcing and productivity benefit is weak; some benefit is noticed in small manufacturing firms
Feenstra and Hanson (1999)	Compares TFP values for companies operating in a 'large country' at aggregate level, seeking to distinguish between the benefits seen through technology implementation and through outsourcing intermediate services	SIC manufacturing industries (aggregated)	Increased technology is responsible for 35% increase in the relative income of non-production workers, whereas outsourcing is responsible for around 15%.
Girma and Görg (2004)	Uses firm-level (SIC) data to analyse TPF growth	UK chemical, mechanical, instrument and electronic manufacturing	Intensive outsourcing is directly proportional to firm-level TFP growth
Gorg *et al*. (2008)	Firm-level data is used to distinguish between the effects of materials and service outsourcing in manufacturing firms	Irish manufacturing companies, domestically and internationally owned	Services outsourcing has little effect on productivity for firms who do not export, but has noticeable effect for those exporting
Raa and Wolff (2001)	A consolidation framework is used to distinguish between goods and services outsourcing and their respective effects upon productivity	US manufacturing firms	TFP growth in the manufacturing industry during the period 1977–1987 was aided by the outsourcing of intermediate service functions

Third, we note that in the instances that changes in TFP have been measured, it is in conjunction with the measurement of structural or environmental changes, such as radical changes in technological capability. For example, Feenstra and Hanson (1999) examined how a TFP increase can be attributed to specific changes carried out by the business. They observed that outsourcing accounted for a 15% increase in TFP magnitude, while technological innovation was responsible for a 30% growth under the same conditions. These observations are the products of investigations which aim to identify the variables that predetermine the success of an outsourcing decision. However, it is also observed that no single variable offers a signal of sufficient clarity to be distinguishable above the combined magnitude of all other signals. From this, we focus in this article on understanding how multiple variables could be considered to assess the impact of outsourcing.

Together, the literature in Table 1 indicate that the outsourcing of internal functions can have a significant impact upon firm productivity, but the magnitude and direction of that impact is not always favourable and is difficult to predict without a more fine-grained analysis of the TFP term. This leads us to believe that there is a significant gap in the understanding of how the context of outsourcing decision affects outsourcing performance. That is, the data in the existing literature is concerned with outsourcing and using aggregate TFP to assess success. Thus, it does not have the resolution for us to be able to differentiate the factors between an outsourcing decision which leads to increased productivity and one which does not, and the use of TFP until now should be categorised as 'determinant', as described by Jiang and Qureshi (2006). Olsen's (2006) statement that sector- and firm-specific characteristics affect the productivity growth supports our effort in this article to divide together the variables which describe the firms 'situation'; the financial, geographical and technical landscape in which the firm operates. To this end, we suggest some exogenous and endogenous variables fitting into those financial, geographical and technological categories which ultimately influence the magnitude of TFP growth the firm

should expect as a result of the particular outsourcing decision. A set of such parameters was outlined in the report by Jiang and Qureshi (2006, p. 48) in their framework for outsourcing results analysis, and categorised into those parameters which have available data to be measured and those which are not supported and therefore immeasurable. In that particular instance, however, due to the retrospective nature of the study, only data which happened to be recorded at the time were available. In this article, we argue that these fiscal, physical and technological parameters can be addressed as key metrics, critical to the outcome of the productivity evaluation.

3. Outsourcing: a TFP framework

In this section, we define and discuss the TFP variable. We then describe a framework that can be used to examine how the composition of this variable would impact an outsourcing decision. To do this, we present an illustrative outsourcing example and show how the context of the example can be analysed using the framework so as to offer insight and benefit to managers.

3.1. *Total factor productivity*

TFP is a factor in the Cobb–Douglas (1928) production function. The now seminal function was introduced as a means to evaluate firm-level and aggregated production magnitudes. The typical two input productivity function describes productivity in terms of the capital and labour applied to a product (Durrand 1937, Aigner and Chu 1968). Capital and labour are subject to an efficiency variable, which is known as the TFP. The classic two-input Cobb–Douglass function is stated in the following form:

$$y = AL^{\alpha}K^{\beta}$$

where Y is the process output, the magnitude of productivity. Typically, this would be measured in terms of quantities of good produced, or revenue generated through sales or exports (if considering an aggregated national product). In this article, we consider the process output to be directly proportional to TFP, where capital and labour inputs are constraints.

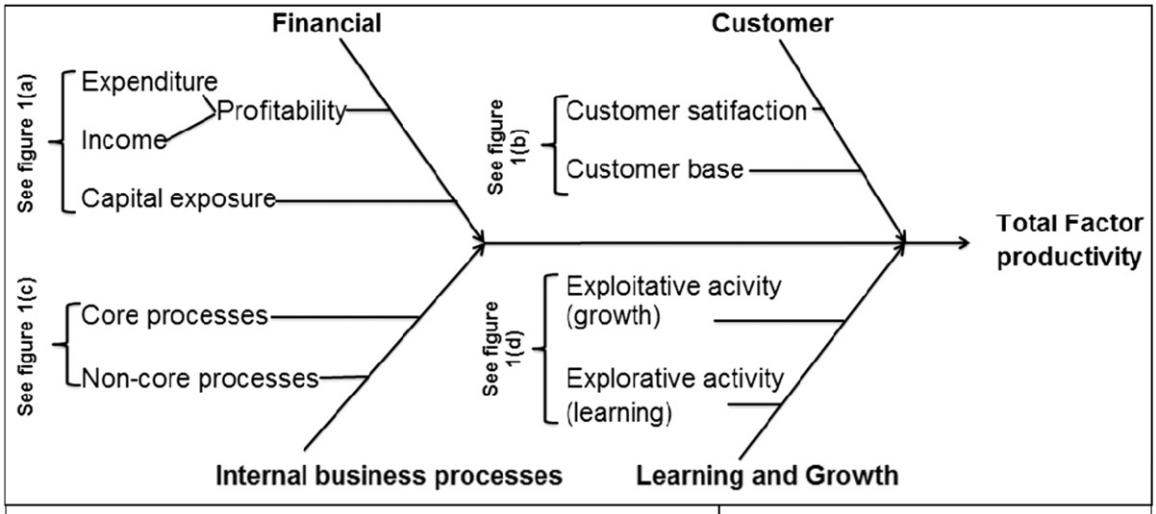
A is the TFP; the other numerous sub-variables (beyond that explicitly accounted for capital and labour) that affect the productivity. The aim of this article is to present a framework for identifying, grouping and evaluating the implicit sub-variables that might constitute the TFP for different outsourcing decisions.

L is the labour input, the hours of labour invested per product. This is assumed to be constant and exclusive from TFP. In reality, however, a change in TFP might have a subsequent affect upon hours required, but to preserve simplicity for the present examination, the labour hours required per product is benchmarked by the in-house process.

K is the capital input, the capital investment required to facilitate production, for both recurring and non-recurring expenditure. As with labour investment, this variable is considered constant for our examination despite fair assumption that some TFP inputs might affect the amount of capital required to carry out production.

α and β are the elasticity constants; these exponents account for diminishing returns, i.e. the values of α and β should each equal less than 1, such that the marginal product diminishes as capital and labour inputs are increased. The values of α and β are derived by means of best fit to the existing data. Cobb and Douglass (1928) themselves employed an α value of 0.75 (and consequently $\beta = 0.25$, assuming that $\alpha + \beta = 1$) which achieved a suitable fit to their 1899–1922 production data. Subsequent studies (using the Durrand (1937) independent exponent form) have tended to agree with values of these magnitudes. For example, Meeusen and van Den Broeck (1977) analysed the 1962 Census of Manufacturing Industries, demonstrating values for α and β ranging from 0.71 to 0.84 and 0.15 to 0.34, respectively, with a combined figure closely approximating 1. The values of α and β are circumstantial; they are specific to a particular industry, geographic location and time period and like TFP are products of the environment in which the company operates. Again like TFP, the elasticity constraints are defined by human actions and typically quantified at an aggregate level; however, these do not vary significantly over time or between economic or social conditions. As such, for this examination, they are assumed to be fixed. Furthermore, for the studies mentioned in Table 1, α and β have also been assumed static, such that productivity changes can be expressed as a product of TFP only.

A criticism of the Cobb–Douglass function concerns its applicability and validity. Labini (1995), for instance, argues that the static values assigned to α and β are insufficient to be able to account for the distribution of production shares, and that a dynamic value (i.e. one that accounts for fluctuations in the rate of change of marginal product) should be implemented in their place. Also, Barnett (2004) points out that the dimensions of the constant TFP are raised to the power of the exponents of labour and capital. Should these exponents each equal unity, the dimensions are



1(a) Financial	Competition	**1(b) Customer**
Materials	Delivery	Product quality
Processing	Quality	Delivery
Currency exchange	Technology Readiness Level	Value
Contract negotiations	Equipment ownership	Back up
Distance		Attractiveness to new customers
Transportation modes		Supplier brand affiliation
1(c) Internal business process		**1(d) Learning and growth**
Labour hours on core productivity		Production volume
Value of core processes		Access to new market
Labour hours on non-core productivity		Knowledge transfer
		Access to technology

Figure 1. Example of how the Ishikawa diagram can be used to unpack TFP.

acceptable and meaningful, but we have already established non-integer values <1 are typical, in which case the dimensions of TFP are meaningless. Such criticisms indicate that TFP, while appropriate for examining the link between outsourcing and performance, has been treated as a 'dumb' number. This constrains the TFP to a measurable but unintelligible variable unable to help decision makers assess a current, unique set of outsourcing circumstances. With the following framework, we present a method by which managers can evaluate the circumstances in which they are exposed to, the effect these decisions might have on the TFP value they should expect to achieve through implementation of an outsourcing strategy.

3.2. *The framework*

The framework we present is used to unpack and define TFP for different outsourcing decisions. It involves two major steps.

In the first step, we employ the problem-solving tool, the Ishikawa (1990) diagram, to unpack TFP variable into a number of sub-variables. We identify TFP as the observed effect or symptom in the Ishikawa diagram, from which point we can begin to draw out the sub-variables which influence it, and furthermore the subsequent variables influencing them. Each level of variable is broken down until we have variables that can be individually measured. As a problem-solving method, the Ishikawa diagram assumes that each 'branch' or sub-variable (Figure 1) is of equal importance to its counterparts at the same hierarchical level. We note, however, that some of the branches will ultimately have a greater influence on the TFP magnitude than others, but for now the diagram serves the purpose of allowing us to illustrate the causes behind TFP magnitude changes. Furthermore, while the Ishikawa diagram traditionally has four branches or the 4 Ms – materials, machines, manpower and methods – that unpack the causes behind internal manufacturing process problems, the branches of the

Table 2. Description of potential suppliers.

Characteristic	Supplier 1	Supplier 2
Geographic proximity	Based in a similar geographic location to the purchasing company	Geographically distant from the purchasing company
Growth approach	Long established business based on traditional working methods	Business model based around rapid growth
Labour force	Skilled labour with higher wages	Low labour cost
Capabilities	Similar capabilities to in-house manufacture	Maintains and implements cutting edge technology
Process	Small batch sizes	Large batch sizes

diagram can be altered to focus on variables pertinent to different situations. We employ the four perspectives, customer, financial, internal business process and learning and growth, from the strategic performance management tool, the balanced scorecard (BSC) (Kaplan and Norton 1992). These perspectives provide a coherent link between a corporate mission statement and the behaviours and outputs of firms and thus can be used as sub-variables to unpack and make the causes of TFP growth intelligible. The first of these sub-variables is the financial perspective, which is intended to describe the performance of the business from the perspective of the shareholder. Second, the customer perspective is a sub-variable for how outsourcing decisions affect the perception of the customer of the business. Further, the internal business process perspective is the sub-variable for how outsourcing impacts the internal processes by which the business creates value. Finally, the learning and growth perspective is the sub-variable that measures how the outsourcing decision will extend, diminish or shift existing knowledge gaps and present growth opportunities.

The second step in our framework involves taking the 'measurable' variables defined in the Ishikawa diagram, and creating a comparison table to examine how each variable might vary for different outsourcing options. To do this, the existing in-house (non-outsourcing option) is scored zero, and the variables for each outsourcing option are allocated either a positive or negative score. The scores of the comparison table are then summed to assess the relative positive and negative effects each outsourcing option has on productivity.

3.3. *Framework illustration*

By means of example, we proffer a hypothetical situation whereby two alternative external suppliers are being considered by an North American owned and located manufacturing company to carry out a non-core manufacturing process. The particular measures we use for this illustrative example were derived from the authors' experience in the aerospace manufacturing sector. The primary branches of Figure 1 were defined by the BSC perspectives – financial, customer, internal business process and learning and growth – and provide a universal starting point for considering the potential implications of an outsourcing decision.

Two potential supplying companies are considered. They manufacture a typical static gas turbine engine component. One is a long established and reputable local supplier and the other is a recent internationally located entrant to the market. The suppliers are characterised by the criteria shown in Table 2. To score and compare the suppliers using the TFP sub-variables shown in Figure 1, we present Table 3. It indicates that the benchmark (in-house) method would yield no difference in TFP, supplier 1 would result in an increase in TFP on the basis of a score of +5 and supplier 2 would offer further benefit over both the benchmark and supplier 1 with a score of +9. We deconstruct these scores to develop general comments about the categories of sub-variables as follows.

3.3.1. *Customer*

Supplier 1 offers an overall negative effect upon TFP magnitude due to not being able to control delivery schedules. Supplier 2 offers overall benefit despite negative connotations of offshore outsourcing: supplier brand affiliation and the attractiveness to new customers both suffer due to increased perception of quality escapes caused by outsourcing.

3.3.2. *Financial*

The example indicates supplier 1 to be the most preferred source in terms of cost, centring around

Table 3. Comparison of suppliers using the metrics in Figure 1.

Category	Metrics	In house	Supplier 1	Supplier 2
Customer	Product quality	0	0	1
	Delivery	0	−1	1
	Value	0	−1	1
	Back up	0	−1	1
	Attractiveness to new customers	0	−1	−1
	Supplier brand affiliation	0	1	−1
	Total	0	−3	2
Financial	Materials	0	0	1
	Processing	0	1	1
	Currency exchange	0	0	−1
	Contract negotiations	0	−1	−1
	Distance	0	0	−1
	Transportation modes	0	0	−1
	Competition	0	0	−1
	Delivery	0	0	1
	Quality	0	0	1
	TRL	0	1	1
	Equipment ownership	0	1	1
	Total	0	2	1
Internal business process	Labour hours on core productivity	0	1	1
	Value of core processes	0	1	1
	Labour hours on non-core productivity	0	0	0
	Cost of non-core activities	0	0	0
	Total	0	2	2
Learning and growth	Production volume	0	1	1
	Access to new market	0	1	1
	Knowledge transfer	0	1	1
	Access to technology	0	1	1
	Total	0	4	4

a benefit in reduced capital expenditure. Supplier 2 also offers negligible benefit according to the example.

3.3.3. *Internal business processes*

Both suppliers 1 and 2 appear to offer similar benefit to the purchasing company through the liberation of hours to be spend on core competences.

3.3.4. *Learning and growth*

Both suppliers 1 and 2 offer great benefit to the purchasing company by opening knowledge diffusion routes.

Analysis of this illustrative scoring example (particularly the cost-based variables) highlights a limitation in our relatively simplistic comparison method. By not assigning importance to each sub-variable, and similarly not calculating magnitudes of differentiation for our measurable variables, we allow what might be insignificant factors such as transportation/logistical expenses to take an equal leverage upon overall score as a primary aspiration such as processing cost reduction. This manifests itself as a reduced magnitude for the total financial benefit, despite the intention of our demonstrative scoring to show that supplier 2 would yield a significant cost saving.

A question regarding data being populated into the study is also presented; how do we confirm the quality of the data upon which our decision is based? If the data are not of sufficient quality, does the output of the exercise offer us any greater insight than a comparison of recurring cost data (comparison of quotations) alone? It is clear that if we are to either increase the number of metrics we are considering, or increase the volume of empirical data supporting each metric, the reliability of the result increases.

In sum, the example simply shows how the framework can be used to deduce the most beneficial outcome (i.e. supplier 2). It maps and makes transparent our assumptions about benefits in cost reduction as well as increased customer satisfaction (though increased product quality) and internal 'Knowledge and Learning' by knowledge diffusion and increased

time spent on core competencies. Largely, this is portrayed by the example and the framework would suggest that supplier 2 is, all things considered, the most favourable option for production of the component. In the context of TFP, the selection of supplier 2 would facilitate higher production volumes if the same capital and labour resources are to be committed, or that capital and/or labour inputs may be decreased to achieve the current level of productivity. Finally, it is important to note that in practice evidence would be presented to support the assumptions and indicate the impacts of the variables in the framework.

4. Discussion and conclusions

The central contribution of our study is the development and illustration of a framework for unpacking the outsourcing decision using the TFP, a variable in the Cobb–Douglass function. With this framework, we argue that it is possible to forecast how TFP variance for different outsourcing options would impact outsourcing performance. This allows managers and researchers to identify the variables which affect the contingent benefit realised by an outsourcing decision. We now discuss several implications of the framework, of relevance to both management practice and future empirical research.

First, where several outsourcing options might all represent an opportunity for benefit, our framework provides a reliable and sanitised method of quantifying the magnitude of benefit. However, as argued earlier in this article, the simplistic comparison method we present is only an illustration; it is not sufficiently accurate to prescribe the level of benefit an organisation should expect to see. Therefore, we suggest that evaluation and comparison methods for other cognate decision-making problems could be applied to TFP forecasting. Currently, there is a considerable gap in our capability for defining measurable variables (the secondary branches of the Ishikawa diagram), how we assign importance to each branch and how we subsequently score and evaluate the data. This problem is suited to multi-criteria decision analysis (MCDA), which develops methodologies for practitioners to apply in order to overcome complex decision problems (Figueira *et al*. 2005). A commonality between MCDA theories is the way in which qualitative/quantitative, explicit/implicit, empirical/derived data is brought together; dimensionally incompatible information from disparate sources is handled in nearly all MCDA problems. It is recognised that MCDA's ability to combine these data in a logical fashion, which replicates the complex evaluation methods we tacitly employ when faced with such problems, makes it especially suitable for use in outsourcing decision problems where we wish to use TFP forecasting.

Second, our literature review highlights how TFP has already been used with reference to outsourcing decision problems, furnishing us with data and accounts of the effects some outsourcing decisions have already made. Provided we can obtain the relevant supporting information (as defined by the preferred MCDA method, above), we suggest application of the TFP forecasting method to the pre-existing studies mentioned in Table 1 and propose how the TFP forecasting method would suggest that the overall productivity change would occur compared to the measured value in each study. As well as being a pertinent example of the framework worthy of discussion in itself, this study would allow us to begin to generate weighting factors for the metrics used, which could be used as baselines in subsequent studies.

Third, our examination might suggest that the TFP variable itself is a function of the measurable variables we identified. Although the measurable variables identified are undeniably linked, significant data are required to solve an algorithm with so many variables, so as to generate an explicit function for TFP. However, application of artificial neural networks (ANN) may meet the same objective. ANNs are seen as particularly useful when considering how many disparate inputs can have impact upon perceivably unrelated outputs; 'it is often easier to have data than to have good theoretical guesses about the underlying laws governing the systems' (Zhang *et al*. 1998, p. 35). Of course, the accuracy of the TFP magnitude output would be directly related to the appropriate selection of input parameters; those inputs would be identified through testing of the model and alignment with the data which is both already available to train the network and would be easily available for the user to measure.

The framework's greatest impact remains with managers faced with an outsourcing decision. With an ability to identify those factors that affect the success of outsourcing, managers not only shall be better informed of the overall impact of the decision, they will also be aware of those factors which have the greatest bearing on success. This allows them to investigate how to affect those factors to best enable a positive result. The metrics used in the TFP forecasting method would be expected to vary between firms, and due to the size of some multinational firms some discrepancy in forecasting metrics may be evident within the same organisation also. To investigate this, and to capture universal opinion on the drivers of TFP, we suggest that a Delphi Analysis be carried out to

determine the company's overall TFP forecasting criteria and their rankings.

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Professor Keith Ridgway is the Executive Dean of the University of Sheffield Advanced Manufacturing Institute comprising the Advanced Manufacturing Research Centre with Boeing (AMRC) and the Nuclear AMRC. The AMRC was established in 2001 to carry out research in manufacturing technologies directly related to the aerospace industry. In addition to Boeing, the AMRC has more than 60 sponsors, including BAe Systems, Rolls-Royce and Messier Dowty. Application of the research developed has led to a step change in the manufacturing capability of many of the industrial sponsors and encouraged their on-going commitment and support. He is a Fellow of the Royal Academy of Engineering, the Institution of Mechanical Engineers, Royal Institute of Naval Architects and Royal Aeronautical Society and was awarded the OBE for services to UK manufacturing industry in June 2005. He has over 160 publications including 57 journals articles.

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