The economics of the UK aerospace industry:

A transaction cost analysis of defence and civilian firms

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Abstract

The primary aim of this thesis is to assess vertical integration in the UK aerospace industry with a transaction cost approach. There is an extensive theoretical and conceptual literature on transaction costs, but a relative lack of empirical work. This thesis applies transaction cost economics to the UK aerospace industry focusing on the paradigm problem of the make-or-buy decision and related contract design. It assesses whether the transaction cost approach is supported (or rejected) by evidence from an original survey of the UK aerospace industry.

The central hypothesis is that UK aerospace firms are likely to make components in-house due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers, which is reflected in contract design. The thesis makes these concepts operational. The empirical methodology of the thesis is based on questionnaire survey data and econometric tests using Ordinary Least Squares (OLS) and logit regressions to analyse the make-or-buy decision and the choice of contract type.

The results from this thesis find limited evidence in support of the transaction cost approach applied to the UK aerospace industry, in spite of a bespoke dataset. The empirical tests of vertical integration for both make-or-buy and contract type as the dependent variable yield insufficient evidence to conclude that the transaction cost approach is an appropriate framework for analysing the UK aerospace industry as applied in this thesis.

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Part I: Theory and Overview

Part II: Empirical Results

Part III: Conclusions

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Preface

The UK aerospace industry has a long and varied history dating back to the antecedents of powered flight. Over a hundred year period there have been many technical successes, as well as much controversy about excessive costs and delays in delivery (*e.g.* TSR-2; Typhoon; Concorde). The aerospace industry is permeated with uncertainty, which is reflected in the nature of aerospace firms. This thesis assesses the economics of the UK aerospace industry from a transaction cost approach using vertical integration as a basis for analysis.

The complex nature of aircraft development and production creates uncertainty due in part to technological change. The core proposition in this thesis is that the issue of complexity and uncertainty can be assessed through the transaction cost approach. Namely, it is predicted that asset specificity, frequency, uncertainty, complexity and small numbers exchange combine to cause the inherent problems in the UK aerospace industry. On this basis, the key characteristics of aerospace production appear most appropriate for a transaction cost analysis, in terms of the make-or-buy decision and the choice of contract type. Alternative hypotheses are presented including monopoly power arguments, a principal-agent approach and game theory. The transaction cost approach certainly can be viewed as complementary with the concept of principal-agent, but monopoly power arguments do not fully capture the complexity of aerospace industry relationships and game theory is too general to assess the research problem.

The main purpose of this thesis is to examine the UK aerospace industry as a basis for testing empirically the relevance of transaction cost economics. This is achieved using an original database from a questionnaire survey of the UK aerospace industry. The thesis comprises three parts. Part I presents an overview of the UK aerospace industry and a survey of the transaction cost literature, with particular attention to the empirical studies since 1975. Part II describes the methodology of the research and empirically tests the transaction cost models, with specific analysis on the paradigm issue of make-or-buy and contract type. Part III brings together the theoretical and empirical work to present a set of conclusions and final recommendations for further research.

The thesis has generated two pieces of published work by the author. Firstly, the analysis of the UK aerospace industry in Chapter Two has been published as a Chapter in the book *Arms Trade, Security and Conflict* (2003) edited by Paul Levine and Ron Smith. The Chapter is titled "The supply-side implications of the arms trade: UK aerospace industry, economic adjustment and the end of the Cold War" and it assesses the uncertainty in the UK aerospace industry over the decade of the 1990s. Secondly, the analysis of the aerospace firm in Chapter Eight has been published as a paper in *Defence and Peace Economics*, Volume 15, Number 6 (2004) edited by Guest Editor Dr. Derek Braddon. The paper is titled "The future of the defence firm: the case of the UK aerospace industry" and it draws upon analysis in this thesis to predict future developments in defence aerospace. Finally, the empirical work contained in this thesis is cited in a Department of Trade and Industry (DTI) Research Monograph: "UK Aerospace Competitiveness: Literature and Research Review" published in August 2001 and edited by Paul Dowdall, Derek Braddon and Keith Hartley.

Overall, the major thrust of this thesis is a questionnaire and econometric analysis of the UK aerospace industry as explained by the transaction cost approach. There are empirical tests of make-or-buy and contract type using data from an original survey and a unique attempt to make operational the transaction cost approach applied for the first time to the aerospace industry in the UK.

At the start of the thesis the words of Alan Mulally, Chief Executive of Boeing Commercial Aircraft are relevant:

> "It's all about range. It's all about speed. It's all about economics."
>
> Alan Mulally (2002). Lecture on the future of flight, Derby, 14 May 2002.

This quote confirms the importance of an economic analysis of the aerospace industry.

List of Tables and Figures

Part I

Theory and Overview

Chapter One:
Introduction

> "Firms, markets, and relational contracting are important economic institutions."
>
> Williamson (1985: 15).

Introduction

This introductory Chapter outlines the central hypothesis of the thesis and its methodology. It explains why UK aerospace is an appropriate industry for this research and presents a plan of the thesis. The analysis is empirical and derives from a problem-based approach. The focus on the UK aerospace industry is from a transaction cost perspective.

The research problem centres on vertical integration in the UK aerospace industry. This is a study of the boundaries between the firm and the market and how companies with complex contracts are structured. The make-or-buy decision and contract design are considered essential aspects of the research that seeks to understand the economic and contractual relationships between firms in the manufacturing supply chain. The transaction cost approach is relevant because it focuses on the organisation of firms and relational contracting at the level of the transaction rather than the market.

The central hypothesis tested is that UK aerospace firms are likely to make rather than buy due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers. A questionnaire approach is used to gather all the relevant information, because very little published data exists in this area. The original contribution of this thesis is threefold. Firstly, it applies the theoretical models of transaction costs to bespoke UK aerospace data for the first time. Secondly, it uses the original database to assess make-or-buy decisions within the aerospace industry. Thirdly, it utilises the original database to understand the design of contracts within aerospace companies. Overall, the thesis contributes to the knowledge of transaction cost economics by assessing the structure of firms in a single industry. It collects unique evidence from an original questionnaire survey using appropriate econometric techniques and critically analyses the operational aspects of transaction cost theory. The next section presents the research problem and the research questions.

The research problem and the research questions

The research problem to be explored in this thesis is the determinants of vertical integration in UK aerospace firms (Jackson, 2003: 79)[1]. Vertical integration can be defined as the extent to which a firm will produce in-house (or make) and procure from the market (or buy). The make-or-buy decision and business-to-business contracts are central to this thesis within the context of company structures (Williamson, 1985: 32). A major feature of the research is the economic, contractual and organisational aspects of manufacturing and how production and purchasing is managed within aerospace firms. This approach relates the boundaries of the firm to the make-or-buy[2] strategy of procurement and the related hold-up problem of contracts. In the New Economics of Industrial Organisation literature the methodology is part of the transaction cost approach, which is developed in Chapter Three. Also, the thesis makes a critical assessment of the current transaction cost literature when applying the theory to the UK aerospace industry in Chapter Four.

There are two research questions considered by this thesis. Firstly, what determines the make-or-buy decision within an aerospace firm? Secondly, what potential hold-up problem exists between aerospace firms in the supply chain from the perspective of contract design? In order to answer these research questions there are empirical tests of vertical integration using make-or-buy and contract type as the dependent variable with the data collected by an original questionnaire survey. *Prima facie* the UK aerospace industry is appropriately modelled by the transaction costs approach, because asset specificity, uncertainty and complexity are evident in aerospace production and long term procurement. However, the aerospace industry is not unique, but it does correspond strongly to the approximate characteristics of transaction costs, especially in terms of the make-or-buy decision. On this basis, the UK aerospace industry is expected to provide an appropriate industry for the application and testing of transaction cost economics.

The thesis develops the concept of vertical integration in the UK aerospace industry, because the industry is characterised by complex contractual relationships between original equipment manufactures, the supply chain and the customer base. Aerospace

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[1] Many of the issues in modern aerospace firms are generic industrial problems, which are also relevant to other major areas of manufacturing, such as shipbuilding, telecommunications, pharmaceuticals and motor car manufacturing as well as service provision.

[2] The nature of make-or-buy decisions will be defined in Chapter Three.

is worthy of attention because issues of vertical integration are crucial for the future delivery of high cost and high risk aerospace projects and the continued profitability of aerospace companies in the long run (Jackson, 2004: 520). Furthermore, make-or-buy decisions and contract design aspects of the transaction cost approach are relevant, because the industry is typified by asset specific investment, technological intensity of design and development plus market uncertainty, where governments act as customer, sponsor and regulator (DTI-ITG, 2004: 27). In particular, outsourcing and long term contracts between firms within supply chain relationships are relevant to the performance of the current UK aerospace industry with the make-or-buy decision reflecting efforts to economise on transaction costs.

The transaction cost approach is potentially suited to assess the economic organisation and contractual features of vertical integration, because it focuses on the firm acting to minimise transaction costs as an efficient means of safeguarding specific investments compared with the monopoly power approach, which focuses on the firm generating monopoly rent by the control of inputs from factor markets and distribution (Klein, 2004: 1). However, the results of this research find little, if any, support for the transaction cost approach as applied in this thesis. The negative conclusion arises in spite of a positive predisposition towards the theoretical framework of transactions costs as an explanation for vertical integration. The next section presents the plan of the thesis.

Plan of the thesis

The thesis is divided into three areas. Part One assesses the UK aerospace industry and the transaction costs approach. Part Two analyses the research questions based on make-or-buy and contract design, plus the empirical analysis of aerospace firms and the related supply chain. Part Three presents the conclusions and directions for further research.

Part One applies the transaction cost approach to the modern aerospace industry in the UK. In particular, Chapter Two assesses the main features of the UK aerospace industry and suppliers from 1992 to 1997, which is the period covered by the survey. Chapter Three provides a literature survey of the current state of the transaction cost theory. It shows how the research problem can be modelled. Chapter Four focuses on the theory of transaction costs developed by Williamson (1975, 1985). It shows how the transaction cost economics study of UK aerospace can be made operational.

Part Two addresses the methodological issues which reflect the lack of published data. Chapter Five introduces the questionnaire survey of UK aerospace suppliers and the methodology of the approach. Chapter Six uses the original data from the questionnaire to construct company profiles. Chapter Seven assesses the transaction cost model in terms of make-or-buy and contract type as the dependent variable. Chapter Eight considers the transaction cost predictions using quantitative data on make-or-buy in the supply chain. Chapter Nine assesses the transaction cost approach in terms of contract design based on the hostage model (Williamson, 1983: 520). In summary, the research questions central to the thesis are addressed in Chapters Six and Seven on vertical integration; Chapter Eight on the make-or-buy decision and finally Chapter Nine on contract design (Williamson, 1985: 18-21).

Part Three presents the thesis conclusions and the implications for aerospace companies. In particular, Chapter Ten provides answers to the research questions and evaluates the operational aspects of the transaction cost model. Also, the need for further research is highlighted. The next Chapter presents a detailed analysis of the UK aerospace Industry (UKAI).

Chapter Two:
The UK Aerospace Industry

> "UK aerospace is an increasingly sophisticated and technologically advanced sector. The aerospace industry is global, fast changing with market opportunities opening across the developing world. Suppliers face intense global competition with pressures to reduce costs, improve quality and meet demanding delivery milestones."
>
> SBAC (2005: 5).

Introduction

This Chapter has three sections. Firstly, there is an introduction to the competing definitions of aerospace. Secondly, there is a presentation of the structure-conduct-performance (S-C-P) analysis of the UK aerospace industry (UKAI) and its supply chain. Finally, there is an assessment of the key features of vertical integration, where the S-C-P approach is used as a starting point for the analysis of markets and hierarchies (Williamson, 1975: 8). The theme of this thesis is that the make-or-buy decision and contract design within transaction cost economics provide a more detailed understanding of the firm than the S-C-P approach. The next section provides definitions of the UK aerospace industry.

Defining the UK aerospace industry

A working definition of actual aerospace production as a whole refers to *those firms involved in design, development, production, repair and support services of aircraft and helicopters for military and civil markets, together with missiles and space systems and related equipment, parts and components*. There are other ways by which to define and categorise the business activity of aerospace and related production. These alternatives are covered in this section. However, the guiding definition of the aerospace industry for this thesis is the one given above.

The UK aerospace industry is a composite of over 3,000 firms, which manufacture aircraft and missiles; plus sub-assemblies, components and provides services to the various UK aerospace programmes (DTI-IGT, 2003: 10). The output of the UK aerospace industry encompasses the production of the Eurofighter Typhoon combat aircraft, the BAE Systems Hawk trainer and Augusta-Westland EH101 helicopter as well as the Storm Shadow cruise missiles first used in the Iraq War in 2003; plus the wings for all the Airbus airliner programmes, including the A380 launched in 2005 and Rolls-Royce Trent aero-engines. In addition, UK firms are world leaders in ejector seats, head-up displays for pilots and in-flight refuelling systems (DTI-IGT, 2003: 5). In 2003, the aerospace industry in the UK employed 121,979 people[1] with an annual turnover of £17.08 billion. These figures include foreign-owned companies operating in the UK, but exclude UK-owned companies which operate overseas (SBAC, 2004: 6). The global distribution of employment and turnover for the UK aerospace industry in the UK, the US and the rest of the world (RoW) is shown in Table 2.1.

Table 2.1: Global turnover and employment in the UKAI, 2003

Geographical Local	Turnover (£ millions)	Turnover (%)	Employment (Number)	Employment (%)
UKAI in UK	17,080	76.3	121,979	75.5
UKAI in USA	4,090	18.3	30,249	18.7
UKAI in RoW	1,270	5.4	9,278	5.8
Global UKAI	**22,390**	**100.0**	**161,506**	**100.0**

Source: SBAC (2004: 6).

Table 2.1 shows that approximately three quarters of turnover and employment is generated by companies based in the UK (both UK and foreign-owned) and one quarter of global UKAI turnover and employment is generated by UK-owned subsidiaries in other countries, of which 75% is located in the strategic aerospace market of the USA (SBAC, 2004: 7). Some 95% of all UKAI activity is either in the UK or the US. The definition of what constitutes the UK aerospace industry is complicated by the global nature of the industry. However, for the purposes of this thesis, the UK aerospace industry will refer to production in UK territories whether UK-owned or not; and the production from UK-owned overseas subsidiaries is deemed to be outside the definition of UKAI. This definition is the one used by the Society of British Aerospace Companies (SBAC) when compiling its membership list used in the primary research in this thesis and is assessed in the next part of the section.

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[1] 2003 is the latest available data. SBAC is currently collecting questionnaire returns from its membership for data relating to the 2004 calendar year.

(a) The SBAC definition of aerospace

The SBAC definition differentiates between three product-related segments namely, aircraft, missiles and space with 95% of business activity in the first category. SBAC also identifies three industry-related sectors namely, aircraft and systems, engines and equipment. In theory, this generates a three-by-three matrix of aerospace activity as shown is Table 2.2, where the £17.08 billion UKAI turnover in 2003, comprises approximately 48% airframes, 22% engines and 30% equipment (SBAC, 2005).

Table 2.2: UK aerospace industry sector-segment mix

Product Sector	Aircraft and Systems	Aircraft Engines	Aircraft Equipment	Total
Aircraft	a	b	c	(a + b + c) = **95%**
Missiles	d	e	f	(d + e + f) = **2.5%**
Space	g	h	i	(g + h + i) = **2.5%**
Total	(a + d + g) = **48%**	(b + e + h) = **22%**	(c + f + i) = **30%**	**Grand Total (100%)**

Source: SBAC (2005: 30) with additions from the author.

The SBAC approach defines airframe production as the manufacture of the main exterior of the aircraft, including the fuselage, wings, nacelles and the tail. Aircraft engine production is the manufacture of the power-source of the aircraft to provide thrust on take-off, sustained flight and landing. Aircraft equipment production is the manufacture of all the other aspect of powered flight, including the avionics, electronics, electrical systems and mechanical controls for the cockpit interior, ancillary equipment for aircrew and aircraft maintenance apparatus.

The overall output of privately-owned aerospace firms is complex and is generally co-ordinated within the aerospace supply chain to achieve an efficient outcome. Indeed, the importance of aerospace supply chain logistics and efficiency is emphasised by Hartley and Braddon in a study of aerospace competitiveness (Hartley and Braddon, 2002: 2). The benefit of the SBAC definition is that is includes the multi-faceted nature of UKAI, because SBAC collects data on the basis of a survey of its membership. In addition, there is consideration of the development of highly specialised equipment and machine tools used in the actual manufacture of the aerospace components, for example, jigs, tools and dyes, which are a vital and necessary part of the UK aerospace industry. These are covered by the SBAC definition of the UKAI.

(b) The SIC (92) definition of aerospace

A definition for aerospace production can also be generated using the Standard Industrial Classification (SIC) codes from 1992, where the aerospace industry is mainly located in SIC (92) 3530, the manufacture of aircraft and spacecraft. Table 2.3 shows the position of aerospace production in the SIC (92) codes in comparison to other transport production such as shipbuilding and railway manufacturing.

Table 2.3: SIC (92) codes of grouping 350

SIC (92) code	Description of activity
351	Building and repair of ships and boats
352	Manufacture of railway, tramway locomotives and rolling stock
353	**Manufacture of aircraft and spacecraft**
354	Manufacture of motorcycles
355	Manufacture of other transport not elsewhere specified

Source: Standard Industrial Classification, UK National Statistics (NS) 2005.

However, a significant proportion of aerospace activity is not located in the 35 two digit code. As a consequence, representation of the aerospace industry by the SIC codes tends to be incomplete, because some of the major suppliers are located outside the SIC definition of **3530**. For example, Rolls-Royce have a primary SIC (92) code of **2911**, (manufacturer of engines and turbines except aircraft, vehicle and cycle engines), whilst other military aerospace suppliers have the SIC (92) code of **2960**, (manufacture of weapons and ammunition) and civilian aerospace suppliers have the SIC (92) code of **3162**, (manufacture of other electrical equipment). Furthermore, many aspects of aerospace production are located in four digit code **3320** (electronic air navigational instruments and systems, guided weapon launching and automatic pilots) and **3330** (manufacture of industrial process control equipment) and not **3530**. Hence, there is a problem of consistency with the SIC (92) approach when defining the UKAI.

In the MM19 Aerospace and Electronics Cost Indices published by the UK National Statistical Office the two SIC (92) codes used for aerospace are:

1. **3530**: The manufacture of aircraft and spacecraft.
2. **2960**: The manufacture of weapons and ammunition.

The Annual Business Inquiry (ABI), which is also part of the data of UK National Statistics Office generates UK data using the SIC (92) coding by sampling businesses by employment size and industry sector. Table 2.4 shows the total turnover, the total employment and the number of enterprises specified by both the **3530** and **2960** from the ABI database. Table 2.4 presents ABI data showing that the weapons and ammunition sector is about 10% of the size of the aircraft and spacecraft sector of UKAI in terms of total turnover and employment.

The main difference between the SBAC data and the ABI data is the method of information collection. SBAC, as a trade association, collects data through a survey of its membership on an annual basis using the definitions from the matrix in Table 2.2. ABI, as a government agency, collect data through a sampling process of industrial activity based on the definitions of the SIC (92) coding. In particular, electronic and mechanical equipment used in UKAI is coded as **3310** and **3320**, but not as **3530** under the SIC (92) codes. However, these areas are covered in the SBAC definitions.

Whilst it has been proposed that air navigation instruments and systems plus automatic pilots and guided weapons gear be relocated from **3330** to **3530** in order to standardise the definitions of the UKIA it is not proposed to move any parts of **3310** or **3320** (www.statistics.gov.uk). Moreover, a similar suggestion is to relocate satellite production from **3530** to **3220** (manufacture of radio and television transmitters and apparatus for line telegraphy) and if implemented would mean an estimated 4% or £0.6 billion of UK aerospace turnover would be removed from the UKAI. Indeed, 30% of the UKAI (as defined by SBAC) could be relocated to other non-aerospace areas, if proposed convergence code changes are implemented by the UK National Statistical Office in 2007. Overall, the ABI-proposed redefining of aerospace categories in the UK is incomplete and does not fully identify the boundaries of aerospace production in the UK, in spite of SBAC sponsoring some of the data collection for ABI.

Table 2.4: Annual Business Inquiry analysis of UKAI by SIC (92) codes

SIC (92) Code	Calendar Year	Total Turnover (£ million)	Number of Enterprises (Number)	Average Total Employment (Number)
2960 Weapons & Ammunition	1995	1,711	181	n/a
	1996	1,671	145	n/a
	1997	1,974	164	n/a
	1998	1,886	159	17,000
	1999	1,850	163	17,000
	2000	1,693	160	15,000
	2001	1,627	159	15,000
	2002	1,638	147	14,000
	2003	1,928	149	14,000
3530 Aircraft & Spacecraft	1995	9,639	1,212	n/a
	1996	11,697	766	n/a
	1997	17,721	971	n/a
	1998	17,601	875	114,000
	1999	17,623	800	116,000
	2000	17,050	811	119,000
	2001	17,387	769	115,000
	2002	15,091	716	106,000
	2003	15,354	664	101,000

Source: Annual Business Inquiry (ABI: 2005): www.statistics.gov.uk

Overall, the difference between the SBAC and the ABI approach to methodology is apparent in the data collected, which is presented in Table 2.5. In particular, the ABI turnover data tends to be greater than SBAC although the two sets of data are close to converging in 2003. The SBAC employment data tend to be greater than ABI except in 2002. This is an unsatisfactory situation as it indicates inconsistency in the collection of the data. ABI and SBAC are working together in the future, in spite of the different methods of data collection between the two organisations, which may result in a structural break in the data as the two methods are harmonised.

Table 2.5: Comparisons between ABI and SBAC

Year	Combined ABI Turnover (£ million)	Combined ABI Employees (Number)	SBAC Turnover (£ million)	SBAC Employees (Number)	ABI / SBAC Turnover (%)	ABI / SBAC Employees (%)
1998	19,487	131,000	17,000	155,000	114.6	84.5
1999	19,473	133,000	17,600	154,000	110.6	86.4
2000	18,743	134,000	18,200	150,000	103.0	89.3
2001	19,014	130,000	18,420	147,000	103.2	88.4
2002	16,729	120,000	16,120	117,000	103.8	102.6
2003	17,282	115,000	17,100	122,000	101.1	94.4

Source: ABI (www.statistics.gov.uk) and SBAC (www.sbac.co.uk)

Table 2.5 confirms that the definitions of aerospace are complicated and using cross-referenced data can compound the issue. The problem of defining the UKAI is because many different engineering disciplines are applied to a specific mode of output. It is worth identifying the engineering aspects of aircraft, spacecraft and missile production in order to fully review the definitions of aerospace.

(c) Engineering output definitions of aerospace

There are alternative definitions of aerospace that involve assessing the engineering aspects of aircraft and spacecraft, which cover the physical characteristics of the output. The physical characteristics include:

1. Fixed-wing aircraft, such as combat jets.
2. Rotary-wing aircraft, such as helicopters.
3. Specialist aircraft types, such as micro-lights.
4. Other products, such as missiles and satellites.

The majority of aircraft produced are fixed wing, but there are a significant number of rotary-wing aircraft for military uses and a variety of leisure and commercial purposes. In terms of technology definitions, the Civil Aircraft Research and Technology Demonstration (CARAD) divide aerospace equipment into four key areas. This also gives a concise insight into a technological definition of the industry. The four main areas show the complexity of aircraft production and the level of advanced integration between airframe, engine and equipment. These categories are:

1. Aerodynamics.
2. Propulsion systems.
3. Materials and structures.
4. Advanced systems.

Aerodynamics is defined as the physical processes which underpin aircraft design and govern the performance of flight. Essentially, this is the design of the central fuselage and wings of the aircraft. Companies in this part of the aerospace industry are involved with the aircraft flight specifications and the aerodynamics of thrust and drag. Propulsion systems are defined as the engine of the aircraft, but would include work on the power-plant evolution and control, noise, compressors, turbines, and combustion. Companies in this part of the aerospace industry are involved with the engine performance, efficiency and reliability. Material and structures cover all generic aspects of the airframe structure and engine components. This would include the stress requirements, heat properties and durability of metals, fabrication and composite materials. Companies in this part of the aerospace industry are involved with physical properties of landing gear, wings, nacelles, propellers, aero-engines and others manufacturing. Advanced systems are defined as the electronic and electrical systems, power plant and flight deck systems of the aircraft. Companies in this part of the aerospace industry are engaged with advances in computer hardware and software of aircraft production and hence there are strong links with the electronics industry. There are aspects of overlap between these four areas that need co-ordination between suppliers, quite apart from the complexity of aircraft integration and assembly.

The relevance of this definition is that it permits the full range of aerospace activity to be shown, since only a limited number of aerospace suppliers actually manufacture complete aircraft For example, BAE Systems produces combat aircraft such as the Eurofighter Typhoon in military markets; and produces the wings for Airbus airliners in civil markets, where BAE Systems owns Airbus (UK). The wider narrative of UKAI production is covered in the engineering output definitions even though they are not dissimilar to the SBAC or ABI definitions above. Given that manufacturing in aerospace is carried out by many firms, then it is worth assessing the definitions of aerospace from the viewpoint of the supply chain, which is the collective term for all firms engaged in production.

(d) Supply chain definitions of aerospace

In terms of the supply chain, the definitions are shown in Table 2.6, which highlights the distribution of firms in the UK aerospace industry. Tier 1 contains the major prime contractors such as BAE Systems, which are also known as super-primes, because these firms integrate and assemble aircraft, satellites and missiles. Tier 2 contains an array of large and medium-sized suppliers such as Dowty Aerospace (flight control systems) and Martin Baker (ejection seats), which supply major equipment and main components. Tier 3 contains a wide range of firms including small and medium-sized enterprises (SME), which supply minor components, parts and services to the other firms in the supply chain, in addition to larger firms who supply only a small proportion of their output to the aerospace industry such as British Steel. This situation further explains why the SIC (92) definitions of UKAI are inadequate, because the aerospace industry uses suppliers that are an integral part of the aerospace supply chain for bespoke components, as well as more generalist suppliers for generic components. These firms form part of the wider manufacturing base of UK industry as a whole, which are included in the SBAC definitions of the UKAI.

Table 2.6: Key characteristics of the UK aerospace supply chain

Tier	Type of firm	Product type	Examples
1 primes	Large-sized and major prime contractors	Aircraft, engines and missiles	BAE Systems Rolls-Royce
2 (i) large	Large-sized equipment manufacturers	Systems/sub-systems and major equipment	Dowty Aerospace Smiths Industries
2 (ii) medium	Medium-sized equipment manufacturers	Structure elements and main components	Pilkington Aerospace Martin Baker
3 various	Variously sized component manufacturers	Materials, processes, software and services	Aerospace Metals Hi-Shear

Source: Based on DTI-IGT (2003: 27).

The industry as a whole can be divided into two further categories of final end-use, namely, civilian aerospace and defence or military aerospace. The first category is the production of passenger, freight and general aircraft (fixed-wing and rotary-wing or helicopter) and satellite systems used for commercial activity and accounted for 51% of UK aerospace turnover in 2003 or £8.78 billion (SBAC, 2004). The second category is the production of aircraft, missiles and spacecraft for military purposes and accounted for 49% of UK aerospace turnover in 2003 or £8.30 billion. Across the European aerospace industry as a whole, civilian aerospace accounted for approximately 70% of turnover in 2003 and military aerospace (including missiles and space) only 30% (AECMA, 2003). This evidence shows the relatively heavy reliance in the UK on military markets due in part to the historical legacy of post-war European defence activity in which Britain has been significantly involved as a former world power as well as the European focus on civil aircraft post-1945.

At the next level military aircraft markets can be divided into fighter, attack, transport, support, and reconnaissance aircraft, reflecting the operational capability of aircraft. In addition there are multi-role aircraft such as Tornado now supplied by one firm. Likewise, civilian aircraft markets can be divided into passenger, freight, sport, regional and business aircraft, reflecting the function or role of the various aircraft and more general aviation, including light aircraft. The relatively straightforward bifurcation of the aerospace industry belies the fact that there can be much overlap between the sectors in terms of cross-over in research, design and production that has led to many spin-offs, for example, the application of the jet engine from defence to civilian aircraft. Nevertheless, the split between defence and civilian aerospace remains a useful way to distinguish the output of companies in the supply chain, in spite of the production of both categories by many firms[2].

In summary, the definitions for core activity in the aerospace industry are not always able to fully capture the complexity of the industry, even though it is possible to categorise output by key factors, such as aircraft part or type of market. The issue of defining the UKAI means that care should be taken when using cross-sourced data

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[2] In the literature, defence and military are used interchangeably as terms of description and so is civilian and commercial. The terms defence and military closely match one another, civilian and commercial do not since defence aircraft can be bought and sold via commercial means, for example. Hence in this thesis, only civilian will be used to describe non-military or non-defence aircraft.

comparisons. The working definition of aerospace which was stated at the start of this section is used throughout the remainder of thesis whilst acknowledging the diversity of the output from the industry, including the global nature of the markets as captured by the SBAC definition. The next section will analyse the aerospace industry by assessing the leading firms in aerospace markets through the Structure-Conduct-Performance (S-C-P) approach (Mason, 1939: 61).

Structure-Conduct-Performance in the UK Aerospace Industry

The S-C-P paradigm provides a fundamental framework for analysing an industry (Williamson, 1975: 90). The approach allows an appraisal of an industry in terms of the structural characteristics, for example, vertical integration, the number of sellers and entry barriers. Then the mode of conduct is assessed, for example, pricing policy and R&D input, followed by an analysis of the allocative performance, such as profit and price-marginal cost relationships. The simple relationship between structure, conduct and performance is shown in Table 2.7 and the line of causation runs from structure to conduct and then to performance as indicated by the arrows. However, reverse linkages are also possible where conduct can affect market structure and where performance can affect market conduct (Clarke, 1985: 3).

The S-C-P approach is considered appropriate for any industry, because it generates a detailed description of the framework for analysing markets. It allows an analysis of the leading companies, which provides an assessment of market concentration and indicators of conduct and performance such as prices and profit, respectively. The S-C-P framework provides a starting point for analysing the UK aerospace industry before applying transaction costs (Williamson, 1975: 6-7).

The S-C-P approach has provided a systematic approach since the original contribution to industrial economics by Bain (1956). In an investigation of vertical integration it is important to assess the underlying characteristics of the markets including the supply and demand conditions before addressing the make-or-buy decision. According to Clarke (1985: 3) the S-C-P paradigm begins with an understanding of the basic conditions of demand, including costs, scale economies and technology. In aerospace, such an assessment would focus on the key role of government procurement on the demand side (military and civil), the rising unit cost of aircraft (in real terms), learning curve effects and the significant technical change over time that is R&D progress (Jackson, 2003: 78-79).

Table 2.7: The Structure-Conduct-Performance paradigm

STRUCTURE
• Number of competing firms • Market concentration • Barriers to entry • Organisational form

↕

CONDUCT
• Pricing policy • Product differential • Research and development

↕

PERFORMANCE
• Industrial profitability • Productive efficiency • Employment • Technical advance

Sources: Clarke (1985: 3) and Douma and Schreuder (1998: 153).

In general, the UK aerospace industry is currently experiencing a period of profound economic change, due to a combination of market and technological uncertainties in both defence and civilian markets (Hartley and Braddon, 2002: 1). The S-C-P approach can be used to assess the market conditions and the structural factors that determine conduct and in turn performance in advance of the more detailed analysis of vertical integration within a transaction cost framework. The next sections will assess the market structure, market conduct and market performance for the UKAI within the S-C-P paradigm.

Market Structure

Table 2.7 shows there are four main aspects to market structure, which are the number of competing firms, market concentration, barriers to entry and organisational form (*i.e.* horizontal and vertical integration). Each aspect will be covered separately.

(i) Number of competing firms

In terms of the number of firms in the aerospace industry, the key companies in the UKAI include BAE Systems plc (fixed wing aircraft); Augusta-Westland Limited (now owned by Finmeccanica, Italy: rotary wing aircraft); MBDA (internationally-owned: missile systems) and Rolls-Royce plc (aero-engines). The number of firms in an industry can be assessed with reference to the supply chain[3] which is simply defined as the business-to-business links between firms that often exists between various stages of the production process. It is usually specified in levels, with level one defined as final assembly, level two as major sub-components and level three as other parts and raw materials as identified in Table 2.6.

Aerospace companies in the first tier of the supply chain can assemble or manufacture aircraft as a prime contractor (*e.g.* BAE Systems: Hawk) or as part of a consortium with leading companies from Europe (*e.g.* Eurofighter Typhoon) and North America (*e.g.* BAE Systems (formerly British Aerospace) and Boeing Harrier/AV-8)[4]. However, not since the Second World War has a single aircraft manufacturer been able to manufacture all the primary parts of an aircraft programme, which explains why the issue of vertical integration in the aerospace industry is important[5]. This is because the other aerospace firms in the supply chain offer economies from specialist knowledge, so that the make-or-buy decisions affect profitability. However, make-or-buy choices vary over time and can be different for every firm hence the issue of supplier-switching is relevant. Prime contractors have to decide whether to undertake work in-house or buy-in from suppliers.

The companies in both segments of the second tier research, develop and manufacture the major sub-assemblies, substantial parts and sizeable apparatus of the aircraft, for

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[3] The supply chain is an imperfect metaphor, but the convention is adopted here.
[4] The USA version of the Harrier is known as the AV-8 (where AV = Attack Vertical).
[5] Similarly, neither a single designer nor one test pilot been solely associated with an aircraft project over this period either, which tended to happen in the pre-war period.

example, avionics equipment (GEC-Marconi Avionics Limited, now part of BAE Systems). The third tier of the supply chain manufactures smaller parts and components or supply raw material for the aerospace industry. This would include steel and titanium (Aerospace Metals Limited), aerospace paint and coatings (AD Aerospace Finishes Limited and Courtaulds Aerospace Europe), aerospace wiring harnesses (Kembrey Wiring Systems), cockpit windows (Pilkington Aerospace Ltd) and aerospace filters (Fairey Mircofiltex Limited). In general, the make-or-buy decision informs the extent of the supply chain through the propensity to out-source components and parts: this where transaction cost analysis is relevant. In sum, the number of firms in UKAI indicates a domestic oligopoly where there a few key suppliers. Some firms have a domestic monopoly such as BAE Systems and all firms face the potential threat of foreign competition.

(ii) Market concentration

In terms of market concentration, the top five firms by rank order in 1997 (the year of the thesis survey) were British Aerospace, Rolls-Royce and Dowty Aerospace, the aerospace division of Smiths Industries and Matra-Marconi Space (now MBDA). This information is shown in Table 2.8. BAE Systems (formerly British Aerospace plc) is the largest single aerospace and defence-related company in the UK and has major defence programmes (*e.g.* Eurofighter Typhoon) and civilian contracts (*e.g.* Airbus wings) in its overall engineering portfolio. The next company is Rolls-Royce plc with a similar portfolio of projects for aero-engines. As a result the aerospace supply chain tends to be specified around the needs of the large prime contractors such as Airbus Industries (European civil aerospace), Boeing (North American civil aerospace) and Eurofighter (European military aerospace). By 2003, BAE Systems had a turnover of £8,387 million employing 68,700 people following a merger with GEC-Marconi and in the same year Rolls-Royce had a turnover of £5,645 million employing over 36,000 people. Table 2.8 details the top fourteen leading UK aerospace companies in alphabetical order, where all these companies are represented in the thesis survey in 1997. In the interim the top 14 companies have changed, in particular the creation of BAE Systems, but for the purposes of this thesis it is considered appropriate to use the original database from 1997 to generate the concentration ratios.

Table 2.8: The leading UK aerospace suppliers in 1997

The name of UK Aerospace Company	Turnover (£ million) (a)	Employees (number) (b)	Aerospace Turnover % (c)	Turnover (£ million) (a x c)
British Aerospace plc	7,267	43,400	95	6,904
Cobham plc	323	4,260	80	258
Dowty Aerospace Ltd	661	614	100	661
GEC-Marconi Avionics Ltd	283	3,656	95	269
GKN Westland Limited	9	277	100	94
Hunting plc	1,316	12,592	17	224
European Gas Turbines Ltd	280	2,761	80	224
Matra-Marconi Space Ltd	400	2,694	100	400
Meggitt plc	265	3,767	90	239
Penny & Giles plc	35	446	80	32
Rolls-Royce plc	4,334	42,600	70	3,034
Siemens Plessey Ltd	216	2,405	45	97
Short Brothers Ltd	353	8,158	100	353
Smiths Industries plc	1,076	13,582	40	431
Total of top 14 sample	**16,818**	**141,212**	**N/A**	**13,220**

Source: FAME (1998) database.

From the data in Table 2.8, it is possible to calculate the concentration ratio for the UK aerospace industry in 1997, which is the year of the thesis survey. Column (a) is the turnover per company of the top aerospace companies and includes non-aerospace business. Column (c) is the proportion of aerospace turnover expressed as percentage of the total turnover. Multiplying column (a) by column (c) provides the proportion of company turnover accounted for by aerospace business. SBAC have calculated that in 1997, the UK aerospace industry sales were £15,100 million. The top five firms account for 75.4 % of total industry sales and the top three firms account for 70.2%, which is typical of manufacturing industry in the UK (Hay and Morris, 1991: 533-534). In other words, apart from the top three firms the remaining companies in the supply chain account for only 29.8% of the value of the industry. Similarly, the share of the industry for BAE Systems alone is 45.7% and 20.1% for Rolls-Royce plc. The concentration ratio for the top 14 UK aerospace companies in Table 2.8 is 87.5%. This indicates that the UK aerospace industry is very highly concentrated indeed with a scale monopoly where one firms had a market share in excess of 25%, namely BAE Systems. These concentration measures are also in line with motor manufacturing, pharmaceuticals and shipbuilding. It also indicates that monopoly power is relevant to the industry and is appropriate for applying the S-C-P approach.

(iii) Barriers to entry

To generate meaningful data on barriers to entry is a problematic exercise in industrial economics (Hay and Morris, 1991: 86). However, it is a worthwhile exercise assessing some of the scale of the incumbent companies, which could act as a financial or logistical barrier for new entrants in the markets. Firstly, BAE Systems and Rolls-Royce had R&D costs of £1,099 million and £281 million, respectively in 2003, (DTI-IGT, 2003). R&D costs are regarded as a proxy for investment and as such can be viewed as a barrier to entry for any potential new entrant, because with huge sunk cost the short run profits are unlikely to induce new entrants in to the market. Indeed, spending on R&D in the UK aerospace industry is currently at 5% of turnover (DTI-IGT, 2003: 31). Other potential barriers to entry include the role of the UK government as a domestic monopsonist in defence procurement who tend to source from UK suppliers, the high costs and high-risk nature of aircraft programmes, long development lead-times and the low volume output of high value products (DTI-IGT, 2003: 27). Cumulatively, a combination of these factors in aerospace shows that the industry is significantly difficult to penetrate by new entrants as the costs are high, the risks are significant and the rewards relatively modest. As a result, 'hit-and-run' entry is an unlikely option for manufacturers in related industries such as ship-building. The resulting conclusion is that UK aerospace is not a contestable market as developed by Baumol (1982: 1-2) where sunk costs are zero and incumbent firms are not protected from the potential threat of new entrants.

(iv) Organisational form

In terms of organisational form, the relatively limited number of UK aerospace suppliers is suggestive of a complex monopoly in domestic markets. The UK aerospace sector has a low propensity to import, even though there is the potential for foreign competition. BAE Systems and Rolls-Royce, both created through merger, nationalisation and later privatisation, are clearly the two main domestic UK aerospace prime contractors, for aircraft and aero-engines, respectively. On the other hand, there are scores of companies with an annual turnover less than £10 million in the supply chain, which suggests firms are not vertically integrated and rely on out-sourcing. For example, from the survey Electtronica (UK) Limited have an annual turnover of less than £2 million, but conducts specialist research into electronic warfare and flight line testing equipment. Similarly, there is Hi-Shear Fasteners Europe Limited with an annual turnover of £16 million to supply airframe fasteners at a unit cost of less than £1. This illustrates the point that the larger firms may prefer to outsource from specialist firms rather than make in-house.

The analysis of organisation form within market structure identifies one of the main weaknesses of the mono-causal S-C-P approach. The simple S-C-P approach assumes structure is exogenously determined and there is no indication about how market structure is shaped in the first place. There needs to be an explanation of market structure, because previous conduct and performance will influence existing structure. This is where the make-or-buy decision within the transaction cost approach is useful because it begins to explain the existence of firms in the first place and views the structure as being determined endogenously. The final section of this Chapter returns to this criticism of S-C-P paradigm, because this is a primary motive for using the transaction cost approach to analyse vertical integration within organisational form.

Overall, there is strong and compelling evidence of a highly concentrated market structure in the UK aerospace industry. The UK aerospace industry in both the civilian and defence sectors can be viewed as a scale monopoly and by 2003 BAE Systems has a market share in aerospace and defence of 37.5%[6] in excess of 25%, which is the official definition of a monopoly. The purchase of GEC-Marconi by BAE Systems is further evidence of a complex monopoly in the industry and vertical integration by the major UK aerospace suppliers. The market structure is also shown by the huge entry costs and government procurement policy, which act as barriers to entry. However, rivalry within the UKAI defence and civil markets could be and is achieved via foreign competition. Given the potential for domestic monopoly power, the S-C-P paradigm predicts there is scope for price setting and collusion in conduct and opportunities for

[6] The 2004 R&D Scoreboard presents BAE Systems sales equal to £8,387 million from a total of £22,347 million for aerospace and defence as a whole.

high growth and super-normal profit in performance. In summary, the market structure of the UK aerospace shows a highly concentrated industry, which means that the make-or-buy decision is an important aspect of vertical integration because it helps to determine the economic nature of the firm. The next section assesses the market conduct of the aerospace industry in the UK.

Market Conduct

Table 2.7 shows market conduct includes an appraisal of company pricing policy, non-price competition and research and development (R&D).

(i) Pricing policy

A major issue experienced by UK aerospace firms includes the supply-side issues of rising unit costs between aircraft programmes, plus the demand-side issues of decreasing order size and uncertain military budgets. Figure 2.1 shows the supply-side problem of rising unit cost in the global military aerospace industry, where the horizontal axis represents time and the vertical axis is an index-linked comparison of aircraft at constant prices. In the UK, BAE Systems claims that the comparative unit costs of front-line combat aircraft have declined relative to those in the US. However, Eurofighter and Tornado remain more expensive than the previous generation of UK military aircraft, namely the Lightning and the Phantom, indicating the supply-side pressure of rising unit costs. At this stage it is too early to predict where the F-35 Joint Strike Fighter programme (JSF) will fit into the picture, but the expected development contract is $19,000 million in 2005 prices (www.jsf.mil).

In general, there have been at least two main consequences of rising unit costs for military aircraft. The first consequence is an income effect as there has been a reduction on the demand-side. The second consequence is a substitution effect as rising unit costs have affected the armed forces[7]. Figure 2.1 highlights the effects of unit costs increasing over time. At the same time, the order size is decreasing but this is not shown on Figure 2.1.

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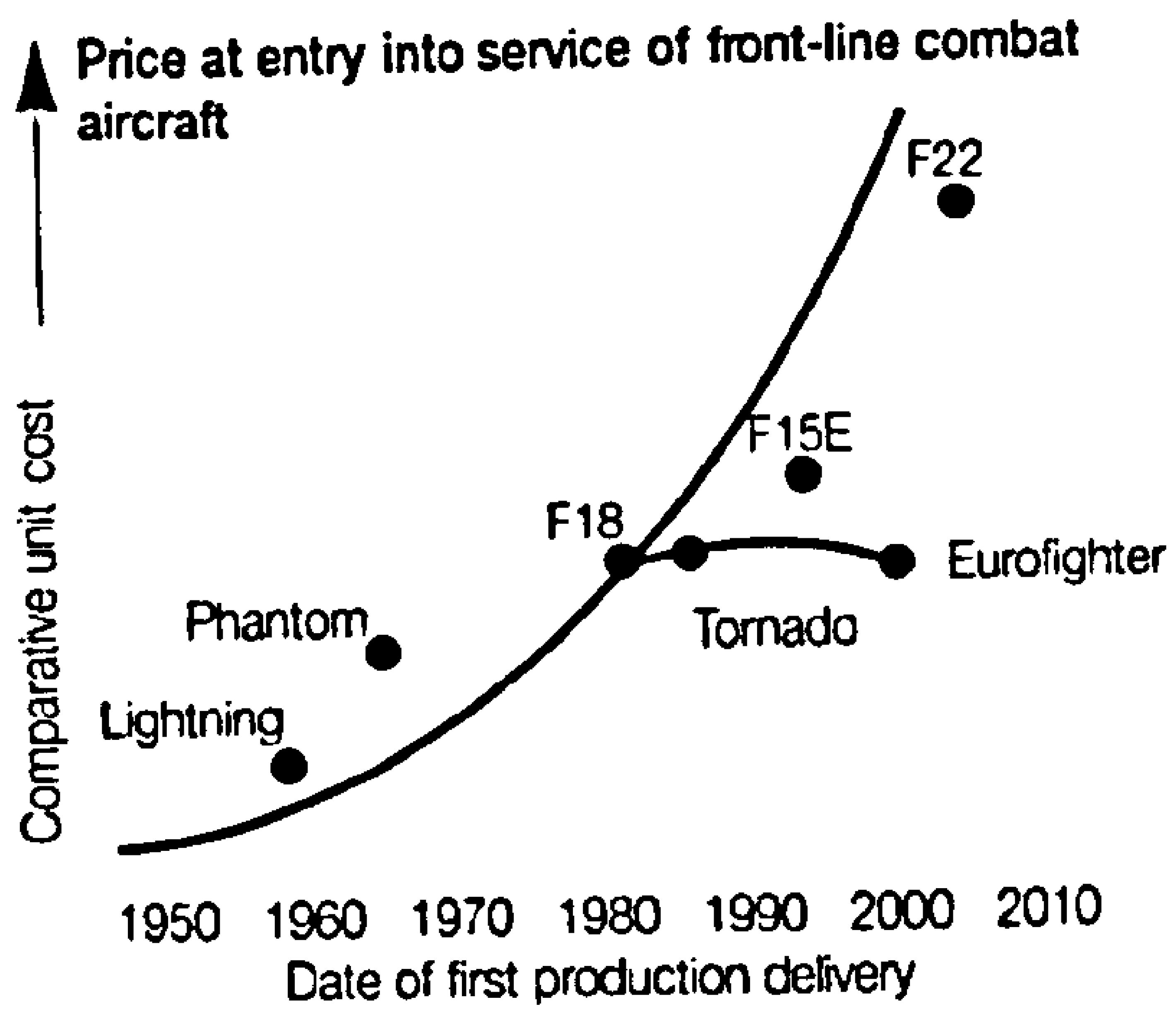
[7] For example, the total number of Tornado aircraft in the UK is 398; whereas for the next generation of the aircraft to replace this aircraft, the Typhoon, the total number is only 232.

Figure 2.1: Rising unit cost of military aircraft



Source: British Aerospace Annual Report and Accounts (1997).

(ii) Product differentiation

In terms of product differentiation, many suppliers exist due to specialist knowledge or being more competitive on price than internal departments at either BAE Systems plc or Rolls-Royce plc. The larger firms tend not to compete solely on price or even quality and buy from the market rather than make. Non-price competition has important consequences for the overall make-or-buy decisions in aerospace supply chain. If national defence agencies or civilian airlines require lower unit costs, then these contracts may only be achievable with substantial outsourcing to suppliers with lower overheads and hence the concept of the flexible firm with specialist know-how. In turn, this means improved supply chain management between the larger multi-national, publicly quoted corporations and the myriad of smaller suppliers, which are often independent. There is a dilemma for the industry as a whole, namely to outsource means a firm can be more competitive, but this also requires greater project management ability and supervision skills of commercial contracts, which ensures that agents (*e.g.* suppliers) depend on the principal (*e.g.* buyer)[8]. Indeed, a fallacy of composition argument may be applied against outsourcing, that is, what is good for a firm, may not be good for the industry, especially in terms of long-term competitiveness (Hartley and Braddon, 2002: 1). In other words, whilst outsourcing

[8] Of course, outsourcing may yield positive externalities for the firm. BAE Systems currently have military aircraft project management skills, which can be transferred to other defence projects.

has the potential to reduce costs within an aerospace firm, it changes the source of production in the future capacity for the aerospace industry.

(iii) Research and development

A major feature of UK aerospace is the level of expenditure on R&D, which in turn affects market conduct, because of the need to invest in R&D in the products and for the future profitability of firms and the industry as a whole. Table 2.9 shows the basic parameters of R&D spend for the UK aerospace and defence industry in 2003-04, including relative measures of R&D for the main firms in comparison with an all industry composite. The UK aerospace and defence industry is R&D-intensive and spends four times the all industry average on R&D as a percentage of sales and two and half times the all industry composite on R&D per employee.

Table 2.9: UK aerospace and defence company R&D for 2003-04

Company Name	R&D (£ million)	R&D % of sales	R&D per employee (£)
BAE Systems	1,099	13.1	16,000
Airbus (UK)**	349	21.3	39,000
Rolls-Royce	281	5.0	7,800
Smiths	130	4.2	4,100
Cobham	40	4.9	4,500
Meggit	20	5.0	5,700
Dunlop Standard Aerospace*	17	3.8	4,400
Ultra Electronics	13	4.5	5,100
AMS**	9	1.9	2,200
Alvis	6	1.7	2,200
Chemring	5	3.9	2,900
VT	1	0.2	100
Thales Optronics**	1	1.6	2,000
Aerospace & Defence Total	**1,972**	**8.8**	**10,700**
All industry composite	**16,599**	**2.1**	**4,300**

Source: 2004 R&D Company Scoreboard: Company data (DTI, 2004).

*Company not listed on the London Stock Exchange as it is owned by BAE Systems.

**Company is a subsidiary of a foreign-owned parent company.

The data also shows that BAE Systems, Airbus in the UK and Rolls-Royce are the major contributors to UK aerospace and defence R&D expenditure in absolute terms (R&D expenditure) and in relative terms (R&D per employee). In particular, BAE Systems accounts for 56% of all the UK aerospace and defence R&D expenditure and collectively the top three firms account for 88% of the UK aerospace and defence R&D expenditure. These figures confirm that R&D is heavily concentrated in the top three firms. As a result, the relative measures of R&D as a percentage of sales and R&D per employee may be skewed by the performance of the top three firms. Further evidence of this situation is that only Airbus in the UK and BAE Systems perform better than the all industry composite on the relative measures of R&D per employee and R&D as a percentage of sales.

A comparison of the UK aerospace and defence industry with other UK industries is presented in Table 2.10 and shows that the UK aerospace and defence accounts for approximately 12% of all UK R&D compared to almost 40% by the UK pharmaceutical and biotechnology industry. The results confirm that aerospace has performed well in comparison to automobiles and electronics, but less well in comparison with another R&D-intensive industry, namely pharmaceuticals and biotechnology. Whilst the aerospace and defence industry spends over twice the industry level on R&D per employee than the electronics and electrical, the pharmaceuticals and biotechnology industry spends three times as much as aerospace on the same measure implying aerospace and defence may be relatively less innovative when compared to the most R&D-intensive parts of UK industry (Jackson, 2003: 83).

Table 2.10: Comparison of UK aerospace R&D for 2003-04

Industry	**R&D (£ million)**	**R&D % of sales**	**R&D per employee (£)**
Aerospace & defence	1,972	8.8	10,700
Automobiles & parts	1,140	4.6	8,800
Electronics & electrical	581	2.6	3,700
IT Hardware	951	7.2	16,600
Pharmaceuticals & biotech	6,516	15.5	31,100
All industry Composite	**16,599**	**2.1**	**4,300**

Source: 2004 R&D Company Scoreboard: Company data (DTI, 2004).

The international comparison of R&D expenditure by other aerospace and defence firms is presented in Table 2.11. In 2003-04 UK and European companies account for 59% of the total international aerospace and defence R&D expenditure. The aerospace and defence firms in France and Italy generally spend more on R&D per employee and as a percentage of sales than the aerospace and defence sector as a whole. In particular, the US defence and aerospace firms consistently spend under 5% of sales on R&D or under £5,000 on R&D per employee. There is an implicit corporate policy by American firms using these relative measures, which is not followed by UK and European firms. That is, the US aerospace and defence firms possibly aim to achieve a target of R&D spend approximately 5% of sales in order to maximise shareholder value; or alternatively there may be relatively more government funded R&D in Europe than the US. However, further analysis of corporate governance is beyond the scope of this thesis.

Table 2.11: International aerospace & defence R&D for 2003-04

Company Name	**R&D (£ million)**	**R&D % of sales**	**R&D per employee (£)**
EADS (Holland)	1,545	7.3	12,409
BAE Systems (UK)	*1,099*	*13.1*	*16,000*
Boeing (USA)	922	3.3	5,900
Finmeccanica (Italy)	865	16.4	19,200
Lockheed Martin (USA)	504	2.8	3,900
Snecma (France)	440	9.7	11,100
Honeywell (USA)	420	3.3	3,900
Rolls-Royce (UK)	*281*	*5.0*	*7,800*
Raytheon (USA)	272	2.7	3,500
Thales (France)	268	3.6	4,700
Northtrop Grumman (USA)	223	1.5	1,800
General Dynamics (USA)	158	1.7	2,300
Aerospace & defence	**7,653**	**4.6**	**6,500**

Source: 2004 R&D Company Scoreboard: Company data (DTI, 2004).

Overall, the section on conduct has shown there are significant cost issues in UK aerospace including the rising unit costs rather than price *per se*. The role of R&D is also shown to be significant in the conduct of UK aerospace firms, even though the level of R&D invested is below the UK pharmaceutical and bio-technology industry, but nevertheless compares favourably with international comparisons in the same industry. The next section assesses market performance of the UKAI.

Market Performance

Table 2.7 shows market performance can be measured in terms of industrial profitability, productive efficiency, employment and technical change.

(i) Industrial profitability

The performance of the UK aerospace industry is generally highly profitable with year-on-year growth reported by firms (Hartley and Braddon (2002: 4). In terms of market performance it is possible to assess the profit and value added nature of the UK aerospace industry. Table 2.12 shows the relative value added measures of the industry at the firm level for the main EU aerospace companies. The UK aerospace and defence firms compare well against other European firms in the sector for value added per employee **(P1)** and value added as a percentage of costs **(P2)**, but below 'all companies' on the Value Added Scoreboard for P2. BAE Systems generates profit as a percentage of sales above the aerospace and defence average, but below 'all companies' whereas Rolls-Royce is below the mean for both measures.

Table 2.12: EU and UK aerospace comparative value added for 2003-04

Company Name	Value added (£ million)	**P1:** VA per employee (£)	**P2:** VA % of costs (%)	Profit % of Sales (%)
EADS (Holland)	7,330	67,200	113.2	1.9
BAE Systems (UK)	4,133	60,000	129.6	5.1
Thales (France)	3,110	54,100	n/a	2.3
Finmeccanica (Italy)	2,213	49,200	122.9	5.6
Rolls-Royce (UK)	2,097	58,100	117.6	4.4
Snecma (France)	1,931	48,600	122.6	6.0
Smiths (UK)	1,285	48,100	134.8	10.7
Dassault (France)	937	77,700	144.3	12.1
SAAB (Sweden)	7680	58,500	117.0	7.1
Zodiac (France)	531	47,600	n/a	11.4
Cobham (UK)	448	49,900	147.5	15.4
Aerospace & defence	**25,229**	**57,700**	**121.4**	**4.5**
All companies	**1,434,612**	**51,500**	**144.1**	**8.2**

Source: 2005 Value added Company Scoreboard: Company data (DTI, 2005).

(ii) Productive efficiency

In general terms, operating profit (or loss) are defined as pre-tax profit plus gross interest cost whereas value added is equal to sales minus the costs of bought-in materials, components and services. Value added (VA) is equal to make, and sales minus value added is equal to buy. For financial accounting data to make the concepts operational, value added becomes operating profit plus employee costs plus depreciation plus amortisation (that is, equal to depreciation for goodwill and intangible assets). Table 2.12 includes the measure of value added and operating profit plus two separate measures. P1 shows the aerospace labour productivity performance across the EU is £57,700 per employee. This figure includes the top four UK aerospace firms, which is higher than the 'all companies' average. P2 shows the measure of efficiency is consistent across aerospace firms except Finmeccanica, which is significantly more efficient at adding value than other firms, including BAE Systems and Rolls-Royce both of which are below the 'all-companies' average. Table 2.13

does the same calculations for the UK aerospace and defence industries as a whole in comparison to other UK industries (Jackson 2004: 3).

Table 2.13: UK industry comparisons of value added for 2003-04

Industry	Value added (£ million)	**P1:** VA per employee (£)	**P2:** VA % of costs (%)	Profit % of sales (%)
Aerospace & defence	10,433	53,100	125.5	5.9
Automobiles & parts	9,796	42,200	112.9	1.2
Electronics & electrical	6,493	30,900	115.0	n/a
IT Hardware	4,426	56,400	97.7	n/a
Pharmaceuticals & biotech	22,859	98,500	194.5	8.6
All industry composite	**494,223**	**48,100**	**152.7**	**8.4**

Source: 2005 Value added Company Scoreboard: Company data (DTI, 2005).

UK aerospace and defence perform comparatively better than automotives and electronics, but lag behind pharmaceuticals and bio-technology. Indeed, the performance of UK pharmaceuticals and biotechnology industry is 85% better than that of the UK aerospace and defence industry in terms of labour productivity (P1) and over 50% better in terms of adding value efficiency (P2).

(iii) Employment

The performance of the UKAI can be measured in terms of the number of people employed and the skills mix of the workforce. As shown in the opening section, definitions of UKAI employment are problematic, but the figures supplied by SBAC show that aerospace employment in the UK has fallen from 218,000 in 1985 to 122,000 in 2003 and SBAC also claim that a further 150,000 people are indirectly employed in UKAI (SBAC, 2004). However, in spite of the significant reduction in the number of people employed in the industry, there are some other factors to consider. In 2003, 30% of all employees held a university degree or equivalent and 15% of the UKAI workforce were employed in R&D. These figures indicate the UK aerospace industry has a highly-educated and innovative workforce. The emphasis is placed on capital investment in employees and future products rather than a labour-intensive industry, which accounts for the reduction in the total number of employees in the industry.

(iv) Technical advance

Performance can also be assessed through technical advance of the UK aerospace industry. Given the growth of technology (Gummett and Reppy, 1988: 8), there is a recent trend for UK aerospace companies to form consortia with other European companies. With the exceptions of the Harrier Jump-jet and the Hawk trainer, UK aerospace companies have only built military aircraft with other partner European companies, since the cancellation of the TSR-2[9] in 1966. This is due in part to the rising unit costs of aircraft and declining order size from the Royal Air Force (RAF). There is a similar trend in civilian aerospace, which led to the creation of Airbus Industries, a pan-European consortium, which has been able to compete with Boeing in the US by gaining scale economies.

In summary, the S-C-P paradigm has provided a framework for describing vertical integration in the UK aerospace industry at the level of the market. The appraisal of market structure finds there is evidence of a highly concentrated market structure in the UK aerospace market with a scale monopoly in both the civilian and defence sectors. The result is that there is a reduced level of competition between firms in similar domestic market segments. The assessment of market conduct shows there are significant production cost issues in the industry principally relating to R&D expenditure that influence the conduct of aerospace firms. The result is that R&D is used as a form of competition between firms, where R&D is also a possible barrier to entry. The evaluation of market performance shows profitability in the UKAI to be satisfactory in comparison with other engineering industries such as motor car production and unsatisfactory in comparison with R&D-intensive industries such as pharmaceuticals and bio-technology.

However, whilst the S-C-P approach can identify the underlying factors of competition between firms in any given industry, it falsely assumes that market structure is exogenously determined. As a result, the mono-causal assessment of market structure

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[9] The multi-purpose TSR-2 (tactical, strike, reconnaissance) was cancelled during the development phase, as a result of spiralling costs and project delays.

within the S-C-P paradigm does not fully contribute to a detailed understanding of vertical integration, which is central to this thesis. The S-C-P assessment is overly descriptive and too general for the purpose of analysing organisational structure in UK aerospace firms. The next section identifies transaction costs a potential way of analysing the research problem, because the make-or-buy decision is the paradigm problem in transaction cost approach, which attempts to analyse vertical integration.

Vertical integration and transaction cost economics: the research problem

The S-C-P describes an industry using aggregate data and market level comparisons (Hay and Morris, 1991: 587). Whilst this is necessary for assessing an industry, it is not sufficient for the purposes of this thesis, which aims to assess vertical integration through the make-or-buy decision. The link between market structure and vertical integration is actually presented by Williamson as the organisation of economic activity within *and* between both markets and hierarchies (Williamson, 1975: xi). Williamson argues because S-C-P has characterised the research into industrial organisation in the post-war period that:

> "[a] goal of profit maximisation is ordinarily imputed to the firm, internal organisation is largely neglected, and the outer environment is described in terms of market structure measures such as concentration, barriers to entry, excess demand, and so forth. The distribution of transactions between the firm and market is mainly taken as a datum."
>
> Williamson (1975: 8).

However, there are two main criticisms of the S-C-P paradigm relevant to this thesis. Firstly, the simplified S-C-P approach assumes structure is exogenously determined, but fails to explain the nature of the market structure. The transaction cost approach explains the existence of firms and views structure as being determined endogenously through the minimising transaction costs via the make-or-buy decision. Secondly, the S-C-P approach is most useful for analysing single product firms, because a single product is specific to a given market (Worthington *et al.* 2005: 212). This Chapter has shown the complex nature of UKAI across many products and markets. Taken together, these are both compelling reasons to use the transaction cost approach to analyse vertical integration within an analysis of organisational form or structural governance. As Williamson states:

> "Just as market structure matters in assessing the efficacy of trades in the marketplace, so likewise does internal structure matter in assessing the internal organisation."
>
> Williamson (1975: 9).

The implication of S-C-P for this thesis is as a starting point for industry analysis, but it does not address the reasons why firms exist in the first place. The transaction cost approach with its focus on the make-or-buy decision shows how organisational structure can be endogenously determined. That is, the S-C-P approach considers the issue of how firms should compete with each other at the market level; whereas the transaction cost approach considers the issue of which activity should be performed in-house (make) or by the market (buy). In the S-C-P framework, governance structure is assumed to be exogenous and beyond the scope of the approach. The transaction cost approach is potentially suited to assess the economic organisation and contractual features of vertical integration, because it focuses on the firm acting to minimise transaction costs as an efficient means of safeguarding specific investments compared with the monopoly power approach, which focuses on the firm generating monopoly rent by the control of inputs from factor markets and distribution (Klein, 2004: 1).

In summary, this thesis has identified the limitations of the S-C-P paradigm in respect to explaining vertical integration. Transaction cost economics extends the analysis of market structure through the make-or-buy decision and demonstrates that the firm is a substitute for the market. As a result, vertical integration is explained by transaction cost economics whereas it is not by the S-C-P paradigm.

Conclusions

In conclusion, this Chapter has defined the UK aerospace industry in a number of meaningful ways and provided a working definition informed by SBAC. The Chapter has also used the S-C-P approach to assess the UK aerospace industry, which has shown that there is evidence of a scale monopoly within a domestic oligopoly market structure. However, there are theoretical concerns about the S-C-P approach, which has ultimately led to the conclusion that the transaction cost approach is potentially more suitable for explaining vertical integration and the existence of firms. Overall, this Chapter has outlined the UK aerospace industry and sets the context for the main themes of the thesis with its focus on the make-or-buy decision and contract design.

The next Chapter deals with the literature on transaction costs. Specific reference is directed towards make-or-buy decisions and the role of contracts within a transaction cost framework, which is potentially more insightful for understanding vertical integration than the S-C-P approach.

Chapter Three:
Literature Survey of Transaction Costs

> "...economic institutions of capitalism have the main purpose and effect of economising on transaction costs."
>
> Williamson (1985: 17).

Introduction

This Chapter surveys the transaction cost economics literature by analysing the theoretical foundations and the empirical applications of the make-or-buy decision. The make-or-buy decision is the paradigm problem of transaction costs economics, since choice among alternative modes of production is resolved by minimising the costs of the transaction (Shelanski and Klein, 1995: 341). That is, a firm can either make the required inputs or buy the inputs from the market and maintain contractual relationships with supplies (Klein, 2004: 1). The transaction cost approach explains why firms exist (Domberger, 1998: 60).

This Chapter is divided into three parts. Firstly, the definitions of transaction costs are presented showing how transaction costs differ from production costs. Secondly, there is an assessment of the theoretical foundations of transaction costs and the development of the theory. Finally, there is an analysis of over 70 empirical studies of transaction costs, including how the transaction cost approach works in practice.

Definitions of transaction costs

This section defines transaction costs in detail, because there is strong criticism of the transaction cost literature concerning the lack of clear-cut definitions (Dietrich, 1994: 23). Indeed, in the absence of an appropriate definition, the transaction costs approach would be unable to provide an understanding of the difference between firms and markets and remain a concept with a list of factors that relate to only the "mode of analysis" (Hodgson, 1988: 200). That is, the definition of transaction costs has to identify where transaction costs differ from the accepted economic definition of production costs.

To define transaction costs Williamson (1985: 19) uses the earlier definition presented by Arrow (1969: 48) that provides a general portrayal of transaction costs as follows:

> Transaction costs are the "...costs of running the economic system..."
>
> Arrow (1969: 48).

The benefit of this definition is that it implies that transaction costs are different to production costs, because the costs of providing goods and services are captured by the production function and the transaction costs are the additional costs of managing economic activity. Hodgson (1988: 200) refers to this definition as a "vague characterisation" because it is imprecise and difficult to make operational. Moreover, *all* types of costs could be defined in theory as contributing to administering the economic system, including production costs and hence the definition of transaction costs remains unclear in spite of Arrow's definition.

Williamson (1985: 19) also uses an analogy to define transaction costs as follows.

> "Transaction costs are the economic equivalent of friction in the physical systems."
>
> Williamson (1985: 19).

To describe transaction costs as "friction" has the advantage of differentiating between an economic system without transaction costs (presumably the equivalent to a vacuum in a physical system) and an economic system with transaction costs. That is, friction is a comparative concept. Hence:

> "Frictionless ideals are useful mainly for reference purposes."
>
> Williamson (1979: 261).

However, Hodgson insists that an analogy is not a substitute for a meaningful definition and therefore comments:

> "The failure to provide a definition of such a crucial term [as transaction costs] is systematic of the lack of precision in much of Williamson's work."
>
> Hodgson (1988: 200).

In order to advance the discussion of defining transaction costs, Hodgson refers to the original work by Dahlman (1979: 148), which identifies three sequential episodes of the transaction. The first phase is the search and information costs; the second phase is the bargaining and decision costs and the third phase is the policing and enforcement costs. Hence, transaction costs are defined as the costs of finding the information, negotiating with information and monitoring through information, which altogether reduces to the cost of a "lack of information" (Hodgson, 1988: 201).

This definition of transaction costs as an aspect of information economics allows the crucial distinction to be made between transaction costs and production costs, which is an important contribution to the wider economics literature. Economic costs fall into one of two broad areas, namely production costs and transaction costs (Jones, 2004: 287). Their definitions are as follows.

1. **Production costs** are defined as the costs of making and distributing goods and providing services, which include the costs of the factors of production such as labour, capital, land and raw material.
2. **Transaction costs** are defined as the costs of using the market, which include discovering prices, negotiating contracts and monitoring subsequent outcomes all of which involve a lack of information.

Accordingly, Hendrikse (2003: 211) asserts:

> "Transaction cost economics simplifies this analysis [of economic costs] by assuming that transaction costs and production costs (*e.g.* the presence or absence of economies of scale) are determined separately and can be added together in order to determine the total costs of a certain way of organising."
>
> Hendrikse (2003: 211).

The logic of this approach is that economic costs are the sum of the production costs and the transaction costs. This means that firms are an alternative method of co-ordination to markets given that economic systems do not operate with full and perfect information (Koutsoyiannis, 1979: 107). The transaction costs approach implies that production costs are not as important as transaction costs when determining the choice between the firm and the market, given a lack of information (Hendrikse, 2003: 211).

Furthermore, the economic survey of transaction costs by Shelanski and Klein (1995: 335) shows that:

> "Transaction cost economics studies how trading partners protect themselves from the hazards associated with exchange relationships."
>
> Klein and Shelanski (1995: 336).

In other words, transaction costs are:

> "...above and beyond contracted prices, including the acquisition of costly information, the costs of monitoring performance, the costs of committing specific assets and the costs of handling complexity and uncertainty in reaching agreements."
>
> FitzRoy *et al.* (1998: 8).

The definition of transaction costs is further developed by Hart (1995: 23) who identifies three sources of transaction costs within the standard principal-agent framework, where the principal is the task-setter and the agent performs the task (Besanko *et al.*, 1996: 615). Firstly, decision-makers can not *plan* for all contingencies; secondly decision-makers can not faultlessly *negotiate* about the plans and finally, decision-makers can not perfectly *write* the contracts for the negotiated plan in such a way that would avoid the need for a third party authority such as a court of law. All three areas result from incomplete contracts that give rise to transaction costs, because there is a lack of information.

This result leads to two broad types of transaction costs according to Milgrom and Roberts (1992: 29). The first type is co-ordination costs, which are the costs of compiling and transmitting information. This communication is not perfect and decision-makers often have insufficient and inaccurate information with which to work. This type of transaction costs is associated with the make-or-buy decision, because co-ordination problems are resolved through buying from the market or making in-house depending on which minimises the costs of transacting. The second type is motivation costs, which are linked to either asymmetric information or imperfect commitment. This situation is known as the hold-up problem and occurs where parties to the transaction do not have all the relevant information or face asymmetric information and encounter opportunistic behaviour. The hold-up problem can result in adverse selection (hidden information) or moral hazard (hidden action) for contractual relationships.

Given the general difficulties of defining transaction costs, it is worth introducing the other central criticism, namely that the definition is tautological, so it is true by definition. The implication of the tautology argument against transaction costs is that the concept unnecessarily repeats the concepts of market failure and opportunity cost. In addition, it is an over-simplification to define the market is a substitute for a firm when the market itself can be defined as a group of firms. Indeed, the whole notion of transaction costs is criticised as being too general, which leaves it open to the fundamental critique of being difficult to define, without a meaningful unit of measurement and altogether the status of "special case" concept (Dietrich, 1994: 8). Transaction cost economics is viewed as tautological, because the concept does not necessarily advance the existing understanding of firms in a market environment and at best has a limited role under certain conditions. Whilst it is obvious to state that production can be either through the firm or the market and that this sheds little new light on the firm, nevertheless it remains an alternative view that firms can succeed to supply where markets fails (Hodgson, 1988: 299). Indeed, it is an original insight from the transaction cost approach to explain the boundaries of the firm in terms of both productive technology *and* the costs of business transactions (Klein, 2004: 2). Hence, a transaction cost approach remains worthwhile and indeed, the language of transaction costs is becoming more widespread. For example, Foley (1999: 2) claims that the UK is moving towards a 'friction-free' economy, where information is more accessible electronically, which opens economic activity to greater levels of competition. That is, economic market structure has the potential to be described as an approximation of a perfectly competitive model. Nevertheless, transaction cost analysis is not a "special case", because:

> "[m]any businesses and jobs [which] still rely on the presence of market friction - entry barriers, switching costs, information costs etc."
>
> Foley (1999: 2).

A 'friction-free' economy may be possible in certain areas of economic activity, where gathering and processing simple and costless information is required to perform a straight-forward transaction, but with aerospace production where the information is more complex then the friction remains. Notwithstanding, transaction costs are apparently omnipresent, which does leave the concept open to the charge of being true by definition (Dugger, 1989: 607). This can be viewed as strength rather than a weakness, if the source of the transaction costs can be identified as attempted by Hart (1995: 23). However, the transaction cost model tends to lack conclusive support and the purpose of this thesis is a test of a specific transaction costs aspect, namely the make-or-buy decision in the UK aerospace industry. The next section will develop the definitions of the make-or-buy decision and the associated hold-up problem.

(a) The make-or-buy decision

The concept of make-or-buy is gaining wider acceptance in the mainstream economics literature, because of the markets and hierarchies schema[1] (Milgrom and Roberts, 1992: 20). The dichotomy is straightforward: economic production is co-ordinated either externally if the relevant labour or product market exists (the buy option); or internally, if a firm can be created to perform the task (the make option). If a firm buys from the market then there is the possible need for external contracts to be written, which can attract so-called "ink costs" or the repeated changes to a given

[1] Two textbook examples, which explicitly use transaction costs as a theoretical basis, include Douma and Schreuder (1998) and FitzRoy *et al.* (1998). Kreps (1990) was one of the first textbooks to use transaction costs in mainstream economics.

contract (Kreps, 1990: 767). Economic decision-makers within firms differentiate between the two alternatives of make and buy subject to a cost minimisation constraint. This approach defines boundaries of the firm in terms of vertical integration. Intra-firm co-operation becomes the preferred mode if the firm is the most efficient form of production. Similarly inter-firm competition becomes preferred, if the market as a whole is the most efficient option. In the latter case a firm that buys from the market will use what are termed "market firms" that specialise in the production of a given component, part or service (Besanko *et al.*, 1996: 77). Market firms can achieve greater economies of scale and therefore can produce at a lower unit cost than a firm further downstream. Whilst this approach is not a radical departure from the neo-classical economics paradigm, it is nevertheless a change in emphasis, which refers to institutional "grit and grime" to prevent the smooth function of markets, (Leslie, 1993: 199-202). In particular, mainstream economic theory views vertical integration as an efficient form of rent-seeking. It is a way to earn monopoly rent by the control of inputs markets and distribution. Alternatively, transaction cost theory views vertical integration as an efficient means of safe-guarding specific investments under conditions of incomplete information (Klein, 2004: 1).

In general terms, there are three levels of make-or-buy decisions, which need to be defined (Probert, 1997: 13). The level of the make-or-buy decision ranges from overall company strategy to specific procurement decision in the long run and the short run.

1. **Strategic make-or-buy**. The strategic make-or-buy decision is at a higher level where a firm decides whether to invest in a manufacturing capability or use the capacity of another organisation. Such a level of decision tends to be longer term and determines whether a firm encompasses production in-house or not.

2. **Tactical make-or-buy.** The tactical make-or-buy decision is usually in response to changes in the supply-side, where it is not possible to make in-house in the short run. This level of decision tends to be temporary and is often a response to an imbalance in the factor markets resulting from either excess supply or deficient supply.

3. **Component make-or-buy.** This make-or-buy decision is often at an early stage of design and takes the form of deciding whether it is economical to manufacture a part or component in-house or not. If the firm buys from the market then it purchases from a market firm, which specialises in the production and distribution of that specific part or component at a lower unit cost of production.

As a result, the make-or-buy decision has implications for the governance structure of firms, because transaction cost economics is the analysis of alternative institutions of governance (Klein, 2004: 3). Williamson claims that economic organisation should:

> "...align transactions, which differ in their attributes, with governance structures in a discriminating (mainly transaction cost economizing) way."
>
> Williamson (1991: 79).

The governance structures defined by Williamson in terms of vertical integration take one of the following three forms.

1. **Markets** are defined as where buyers and seller interact and the place for firms to buy from specialist companies (or market firms). This relates to the buy option within the make-or-buy decision of the firm.
2. **Hierarchies** are defined as where the organisation of the firm is internalised to generate the production in-house. This relates to the make option within the make-or-buy decision of the firm.
3. **Hybrids** are defined as a combination of the partial alignment between markets and hierarchies. Hybrids take the form of long term contacts, franchises, networks, alliances and other forms of firms such as ownership agreements and property rights including licensing.

Overall, the make-or-buy approach recognises vertically integrated firms as a feature of the modern industrial enterprise (Besanko *et al.*, 1996: 72). It is an approach that simultaneously defines the boundaries between the firm and the market, as well as highlighting the capabilities of a firm (Kreps, 1990: 743). By virtue of being a selection process between comparative institutions, make-or-buy decisions can be regarded as a choice variable and assumes a significant strategic importance. However, there is a major problem with this approach, namely, the market does not occur naturally by itself as implied by Coase (1937: 388). Markets and firms (or hierarchies) have in common the fact that each is a construct of economic expediency. According to Dugger (1989):

> "[t]he market is not a natural phenomenon. It bears no resemblance to the Grand Canyon or the Rocky Mountains. Instead, it is a manmade phenomenon. It resembles the Panama Canal or the Empire State Building."
> Dugger (1989: 607).

In sum, firms are hierarchies and the market comprises market firms. As a result, the make-or-buy decision is the choice of whether to produce in-house or procure from a supplier. The next part of this section defines the hold-up problem.

(b) The hold-up problem

The hold-up problem is defined as investments that become inefficient because of *ex post* opportunism (Hendrikse, 2003: 458). The cause of the *ex post* opportunism is relationship-specific investment known as asset specificity. A hold-up problem is linked to credible threats[2] between rivals or in situations of conflict, where there are irreversible or specialised investments (Williamson 1985: 167). The concept of the hold-up problem is closely related to the hostage-taking model (Williamson, 1983: 519). In assessing unilateral and bilateral exchange, there must be a consideration of how economic agents may hold the specialised assets hostage if the contract is not precisely defined. This is known as opportunism since one or more of the parties involved have to negotiate contracts in order to get the terms of the deal correctly specified and avoid the hold-up problem. In this sense, the ink cost (of re-negotiation and haggling with suppliers) must be less than the cost of losing a hostage in a conflict situation, because of the specificity of asset (and investments).

The hold-up problem can also be seen as quasi-rent, which is defined as earning from a factor of production (that is, economic rent) in the short run and transfer earnings in the long run (Griffith and Wall, 2000: 708). Both the hold-up problem and quasi-rent are central to make-or-buy issues. In terms of the decision-making process, transaction costs are a choice between make-or-buy and involve contracts and hostage taking by trading partners. The hostage-taking is measured by the quasi-rent, which is

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[2] The opposite of credible threats is credible commitments, which are used in support of alliance to promote exchange. Credible commitments are also the result of irreversible and specialised assets and investments but form part of the safeguard in favour of co-operation. In terms of game theory, credible threats are non-co-operative games with conflict (or prisoners' dilemma) and credible commitments are co-operative games without conflict (or the folk theorem).

further clarified as the alternative between the make strategy and the buy strategy. A make strategy is adopted where there is quasi-rent, because to make a component or part is a way to safeguard against *ex post* opportunism in situations of relationship-specific investments. A buy strategy is adopted where there is no quasi-rent, because no safeguards are required with generic components or parts, which can be readily purchased from the market. Hence:

Make Strategy (quasi-rent > 0)

$$G_i = G_i^* \qquad \text{Eq. 3.1}$$

$$\text{if } L_i^*(\omega_i) < L_i(\lambda_i, \omega_i) \qquad \text{Eq. 3.2}$$

Buy Strategy (quasi rent = 0)

$$G_i = \tilde{G}_i \qquad \text{Eq. 3.3}$$

$$\text{If } L_i^*(\omega_i) \geq L_i(\lambda_i, \omega_i) \qquad \text{Eq. 3.4}$$

Where:

G_i = chosen institution; G_i^* = internal; $\tilde{G}_i$ = external;

L_i^* = internal costs; L_i = market costs;

(λ) = specificity; (ω) = complexity.

This analysis fully emphasises the notion of transaction cost minimisation; or the make-or-buy decision. In essence, decision-makers either create output through the firm (vertical integration) or engage the market (long term contracts). However, the chosen institution, either the firm (internal) or the market (external) can be liable to *ex post* opportunism (Williamson, 1983: 522-526).

Overall, the make-or-buy decisions and the hold-up problem can be viewed as relevant areas of analysis for assessing the UK aerospace industry, because there is a role for outsourcing and contractual arrangements, respectively. The first part of this Chapter has attempted to define transaction costs in terms of the make-or-buy decision and the hold-up problem. The hold-up problem has been presented in terms of contract design and the make-or-buy decision in terms of economising ahead of assessing the transaction costs approach and its relevance to the UK aerospace industry. The next section reviews the transaction cost literature, including its theoretical foundations and developments.

A review of the theoretical transaction cost literature

The heritage of transaction cost theory dates back to the seminal work of Knight (1921), Commons (1934), Coase (1937) and more recently Arrow (1969). The theoretical concepts of transaction costs were first brought together by Williamson in *Markets and Hierarchies* (1975) and *The Economic Institutions of Capitalism* (1985). The fundamental works of this approach outline the importance of economics, law and organisation in assessing the boundaries between the firm and the market. The task of generating empirical results on the central transaction cost hypotheses was started by Williamson (1976: 73), after which there has been a significant body of work attempting to make operational the basic paradigm problem of make-or-buy (Shelanski and Klein 1995: 341).

It is the aim of this thesis to make transaction cost theory operational and to test the significance of both make-or-buy and contract type as dependent variables in a transaction cost model. To this end, the remainder of this Chapter assesses the theory of the transaction cost approach and the related empirical analysis, which has been developed by many researchers in line with the work by Williamson (1976: 100).

To begin with, the convention in the transaction cost literature is to accept Coase (1937: 390) as the pioneering contribution, upon which Williamson (1975, 1985) developed the critical core of the analysis. Using the transaction as the basic unit of exchange (Commons, 1934: 4-8) and identifying uncertainty as important (Knight, 1921: 270), Coase delivered the insight that the firm and the market act as alternative modes of organisation. That is, the firm and the market are close substitutes, which generates the make-or-buy decision.

Next there is individual assessment of the work by Knight, Commons, Coase, Arrow and then Williamson in respect of the theoretical development of transaction costs.

(a) The contribution of Knight

The work by Knight (1921) remains a landmark in the development of theoretical economics and in particular institutional economics. Knight identifies that economic systems are either complex (*i.e.* partial) or dynamic. The analysis of economic behaviour is limited by imperfections in knowledge. This limitation is known as uncertainty, which in turn has two forms. Measurable uncertainty is known as risk or chance; otherwise non-quantifiable risk is true uncertainty. When statistical probabilities can be attached to outcomes this is risk (or measurable uncertainty). In this case insurance contracts may be derived in order to offset some of the costs of the risk and thereby reduce liability for the full cost of the eventual outcome. The choice faced by economic agents is between either zero insurance costs (and the liability of full costs if the adverse state of nature is revealed); or insurance premiums (and the right to compensation if the adverse state of nature is revealed). It can be assumed there are two states of nature S_1 and S_2; where $S_1 > S_2$ with a probability π of S_1 occurring and probability of $(1 - \pi)$ of S_2. Therefore, either of the following outcomes will apply, viz:

$$S_1 = W \qquad (\pi) \qquad \text{Eq. 3.5}$$
$$S_2 = W - FC \qquad (1 - \pi) \qquad \text{Eq. 3.6}$$

is the outcome without insurance; or

$$S_1 = W - P \qquad (\pi) \qquad \text{Eq. 3.7}$$
$$S_2 = W - P + B \qquad (1 - \pi) \qquad \text{Eq. 3.8}$$

is the outcome with insurance.

Where: W = wealth endowment
FC = full costs
P = insurance premium
B = insurance benefits
π = probability of S_1 occurring
$(1 - \pi)$ = probability of S_2 occurring.

It is also assumed that the probabilities associated with the outcomes are known and the premiums are actuarially correct. This is known as a premium or an actuarially fair gamble which is akin to the bet associated with rolling dice or spinning a coin that Knight labels as *a priori* probability. Other types of probability identified by Knight are statistical probability (or empirical evaluation of frequency) and estimates (or judgements). Whilst the latter two types of probability allow additional realism, it creates further complication and inexact interpretation of the data. The lack of confidence in estimates or judgement is true uncertainty, where the outcomes are extremely difficult to predict and hazardous to use. This situation is the antithesis of perfect knowledge because of asymmetric information, imperfect knowledge and the inability of economic agents to instantly compute all the relevant data. The insightful contribution of Knight is therefore to highlight the inexact nature of economic inquiry in the presence of complexity and ignorance.

Knight charts three quite different scenarios. Firstly, with perfect knowledge, full information and no ignorance the world is characterised by certainty. As a consequence of complete awareness, economic agents operate in the absence of probability, because there is no need for predictions (and therefore no role for insurance, judgement and even gambling). Loasby (1976: 5) regards this as the paradox of choice, where genuine choice cannot be predetermined:

> "If choice is real, the future cannot be certain; if the future is certain there can be no choice."
>
> Loasby (1976: 5).

These ideas are later associated with the human factors in transaction costs. Knight has described in essence a situation of unbounded rationality with no scope for opportunism. Whilst it is Simon (1957: 198) who eventually develops these concepts fully, it is clear that Knight appreciates the problems related to search, choice and information. These are recurrent themes in transaction costs and culminate in the hold-up problem, where hostage taking is prevalent with specific assets (Williamson, 1983: 522). The analysis develops into aspects of microeconomics and the law of contract, which is important for assessing the UK aerospace industry.

Secondly, once ignorance is assumed in addition to a lack of information, then there is a role for probabilities to be assigned to outcomes. If probability reasoning can be applied this is known as risk (or measurable uncertainty). As such, various outcomes are given certain quantifiable probabilities. Knight acknowledges that an exhaustive search for probabilities is not always possible, due to search costs, which gives rise to insurance and limited judgement and estimates. The ultimate extremes of this approach can range from identifying the probabilities of rolling dice to long-term scenario planning.

Finally, if outcomes are unknowable, by definition, this is true uncertainty. This situation requires full estimation, judgement and forecasting by economic agents. Therefore, it is regarded as actual uncertainty characterised by both bounded rationality and opportunism. However, probability reasoning cannot meaningfully be applied in situations of true uncertainty, because of imperfect knowledge and incomplete or asymmetric information between decision-makers. Where probabilities are applied in situations of true uncertainty, then moral hazard and adverse selection occur to characterise the market (Biswas, 1997: 31; Hillier, 1997: 81). As a consequence, the insurance episode reduces incentives (moral hazard) and distorts signals (adverse selection), which is modelled as a principal-agent problem. In summary, the work by Knight is important to modern institutional economics in general and transaction costs in particular, because of the emphasis on risk and uncertainty first developed by Knight, which is central to the current understanding and analysis of information in microeconomics.

(b) The contribution of Commons

The contribution of Commons (1934: 4) to the overall understanding of economic institutions is also highly significant. The single most important insight to transaction cost economics offered by Commons is to re-base the unit of economic activity from market exchange to transactions. In essence, Commons wanted to discover a unit of activity, which is universal to economics, law and ethics. The fact Williamson (1975: 385) later corrupted the trinity to economics, law and organisation is testimony to the importance of Commons in the development of the transaction cost literature.

Prior to Commons there was considerable ambiguity concerning the basic economic unit of activity. Historically, economic analysis was based in part upon ownership of commodities and trade. Commons dates this approach back to Locke (1690) and upon the concept of property:

> "The state of nature has a law to govern it, which obliges every one .... that being all equal and independent no one ought to harm another in his life, health, liberty or possessions."
>
> Locke (1690) paragraph 6.

The traditional view regarding the ownership of commodities was carried forward by the subsequent work by Ricardo (1819), Menger (1871) and Marshall (1890). This collection of writing ultimately led to the foundations of neo-classical economics and has developed into the foundations of the competitive free-market model. However, Commons argues that the mechanism proposed by Locke is insufficient to connect economics, law and ethics. Three principles are needed, which are conflict, dependence and order. The conflict element arises from contrasting interests in relation to ownership; dependence highlights the mutual interdependence of interests and order is the security of expectations (given that the future is uncertain). Overall, conflict, dependence and order are necessary and sufficient conditions, within a transaction for creating the basic unit of activity. Thus:

> "Transactions.... are not the "exchange of commodities" in the physical sense of "delivery", they are the alienation and acquisition, between individuals of the rights of future ownership of physical things, as determined by the collective working rules of society."
>
> Commons (1934: 58).

Therefore, Commons injects a huge degree of dynamic analysis into the proceedings. Law, economics and ethics are thus connected as follows. The legal element is captured by the contract or the transfer of rights embodied in the exchange. This allows for interaction between economic agents other than casual and informal spot markets. Indeed, there may be complex and more formal aspects to the exchange, which is the basis of modern exchange markets and hedging (Commons, 1934: 5).

The economics component is embodied by the buying and selling of the rights, which relate to future ownership. Essentially this is where production coincides with consumption under a specified time frame. The ethics detail the actual rules, which coordinate society. As identified previously, Williamson (1985: 385) substitutes the latter element for organisation. The intention of this change is to emphasise the economic features of the exchange and governance structures.

Given that a transaction is the transfer of ownership, Commons provides taxonomy to differentiate between three types of transactions. In bargaining transactions all parties to the exchange are equal and voluntary. This allows a free movement of prices between the buyers and the sellers. A managerial transaction anticipates the hierarchical structure between economic agents, where there is a legal superior (and by definition a legal inferior). This is clearly a rudimentary version of the principal-agent problem, and in particular has echoes of adverse selection and moral hazard. Finally, a rational transaction is the negotiation between several parties and as such it creates a team production function or collective action (Sandler, 1992: 14). Output and prices within aerospace may be regarded as relational transactions. In essence, bargaining transactions can be viewed in terms of property rights, managerial transactions in respect to principal-agent problems and relational transactions as a club good, which generates burdens and benefits.

In further analysis, Commons also highlights the difference between strategic and routine transactions. Within the transaction cost approach there is always a certain degree of asset specificity. The strategic transactions are those with high asset specificity, whereas routine transactions are those with low asset specificity. Whilst these conclusions about complex markets and spot market transactions are not too explicit in the analysis by Commons, it is nevertheless important enough for Williamson to incorporate this within transaction cost economics.

Moreover, Commons offers initial insights into the make-or-buy decision. The terminology is loose and the definitions are imperfect, but Commons touches upon the essence of transaction costs as follows:

> ".... the 'internal' economy turns out to be the engineering economy of managerial transactions producing use-values; the external economy becomes the proprietary economy of bargaining transactions ...."
>
> Commons (1934: 297).

In other words this is a clear expression of make (internal economy) and buy (external economy), which pre-dates Coase (1937: 390).[3]

Finally, Commons incorporates the notion of property rights from the viewpoint of economic transactions. In this analysis the legal implications of the transaction overlap with the economic considerations (Commons, 1934: 93). Therefore, a transaction involves a transfer of future rights, but Commons does not claim credit for the concept of property rights *per se*.[4] However, the analysis by Commons, places property rights as a central idea. However, property rights are:

> ".... not something foreordained by divine or natural 'right' or materialistic equilibrium, or laws of nature".
>
> Commons (1934: 93).

Commons insists upon the notion of property rights being viewed as the due process of law in an uncertain world. Hence:

> ".... property rights are the collective activities of government or other concerns apportioning to individuals an exclusive claim against others in the use of anything that is expected to be scarce enough to create conflict over exclusive use."
>
> Commons (1934: 303).

This is a tradition, which runs consistently through the subsequent transaction costs approach (Williamson, 1975: 3). Subsequently, Hart (1995: 29) uses the property

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[3] Coase (1937) claims the rudimentary ideas as early as 1925 in an unpublished letter.

[4] Commons (1934) credits the development of property rights to Jevons (1871), Walras (1874) and Böhm-Bawerk (1884).

rights approach to analyse the hold-up problems in a merged firm, which is especially important during a period of merger activity and consolidation in an industry.

In summary, the contribution by Commons within the transaction costs literature is usually confined to the credit for introducing the transaction as the basic economic unit of analysis (Williamson, 1985: 6). However, this misrepresents the importance of Commons, who also introduces many other concepts including principal-agent related issues, internal or external economies and asset specificity, as well as contributing to many other areas most notably contract theory (Bolton and Dewatripont, 2005: 551). This sizeable contribution is partially captured as follows:

> "…. transactions are interdependent and variable in a world of collective action and perpetual change which is the uncertain future world of institution economics."
>
> Commons (1934: 93).

Combined, the path-breaking work by Commons and Knight has led directly to many concepts in the transaction costs literature, such as the focus on the transaction plus uncertainty and ultimately the work by both Coase and Williamson.

(c) The contribution of Coase

The work of Coase (1937 and 1960) is seen as an important contribution to the entire transaction cost approach. According to Coase, production is synchronised through markets by the price mechanism. A firm can reduce the cost of the transaction, if the costs of transacting are greater in the market. Hence,

> "The main reason why it is possible to establish a firm would seem to be that there is a cost of using the price mechanism. The most obvious cost of 'organising' production through the price mechanism is that of discovering what the relevant prices are. This cost may be reduced but it will not be eliminated by the emergence of specialists who will sell this information."
>
> Coase (1937: 390).

This insight from Coase is crucial in establishing the make-or-buy decision as the paradigm issue of transaction costs. In other words:

> "…a pure Coasian definition sees firms as the means of co-ordinating production without using market exchange."
>
> Cowling and Sugden (1994: 2).

Indeed, Pitelis (1993: 7) states that mainstream microeconomic theory has been transformed by the transactions cost economics inspired originally by Coase (1937). The history of economic thought in this area of inquiry can be divided into three stages. Firstly, in the pre-Coase era, the market alone was regarded as being able to allocate scare resources through the price mechanism. This mono-institutional view of microeconomic activity was concerned primarily with market equilibrium and market efficiency. This has lead Williamson (1975: 20) to remark:

> "In the beginning there were markets".
>
> Williamson (1975: 20).

Firms are viewed as a near perfect substitute for markets and hence firms can succeed in supply, where the market has failed, due to transaction costs. Secondly, following the 1937 article by Coase, on the nature of the firm, duo-institutional theory developed wherein scarce resources could be allocated by either the firm or the market (*i.e.* market firms). With two different sets of institutions to choose from, firms or markets, decision-makers could either make or alternatively buy. The decision is actually determined by which of the two institutions minimises the various transaction costs. Finally, as a result of the 1960 article by Coase on the problems of social costs, multi-institutional theory was created along the same lines because the state could also be viewed as a mechanism for the allocation of resources, along with the firm and the market.

The work by Coase is important to make-or-buy decisions, because information is central to economics of vertical integration (Coase, 1937: 388). In addition,

> "...the costs of carrying out exchange transactions through the price mechanism will vary considerably as will also the costs of organising these transactions within the firm."
>
> Coase (1937: 396).

This observation from Coase delivers a way of assessing the make-or-buy decision with the firm as a close substitute for the market. However, this break-through from Coase was not improved until the initial work of Arrow (1969) and then the major work of Williamson (1975), which followed several decades later.

Whilst the original approach from Coase has attracted much criticism for being too theoretical, most notably from Hodgson (1988: 207) and Loasby (1994: 15) the intention of transaction cost economics is to amplify the view that an economic analysis of the firm was largely lacking prior to the seminal work by Coase. However, this view does underestimate the insightful work by Knight (1921) on risk and uncertainty and Commons (1934) on institutional economics. Nevertheless, it is accurate to state that Coase (and later Williamson) have transformed microeconomic theory into specific analysis of transactions and information.

(d) The contribution of Arrow

The source of the more recent developments in transaction costs since Coase (1937) can be traced to a defining article of Arrow (1969: 59)[5]. The contribution of Arrow[6] is important in both the theoretical and empirical understanding of transaction cost economics. Arrow highlights the three primary areas of transaction costs namely exclusion costs, costs of information and disequilibrium costs. This analysis views transaction costs in terms of market failure. Accordingly,

> "In a price system, transaction costs drive a wedge between buyer's and seller's prices and thereby give rise to welfare losses as in the usual analysis."
> Arrow (1969: 60).

As a consequence, Arrow is the first to recognise that a transaction cost approach is market-based (Deitrich, 1994: 29). Arrow predicts a role for transaction costs in respect of public goods (exclusion costs), price discovery (information costs) and resource allocation (disequilibrium costs). In addition, Arrow makes the wider point that all non-market allocation, by definition is a 'second best' solution. As a result, a firm cannot restore Pareto efficiency in the presence of this type of market failure, which is sub-Pareto efficiency. This is true because,

> "[m]arket failure is the particular case where transaction costs are so high that the existence of the market is no longer worthwhile."
> Arrow (1969: 60).

This is the reason for the existence of the firm as opposed to resource allocation exclusively by the market. The full spread of analysis ranges from markets to firms through a complex system of contracts. Williamson (1985: 32) continued this analysis as prescriptive and states firms should:

> "[o]rganise transactions so as to economise on bounded rationality while simultaneously safeguarding them against the hazards of opportunism."
> Williamson (1985: 32).

On an empirical note, Arrow provides the basis for much of the subsequent work on vertical integration, anti-trust legislation and bounded rationality. This contribution helped the development of transaction cost economics in respect of changing of contracts (ink costs) and the formation of collective action (hybrid organisations). Overall, this is considered as the hold-up problem, modelled by Williamson (1983:

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[5] Dietrich (1994: 20) asserts that Arrow (1969) was the first author to directly use the term 'transaction costs'. Previously Coase refereed to the phenomena as 'marketing costs' (Coase., 1937: 392).

[6] Indeed, the contribution of many economists in this sphere contains a number of Nobel Laureates in Economics, including Kenneth Arrow (1972), Ronald Coase (1991), Douglass North (1993) and Joseph Stigler (1982).

522) as the hostage model, where there is credible commitment as well as credible threats in the exchange. Next, the importance of the theoretical work of Williamson (1975, 1985) to the transaction costs approach is assessed.

(e) The contribution of Williamson

The extensive work by Williamson has developed the work of both Coase (1937: 386) and Arrow (1969: 59) to create a wider theoretical literature basis for transaction costs. A sizeable part of the work is based upon the premise that the co-ordination of resources by decision-makers is a process of minimising transaction costs (Kreps 1990: 744). To this end Williamson has acted as a conduit through which a great deal of empirical work has been generated in economics, law and organisation (Williamson, 1985: 2-7). Essentially three forms of co-ordination are apparent (Coase, 1960). Resource allocation can occur through the price mechanism or spot markets[7], via long term contracts (Menard, 1995: 161) or through non-market forms (Arrow, 1969: 59-60). The latter category involves two more alternatives, namely the visible hand of the firm (Chandler, 1977: 35) or the hybrid form of the firm-market boundary (Alstron and Gillespie, 1989: 191). This latter category has a rather fluid definition and incorporates many different forms such as franchise and government procurement agencies. Finally, the important issue of contracts is dealt with extensively by Williamson (1975, 1985). It is clear that if firms are to engage the market then there must be some safeguard against the hazards of procurement between firms. The complexity of the contract depends on the type of transaction. In a spot market exchange, so-called because the transaction is 'on-the-spot' there is immediate exchange of standardised contracts because exchange is instantaneous (Milgrom and Roberts, 1992: 131). However, where there is more uncertainty in the exchange due to the long-term nature of exchange or asset specificity, then there is a need to negotiate contracts in order to facilitate the transaction.

According to Williamson (1985: 68) there are a variety of contracts between economic agents, including informal agreements, hybrid contracts, long-term contracts and franchising. In general, a system of contracts has to facilitate exchange (MacNeil, 1978: 738). This purpose is especially relevant if transaction costs are

[7] The term spot market is credited to Hayeck (1945), in which exchange between economic agents was conducted 'on the spot.' Therefore, spot markets by definition assume zero transaction costs.

present and when there are no spot markets. There are three types of contracting tradition according to Williamson (1985: 69-72).

1. **Classical contract law,** where standard market transactions apply and the terms of the contract are completely specified *ex ante*.
2. **Neo-classical contract law,** where third parties are included as attempts to incorporate contingent contracts.
3. **Relational contracting,** where the relationship between the parties must be specified and the transactions must conform to the law of contract.

In general, the role of contracts in transaction costs can be linked to the notion of governance structures and market responsibility between economic agents. The work by Williamson shows that transaction cost economics goes beyond the make-or-buy dichotomy (Williamson, 1985: 368). That is, transaction cost economics centres upon the behavioural assumptions of bounded rationality and opportunism (Williamson, 1985: 45-49). Bounded rationality is based upon the premise that both informational complexity and informational uncertainty prevent decision-makers from computing and acting upon all the relevant data (Dietrich, 1994; 19). This stems from the work by Simon (1957: xxv) in which it is asserted that individuals are:

> "... intentionally rational, but only limitedly so".
>
> Simon (1957: xxiv).

The reasoning behind this stems from recognition that economic agents do attempt to be rational within certain constraints. Accordingly, not every single event can be accounted for and not every single price can be discovered. Since *ex ante* search costs can be excessive, some individuals simply curtail these costs by acting in a rational way, but within the limited information at their disposal. In that sense bounded rationality is recognition that markets are not perfect, because cognitive human maturity is not perfect. Indeed, even if information was perfect, it is unlikely that human decision-making can process the data and always reach the correct outcome. Whilst humans act rationally this rationality is nevertheless constrained.

In terms of human behaviour, the other factor is opportunism, which has been described by Williamson (1985: 47) as:

> "...self-interest seeking with guile".
>
> Williamson (1985: 47).

Opportunism is essentially the prospect of viewing individuals as highly competitive with an objective function in line with self-interest (Hodgson, 1988: 155). However, this does not imply that economic agents are deceitful or fraudulent; simply that opportunistic behaviour dominates the overall objective function. In essence, it is possible to equate bounded rationality with adverse selection as an *ex ante* issue and equate opportunism with moral hazard as an *ex post* issue.

Both bounded rationality and opportunism are the human factors within transaction cost economics and this implies that individuals have a different economic outlook from individuals within other models, which assume complete rationality and self-interest without guile. Kreps (1990: 217) cites temporary general equilibrium as an example of the latter. The analysis and predictions of transaction costs can not be easily compared with other economic models, but there are no assumptions of full and perfect information as with neo-classical economics (Klein, 2004: 24).

The non-human factors, which are involved in transaction costs, include asset specificity, the level of uncertainty and the frequency of the transaction (Kreps, 1990: 747). These dimensions to the transactions are defined as follows:

1. **Asset specificity** is the degree to which a transaction has specific aspects or features such as physical or attributes.
2. **Uncertainty** is the major complexity that derives from bounded rationality and is linked to the work of Knight (1921).
3. **Frequency** is the extent to which the transaction occurs either as a one-off or a recurrent event.

In respect to the make-or-buy decision the link between asset specificity and frequency is highlighted in Table 3.1. The frequency variable can be split between occasional transactions (or generally one-off) and recurrent transactions, which occur repeatedly. Similarly, asset specificity can be non-specific at one extreme to highly specific at the other with mixed in between. Williamson (1985: 73) refers to complete specificity as idiosyncratic because the investment is peculiar to that individual or organisation. The distinctive nature of the specificity means that the quasi-rent is higher, which is the difference between the use of an asset and the next best alternative. Where transactions are non-specific it is preferable to buy even if the frequency is occasional or specific. Likewise, where transactions are specific it is preferable to make even if the frequency is occasional or specific.

Table 3.1: Commercial transactions: asset specificity and frequency

	The Investment Approach		
Frequency	**Non-specific**	**Mixed**	**Idiosyncratic**
Occasional	Purchase of standard equipment **BUY**	Purchase of customised equipment **BUY/MAKE**	Construction of a plant **MAKE**
Recurrent	Purchase of standard material **BUY**	Purchase of customised material **BUY/MAKE**	Site-specific transfer **MAKE**

Source: Williamson (1985: 73).

Where: Buy = procurement from external spot markets (market);
Make = production by internal sources (hierarchies);
Buy/Make = variable strategy, including long term contracts, competitive tendering, franchises and licensing.

Table 3.1 shows that Williamson regards asset specificity as the most important dimension to the transaction, even though with the mixed asset specificity the outcome can be make or it can be buy. Table 3.1 also identifies theoretical extremes in the decision-making process, where in reality the mixed strategies of make and buy may apply to different areas within a firm. The implications of the make-or-buy decision are profound for purchasing and production strategies, because both the market as well as the firm is an artificial entity, which are created by economic agents to facilitate various forms of exchange. This analysis will be examined by a close analysis of the transaction cost model in Chapter Four.

From the preceding analysis it is clear that there is considerable scope to apply a transaction cost approach to aerospace and defence. Indeed, Dugger (1993) has correctly pointed out that:

> "The defence contract is heavily laden with transaction cost problems".
>
> Dugger (1993: 203).

It is a major gap in the literature that there has been no systematic application of transaction cost economics to either aerospace or defence procurement or the manufacturing of aerospace goods and services. *Prima facie*, there is no reason why the transaction cost approach should have been previously applied to aerospace.

However, the industry has the sufficient and necessary conditions to warrant being assessed by the transaction cost methodology, which is the focus of this thesis through the make-or-buy decision.

Summary of literature search

The main findings of the theoretical literature review are that the Knight developed the theme of uncertainty; Commons allowed the unit of analysis to be at the level of the transaction; Coase viewed firms and markets as substitutes; Arrow developed the initial concept of market failure and Williamson brought all the concepts together as markets and hierarchies or the make-or-buy decision.

In summary, there are at least four methodological elements to theoretical transaction costs economics, which are relevant to this thesis (Kreps, 1990: 744). These are:

i. The basic unit of economic analysis is the transaction.

ii. The human factors involved are opportunism and bounded rationality.

iii. Transaction dimensions are asset specificity, frequency and uncertainty.

iv. The make-or-buy choice is based on economising on transaction costs

Firstly, the make-or-buy framework allows the choice of the comparative institution to focus on the transaction as the unit of exchange and not only aggregate supply and aggregate demand at the level of the market. As a result of analysing the transaction, *ex ante* search and bargaining costs, plus *ex post* monitoring and enforcement costs become central to the approach. Secondly, information issues are central allowing a moral hazard assessment of opportunism and an adverse selection assessment of bounded rationality. Hence, the hold-up problem can lead to hostage taking situations and the need for the law of contract and the law of tort, given the two behavioural assumptions. Thirdly, a measure of transaction costs is possible if the dimensions of the transaction can be accurately calculated. Of course, this is the challenge for empirical research given there is little or no relevant published data in the area (Williamson, 1985: 390). Finally, the make-or-buy decision is the paradigm problem in transaction cost economics as a way to economise on the alternative modes of production. This can be meaningfully applied to both the boundaries of the firm as well as the logistics of the supply chain and highlight the claim that economics, law and organisation are at the focal point of transaction costs (Williamson, 1985: 385). A review of the empirical studies will be presented in the next section.

A review of the empirical transaction cost literature

Appendix I presents a comprehensive list of empirical studies in transaction cost economics. It is based on classifications devised by Williamson (1989: 173) and adopted by Shelanski and Klein (1995: 338), which in general differentiates between case studies and statistical analysis. Whilst the list is not exhaustive it is designed to be indicative of the empirical studies available since the publication of *Markets and Hierarchies* (Williamson, 1975). The empirical studies are an attempt to make operational the theoretical approach offered by Williamson in a meaningful and cogent way, beyond the purely descriptive. There are three broad types of empirical work into transaction cost issues (Shelanski and Klein, 1995: 338).

1. **Qualitative case studies** for example a business history.
2. **Quantitative case studies** for example costs study.
3. **Cross-sectional econometric analysis** for example industry investigation.

The first category is qualitative case studies, in which research is conducted into a specific transaction or event. The original example of this type of work is Williamson (1976), where the author investigates the legal and economic issues of a cable TV franchise in some depth. This type of analysis is common in transaction cost economics for two reasons. Firstly, there are data collection issues with the key transactional variables that make industry to industry comparisons very difficult. Secondly, the law dimension of the paradigm lends itself well to case specific analysis. In fact, there can only be a proper consideration of the law of contract (that is, the hold-up problem) and the closely related law of tort (that is, the externality problem) through detailed analysis of individual cases. Indeed, Coase has an impact on both the law of contract and the law of tort, via the problem of transaction costs (Coase, 1937) and the problem of social cost (Coase, 1960), respectively. Other examples of this approach which reflect the legal dimension to transaction cost economics include Palay (1984) a consideration of rail freight; Goldberg and Erickson (1987) an investigation of petroleum coke; and Nichols (1995) a commentary on leisure services. The main finding of the empirical work is that transaction costs can be applied to an industry and therefore there is academic credibility to the approach, especially following the work by Chandler (1977).

The second category is quantitative case studies, where research is conducted on a detailed and thorough aspect of governance structure or contract. The original example of this approach is Klein, Crawford and Alchian (1978), in which automobile suppliers are assessed in respect to make-or-buy. The seminal papers by Monteverde and Teece (1982 a, b) develop this approach in the same industry and establish a clear framework for assessing specific transaction costs issues. The methodology used proxies to measure the transaction cost variables with vertical integration as the dependent variable. The detailed nature of this work is significantly beyond an analysis of output and prices and used probit and logit regression analysis. The main findings for this category of studies are that the transaction cost approach can stand up to a critical economic analysis. In general, the results are consistent with the transaction cost approach to vertical integration and are robust in spite of the imperfect proxy variables. Hence, Williamson (1985: 104) has commented that the transaction cost approach is microanalytic, because it focuses on the transaction as the basic economic unit of analysis.

The third category is cross-sectional econometric analysis, where the research is quantitative and attempts to measure and analyse the key transaction cost variables in a direct way. This is a very difficult process, because transaction cost variables are difficult to accurately measure across industries and between firms, hence data problems are evident. An early undertaking to use empirical analysis is seen in the study of large firms carried out by Steer and Cable (1978) and across industries by Levy (1985). The study by Steer and Cable used OLS estimates of organisational form with profit as the dependent variable and firm size, firm growth and organisational form as the explanatory variables. Whilst the econometric studies have become increasingly more sophisticated, severe measurement problems still trouble the transaction cost approach since the transaction cost variables are not from officially published sources. This has had the possible effect of limiting the number and scope of empirical studies conducted under a transaction cost framework, because the data are rarely if ever found in published sources. Nevertheless, the main findings are a positive proof that the transaction cost approach is capable of being subject to a rigorous and econometric treatment of its logic.

Williamson (1989: 173) attempts to categorise the empirical studies of transaction costs into ten areas and Appendix I outlines the author, year in chronological order, country and industry of each study using this Williamson system of classification of empirical transaction cost analysis:

1. **Statistical models**, for example, Monteverde and Teece (1982 a).
2. **Bivariate tests**, for example, Masten (1984).
3. **Contractual vignettes**, for example, Chandler (1977).
4. **Focused case studies**, for example, Williamson (1976).
5. **Contractual studies**, for example, Masten and Crocker (1985).
6. **Vertical integration**, for example, Helfat and Teece (1987).
7. **Multinational studies**, for example, Gatignon and Anderson (1986).
8. **Business history**, for example, Chandler (1977).
9. **Corporate governance**, for example, Hallwood (1991).
10. **Organisation of unions**, for example, Anderson and Schmittein (1984).

This list allows the potential range of transaction costs methodologies to be assessed. There are three different types of studies where the methodologies range from discursive and descriptive case studies to complex econometric analysis. The first type of study includes the statistical models, bivariate tests and vertical integration studies, which tend to use econometric techniques to test data. The second type of study includes tests of vertical integration, multinational studies and governance structures, which tend to use quasi-quantitative data analysis. The final type of study tends to be discursive and qualitative in nature and include the contractual vignettes and studies, focused case studies and business histories. For the purposes of this thesis there will be both statistical models and bivariate tests of the data from the UK aerospace survey, because this is the most significant and robust way to assess the transaction cost approach. Whilst there will also be discursive commentary on the dataset in this thesis, the more successful studies have employed econometric techniques in order to accomplish better predictions from the model and that will be followed here as well.

So far this section has attempted to categorise the empirical studies. For this thesis, there will be an assessment of vertical integration in the UK aerospace industry using a transaction cost approach and consideration of the results through statistical analysis. The study by Masten (1984) used a similar approach for aerospace in the US at the firm level. At the industry level the study by Lyons (1995) is similar to this thesis, especially since data was collected through a postal questionnaire of UK manufacturing firms.

To summarise, Appendix I presents over seventy of the significant empirical works undertaken on transaction cost since the publication of the seminal book *Markets and Hierarchies* by Williamson (1975). The list covers a large number of industries including timber harvesting, automobile components and popular music, as well as the main sectors of agriculture, manufacturing and services. There is also a wide array of transaction cost methodologies from the business history pioneered by Chandler (1977) to the probit and logit regression analysis within the econometric tradition (Lyons, 1995). However, a major criticism of the body of empirical work is that the overwhelming majority of work is undertaken in the US and only a few elsewhere, mostly the UK. Hence, the studies are not representative of transactions costs globally. Also, very few studies compare the transaction cost results with any other explanations. The work by Mahoney (1992) is a rare example of reviewing across the literature. Finally, it is worth noting for later in this Chapter that the papers by Masten (1984), Masten *et al.* (1991), Crocker and Reynolds (1993) and Finch (1998) deal specifically with the aerospace industry or defence and as such form the focus of this section.

The next section attempts to categorise and critique the growing body of empirical work. There are two key features to this section. The analysis will assess the list generally for the evidence of transaction costs. In addition, it will analyse the list for the work on aerospace in particular and also defence generally, for clues to improve the model to be used in Part Two of this thesis.

The most recent work by Klein (2004: 9) argues that the empirical evidence of make-or-buy decisions can be divided into five categories. These categories are as follows:

1. **Component procurement:** the make-or-buy decision.
2. **Contracts and contractual design:** the hold-up problem.
3. **Forward integration: marketing and distribution:** vertical integration.
4. **Informal agreements:** negotiation and settlement.
5. **Other examples:** business cases.

Each category is assessed in terms of the contribution to this thesis.

(a) Component procurement

The contribution of Masten (1984) and Masten *et al.* (1991) on make-or-buy in defence and aerospace has been very significant, especially for the purposes of this thesis. Masten (1984) attempts to analyse the relative costs of internal and external procurement in the defence-related aerospace industry and presents the most direct application of the make-or-buy decision to defence. In essence, Masten uses bivariate methods to test for association between attributes of the transaction and contract type. The main focus is the administration of subcontracts in the aerospace industry by prime contractors. A secondary focus is a discussion of how the government chooses the prime contractor in the first place. Overall, the analysis is concerned with a trade-off between the opportunity costs of an inflexible contract and the ink costs of renegotiations under a bilateral monopoly. The hypothesis is written in terms of asset specificity.

> "The more specialised.... [are] the assets, the larger will be the quasi-rents at stake over that period ....".
>
> Masten (1984: 405).

In other words, there is a possible positive correlation between the complexity (and uncertainty) of a transaction and the costs of the transaction.[8] The model that is tested is specifically written in terms of the make-or-buy decision. In particular, the choice variable is given as Gi, which is the institution chosen by the firm to acquire the product or process. $\overline{G}i$ is the external source of procurement, G_i^* is the internal source. In summary:

(make):	Gi	=	G_i^* if L_i^* (wi) < $\overline{L}$ (λ i, wi)	Eq. 3.9
or				
(buy):	Gi	=	$\overline{G}$i if L_i^* (wi) $\geq$ (λ i, wi)	Eq. 3.10
Where:	L_i^*	=	costs to source internally	
	$\overline{L}$i	=	costs to source externally	
	λ	=	asset specificity	
	w	=	complexity of transaction.	

The empirical test involved identifying 1,887 aerospace component specifications and using a team of key personnel to decide which items were purchased from external sources. For example, at one extreme all 180 component specifications under the category connectors were sourced from the market (buy); whereas all 80 harness/coax component specifications were produced in-house (make). Questionnaires were then

[8] Robertson and Langlois (1995: 548) correlate between ownership and coordination integration.

devised to generate variables on complexity and asset specificity, the latter including whether bespoke or generic parts were required. Using a probit model to test the choice between make and buy, Masten supports the hypothesis that as complexity and asset specificity increase, so does the probability of the component being produced in-house. However, Masten also identifies that there is a high propensity to source item from the market, especially in the absence of significant asset specificity and complexity. This is because there are greater costs involved in the make option, especially for the government. Thus:

> "[e]vidence from both stages of the defence procurement process indicates a general reluctance on the part of administrators to internalise transactions ...."
>
> Masten (1984: 416).

The specific case nature of this study by Masten means it is difficult to generalise from the results. However, this study is significant overall because of the use of probit methodology and in particular to this thesis due to the application to the aerospace industry in the USA. Rogerson (1995) offers some support for Masten for US defence procurement:

> "Many observers believe that government either lacks the ability to take production in-house .... or simply does not want to design and produce its own weapons because of an ideological preference for private enterprise."
>
> Rogerson (1995: 317).

In sum, Masten (1984) assumes under the reduced form analysis that the true costs of organisation, both make-or-buy were known. This has an important outcome that may be generalised for subsequent research, making the approach developed by Masten very significant. However, the costs of the institution not chosen may actually be unknown. Assume the true costs of the organisation are as follows:

G^0	=	$X+e$,	if $G^0 < G^m$,	(make)	Eq. 3.11
G^m	=	$Z+\mu$,	if $G^0 \geq G^m$	(buy)	Eq. 3.12

Where:	G^0	=	costs of internal organisation
	G^m	=	costs of market
	X	=	vector of attributes (make)
	Z	=	vector of attributes (buy)
	$e + \mu$	=	normally distributed random variables.

If the make option G^0 is chosen then the cost of G^m will not be available. However, if it assumed that G^0 is chosen because it is the least cost option then it is possible to estimate G^m, given that the probability of observing G^0 can be written as follows:

$$\text{Prob}(G^0 < G^m) \quad = \quad \text{Prob}(e - \mu < Z - X) \qquad \text{Eq. 3.13}$$

Masten (1984) assesses the hypothesis that the costs of G^0 will be less than G^m because aerospace has a high proportion of labour-intensive and low technology tasks. The evidence to test this hypothesis is taken from a survey questionnaire of key respondents involved in a sample of make-or-buy decisions inherent in the aircraft construction programme. The standard transaction cost variables are present, including complexity (uncertainty), physical asset and human asset specificity. Probit estimations are made of the make-or-buy decisions and a simple regression is also employed. In the latter case G^0 was the dependent variable and internal organisation specifications were the independent variables. This allows an estimation of the dollar cost of organisation.

The contribution of the work by Masten (1984) in terms of this thesis is threefold. Firstly, the findings show that aerospace production is an appropriate industry to study in the context of transaction costs. It is no coincidence given asset specificity and uncertainty in the nature of aerospace business that Masten used the industry as the basis for the pioneering study in the field. Secondly, the results show that it is possible to directly measure the various transaction cost variables in particular make-or-buy. This outcome is crucial in the attempt to test the paradigm problem of make-or-buy as it demonstrates there is a precedent in the research area to follow. Finally, the use of probit analysis adds credibility to the research and shows how the transaction costs approach can be made operational with econometric analysis. In the case of this thesis logit analysis is used where there is a limited dependent variable such as make-or-buy, which is very similar to probit. In sum, the paper by Masten is central to the methodology of this thesis, which seeks to expand and develop transaction costs analysis of the aerospace industry in the UK.

Masten *et al.* (1991) continues the transaction cost theme of comparative institutional efficiency with an empirical study of naval shipbuilding in the US. Other transaction cost studies have focused on mainly manufacturing industries (except Anderson and

Schmittlein in a following category) and estimations of reduced form relationship between the type of organisation (make or buy) and contract type. In this study censored regression techniques are employed to a large vessel construction programme and the procurement of naval ship components. This is detailed in Table 3.2 below:

Table 3.2: Naval construction: estimated make-or-buy costs

All Figures in US $	**Make Items (n = 43)**	**Buy Items (n = 31)**	**Total (n = 74)**
Estimated Costs	1,863,620	1,717,710	3,581,330
Costs if all components made internally	1,863,620	2,945,930	4,809,260
Costs if all components sub-contracted	5,435,200	1,717,710	7,155,060

Source: Masten *et al.*, (1991: 21).

The results are very insightful for the make-or-buy approach as a whole. If an organisation can make the items it can produce cheapest in-house (and buy all other items) then this is the most efficient outcome. Hence, the evidence ranks the costs of organisations with the hybrid firms (make and buy) as the least cost; the internal firm (make only) the next expensive; with the external firm (buy only) as the most expensive. This result is supported in the economic literature by Ouchi (1980) with work on clans and networks[9] (that is, make and buy); and in the procurement literature by various means. In other words, if the firm had to make all the items it could buy for less from the market, then the cost of these items would increase by 71%. Similarly, if the firm had to buy all the items it currently makes then the cost would increase by almost three times. Evaluation of these results show there are greater cost savings for a firm producing all components in-house than the cost savings made from buying all components from the market.

Overall, the results support some of the transaction cost arguments and as such Masten *et al.* refers to the outcome as quasi-integration. Nevertheless, the research generates some interesting results about the internal costs of organisation. For example, the naval construction firm is unlikely to integrate engineering-intensive activities and more likely to integrate labour-intensive activities, on the basis of make-

[9] This emphasises neither a co-operative approach nor an adversarial approach to the market.

or-buy due to human asset specificity. If the internal costs of organisation minimise the transaction cost then a make strategy is followed by the firm.

(b) Contracts and contractual design

The contribution of Crocker & Reynolds on aerospace is also highly significant from a transaction costs perspective. Crocker and Reynolds (1993) attempt to develop transaction cost issues of US Air Force engine procurement through the notion of incomplete contracts. This research recognises the need for incentives in contracts and identifies of opportunism by defence firms. In essence, Crocker and Reynolds recognise contract design difficulties faced by defence procurement agencies. There is a cost trade-off between more complete contracts, which reduce *ex post* opportunism, and incomplete contracts, which do not incur *ex ante* design costs. The conclusion has clear implications for transaction costs:

> ".... the degree of contractual completeness chosen in practice reflects a desire by parties to minimise the economic costs associated with contractual exchange."
>
> Crocker and Reynolds (1993: 126).

This is viewed in terms of so-called ink costs that are the cost of renegotiating contracts (Lewicki *et al.*, 2001: 99). If there were zero transaction costs then defence contracting would simply involve specifying all the relevant issues and contingencies in the design of the contract. However, once it is recognised that contracting is not costless then contract design can either reduce *ex post* opportunism or *ex ante* ink costs (from constantly re-drafting the contract) of long term contracts which are commonplace in defence procurement. Therefore, defence and aerospace firms view long-term contracts as an alternative to spot markets in the face of uncertainty and complexity (Williamson, 1975: 245). Chandler (1977: 10) has famously coined the phrase of the visible hand (long term contracts) as an alternative to the invisible hand (spot markets). Hence:

> "[t]he degree of environmental complexity and the likelihood of opportunism come directly to bear in the design of military procurement contracts. By its nature, defence acquisition involves substantial recurring investment in relationship-specific assets by a relatively small group of highly specialised defence contractors."
>
> Crocker and Reynolds (1993: 129).

In order to test these issues, a list of contract types was drawn up (including firm-fixed price and not to exceed price) and applied to a panel dataset of contracts for both the F-15 and F-16 engines procured from General Electric and Pratt and Whitney between 1970 and 1991.

The hypothesis states that the efficient degree of complete contracts is evident in contract type, which reflects uncertainty, opportunism, and complexity. The model of reduced form relationship is:

$$P^*_{it} = P_i(\omega_{it}, L_{it}) + \varepsilon_{it} \qquad \text{Eq. 3.14}$$

Where:	P	=	degree of incomplete contracts
	P^*	=	degree of contractual completeness
	ω	=	environmental uncertainty
	L	=	opportunistic behaviour
	ε	=	error term

Using OLS the following empirical relationship was tested:

$$Y_{it} = \alpha i + \beta \varpi \omega_{it} + \gamma L_{it} + e_{it} \qquad \text{Eq. 3.15}$$

Where Y_{it} is the degree of contractual completeness.

The results showed that long-term contracts provided guarantees to defence contractors whom had entered into asset specific contracts with the DoD. Initial uncertainty also diminished over time as contracts became more complete and trust developed on all sides. Also this emphasises the endogeneity of contract type, which previous studies assumed to be exogenous. As a result, Crocker and Reynolds conclude that incomplete contracts are used in contract design as a choice variable, whilst still minimising the costs of the contract.

In addition, there are two other studies on aerospace, a location study of former British Aerospace sites in the UK (Finch, 1998) and a case review of Rolls Royce UK aero-engines (Prencipe, 1996). The work by Finch (1998) does not approach the study from a transaction cost perspective, but it is possible to interpret the analysis as assessing the location asset specificity of Lancashire-based aerospace companies. Also, Finch uses a logit model to assess diversification in the aerospace sector in terms of size of the firm and engineering function. The findings show that the size of firm influences diversification, which can be taken to mean that larger firms do not have the same location asset specificity as smaller firms. The main fault in the study is that it simplistically assumes that British Aerospace is the only core company in the area and therefore does not fully assess the supply chain or the contractual relationship between firms. The work by Prencipe is an assessment of the role of contract design in the aero-engine sub-section of the industry. The study tends to be an overly descriptive account of the domestic monopoly position of Rolls-Royce, but there is some useful assessment of contracts and asset specificity of the company. These latter two studies confirm that there is a scope for a transaction cost approach to the UK aerospace, because each provides support for the model and the methodology. Even though neither study is written from a transaction cost perspective *per se*, the studies do contain references to transaction costs involving location and contract in the UK aerospace industry.

(c) Forward integration into marketing and distribution.

Anderson and Schmittlein (1984) apply transaction cost to the US electronic component industry. The point of the analysis is the empirical study relates to a sub-contractor (rather than a prime contractor) and the focus is on a marketing function[10], namely personal selling (rather than production). This is a test of vertical integration, which recognises the behavioural features of bounded rationality and opportunism. The comparison is between two types of personal selling, namely, a manufacturer representative (buy) or a directly employed sales-person (make). Therefore, this is a test of human asset specificity, since differences in physical assets of companies are insignificant in this context.

Four key variables are highlighted through a questionnaire of sales managers from sixteen companies. Namely, company size, which is not a transaction cost specific variable, asset specificity, uncertainty[11] and frequency (transaction cost variables). Such survey data from one industry, electronic components, does allow the study to be microanalytic, but it is not possible to generalise from the results. As with Masten (1984), this is an estimation of reduced form relationship involving make-or-buy. The hypothesis is then the greater the level of uncertainty, asset specificity and frequency the greater the likelihood of employing a direct sales force (make). The inclusion of

[10] This widens the debate considerably, because previously Masten (1984) was a study of manufacturing projects.

[11] In this case it is internal uncertainty.

the transaction cost variables was statistically significant and important in determining vertical integration.

In particular, internal uncertainty, (that is the difficulty in monitoring individual performance) and transaction-specific assets was strongly associated with employing a direct sales force. This study did not find transaction frequency to have any impact as predicted by Williamson (1985: 60-61). In addition, Anderson and Schmittlein find that the inclusion of the specific transaction cost variables (uncertainty, frequency and asset specificity) improve the results relative to a model of integration simply based on company size. However, there is no indication of how other variables would be included such as lagged profit. Furthermore, the transaction cost variables are good predictors of integration for those electronics firms not included in the survey. Whilst this is initial empirical work which is limited in terms of general implications, it does present evidence that transaction costs are potentially important in determining vertical integration.

(d) Informal agreements

A significant set of work on relational contracts is the seminal study by Monteverde and Teece (1982 a, b). The first article is an attempt to test the transaction costs approach to vertical integration with US automobile industry data and has echoes of the earlier work by Klein *et al.* (1978), in terms of car production and the scope for opportunism. The main point of analysis is asset specificity, because this will help to determine the cost of switching supplier. A firm will tend to buy from the market, if the costs of supplier switching approaches zero. Hence, the prediction that the firm will buy the components when there is a clearly defined and operational spot market. However, a firm will tend to make, if the costs of supplier switching are significant. This is because if the firm continues to buy a component, in the face of high supplier switching costs, then the firm will be exposed to the hold-up problem and hostage-taking. This is also viewed as an issue of quasi-rent, where quasi-rent is defined as the difference between highest value of an asset and the next-highest value of the asset. If the quasi-rent approaches zero, then there is low asset specificity. In this case, the transaction cost economics prediction is that the firm will buy from the market. However, if the quasi-rent is high, then there is also high asset specificity. In this case, the transaction cost economics prediction is that the firm will vertically integrate or make. Hence, Monteverde and Teece (1982 a) hypothesise that assemblers will vertically integrate production when the firm is dealing with specialised and non-patentable know-how, in order to avoid opportunistic contractors and hence the hold-up problem. The main hypothesis reads:

> "The greater is the applications engineering effort associated with the development of any given automobile component, the higher are the expected appropriable quasi-rents and therefore the greater is the likelihood of vertical integration of production for that component."
>
> Monteverde and Teece (1982 a: 207).

A list of 133 car components were assessed in terms of whether the item was purchased from an external source or made in-house by either GM or Ford. If 80% or more (the overwhelming majority) of the required quantity of a component or product is made in-house then the item is coded as make; whereas if 80% or more of the required quantity is procured from outside sources then the item is coded as buy. Once again, because of human asset specificity, both GM and Ford are more likely to bring production in-house if purchasing from suppliers gives that supplier an opportunity for an advantage. The study found that Ford outsources more than GM or alternatively, GM is more vertically integrated than Ford. This suggests that GM has apparently greater transaction costs, which is why the firm has maintained more work in-house. A car assembler or prime contractor will supply itself with a component, if the engineering design contains transaction specific skills, which could be exploited by the opportunism of an external supplier. As a result, asset specificity can lead in part to the hold-up problem. However, the analysis does not raise the issue of why the make-or-buy profile for GM and Ford are not identical given that each operates under largely similar conditions. In answer, an in-depth business case history or analysis along the lines of Chandler (1977) may reveal significant development differences of each firm that account for the alternative approaches. For example, Ford has witnessed largely organic growth, whereas GM has been the product of merger and acquisition, which in part may reflect the different propensities to make and buy between the different parts of the company.

(e) Other examples

For the area of other examples three works are assessed in this thesis, which include Williamson, Chandler in the US and Cable and Steer in the UK. These empirical works are considered in this section.

(i) The example from Williamson

The first significant empirical work on transaction cost economics appeared in 1976, after the publication of *Markets and Hierarchies* by Williamson in 1975. The initial studies were mainly case studies or reviews of business history. The study of franchise bidding for CATV by Williamson (1976: 73) is indicative of this work. The main argument is that cable TV is a natural monopoly and there is a possible hold-up problem caused by bi-lateral monopoly. Williamson considers that regulation is necessary due to both market and technological uncertainty, where uncertainty is a key transactional variable. The real insight of this study is the attempt by Williamson to conduct a microanalytical study of economic behaviour, which examines a contract or transaction in greater detail than simply aggregate market supply and demand. According to the aim of the analysis by Williamson (1976):

> "... it was necessary to examine the contracting process in greater detail than had been done previously to discern the types of difficulties which market mediated encounters and, relatedly, to establish in what respects and way internal (collective and hierarchical) organisation offers an advantage."
>
> Williamson (1976: 74).

In other words, the greater detail at the level of a contract or transaction can be translated in the fundamental issue of make-or-buy. The example of CATV illustrates that there are no frictionless alternatives when supplying a natural monopoly. There needs to be a choice between the make-or-buy modes of exchange, in order to minimise the transaction costs. The specific transaction costs in the example of CATV, include the costs of bidding process, demand uncertainty, asset specificity of the incumbent firm and opportunism. These are all familiar themes of transaction cost and the case study approach allows the analysis to focus on the number of *ex ante* bidders plus the conditions of *ex post* supply. There is inevitably an issue of adverse selection in the bidding process and moral hazard in the final supply, which Williamson highlights in the analysis. The problem with the case study approach is that it can only be used for the purpose of general deduction and also it understates the significant problems of measuring and quantifying the key transactional variables, such as uncertainty and complexity. These problems are left to other papers by subsequent research teams. For example, the approach taken by Goldberg (1976) favours a more legalistic framework for the analysis, whereas the first of several contributions by Teece (1976) is a focused industry studies in this case the transactions of petroleum refining.

(ii) The example from Chandler

The contribution of Chandler (1977) is an important landmark in development of empirical transaction cost analysis. This is because for the first time a significant body of work was assessed under a transaction cost framework (Williamson, 1985). The work by Chandler is an impressive contribution to the history of corporate business and the developments of the modern firm. Essentially, Chandler developed the business history of huge corporations, for example Ford and complex industries, for example American railways. In addition, in his book *The Visible Hand* (1977), Chandler basically shares the view of Williamson (1975: 133) that transaction costs will focus on the alternative means of contracting. Chandler (1977) was one of the earliest researchers to give academic credibility to transaction costs and indeed helped to establish transaction cost in terms of vertical integration, via scale and scope (Chandler, 1990).

A potential offshoot of the work by Chandler is the much-cited paper by Klein, Crawford and Alchian (1978), in which the authors assess suppliers in the US automobile industry. This is a showcase of how transaction costs can begin to explain the trading partnerships and how firms protect themselves from incomplete contracts and asymmetric information. In this industrial study, the conflict between General Motors and Fisher Bodies is examined in terms of the hold-up problem, caused directly by dedicated physical assets following a move from wooden-bodied to metal-bodied cars in the 1920s. The eventual decision by GM to buy-out Fisher illustrates the importance of asset specificity in non-spot market transactions. This analysis predates the hostage model developed later by Williamson (1983), but has all the hallmarks of asymmetric commitment, which ultimately may lead to vertical integration. Klein (1988) revisits this area as a case study, but gives greater emphasis to specific human capital, as the cause of the failure of the long term contract. In essence, GM switched the governance structure from buy to make as a result of the hold-up problem. Other case study approaches are later found in Lilien (1979) and Williamson (1979), which look separately at various aspects of transaction costs from a largely descriptive perspective. The main problem with the case study approach is that it tends not to measure directly the key variables of transaction costs. Also, the results whilst interesting are not always sufficiently robust to generalise. Therefore, a more systematic and statistical approach to the transaction cost approach is required in order to move the analysis forward.

(iii) The example from Steer and Cable

One of the earliest statistical studies was conducted by Steer and Cable (1978) on large companies in the UK. This study was an attempt to predict the organisational form of companies. The basic premise is that the internal form of the firm will help to determine efficiency and hence the internal form is correlated to size, growth and control. The dependent variable is the profit-maximising level of profit for a given firm and the explanatory variables are a vector of organisational form and firm size and growth. Using ordinary least squares (OLS) regressions on data from 82 large UK in the period 1967 to 1971, Steer and Cable found the process of acquiring optimal organisation form to have non-trivial transaction cost (Steer and Cable, 1978: 17). In other words, organisational form matters in explaining inter-firm and inter-industry profitability. In particular,

> "The choice among alternative internal organisation structures also has a pervasive and important implication for the locus of decision-making within the firm..."
>
> Steer and Cable (1978: 28).

One of the next important pieces of statistical work was produced by Armour and Teece (1980) on vertical integration in the petroleum industry 1954 to 1975. The authors found a statistically significant relationship between vertical integration and R&D, suggesting the importance of human specific capital. Hence, technological know-how is rarely traded via arms-length market transaction, because of exposure to the hold-up problem and the potential opportunity for hostage taking. Instead, the conclusion from Armour and Teece is that firms involved with basic and applied R&D will prefer to vertically integrate and avoid outsourcing strategically important work such as innovation and design. As a result, the existence of positive transaction costs will help determine governance structures in modern capitalist firms. Teece (1981) is the first to revisit the notion of large firms, which was first introduced by Steer and Cable (1978). Teece was interested in internal organisation or M-form structure and profitability, where the leading or principal firm in an industry is paired against a control firm for twenty different industries and across two different time periods. M-form innovation is shown to have a statistically significant impact on firm performance, supporting the previous analysis by Steer and Cable (1978) and Amour and Teece (1980), plus the business history case studies of Chandler (1977). Of course, the transaction cost approach is not unique in offering an explanation of this outcome as a monopoly power argument could meaningfully be applied as well.

However, at this early stage of the empirical development of transaction costs the results were viewed as positive, especially the contribution of Alfred Chandler.

Summary

The studies in Appendix I have a common understanding that the transaction cost approach is an appropriate method for analysing the complexities of modern vertical integration through make-or-buy and contract design. The studies share a coherent theoretical foundation and a methodology that is operational albeit over a relatively short period of time since Williamson (1976). The studies do not share a uniform approach nor benefit from a consistent set of results. This variability of interpretation and results is part of a continuing process to establish transaction cost within the wider framework of theories of the firm, rather than a single theory of the firm (Backhouse, 2002: 318-319). It is apparent that there is considerable scope to apply a transaction cost approach to aerospace and defence (Dugger, 1993).

There is no coincidence that three of the major empirical works in transaction cost economics have been related to complex engineering programmes in both aerospace and defence. Masten (1984), Masten *et al.* (1991) and Crocker and Reynolds (1993) assess aerospace production, naval shipbuilding and aero-engine procurement, respectively and provide this thesis with precedence. These are further compelling reasons why a transaction cost approach to the UK aerospace industry is wholly appropriate. However, transaction costs is not solely concerned with complex engineering and since the empirical work of Crocker and Reynolds there has been a array of other applications of the transaction cost model. These studies range from agriculture and transport (Foss, 1996, Pirrong, 1993, respectively) to leisure services and entertainment (Nichols, 1995, Cameron and Collins, 1997, respectively). Also, there is a cross-section of approaches from business case history along the lines of Chandler, for example Argyres (1995: 338) to an econometric analysis, for example Lyons (1995: 431-432). All the studies use transaction cost hypotheses and test vertical integration through asset specificity, frequency and uncertainty and all find support for the approach.

In sum, there are definition issues in transaction cost that should not be ignored and there are also measurement issues to tax the empirical researcher. However, the definitions are not proven to be fundamentally flawed and the measurement problems are not insurmountable to prevent widening the empirical applications of the transaction cost approach to a single industry such as UK aerospace. Even so the research in this thesis proceeds with caution (Klein, 2004: 2). Nevertheless, there are four key findings to emerge from the assessment of the empirical work outlined in Appendix I.

i. The make-or-buy approach can be applied to the aerospace industry through component procurement studies.
ii. The statistical studies of make-or-buy tend to use probit or logit models of analysis for the limited dependent variable.
iii. Asset specificity is considered to be the most important aspect of the empirical work determining make-or-buy.
iv. The hold-up problem can be applied to the aerospace industry through contracts and contractual design.

Overall, there are some important findings to develop in Chapter Four, which include the specific criticisms relating to the transaction costs paradigm. These findings are summarised as follows. Masten (1984) assesses the make-or-buy choice for 12 categories of aerospace components in the US. This work finds a strong predisposition to buy, encouraged by government procurement policies. Also, there is further strong evidence for this in Masten *et al.* (1991) for a transaction cost approach to defence contracting on naval shipbuilding. Taken together these two studies are compelling support for applying the transaction cost approach to aerospace and defence industries in the United States. The purpose of this thesis is to apply the transaction cost approach to the UK aerospace industry.

Crocker and Reynolds (1993) examine US Air Force engine procurement and find evidence of *ex post* opportunism and hold-up problems in sole-source exchange. In addition, a defence firm will have a high propensity to produce in-house, leading to inefficient allocation of resources (for example labour hoarding and 'gold-plating') because the US DoD is only willing to act as vendor for defence equipment. As a result, the issue of the hold-up problem is relevant in aerospace procurement and therefore worthwhile of further investigation from a transaction cost perspective.

Furthermore, Finch (1998) finds evidence of location and facility asset specificity in the UK aerospace industry in the Lancashire area for British Aerospace and its suppliers. Finally, Prencipe (1997) observes an established pattern in the UK of developing and integrating aero-engines in-house and contracting-out components and sub-systems. Overall, there is evidence from North America and Western Europe that issues such as the asset specificity, the make-or-buy decision and the hold-up problem are relevant and measurable in the aerospace sector. Therefore, the transaction cost approach is viable, but the model needs to incorporate the various critiques of transaction costs in order to establish a meaningful research schema.

Conclusions

So far, this thesis has explored the UK aerospace industry in terms of the relevant economic analysis and in particular transaction cost economics. The main conclusion to be drawn is that the UK aerospace industry may be meaningfully assessed in terms of the transaction costs approach due to the nature of the production and procurement decisions. This review has documented gaps in the literature, namely, the scope for applying transaction costs to the UK aerospace industry, especially the make-or-buy decision and contract design.

To conclude, mainstream economic analysis does not fully capture the complexity of the modern aerospace industry. A transaction costs analysis is more subtle than a simple partial equilibrium or market approach and certainly goes beyond a structure-conduct-performance paradigm. Whilst aerospace firms and supply chain network are complicated, it is possible to assess and predict the behaviour of aerospace firms using the transaction cost economics. From the theoretical underpinning developed by Coase, Commons, Knight and Arrow plus the formations of the model by Williamson to the array of applied work in Appendix I, the transaction cost approach is currently in a position to analyse and critically evaluate the UK aerospace industry with a robust and testable framework. The next stage of making the transaction cost economics model operational will form the basis of Chapter Four.

Chapter Four:
Applying the Transaction Cost Model

Introduction

This Chapter presents the transaction cost model and demonstrates that the theory can be made operational through empirical research. The predictions of the transaction cost model are identified, but the imprecise nature of the approach means it is a difficult task to conduct transaction cost investigations. The transaction cost approach is superficially attractive in terms of the choice between markets and hierarchies. However, to make the theory tractable, the empirical research has to create practical data from imprecise concepts. For the research to proceed, problematical decisions have to be made concerning definitions and the choice of data. This Chapter reports on the strengths and weaknesses of previous studies that have attempted to formulate the transaction cost predictions and collected data for empirical testing.

There are three parts to the Chapter. Firstly, the background to the model and the methodology of transaction costs is described. Secondly, there is a section on the transaction model and its hypotheses. Thirdly, the operational aspects of the transaction cost model and methods of testing are presented. The main finding of the Chapter is that the transaction cost approach is difficult to make operational. The relevance of the UK aerospace to transaction costs is emphasised throughout the Chapter. The next section presents a brief background to the transaction cost model.

Background to the model

The aim of this section is to identify the two levels of the make-or-buy decision and to identify the methodology. Transaction cost economics has evolved from a general set of premises articulated primarily by Williamson (1985: 386-387) into a potentially useful economic analysis, which can be applied in all sectors of the economy including defence, education and health (Dugger, 1993: 202)[1]. It has been empirically tested

[1] The full quote from Dugger (1993: 205) is relevant and reads:
"The make or buy decision facing the nation state in the provision of public or private goods is overripe for the application of transaction cost analysis. The provision of defence, health and education could all benefit from such an application".

across many industries such as aerospace, electronics and shipbuilding (Williamson and Masten, 1995: xiii). Dugger identifies two types of organisation that attempt transaction cost minimisation (Dugger, 1989: 607):

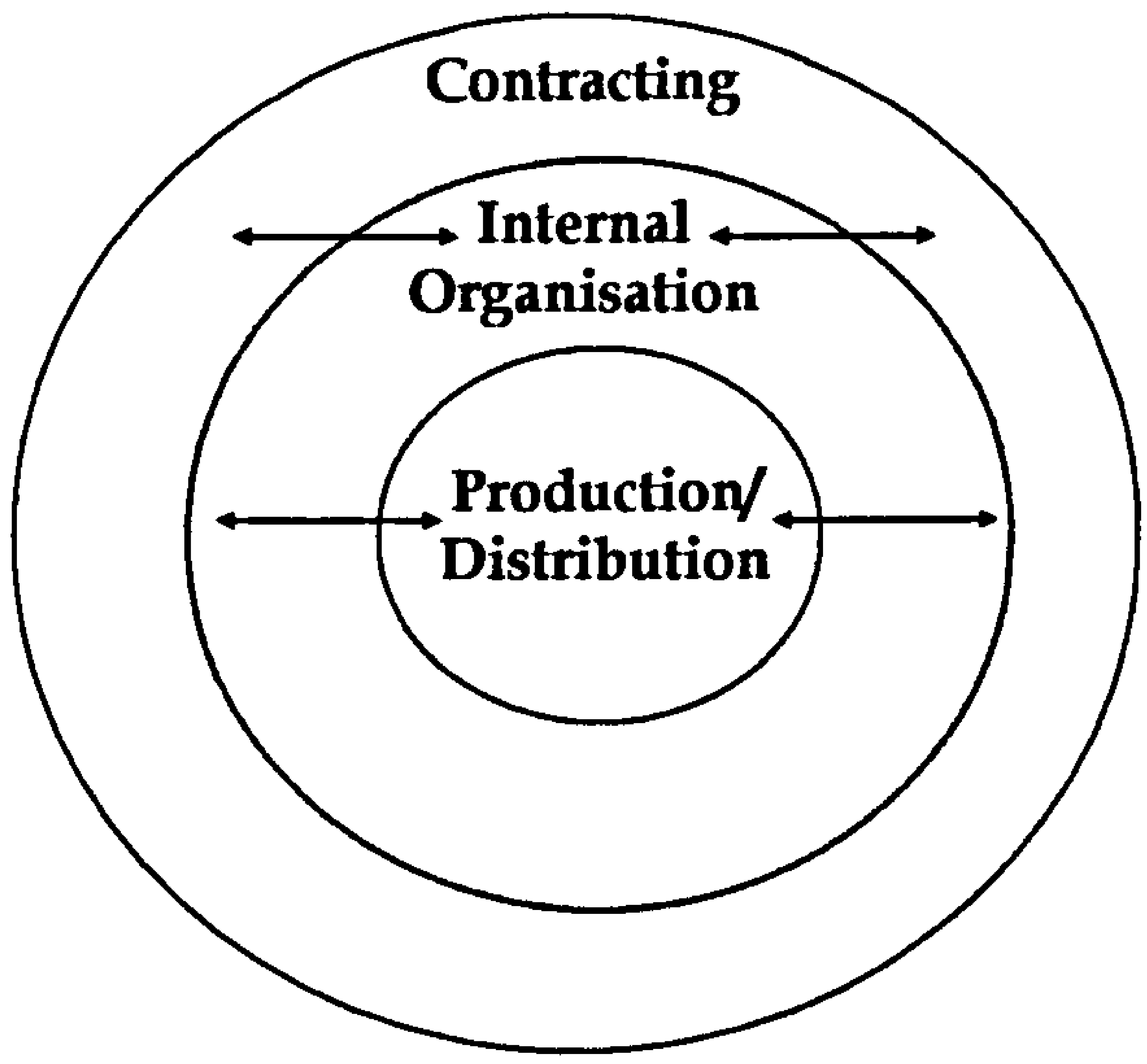
1. **The national state** or government, including procurement agencies.
2. **The corporate state** or firms, including conglomerate organisations.

Both the national state and the corporate state can either make–or-buy. At the government-level of decision-making, the national state can either make "in-house" through public monopolies or buy from private firms operating in national and international markets. There is a strong argument by Dietrich (1994: 169) that transaction costs only exist in the short run because in the long run the choices automatically become more efficient. Furthermore, Dietrich considers economising on transaction costs as a relatively static exercise. As a consequence, he argues that transaction costs are zero in the long run as the dynamic effects of governance structures are created through monopoly power (Dietrich 1994: 179). From this perspective it can be argued that it is inappropriate to apply a transaction costs approach where long run contracts exist. The criticism is relevant to this thesis, where long term relational contracting is clearly central to aerospace and defence production. The response to Dietrich is recognition that the modern firm can be understood as assessing governance structures within organisations through a transaction cost approach. The basis of transaction cost economics is that governance structures at the level of national state depend largely on the make-or-buy decision rather than ways to earn monopoly rent by the control of inputs markets and distribution.

At the firm-level of decision-making, the analysis of Coase (1937 and 1960) has allowed considerable work to be undertaken into the nature of the firm. The general type of model implies the decision-making process is guided by a holistic view of the firm rather than a linear production function. Figure 4.1 represents the firm as concentric relationships with production and distribution at the centre (or make) and procurement in the outer circles (or buy). If the core business of the firm is production and distribution, then the firm has the decision to make-or-buy, which is known as a hybrid form. The transaction cost approach is not the mechanistic black box methodology of the linear production function (Demsetz, 1997: 426).

In the concentric model of the firm, *ex ante* search information and *ex post* policing costs create positive transaction costs. This implies the firm is part of a wider supply chain where the boundaries between the firm and the market exist and determine governance structures.

Figure 4.1: The concentric model of the firm

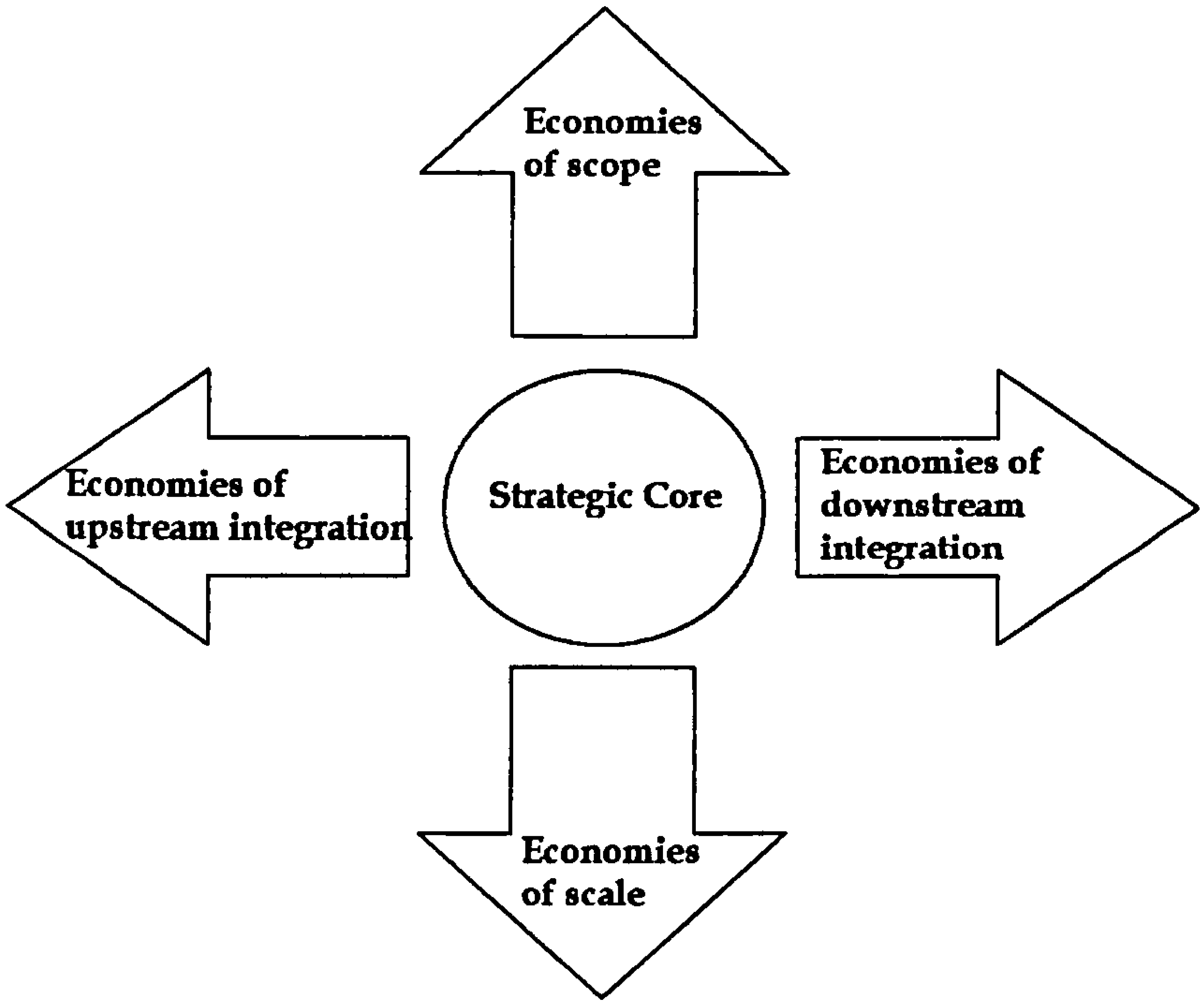


Source: Dietrich (1994: 32).

The concentric model of the firm can be developed into the compass model of the firm shown in Figure 4.2, where vertical and horizontal integration is shown, based on the strategic core at the centre. The strategic core consists of high asset specificity; otherwise it would be more appropriate to buy from the market. An expansion of the boundaries of the firm is achieved by either vertical integration (scale and scope monopolies) or by horizontal acquisition (complex monopolies).

The close link between defence firms (*i.e.* vendor) and government agencies (*i.e.* buyer) may be explained by economies of scale generated 'upstream' in the factor markets (*e.g.* procurement); and economics of scale generated 'downstream' in the goods market (*e.g.* distribution). Both 'upstream' and 'downstream' economies of scale are an attempt to minimise transaction costs. As a result, it is the make-or-buy decision at the firm level which is the focus of the thesis as an analysis of transaction costs in aerospace (Masten, 1984: 404).

Figure 4.2: Vertical and horizontal integration of the firm



Source: adapted by the author.

The implication of the concentric firm is two predictions within the transaction cost economics approach. Firstly, if transaction costs are approximately zero, then economic agents will buy from the market. Secondly, if transaction costs are positive or greater than zero, then economic agents will make in-house. These predictions incorporate transaction cost minimising (economics), the role of contracts (law) and governance structure of the firm (organisation). There are three corollaries, namely firms exist where markets fail (the make option); market firms exist to minimise transaction costs (the buy option) and firms that make and buy are hybrids. However, this is a source of the tautology criticism, because it is over-simplistic to state that firms either make-or-buy, which in turn is difficult to make operational. The next part of this section introduces the economic methodology of the transaction cost models.

The methodology of transaction cost models

The deductive logic of the transaction costs approach is focused on a common structure or universal law (Blaug, 1992). In essence:

> "[b]y a universal law, we mean some such proposition as 'in all cases where events A occur, events B also occur' ....".
>
> Blaug (1992: 4).

Event A in the transaction cost approach is the coincidence of asset specificity, bounded rationality and opportunism; event B is the full catastrophe of transaction cost, where asset specificity, opportunism and bounded rationality are all present (Williamson, 1986: 178). These methodological features remain firmly embedded in the architecture of neo-classical economics (Dietrich, 1994: 179). Williamson (1986: 175-176) terms the approach by definition as micro-analytic, which is another expression for partial equilibrium analysis, including constrained optimality (internal features) and the price mechanism (external features). However, transaction costs economics assume a market solution is possible.[2] Nevertheless, once the problem of positive transaction costs is introduced, then the make-or-buy strategy itself becomes the most preferred outcome. In other words:

> "....transaction costs would have to be considered external to the individual decision-making process .... The claimed sub-optimal state is thus seen as being optimal with regard to the barrier of transaction costs."
>
> Boland (1986: 33).

In theory, an economic environment with zero transaction costs is a relatively static and populated by the one-person firm (Demsetz, 1997: 427).[3] Positive transaction costs generate the need for a comparative institutional approach. The criticism of the methodological approach centres upon whether or not it is tautological. Thus according to Boland:

> "If the transactions cost is in any way influenced by prices, the explanation become circular or at best incomplete."
>
> Boland, (1986: 146).

Transaction costs are prone to this criticism of tautology, because the features of the approach are universal: the arguments underlying the theory may appear circular but are not necessarily true by definition. However, transaction costs are not absolute and can be viewed as part of a continuum allowing a more general approach to be adopted. Indeed, the tautology criticism is not conclusive simply because transaction costs can be applied to many areas. The main argument against the circular nature of transaction costs is that the approach itself is far more rigorous than the tautology argument

---

[2] The neo-classical paradigm assumes zero transaction costs. Langlois and Robertson (1995: 29) predict zero transaction costs in the long run under transaction cost economics. This is similar to the Marshallian theory of the firm and the idea of Dietrich (1994: 179).

[3] This inspired Williamson's famous quote "In the beginning there were markets ..." Williamson (1975: 20) criticised by Loasby (1976: 65-66).

implies. In other words, transaction costs are viewed on many levels from the general concept of friction in the economy to the detailed nature of make-or-buy, where the latter is not tautological in nature. As a direct consequence of a deductive approach, transaction cost economics has evolved into a generalist theory of industrial economics, combining organisation, law and economics.

Transaction costs have also been applied to specific categories of hybrid firms, namely, multinational corporations or the conglomerate enterprise (Kay, 1984: 78). This is because internalisation leads directly to the hierarchical development within firms and ultimately to the M-form architecture, (Williamson, 1985: 128). In contract, the S-C-P paradigm assumes firm structure is determined exogenously, which is why transaction cost economics is used in this thesis. M-form structures are possible, if internal divisions create individual profit centres within the various departments of a firm (and as a result beyond the one-person firm). Conglomerates may be explained by failures in capital markets, which encourage apparently unconnected firms to merge. Also, there is evidence of the M-form firm and economies of agglomeration (Fujita and Thisse, 2002: 3) and company towns (Williamson, 1985: 35).

Overall, this thesis develops an empirical approach to the issues of the make-or-buy decision and contract design, because transaction costs assumes firm structure is determined endogenously and not exogenously as with the S-C-P paradigm. The next section presents the transaction cost model.

The Transaction Cost Model

An economic environment, which is characterised by positive transaction costs, is one where the firm tends to be a collection of contracts (Williamson, 1985: 43). The definition of the firm as a series of contracts is made operational by Williamson (1985: 230) through formulating the boundaries between the firm and the market:

Firm = f (internal contracts, external contracts) Eq. 4.1

Where:

internal contract = f (core skills, organisational incentives).

external contract = f (complementary skills, inter-organisational incentives).

According to Shelanski and Klein (1995: 336):

> "Transaction cost economics studies how trading partners protect themselves from the hazards associated with exchange relations."
>
> Shelanski and Klein (1995: 336).

As a consequence, the decision to make-or-buy develops the firm into a mixture of internal core activity (make) and strategic external alliances (buy) and also a hybrid. Besanko *et al.* (1996: 73) confirms this notion as follows:

> "To resolve the associated make-or-buy decisions, the firm must compare the benefits and costs of using the market as opposed to performing the activity in-house."
>
> Besanko *et al.* (1996: 73)

This is converted into a prediction through the existence of transaction costs. That is, a firm will make-or-buy depending on the presence of three factors, namely, asset specificity, bounded rationality and opportunism. Asset specificity is critical to protect against, because once there is relationship-specific investment then the hold-up problem tends to follow. However, Williamson also considers human factors (bounded rationality and opportunism) and environmental factors (uncertainty and small numbers) as important in respect to the eventual outcome. This can be shown in the organisational failures framework in Figure 4.3.

Figure 4.3: The organisational failures framework

Human Factors	Transformation	Environmental Factors
Bounded Rationality	←→	Uncertainty & Complexity
Opportunism	←→	Small Numbers

Source: Williamson (1975: 40).

In the organisational failures framework, bounded rationality is linked with uncertainty and complexity, whereas opportunism is linked with small numbers exchange. Bounded rationality will be created once uncertainty or complexity is present and there is no longer a classical contract. Similarly, small numbers in the transaction will generate opportunism, because the firm will move from a situation where there are many *ex ante* bidders to fewer *ex post* suppliers, which is known as the fundamental transformation (Williamson, 1985: 55). The connection between the human factors with the environmental factors shown in Figure 4.3 is crucial to the analysis. According to Williamson (1986: 178):

> "The full catastrophe appears when bounded rationality, opportunism and asset specificity are joined".
>
> Williamson (1986: 178).

Whilst an expression noting the full catastrophe is rather overstating the case, it does convey the sense of how transaction costs are different from neo-classical economics. The basic equation in the transaction costs framework is usually specified using the dimensions from Figure 4.3 (Williamson, 1985: 52):

$$TC = f\,(\text{asset specificity, bounded rationality, opportunism}) \qquad \text{Eq. 4.2}$$

Where: TC is transaction costs

A firm will buy (from the market) if none of the factors are present or if the costs of make are greater than the costs of buy. The concepts of asset specificity, bounded rationality and opportunism, which were introduced in the previous Chapter are important to the model and require more detailed definitions.

(a) Asset Specificity

The straightforward definition of an asset is any property which is owned (or leased) by a firm or individual. This property can be physical assets, for example, plant and machinery; or human assets, for example, R&D staff and skilled employees. All assets such as physical, financial or human can be given a monetary value or an opportunity cost. If there is an alternative and competing use for the asset then the opportunity cost will be high, which is related to the transferability of the asset. If the opportunity cost of an asset equals zero, then the asset is totally specific with no alternative use. Asset specificity is greater in the short run, because there are fewer alternative uses with all factors of production being variable in the long run, which is linked to the concept of quasi-rent (Williamson, 1985: 30).

Asset specificity contributes to market uncertainty due to relationship-specific investments. This is manifest within incomplete contracts and non-standard commercial contracting. In sum, asset specificity adds to the costs of transacting because of relationship-specific contracts. The four broad types of asset specificity are site, physical, human and dedicated (Williamson, 1985: 95-96) with reputation as the fifth. The first four aspects of asset specificity are highly significant for aerospace firms that face relationship-investments and long term contracts.

1. **Site Asset Specificity**

Site asset specificity is the actual factory or industrial unit where production and distribution takes place. This resource is immobile, although it may have alternative uses. For example, a final assembly point for a military aircraft could be employed for civilian aircraft production with additional investment. However, the actual location of the site is non-transferable. There has been the closure of several military aircraft sites in the UK over recent years including Kingston in 1991 and Preston in 1990. For example, the Preston site was regarded as incapable of being used as a modern production facility and in addition the area was too close to the central business district of Preston. Not only was it possible to re-locate production elsewhere, but it was also possible to transfer the site to alternative and more profitable use. In transaction cost terms there was a low quasi-rent on the Preston site. As a consequence the aircraft factory was demolished and the land was sold to commercial developers who built office accommodation and houses, whilst production was transferred to a modern production facility at Warton a few miles away.

2. **Physical Asset Specificity**

Physical asset specificity comprises the actual technological assets engaged in the manufacturing process. At the extreme, it relates to the highly specific jigs and tools, which can be used for a single specific purpose, for example, the manufacture of the Typhoon military aircraft. The same principle applies to numerical control (NC) machining or bespoke software used in avionics. There is also a notion that the physical assets can involve patents, licenses and other property rights. Physical asset specificity is relevant to all complex engineering projects such as aerospace, because of the huge capital investment in the industry. In this respect, a life cycle approach is an important consideration for the analysis. Some physical assets will not only depreciate over time, but also become less relevant and important as technological change occurs. This was showcased within the former arms race between the respective military establishments in the United States and the Soviet Union especially in defence aerospace.

3. **Human Asset Specificity**

Human asset specificity is related to the know-how, experience and ideas of employees. The creativity and innovation of firms originates from its employees. In certain research-intensive industries, such as aerospace and electronics, it is the employees which make possible day-to-day problem solving. Such engineering disciplines in aerospace include metallurgy, fabrication and mechanical engineering that help to assemble complex aircraft, missiles and spacecraft. The range of the human input spans from broad-brush entrepreneurial skills to more detailed practical on-the-job skills including education and training. Human inputs are essential if work is to come to fruition. However, there are incentives to hoard valuable labour and information within firms and even incentives for individuals within firms to move to rival firms, where the skills may be transferable within an industry even if the skills and training are highly specialised.

4. **Dedicated Asset Specificity**

The top-level definition of dedicated assets highlights those specialised investments required by a customer. These investments cover a wide area from research and development, training and education to auditing and lobby activity. This is not meant to be a category to cover a multitude of factors. It is necessary to highlight the broad spectrum of every specific investment, which firms must necessarily undertake to fulfil the needs of the customer. By definition a decision to invest on behalf of a client is a decision that involves relational contracting. This is certainly true in aerospace markets, where for military aircraft the UK government acts as customer, sponsor and regulator (DTI-ITG, 2004: 27).

5. **Reputation Asset Specificity**

The final asset specificity does not directly originate from Williamson (1985: 95). The reputation asset specificity is derived from empirical research into the transaction costs of marketing. Reputation asset specificity is investments in brand value, which can be costly to acquire for example, Boeing. It can be argued that this form of asset specificity is a sub-set of dedicated asset specificity, which identifies how asset can be devoted to a specific purpose such as the marketing mix. Reputation can be gained through first mover advantage, developing a status for excellence or from being the incumbent. Route to market and creating a brand image or product reputation all require relationship-specific investment, which is why this is considered to be similar to dedicated assets.

A detailed analysis of asset specificity reveals the implied prediction of transaction costs namely, that non-specific assets are required for efficient markets. This is because highly specific assets give rise to opportunism, which have transaction costs and tend to be inefficient (Dietrich, 1994: 22). As a result, there is a need for third parties to help in resolving disputes, for example, courts, arbitration or independent experts. The transaction costs approach highlights the fixity of assets, uncertainty in decision-making, the complexity of contracts, as well as provides an explanation of the make-or-buy decision.

(b) Bounded rationality

Bounded rationality is a behavioural feature of transaction costs and is linked to both uncertainty and complexity in Figure 4.3. The definition of uncertainty offered by Knight is an outcome that is unknown or unknowable that is, outcomes that can not have probabilities assigned to the set of feasible results (as opposed to risk where probabilities can be designated). The basic notion here is that individuals only have a limited capacity to process all the market information that is available. Whilst decision-makers attempt to be rational, this is only possible in a partial way and hence bounded rationality. The human factor of bounded rationality is viewed as an environmental factor and becomes uncertainty, which will be measured in this thesis by identifying unexpected changes in supply and demand.

Given the nature of business-to-business aerospace supply chains (and the need for firms to be constantly buying and selling goods and services) uncertainty will be directly measured in terms of supply and demand. That is, demand uncertainty will be measured in respect to the likelihood of unexpected changes in demand for the products of the firm. If there is little likelihood of unexpected demand then it can be deduced that demand uncertainty is low and vice-versa. Also, supply uncertainty will be measured in respect to the likelihood of unexpected changes in supply for the components purchased by the firm. If there is little likelihood of unexpected supply then it can be deduced that supply uncertainty is low and *vice versa*.

(c) Opportunism

Opportunism is also a behavioural feature of transaction costs and referred to as self-interest with guile, by Williamson (1975: 26) and involves the hold-up problem, which can be replicated by the hostage model in Chapter Nine. Opportunism is linked to the problems of bi-lateral monopoly and the effect of small number exchange, shown in Figure 4.3. Individual economic agents may not set out to look for opportunistic events, but similarly will not ignore opportunities once they occur. Also, there is the vital notion of what the model predicts, because firms need to provide contracts to safeguards against opportunistic behaviour. The small number exchange will be measured directly in the thesis by asking the firms to describe the number of UK aerospace suppliers in the main markets of the firm. The number of UK suppliers is low, where there is a significant degree of monopoly power and the number of UK suppliers is little or no monopoly power, which is identical to the S-C-P paradigm. This question captures an element of monopoly power as well as *ex post* small number exchange and can justify the view that monopoly power is a special case within the transaction cost paradigm and not the opposite way round as stated by Dietrich (1994: 23). If bounded rationality, asset specificity and opportunism are joined then the outcome is transaction costs in Table 4.1 below.

Table 4.1: The full catastrophe of transaction costs

Bounded Rationality	Asset Specificity	Opportunism	Outcome
Zero	Zero	Zero	**Complete Contracts**
Positive	Positive	Zero	**Chinese Contracts**
Positive	Zero	Positive	**Contestable Markets**
Zero	Positive	Positive	***Ex Ante* Planning**
Positive	Positive	Positive	**Transaction Costs**

Source: Williamson, (1985: 31) with additions by the author.

The full catastrophe of transaction costs is apparent in Table 4.1 where the make-or-buy decision depends on the dimensions of the transaction (Williamson, 1986: 178). Each economic environment (with and in some cases without the presence of each of the three dimensions) is considered next.

(a) Complete Contract (Zero Transaction Costs)

The antithesis of transaction costs is complete contracts, where indeed contracts are no longer strictly necessary because there is information symmetry. In this scenario there is unbounded rationality, an absence of opportunism and no asset specificity. The result is the likelihood that economic agents can maximise profit with certainty from the various market encounters. The two ends of the spectrum range from minimising transaction costs to safeguard investment specific investments (uncertainty) to maximising profits subject to cost minimisation (certainty). The frictionless economy is one where transaction costs are zero and as a result there are complete contracts. It is difficult to pinpoint specific market examples of frictionless transactions, which is like a vacuum in the physical sciences. Complete contracts can be viewed as a benchmark against which in theory it is possible to compare other types of markets. However, there are examples of long term relational contracts, which are typical in the UKAI such as the JSF in military aircraft.

(b) Chinese Contracts (No Opportunism)

If there is no opportunism then by definition there is trust in the exchange process. Participation and truth telling is more likely to occur since each transaction will not require a revelation mechanism. Handy (1994: 80-81) describes this as a Chinese contract, which dates back to ancient Chinese transactions whereby there was no resort to litigation. It is social honour and saving face that is important to the ancient Chinese system of resolving disputes reflecting a greater emphasis on social and cultural norms and less on the law. Such contracts are designed to benefit both sides of the exchange and as a consequence are mutually self-enforcing. The exchange is open and transparent, which generates trust and co-operation. There is no opportunism and no huge or costly legal apparatus. In other words, there is a strong culture of self-motivating and social enforcing mechanism and no need for legal discourse, because disputes are rare and regarded as socially unacceptable.

(c) Contestable Markets (No Asset Specificity)

Baumol *et al.* (1982) acknowledge transaction costs in the exchange process. Whilst Williamson (1986: 189) regards transaction costs as significant and having a positive value, Baumol *et al.* (1982: 351) see them as approaching zero in line with orthodox neo-classical economics: hence transaction costs are assumed to be zero. With insignificant or zero transaction costs, the 'hit and run' entry condition of a perfectly contestable market is made possible. The existence of asset specificity makes costless entry and costless exit unfeasible. It is noteworthy that other theories in economics assume away the problems of transaction costs in order to make stronger predictions such as auction theory (Milgrom and Roberts, 1991: 28-29).

Transaction costs and contestable markets do have certain themes in common and form part of the New Economics of Industrial Organisation. However, each approach analyses a very different type of market situation. Neither approach is universal or straightforward to prove empirically. A contestable market is likely to be a special case within transaction cost economics, where there are sunk costs and no barriers to entry, but there are still transaction costs.

(d) *Ex-ante* Planning (No Bounded Rationality)

By definition all planning tends to be done *ex ante*, so the need for specific contracts in the face of unbounded rationality is difficult to conceptualise, in spite of the presence of opportunism. This is because unbounded rationality allows economic agents to generate and analyse the relevant information from the beginning of the transaction. All issues and difficulties can be considered *ex ante*, which allows for a complete bargain albeit that this situation creates difficulties for empirical testing. Asset specificity and opportunism are secondary considerations. This particular state of the world highlights the considerable importance given by Williamson to the work by Simon (1957). Economic agents can compute information, but find it problematical to comprehensively deal with complete information. Any disputes or contract drift, which may arise as a result of the *ex ante* bargain are either dealt with in the contract specification and/or through litigation in the court system. This is a situation of moral hazard where there is hidden action. Notwithstanding, Williamson is perfectly clear on the situation where bounded rationality is absent:

> "Contract, in the context of unbounded rationality is therefore described as a world of planning."
>
> Williamson (1986: 178).

The significance of this statement is that Williamson expects planning to replace contractual arrangements when there is unbounded rationality, because there is information to avoid the need to safeguard against the hazards of the transaction. As a result, in the world of bounded rationality the role of the contract becomes very important not only as an exchange arrangement, but also for regulating behaviour and defining incentives between economic decision-makers.

(e) Transaction Costs (Positive Transaction Costs)

The situation where asset specificity, bounded rationality and opportunism coincide is where positive transaction costs emerge manifest. Bounded rationality, opportunism and asset specificity are all necessary and sufficient conditions for transaction costs to exist and assessing these variables will generate a transaction costs analysis. In this state of the world, there is little or no trust between economic agents, which results in opportunism. The planning process is incomplete because of bounded rationality; and asset specificity results from idiosyncratic investment and opportunism means long-term relational contracts. These situations are applicable to the UKAI as well as other industries. Risk and uncertainty, information deficiency and principal-agent problems blight the exchange between economic agents. The result is vertical integration by organisations, missing markets, as well non-standard and incomplete contracting. For example, the development of aircraft is a complex activity and requires considerable amount of R&D, which generates uncertainty. There is specific investment that needs to be protected and this leads to vertical integration as an effective way to organise production, where asset specificity is the most significant. If at least one of these factors is set to zero then other related markets will materialise as described above.

The analysis assumes that all resource allocation is marked-based and a function of economising within the scope of firms. It is true that identifying positive transaction costs and predicting the resultant impact on markets and contracts as shown in Table 4.1 is a challenging task. It is logical to suggest that Chinese contracts and *ex ante* planning are particular types of cultural and market situations, respectively. Also, contestable markets are a special case within transaction costs and complete contracts are a comparative benchmark. The implication is that there is a propensity for transactions costs to occur most often in markets situations (Shelanski and Klein, 1995: 339). In practical terms transaction costs seem ubiquitous, but this may be because the definitions are superficial and ill-defined (Dietrich, 1994: 174). The next part of this section assesses the hypotheses generated by the transaction costs model.

Transaction cost hypotheses

The transaction cost approach presented by Williamson states that the governance structures are based on how firms minimise transaction costs. That is:

> "The basic transactions cost economics strategy for deriving refutable implications is this: assign transactions (which differ in their attributes) to governance structures (the adaptive capacities and associated costs of which differ) in a discriminating (mainly transaction cost discriminating) way.
>
> Williamson (1989: 136).

Furthermore, contractual arrangements are identified as significant:

> "Although marginal analysis is sometimes employed, implementing transaction cost economics mainly involves a comparative institutional assessment of discrete institutional alternatives – of which classical market contracting is located at one extreme; centralised, hierarchical organisation is located at the other and mixed modes of firm and market organisation are located in between."
>
> Williamson (1985: 41-42).

There are three implications of the transaction cost approach. Firstly, it regards the firm as a governance structure rather than a production function. Secondly, it regards the role of contract as essential to the comparative analysis. Thirdly, the boundaries between mixed modes of firms and markets are determined by make-or-buy decisions.

A working hypothesis would identify how firms use contracts to choose trading partners in order to minimise the hazards of asymmetric information at the lowest cost of organising (Klein, 2004: 3). In particular:

> "Consider the decision of a firm to make or buy a particular good or service. Suppose that it is a component that is to be joined to the mainframe and assume it is used in fixed proportions. Assume, furthermore, that the economies of scale and scope are negligible. Accordingly, the critical factors that are determinative in the decision to make or buy are production costs and the ease of effecting inter-temporal adaptations."
>
> Williamson (1989: 151).

For the purposes of this thesis, three hypotheses are relevant. Firstly, the Monteverde and Teece (1982 a: 206) hypothesis is relevant because it sets out the make-or-buy decision for the firm and is subsequently the hallmark for transaction cost hypotheses. This hypothesis is the first to follow the Williamson approach and is repeated throughout Appendix I (for example John and Weitz, 1988: 106). Monteverde and Teece specify the dependent variable in binary form using a probit model, which is also an approach used in this thesis. Secondly, the Masten (1984: 405) hypothesis is relevant because it is applied to the aerospace industry in the US. Also, it recognises the pivotal role of asset specificity in the make-or-buy decision, which is similarly adopted in this thesis, given the nature of the UK aerospace industry. Asset specificity is shown to be fundamental by Mulherin (1986: 220-221) and Crocker and Masten (1988: 330) again an issue that is vital to the aerospace industry. Finally, the hypothesis presented by Lyons (1994: 260) is relevant to this thesis, because it develops the link between manufacturing in-house (make) and procurement from the market (buy) as a feature of contract design. The approach adopted by Lyons is useful to the UK aerospace industry due to the nature of manufacturing and the procurement process as a whole. Therefore, three key hypotheses for this thesis are Monteverde and Teece (1982 a), Masten (1984) and Lyons (1994, 1996), because collectively these studies allow make-or-buy and contract design to made operational using a probit or logit regression methodology; and are applied to the aerospace industry specifically or manufacturing in general. Each study is assessed in turn.

(i) Monteverde and Teece (1982 a, b): make-or-buy decision in a binary form

The work by Monteverde and Teece (1982 a: 206) on USA car components analyses the incentives for backward vertical integration. The approach is stated as follows:

> "We hypothesize that assemblers will vertically integrate when the production process broadly defined, generates specialized, non-patentable know-how. When production processes are of this kind, both assembler and supplier are exposed to the possibility of opportunistic re-contracting."
>
> Monteverde and Teece (1982 a: 206).

The research attempts to study the costs of switching supplier when there is asset specificity, which results in the possibility of opportunism. There is a choice of make-or-buy where the dependent variable is specified in binary form. Hence:

> "The dependent variable we construct is dichotomous; each sample component is coded as being predominantly manufactured in-house or by an external supplier."
>
> Monteverde and Teece (1982 a: 207).

The strength of the research is that a dichotomous dependent variable can be used to test the data via a probit model with cross-sectional data (Monteverde and Teece, 1982 a: 211). This is because there is a limited dependent variable on the left-hand side of equation 4.2, which is not possible to test with an ordinary least squares regression. The testable hypothesis used in the research is:

> "The greater is the applications engineering effort associated with the development of any given automobile component, the higher are the expected appropriate quasi-rents and, therefore, the greater is the likelihood of vertical integration of production for that component."
>
> Monteverde and Teece (1982 a: 207).

The dependent variable was generated from a list of 133 car components and used as a proxy for transaction-specific skills. If 80% or more of the supply requirement of a component was in-house then it was labelled as make. Conversely, if more than 20% of the supply requirements were purchased from the market then it was labelled as buy. Although a figure of 80% is arbitrary, this threshold remained highly significant even if the level for make was changed to 70% or 90%. The independent variable was engineering effort, which was a surrogate measure of asset specificity and developed using a Likert scale. Also, control variables were introduced into the model to avoid misspecification of the model. If a component was specific to a particular company then it was identified with a control variable; and if a component was integrated into a wider system then it was also identified with a control variable.

The results form the probit analysis show that if the engineering design contains transaction-specific skills then car-assembling firms such as General Motors (GM) and Ford would make in-house; otherwise they will buy from existing spot markets. Also, car-assemblers will avoid exposure to the opportunism from suppliers through backward vertical integration when components are firm-specific and are highly integrated with other parts in a system. Monteverde and Teece conclude that the results confirm the hypothesis and give support to the transaction costs because:

> "GM and Ford are more likely to bring component design and manufacture in-house, if relying on suppliers for reproduction development service will provide suppliers with an exploitable first-mover advantage."
>
> Monteverde and Teece (1982 a: 212).

The work by Monteverde and Teece is important in three areas. Firstly, it uses a binary dependent variable for make-or-buy; secondly it generates a proxy for human asset specificity and finally it uses probit analysis. However, whilst it uses control variables for engineering effort, it does not explore other measures of asset specificity such as location. Location asset specificity would appear important to USA car production given the significant cluster of car assemblers and component suppliers in the Detroit area of Michigan where the majority of USA car production is located. Also, there are no explanatory variables for uncertainty and complexity. This means whilst the Monteverde and Teece research is significant it is only partial in terms of the transaction cost approach. This weakness of the research was due to data collection problems because the car-assemblers were highly sensitive to revealing make-or-buy decisions. Finally, this approach to the make-or-buy decision was at the level of systems and not the market and does not take account of the institutional choice between firms and markets unlike this thesis, which develops make-or-buy at the market level. Another benefit of the approach adopted in this thesis is the respondents to an anonymous questionnaire survey are more likely to disclose data on make-or-buy than an interviewee where the sensitive data is compared against a close rival at the systems level and not at the wider market level.

(ii) Masten (1984): make-or-buy decision and probit analysis

The work by Masten (1984: 403) focuses on the make-or-buy decision by US aerospace firms. It attempts to link the various aspects of asset specificity, frequency and uncertainty with contract type. Hence:

> "Idiosyncratic assets, because of their specialised and durable nature, imply that parties to a transaction face only imperfect exchange alternatives for an extended period. The more specialised those assets, the larger the quasi-rents at stake over that period and hence the greater the incentive for agents to attempts to influence the terms of trade through bargaining or other rent-seeking activities once the investments are in place."
>
> Masten (1984: 405).

Masten identifies the make-or-buy plan at two levels as outlined at the start of this Chapter. Namely for defence aerospace:

> "The administration of procurement in this [aerospace] industry is two-tiered. On the first level, the government chooses a prime contractor who is assigned overall responsibility for a particular program; and on the second, the contractor manages the production of the system itself, including what is of particular interest here – the administration of subcontracts."
>
> Masten (1984: 404).

The transaction costs analysis shows that if firms vertically integrate through the make decision this will have implications for hierarchies, (Williamson, 1975: 49). Even if there is a buy decision, then this has implication for other firms in the supply chain known as market firms. Similarly,

> "The greater the complexity of the transaction and the level of uncertainty associated with it, the greater the likelihood of being bound to inappropriate action....In sum, the more idiosyncratic are the investments associated with a particular transaction, the greater are the incentives to incur the costs of writing more detailed and long term contract."
>
> Masten (1984: 405).

Masten asked the procurement team in a large aerospace firm to assess which of 1,887 components are make and then developed two measures of asset specificity. The first measure was design specificity and the second was site specificity. A measure of complexity was used as a binary variable because demand uncertainty could not be used at the systems level. With make-or-buy as a dichotomous dependent variable the probit regression generates a pseudo R^2 of 0.61. This result shows acceptable explanatory power for the model. In a similar study by Masten *et al.* (1989) of 118 motor vehicle components the pseudo R^2 is 0.36, which in comparison to Masten (1984) is modest explanatory power. Complexity and design specificity are highly significant and with the correct positive sign; but co-location is not significant even though it has the correct positive sign. Masten conclude that government policy in the USA and contractor procurement policy indicate a "strong predisposition" towards buy, but this situation is reversed when components are specialised and complex since there are hazards to market exchange (Masten, 1984: 416).

The strength of the research is that the decision to make-or-buy can be modelled in terms of designing the contract to avoid opportunism and the results show relatively significant explanatory power. Masten also represents the make-or-buy choice as a dichotomous variable and uses a probit model of estimation (Masten 1984: 410). Like Monteverde and Teece, Masten also used cross-sectional data and focused on a single industry to restrict the need for absolute measures of asset specificity and complexity. Masten develops the use of questionnaires, but crucially also develops other transaction cost variables to test the hypothesis. The weakness of the research is an inability to generalise from the approach, because the analysis is at the systems level within a single firm rather than a specific market. Also, the role of contracts is not developed either, which is a problem for assessing aerospace firms, which are characterised by long term and relational contracts. Unlike the research by Masten this thesis will take into account uncertainty and not focus only on complexity. The thesis also incorporates an analysis of contracts and assesses the role of contract design. Finally, it is possible to generalise the research in this thesis, because it samples a significant number of firms across the aerospace industry.

(iii) Lyons (1994, 1996): contract design and probit analysis

Lyons (1994) views contract design an important issue in transaction cost minimisation, but only in the absence of spot markets. This is because spot markets deal at arms-length with suppliers, whereas other market types require relational contracting. Constant changes to contracts such as negotiation, haggling and writing will result in ink costs. As a result, contracts written in the absence of standard spot market contracts then face the hold-up problem. This is because:

> "...specific assets and opportunism are at the heart of making transaction costs into a falsifiable theory."
>
> Lyons (1994: 259).

The hypothesis tested by Lyons (1994) is in the form of a question:

> "What determines the probability of sub-contractor-customer relationship being governed by a formal contract?"
>
> Lyons (1994: 259).

The work by Monteverde and Teece (1982 a) and Masten (1984) assess the make-or-buy decision within a single firm or between two firms and identify a number of specific components. The work by Lyons assesses the make-or-buy decision across many firms, which is the approach of this thesis. The questionnaire used by Lyons was sent to 1,000 general engineering firms and there were 103 responses (that is a 10% response rate). In the questionnaire, Lyons required the respondent to answer in terms of the most important customer or supplier. This technique is vital in establishing the context of the response, since unlike Monteverde and Teece (1982 a) and Masten (1984), this research was at the level of the market and not a closed system. The Lyons methodology also uses a dichotomous dependent variable and also tests using the probit model. The suggestion of the research is that the make-or-buy decision has implications for contract design as a way to avoid opportunism in the face of relationship-specific investments. The dependent variable was not make-or-buy, but the probability to write a formal written contract, whilst the "proximate determinants of transaction costs" are vulnerability, complexity, size and trust (Lyons, 1994: 260-264). Vulnerability is a proxy for opportunism; complexity is a proxy for bounded rationality; size is a proxy for ink costs and trust is a proxy for safeguards. Lyons uses a probit model and the results show "powerful support for the transaction cost theory of contract" (Lyons, 1994: 272). That is:

> "Bounded rationality has been shown to influence the writing of contracts through the complexity of specification for advanced technology inputs. Fear of opportunism particularly in relation to specific investments, has an even stronger influence: The more vulnerable a supplier is, the more likely she is to negotiate a formal contract."
>
> Lyons (1994: 272).

The strength of Lyons research for purpose of this thesis is that the transaction cost approach is important for contract design. This facet of transaction costs has been overlooked in previous studies. Also, the questionnaire approach can be used to gather data beyond the level of a closed system, which has been preferred by the other two selected studies. As a result the questionnaire can be written to capture information from different suppliers across an industry or sector. In previous studies, key decision-makers in specific firms were interviewed, which may result in a biased selection of interviewees.

The weakness of Lyons research is that there is no direct measure of make-or-buy, which would have been relatively straightforward to achieve given the questionnaire approach. Indeed specifying the hypothesis as a question limits the test of vertical integration within the framework of make-or-buy. This thesis will build upon the general approach presented by Lyons and then directly test the make-or-buy decision and contract design within the transaction cost paradigm. The original contribution of this thesis is a questionnaire survey approach utilised by Lyons, but used directly on the make-or-buy decision and contract design. It builds upon the pioneering work of Monteverde and Teece who developed make-or-buy in a binary form and the probit or logit regression methodology of Masten.

Summary of the transaction cost model hypotheses

In summary, the make-or-buy hypotheses derived from the transaction cost model can be specified in the following ways to generate a set of testable features:

i. The make-or-buy decision as the paradigm problem of transaction costs can be modelled a binary or dichotomous dependent variable. This allows the research to use econometric studies of analysis and rigorously test the predictions of transaction costs.

ii. Choice among alternative modes of production to be resolved by minimising the costs of the transaction and can use probit or logit models for the analysis with a limited dependent variable. This allows the research to go further than descriptive statistics and cross-tabulations and use econometrics and make operational the transaction cost model.

iii. Contract type can be used in conjunction with the make-or-buy decision as an attempt to understand vertical integration. This approach is useful for analysing the behavioural features of transaction costs such as safeguards against the threat of opportunism.

The hypotheses of the three key studies suggest that there is scope for the transaction costs approach to overcome the criticisms of tautology and measurement deficiencies that are contained in the previous Chapter. The final section in this Chapter will consider how to measure and test the variables expressed in the transaction cost hypotheses that are relevant to this thesis.

Applications of the transaction cost model

Applying the transaction cost methodology develops the model where the dependent variable is a proxy for transaction cost (Williamson, 1985: 52). The relationship is presented in equation 4.3.

$$TC = f(AS, F, U/C, SN) \qquad \text{Eq. 4.3}$$

Where:

TC = transaction costs, AS = asset specificity, F = frequency,

U/C = uncertainty / complexity, SN = small numbers.

Williamson (1985: 34) specifies asset specificity as variable k. If k > 0, then asset specificity is both positive and significant. If k = 0, then exchange takes place through a spot market. There is another related variable, namely s, which measures the safeguarding of the transaction through a contract. If s = 0, then there is no safeguard, but if s > 0 a safeguard exists. These have implications for the efficiency of the market price as indicated below, where p_1 is the lowest price in the spot market and $\bar{p}$ is the highest price in the presence of asset specificity and no safeguards. If a contract is employed to safeguard an asset specific transaction, then an intermediate price $\hat{p}$ prevails, which is higher than p_1 but lower than $\bar{p}$. Both k and s are measured in this thesis (see Table 5.1). This analysis is show in Table 4.2 below.

Table 4.2: Safeguards and asset specificity

Price (p)	Asset Specificity (k)	Safeguards (s)
p_1	K = 0	s = 0
$\bar{p}$	K > 0	s = 0
$\hat{p}$	K > 0	s > 0

Source: Williamson (1985: 33).

Where: $p_1 < \hat{p} < \bar{p}$ Eq. 4.4

The next part of this section attempts to measure asset specificity, frequency, uncertainty, complexity and small numbers in this thesis.

(a) Asset specificity

Asset specificity is fundamental to transaction costs, because specific investments require safeguarding through relational contracting. Williamson views asset specificity as the "degree to which an asset can be redeployed to alternatives and by alternative users" when there is no reduction in productive value (Williamson, 1989: 142). However, measurement problems are an acute issue in the empirical transaction cost literature. The aim of the thesis is to show that these measurement problems can be overcome and form a substantially original element in Part Two. This thesis has to deal directly with measurement issues. Since asset specificity is an important variable there will be four direct measures of asset specificity used in this thesis. Firstly, to measure the asset specificity of location, firms are assessed in terms of proximity to the most important customer. This generates a response based on a similar issue in the questionnaire by Lyons (1994) that measures whether location is important to aerospace firms by measuring in miles the distance from the most important customer. Secondly, to measure the asset specificity of facilities and equipment, firms are asked to rank how specific the production process is to the company. Given the high levels of investment in the UK aerospace industry this is expected to be a significant variable. In order to add some detail firms are asked to give examples of core activity that are highly specific to the firm. Thirdly, to measure human asset specificity firms are asked to rank how specific are the skills, knowledge and experience of employees to the company. Once more, given the high level of training and skilled qualified scientists and engineers in the UK aerospace industry this is expected to be a significant variable. In order to add some detail firms are asked to give examples of occupational groups that are highly specific to the firm and this is dealt with in Chapter Five. Fourthly, to measure the dedicated asset specificity and commissioned investments the firms are asked to rank how specific are the production process of the company to the most important customer. This variable is expected to yield significant results given the close working relationship between firms in the supply chain. For example, Rolls-Royce is highly unlikely to design and manufacture an aero-engine that does not fit into the range of airframes produced by BAE Systems even though the UK market on its own is too small for Rolls-Royce. Finally, reputation asset specificity is not covered in this thesis, because it is an explicit marketing issue of branding and product value and not necessarily relevant to an economics study of the UK aerospace industry.

(b) Frequency

If there are frequent or recurrent transactions then the fixed costs of the specialised governance structure are best recovered through the firm that is by making the component or part. Table 4.3 shows that asset specificity given as the investment approach is the dominant factor. If the asset is non-specific then frequency is irrelevant since transaction cost theory predicts the classical contracting mode of the market. If the asset specificity is mixed or idiosyncratic then the frequency determines whether neo-classical contracts prevail (occasional transactions) or relational contracts prevail (recurrent transactions).

Table 4.3: Efficient governance

	The Investment Approach		
Frequency	**Non-specific**	**Mixed**	**Idiosyncratic**
Occasional	**Market Governance**	**Trilateral Governance** (Neo-classical Contracting)	
Recurrent	(Classical Contracting)	**Bilateral Governance** (Relational Contracting)	**Unified Governance** (Relational Contracting)

Source: Williamson (1985: 78).

The measurement of frequency can be specified along a continuum from one-off transactions to frequent repeat transactions. For example, in aerospace ball-bearings are frequent transactions and ejector seats are rare transaction. In this thesis, the frequency variable is measured along a Likert scale with intervals or reduced to a binary code of either frequent or infrequent transactions. The dimension of frequency in the transaction cost model should be included, but in practice is dominated by dimension of asset specificity as shown in Table 4.3.

(c) Uncertainty and Complexity

The dimension of uncertainty is usually co-specified in terms of complexity (Williamson, 1985: 51). However, the concepts of uncertainty and complexity are not identical. Uncertainty is immeasurable risk and complexity is the difficulty or intricacy of a problem. There is some overlap between the two terms, because complexity can lead to uncertainty. In the Masten research it was not possible to test for the effects of demand uncertainty, because the make-or-buy decision only focused on internal systems. The variable for uncertainty was then substituted for complexity, which was defined as a proxy for the degree of uncertainty (Masten, 1984: 409).

In terms of measuring uncertainty, the transaction cost theory predicts that asset specificity is the dominant factor over uncertainty. Table 4.4 shows that the market (that is, the buy option) is the preferred choice if asset specificity is low, irrespective of whether uncertainty is high or low. Nevertheless, uncertainty does determine whether long term contracts or the hierarchy (that is, the make option) is chosen if asset specificity is high.

Table 4.4: The choice between asset specificity and uncertainty

ASSET SPECIFICTY	LOW DEGREE OF UNCERTAINTY	HIGH DEGREE OF UNCERTAINTY
Low	MARKET	MARKET
High	LONG-TERM CONTRACT	HIERARCHY

Source: Hendrikse (2003: 214).

The research in this thesis is across a focused single industry in line with Lyons (1994) and it is possible to specify uncertainty in terms of both supply and demand. Firstly, the likelihood of changes to supply can be a measure for supply uncertainty. Secondly, the likelihood of changes to demand can be a measure for demand uncertainty. In this thesis, the measure of complexity is unnecessary given that uncertainty has been encapsulated in a focussed study of single industry, whereas the research by Masten was a single system.

(d) Small Numbers

The problem of opportunism is only apparent if there are small numbers of *ex post* trading partners reduced from many *ex ante* bidders. If large numbers of buyers and sellers exist in the market that regularly trade with one another then when one firm provides an inferior product or service the buyers can switch supplier. However, the option of supplier switching is not possible if the supplier has a pure (or scale) monopoly. From Figure 4.3 the human factors of bounded rationality and opportunism combine with the environmental factors of uncertainty plus complexity and small numbers exchange and lead to transaction costs. The measurement of small numbers is also possible with a study of an industry as opposed to a system. Small numbers exchange links back to the threat of opportunism and the hold-up problem. On a scale from low to high the number of suppliers can be used to assess whether the firm faces the threat of opportunism on the supply-side that is monopoly power. Similarly, on a scale from low to high the number of customers can be used to assess whether the firm faces the threat of opportunism on the demand-side namely monopsony power. These measures have implications for how firms will plan, negotiate and safeguard contracts with the supplier-base and the customer-base.

Overall, the criticism often raised is the dimensions of the transactions and the human factors are difficult to measure (Dietrich, 1994: 68). Indeed, if variables are problematic to quantify, either in ordinal or cardinal terms, then this makes the calculation of make-or-buy an infeasible task and an empty exercise. Furthermore, the implicit assumption of a choice between markets and hierarchies is a redundant notion, especially if the precise measurement of the transaction costs is not possible. Perrow (1981) continues the attack by claiming the transaction costs arguments are inconsistent, that is both the firm and the market reproduce transaction cost and not only the market. Although the body of empirical studies has at least attempted to render this criticism as superfluous, it remains a valid point that research in transaction costs is problematic due to data quality and the need to use proxy variables. It is acknowledged in this thesis that a careful approach is required, which is developed in Chapter Five.

As little or no data exists in published or official sources, original data needs to be collected for the purposes of the research. Whilst it is routine to use official data sets in economics this should not preclude the collection of data from other sources as happens in other academic disciplines involving behavioural research, for example experimental psychology (Borkowski and Anderson, 1976). Data collecting from primary sources is time-consuming and challenging and could lead to benefits such as the direct measuring of a variable rather than resorting to a proxy or an alternative viable. Transaction costs can be assessed through questionnaires (similar to the RPI and GDP measures elsewhere in the collection of primary economic data by official government agencies). There are difficult decisions concerning the choice of data, but these are not impossible decisions and therefore the research in this thesis should proceed. The next part of the section assesses the predictions of the transaction cost economics paradigm.

The main tests of the transaction cost approach

The general hypothesis of the transaction cost framework is based on the paradigm make-or-buy issue (Shelanski and Klein, 1995: 336). In terms of this thesis the following hypothesis is tested on aerospace firms in the UK:

> H_0: Aerospace firms have a higher propensity to integrate activities, when transaction costs are positive that is, make. Or conversely, firms have a lower propensity to integrate activities, when transaction costs are zero that is, buy.
> H_1: Aerospace firms do not relate the make-or-buy decision to the existence (or absence) of transaction costs.

The null hypothesis states that positive transaction costs result in hierarchies and zero transaction costs result in markets. The alternative hypothesis states that transaction costs are unrelated to the make-or-buy decision. As a result the hypothesis is not a test of causality. Also, there are predictions made by transaction cost economics, which relate to the dimensions of the transactions, namely asset specificity, uncertainty or complexity and frequency, plus the issue of small number exchange. These predictions relate directly to the make-or-buy decision and contract design. In order to make the concept of transaction costs operational the predictions of the approach have to be assessed in more detail. The next step is to assess the predictions for asset specificity, uncertainty and frequency and small numbers.

1. **Asset specificity of investment:**

If asset specificity is low or where assets are general, then the decision is buy from the market or outsource. If asset specificity is high or where assets are specific, then the decision is make in the firm that is, in-house[4]. Inputs requiring a specific production technology are more likely to be produced in-house (make). Hence:

> a. Non-specific and generic transactions, where $k = 0$ (either occasional or recurrent) are efficiently organised by markets (buy).

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[4] Outsourcing might occur on occasion if long term contracts are awarded to production investment in highly specific asset, for example PFI for the RAF tanker fleet.

b. Specific transactions that entail mixed or idiosyncratic investment, where $k > 0$ (either occasional or recurrent) are organised internally (make).

Asset specificity is expected to be a significant issue for UKAI, because of relation-specific investments. The prediction for UK aerospace is that firms are more likely to make components due to relatively high asset specificity and thus firms will tend to be vertically integrated.

2. **Frequency of the transaction:**

If frequency is low, then the decision is buy from the market. If frequency is high, then the decision is make for the firm. This decision is due to the high volume, which will result in lower unit costs of the component for the firm that makes in-house. However, specialist suppliers with high volume can also obtain economies of scale and scope and firms will buy from these firms depending on the asset specificity as shown in Table 4.3.

a. If transactions are non-specific or generic ($k = 0$), then it is efficient to organise via the market, whether transactions are occasional or recurrent (buy).

b. If transactions are specific or bespoke ($k > 0$), then it is efficient to organise via hierarchies, whether transactions are occasional/recurrent (make).

The prediction for UK aerospace is that firms will make and buy because there are both specific and generic components required in the production process.

3. **Uncertainty in the transaction:** (this is a proxy for bounded rationality)

If uncertainty is low or certainty is present, then the decision is buy from the market. If uncertainty is high, then the decision is make in the firm.

a. Under conditions of certainty and no complexity transactions are efficiently organised by markets (buy).

b. Under conditions of great uncertainty and significant complexity, transactions are efficiently organised internally (make).

In relation to uncertainty, two other hypotheses confirm that it is advantageous for the firm with high volume and technological uncertainty to make rather than buy in order to eliminate any potential scope for opportunism or hold-up from current or future suppliers, see Table 4.4. Hence:

c. Volume uncertainty. The experience of volume uncertainty leads to making rather than buying a component.

d. Technological uncertainty. The experience of technological uncertainty increases the likelihood of making rather than buying a component.

The issue of quasi-rents is similarly important in this respect. This is because the higher the saving from the market, then the more likely a firm will buy from the market. It is likely that this may be particularly true for large firms with multi-site, multi-products operations, where overhead cost may be higher than a smaller more flexible firm. There is limited evidence for this in the pilot survey, where suppliers or sub-contractors to BAE Systems were winning competitive tenders for small engineering work against other internal divisions or departments within BAE Systems on cost grounds (see Appendix III). The prediction for UK aerospace is that firms are likely to make due to relatively high levels of uncertainty in the transaction.

4. **Small numbers exchange** (this is a proxy for opportunism)

If small numbers exist in the transaction, then the decision is make, since there is scope for opportunism resulting in the hold-up problem. If small numbers do not exist or there is a competitive market in operation, then the decision is buy from the market, because there is reduced scope for opportunism and little threat of hold-up:

a. Small numbers supply or exchange increases the incentives to haggle and distort information, which is overcome by vertical integration (make).

b. Large numbers supply or exchange decreases the incentives to haggle, posture and distort information, hence markets prevail (buy).

The prediction is that UK aerospace firms will make due to small number exchange. The competitiveness of the supply market tends to increase the production cost advantage of suppliers. There are links back to what is produced in-house, other than project management skills and in turn this comes down to asset specificity. Therefore, if up to 70% is out-sourced by the larger suppliers, then the remaining 30% is likely to be where there is high asset specificity. Similarly with quasi-rents, the higher the supplier production cost advantage then the more likely the firm will buy rather than make a component. Indeed, this is why the up to 70% of the total value of BAE Systems aircraft is out-sourced to the market. There is a Williamson-based adage strongly in vogue in the UK aerospace industry, namely why make when you can buy?

Summary of the operational aspects of the transaction cost model

In summary, there are three issues concerning the operational aspects of the transaction cost approach for this thesis:

i. The definitions of the explanatory variables remain problematic, which makes data collection a difficult task. The best solution to this problem is to generate data using a customised questionnaire, which has the benefit of creating substantial and relevant data (see Monteverde and Teece, 1982 a).

ii. The measurement of the transaction costs attributes is difficult and often requires proxy variables. The best solution to this problem is to measure the variables in a process or system (see Masten, 1984) and in a specific industry (see Lyons 1994). This has the benefit of creating consistent and robust data.

iii. The transaction cost approach can specify a testable hypothesis, but these hypotheses are not a test of causality.

Conclusions

This Chapter has assessed the transaction cost model in terms of its methodology, hypotheses and the potential ways of applying it to the UKAI. The section on the methodology of transaction costs has reinforced the importance of previous empirical studies to this thesis and shows asset specificity to be particularly important. The section on hypotheses has shown the importance of testing the make-or-buy decision and contract design as dependent variables. The section on the method of testing has confirmed it is challenging to overcome the measurement problems and criticisms of tautology, which has been levelled at the transaction cost approach. Notwithstanding, there are a number of micro-analytic studies, which have been undertaken using the transaction costs approach, which connects the transaction cost approach to the study of aerospace and defence (Masten, 1984).

Overall, the remaining issue for this thesis is data collection. Official data sources provide breadth, whereas transaction cost data require depth, which usually has to be collected first-hand from the firm via a questionnaire survey. This Chapter has shown that the transaction approach has developed a testable model given in equation 4.3 for which the outcomes are shown in Table 4.1. Whilst significant problems of inconsistent measurement and the choice of dependent variable persist it is possible to operationalise the transaction cost approach.

In conclusion, the transaction cost model has been specified in this Chapter and the predictive nature of the approach has been assessed. The remainder of this thesis will concentrate on making operational the testing of the make-or-buy decision and contract design at the firm level. The thesis has collected a unique dataset in order to achieve this objective, which has been informed by three key studies identified above. Finally, this completes the first part of the thesis on transaction cost theory and methodology. The second part reports on the empirical study of the UK aerospace industry using the transaction cost approach. The next Chapter will analyse the population and sample of the original survey conducted for this thesis.

Part II

Empirical Results

Chapter Five:
Methodology and questionnaire

Introduction

This Chapter presents the research methodology of the survey and describes the questionnaire used to collect the primary data. The central feature of the research in this thesis is a large-scale, in-depth survey combined with a rigorous single industry analysis (Remenyi *et al.*, 1998: 43). The evidence required for this approach is obtained from both primary and secondary sources, namely an original questionnaire, plus published reports and company accounts, respectively (Fink and Kosecoff, 1998: 39). These data are subject to statistical and econometric analysis and are used to test the two research questions. Namely, what determines the make-or-buy decision within an aerospace firm? And, what potential hold-up problem exists between aerospace firms in the supply chain from the perspective of contract design?

There are three sections in this Chapter. Firstly, the research methodology is identified and the survey population of SBAC membership is documented. Secondly, the pilot survey is conducted and specified in terms of informing the design of the questionnaire. Thirdly, the survey sample is specified and each of the three parts[1] of the questionnaire is described in turn. The results from the questionnaire form the majority of Part Two of the thesis. The next section analyses the research methodology and assesses how to make the questionnaire operational.

Research methodology

The research methodology attempts to use both logical reasoning and empirical observation (Remenyi *et al.*, 1998: 43). This is in line with a positivistic approach and it is for this reason that one of the central research tools is the questionnaire survey[2]. The positivistic research strategy is regarded as more appropriate in this context than the phenomenological[3] strategy, where the former is usually adopted by physical

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[1] The three sections are as follows: Section A is company profile. Section B is company supply chain. Section C is company transactions.
[2] According to Remenyi *et al.* (1998: 57) the 'logic of a traditional survey is strictly positivistic'.
[3] A phenomenological approach is usually adopted by the social sciences, Remenyi *et al.* (1998: 93).

sciences. This is because the actual research problems are examined using quantitative analysis, which can be used to observe and measure actual outcomes. As a result, a direct test of the null hypothesis is possible, using a positivistic approach. Whilst the majority of this research uses quantitative data, there is also analysis of qualitative data, where appropriate, especially in terms of contracts. However, in this thesis there is an additional need to generate original data to test the predictions of transaction costs since there are no available published data close enough to be a proxy at the firm level in the aerospace industry[4].

The questionnaire survey information was gathered primarily by a postal questionnaire and supported by interviews with key respondents in selected companies. The aerospace companies selected for the survey were all members of the aerospace trade association namely the Society of British Aerospace Companies (SBAC). In 1997 there were 187 full members of SBAC and 82 of these firms completed the questionnaire, which represents a response rate of 44%. The firms which completed the questionnaire include BAE Systems and Rolls Royce as well as four aerospace suppliers in the North West of England that participated in the pilot survey. In the SBAC population, the companies range from large multi-site, multi-product, multi-national aerospace companies, which occupy the position of prime contractor in the supply chain, to small and medium-sized service and component suppliers. The questionnaire has been designed to provide not only a detailed cross-section of the aerospace industry, but also longitudinal developments. This allows an analysis of dynamic changes, in addition to the static position at any point in time and as a result a questionnaire approach is a suitable data collection method. The full details of the questionnaire are developed later in this Chapter and a summary of the statistics is reported in Chapter Six.

The secondary data field is generated from a number of business and economic sources. One of the main sources of information is the Financial Access Made Easy (FAME) CD-ROM database, which provides full company accounts and business

[4] This research has not ignored the theoretical contribution of economics. Indeed, the previous Chapter has shown the theoretical underpinning to be highly significant. However, to fully understand the research questions and the profound changes affecting the UK aerospace industry at present, an empirical approach remains the most logical choice, which is nevertheless derived from a sound theoretical basis.

ratios for a wide range of UK companies from 1993 to 1998[5]. From this database it is also possible to specify industry aggregates, which allows an assessment of profitability across different industries and check the accuracy of the responses from the survey. Other sources include published company reports and accounts for public limited companies, as well as company-produced product and service listings, especially from private limited companies. Company information on ownership and the year of company formation is located in Who Owns Whom and Dunn & Bradstreet, respectively. Data on aerospace companies has been obtained from SBAC, Jane's and AIRLINE, an aerospace research centre based at Warwick. Data on defence companies has been obtained from the MoD and the Defence Manufacturers Association (DMA). Aggregate economic information has been gathered from Economic Trends, the Employment Gazette and the Monthly Digest of Statistics. The research methodology is primarily empirical and positivistic, combining longitudinal and cross-sectional research with both primary and secondary data. The analysis uses statistical methods and econometric procedures to answer the research questions.

The specific approach of the questionnaire technique is a method for analysing quantitative and qualitative issues in the UK aerospace supply chain (Symon and Cassell, 1998: 1-2). The main purpose of the questionnaire is to test the transaction cost model in an industry where there is no relevant published data. In the absence of any relevant data, the questionnaire has been designed to maximise the potential response rate, including closed-ended questions, making the questionnaire length relatively short and allowing anonymity and confidentiality of respondents (Remenyi *et al.*, 1998: 152).

The main advantage of closed-ended questions, multiple-choice alternatives and Likert scaling is the ease and quickness of response. Companies are in business to make money, not to answer unsolicited questionnaires.

According to Edwards *et al.* (1996: 25):

> "It takes considerably less effort to check a box, select an alternative or rate something on a 1-to-5 scale than to think of and write a narrative answer".
>
> Edwards *et al.*, (1996: 25).

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[5] There is a disclosure lag for certain companies, which creates gaps in the database for the latest year, in this case 1998. As a result, few companies had reported the 1998 figures, but all reported 1997.

The closed-ended questions with response alternatives and Likert scales reduce the effort and time required completing a questionnaire. In addition, it communicates the same frame of reference for all those in the population and allows the answer to be more easily converted into quantitative variables. Closed-ended questions do have philosophical drawbacks, not least of which is that it can inhibit the questionnaire respondent from giving more detailed information and funnels the replies in a potentially pre-specified way. However, on the whole this approach is better suited for the purposes of the research, because it allows quantitative data to be gathered, in addition to those items, which ask demographic questions.

Wherever possible non-committed responses were made available, for example, sometimes in order avoid prejudicing a response and allow special alternatives to be expressed. However, item branding, where respondents are instructed to skip questions, which may not be applicable was not included, since this increases the overall level of non-response. Indeed, many respondents replied with *"not applicable"* in any case, which justifies this decision.

The number of points on the Likert scale was specified as ten and is within the conventional range of between 5 and 10. Whilst it is acknowledged that a greater number of points do not necessarily enhance the measurement responses, a decimal system was preferred to augment the ease of understanding for the respondent. Edwards *et al.* (1996: 25-26) recommend using five point scales, because it contains a neutral point or mid-point and is relatively concise. There is no definite conclusion covering the use of midpoints and a system based on ten has an intuitive logic. Furthermore, all items using the Likert scale response format are labelled with meaningful anchors, for example 1 equals general and 10 equals specific. Likert scaling is the most used system in the literature and is preferred to either Thurstone scaling and semantic differential scaling in organisational surveys. Likert scaling does have drawbacks, including whether a scale of five in one firm is truly comparable with a scale of five in another. Also, Likert scaling does tend to be artificial and as a result potentially unable to capture the complexities of an issue. These issues were fully considered and it is nevertheless deemed suitable to use the Likert scaling, not least as it is the convention to do so in the empirical literature (Masten *et al.*, 1991: 265). More compelling is the role of the Likert scales to be a genuine attempt to secure a true and accurate record of any given question, in spite of the limitations.

It is important to consider response bias with closed-ended items. For example, response order affects yea-saying or nay-saying, acquiescence and fatigue effects. In this questionnaire, response order effects are not a major issue since only a few questions have a listed reply. Where it does occur, respondents were requested to rank their replies to certain questions. Yea saying, nay saying and acquiescence are not considered a major problem in this type of questionnaire, because the questions are not directly assessing behaviour. Nevertheless, wherever possible items have included a neutral response as well as both negative and positive ones. Moreover, several questions have positively and negatively worded items; or balanced scale approach. Fatigue effects are overcome by making the questionnaire relatively brief, that is, between four to eight pages, where four is considered short and more than eight is considered long (Edwards *et al.*, 1996: 25).

Finally, the issue of the marginal make-or-buy decision was considered to be so important that the same question was deliberately asked twice in separate parts of the questionnaire. The marginal make-or-buy decision is where the firm is asked its strategy if the cost of making a component equals the costs of buying from a supplier. By receiving two responses from exactly the same question, the consistency of the respondent can be assessed. The importance of this question is that it is one of the dependent variables.

Next the operational approach to transaction costs is developed in more detail as well as a consideration of the testing issues. The questionnaire survey undertaken for this research developed many of the techniques and methods of the previous studies outlined in Chapter Four. The premise of the work is a comparative assessment of in-house production costs against the costs of procurement from the market that is the make-or-buy decision. If the production costs of the firm are greater than procurement costs from the market, then a decision to buy is recommended. Whereas if the production costs of the firm are less than procurement costs from the market then a make decision is recommended. In the transaction costs literature, the make-or-by decision is associated with high asset specificity, considerable uncertainty and high frequency. The next section looks in detail at the population used in the survey.

The survey population

The population of the study is determined by membership of the Society of British Aerospace Companies (SBAC), which is a UK-based industry trade association. The assumption made in this thesis is that the UKAI population is wholly accounted by the SBAC membership list. This is because all the prime contractors are represented, including BAE Systems plc (British Aerospace plc at the time), Rolls Royce plc and GEC-Marconi plc (now part of BAE Systems), as well as the majority of second tier suppliers and many third tier sub-contractors. In total, 187 companies were members of SBAC in 1997, ranging from organisations that are exclusively engaged in aerospace activity, for example, GEC-Marconi Avionics, to others where aerospace business represents only a small proportion of company turnover, for example, British Steel Engineering Steels (see Chapter Two). SBAC has estimated that the membership accounts for 70% of the value of UK aerospace markets[6]. The remaining 30% represent a particularly wide cross-section of companies outside of UKAI. Whilst some of these unaccounted companies do not want to be a member of a specific trade association, others that are far removed from prime contractors presumably may not realise their indirect involvement with the aerospace supply chain. It is possible that the companies who comprise the residual 30% will be changing on a relatively frequent basis, as aerospace companies switch suppliers for a variety of reasons. Alternatively, when suppliers view other markets as potentially more profitable[7] then they will exit aerospace because of efficient market operations. To this end, the member companies of SBAC have attempted to generate more stability in the supply chain, as well as trust between suppliers, by the establishment of Supply Chain Relationships in Aerospace (SCRIA). This is a system for benchmarking in which participating companies agree to quality auditing; information sharing and greater co-operation with one another in return for more stable long term contracts. It is an essentially inquisitorial approach to supply chain management, rather than an exclusively adversarial or competitive one. The complexity of aircraft production tends to make this approach necessary. The findings from the SCIA

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[6] The figure of 70% was confirmed in a conversation in March 1998 between the author and Keith Hayward, Head of Research at SBAC.

[7] See Masten (1984: 404) on supplier switching in USA aerospace companies and Masten *et al.* (1991: 265) for supplier switching in USA naval shipbuilding.

research are twofold. Firstly, that the supply chain in UK aerospace is larger than anticipated and shows considerable diversity of the supply chain. Secondly, that there is much co-operation between the firms in the supply chain, which has implications for contractual relationships.

A great deal of the methodological literature is consumed by the importance of selecting the survey respondents. In this case the target population was identified as companies engaged in the UK aerospace industry. Since the SBAC membership covers 70% of the value of the UK aerospace industry (although not necessarily 70% of the actual companies[8]) it was decided that this is a sufficient proportion of the population. Therefore, the study conducted a survey of the known 70%, rather than search for the residual 30%, which is an activity that SBAC itself is finding a difficult task[9]. This is due to the life cycle of companies in this latter category and the potential for 'hit and run' entry, where it may become more profitable to supply other industries, for example, motor vehicle manufacturing. As a result, it was considered more efficient for the survey to focus on the 70% majority rather than seeking to find the 30% minority of the value of the UK aerospace industry. Also, for reasons of confidentiality, the results were aggregated, so that no firm could be identified from the survey, which contributed to the increase in returns (Remenyi *et al.*, 1998: 156).

This questionnaire approach adopted in this survey has advantages over simple random sampling, because the sample in question has a known and quantifiable value (Lyons, 1994: 261). This will also have the potential effect of reducing the sampling error of the sample size, especially if the major prime contractors all respond to the survey. Furthermore, due to the way the questions have been written, certain sub-groups can be analysed, for example civil and military aerospace companies. The use of stratifying the population by certain characteristics of each sub-group is important for testing and prediction. For example, one potential hypothesis states that defence firms and civilian firms in aerospace have identical transaction costs. The population will be split into two groups, where defence aerospace firms are the subject group and civilian aerospace firms are the control group. Hence, differences between the two

[8] This is due to market concentration and the dominance of large firms such as BAE Systems and Rolls-Royce plc.
[9] This information was given by Keith Hayward, formerly Head of Research at SBAC.

sub-groups will be assessed in terms of the predictions of transaction costs in order to accept or reject the null hypothesis. The next section assesses the contribution of the pilot study and its relevance in understanding the full population of aerospace firms and how it was used to inform the final questionnaire.

The pilot survey

The pilot survey was conducted before the full questionnaire was issued, in order to comply with the best practices of questionnaire design (Fink and Kosecoff, 1998: 10). The pilot survey has three primary functions, namely to determine if companies have collected the data required; to establish if companies are willing to disclose the information and to test the validity and importance of questions. The aerospace industry remains a highly competitive environment where UK companies compete in many exacting global markets, especially in North America. Appreciation of commercial sensitivity is a vitally important consideration for firms in civil markets and military secrecy is also vitally important for firms in defence markets. As a result, a meeting was requested with selected companies to discuss the overall questionnaire design. The aim was to make the questions as meaningful as possible and acceptable for these companies to participate and fully complete the form.

The pilot study began in June 1998 when fourteen aerospace companies were contacted by letter requesting their participation in the study. The sample was chosen by geographic location, since all the companies which were contacted had registered addresses in the North West region of England according to the SBAC membership list of May 1998.[10] The North West is a highly strategic region for UK aerospace.[11] In the area, British Aerospace plc comprises British Aerospace Defence (sites at Samlesbury and Warton plus Preston until 1990), British Aerospace Airbus (sites at Broughton and Chadderton), British Aerospace Regional Aircraft (a site at Woodford), British Aerospace Dynamics (sites at Chorley and Lostock), plus Ferranti International, also based in Oldham. Although British Aerospace plc (now BAE Systems) has its registered headquarters in Farnborough, it is clear that the North West region of England is a very important area for the aerospace industry as a whole. In

[10] This is accessed from the SBAC homepage on the Internet using http//:www.sbac.co.uk
[11] The South East and the South West are also strategically important for the aerospace industry.

the defence sector, Warton is the final assembly point for the Hawk, Tornado and Typhoon, where defence accounted for 74.6% of the 1997 corporate turnover of British Aerospace plc, (the biggest single aerospace company in the UK). It is for these compelling reasons that the North West region was chosen for the pilot study. From the fourteen companies that were contacted, four agreed to participate and of the remaining ten, three declined to participate and seven did not answer the letter. The latter companies were contacted by telephone, where two more companies agreed to participate, but in the final version of the questionnaire only and not the pilot. The response rate was 28.6% and overall the reaction from firms was mixed. However, where companies did agree to participate, then the co-operation was excellent and the answers given were full and very helpful.

The problem of whom to send the pilot questionnaire was overcome by telephoning the companies prior to sending the letter and asking the company receptionist for the name of the most appropriate contact. Whilst the replies given were well meaning, the request to participate in the pilot study may not have been received by the appropriate employee. The issue of finding the appropriate personnel to complete questionnaires and surveys is highly significant and in part will determine the final response rate (Edwards *et al.*, 1996: 100). Obviously, the person with the appropriate knowledge and expertise needed to complete a questionnaire varies between companies. In part this was overcome in the final version of questionnaire through obtaining a complete list of companies and direct contact names supplied by SBAC[12]. The list of contact names contained those specific personnel who have responsibility to complete or co-ordinate the company reply to the quarterly SBAC questionnaire. As a result the final questionnaire was accurately targeted using an up-to-date mailing list, which improved the likelihood of increasing the response rate[13]. The lessons that were learnt from the pilot study was to be precise with the questions so that it is straightforward and reduce the length of the questionnaire to a maximum of seven pages. The full details of the four interviews are given in Appendix III.

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[12] This list was provided courtesy of Keith Hayward, formerly Head of Research at SBAC.

[13] It does not necessarily follow that the response rate should be higher with this list, but at least the questionnaire was received by a named person in the organisation, who often forwarded it to the most appropriate contact. The final response rate of almost 44% was acceptable and is partial evidence that a well-targeted questionnaire is vital for an acceptable response rate.

The pilot survey identified a number of key issues, which were relevant to the questionnaire itself. Firstly, companies are in position to disclose quantitative data as far back as 1992. Secondly, the Likert scale is acceptable between 1 and 10, although it is preferable to specify the exact range. For example, where 1 equals low and 10 equals high, this must be labelled on the scale. Thirdly, due the general nature of certain questions, the use of terms such as most important customer is preferable to typical or average customer. Finally, the extensive use of tick boxes and tabulated responses would considerable reduce the time needed to reply and thereby increase the response rate. The next section assesses the questionnaire as a method of data collection.

The questionnaire

The lack of relevant published data makes the questionnaire an essential exercise in transaction cost approach (Lyons, 1994: 262-263). The aim is to establish the reasoning behind production and procurement decisions and to identify the supply chain in the aerospace industry. The population is divided into company size (turnover, profit and employees), company location and number of years the company has been trading. Since a large proportion of these data can be accessed from public sources, for example FAME it was decided not to ask all of these questions in the questionnaire. Otherwise, this would have increased the length of the questionnaire (and thereby decreases the likelihood of a response from any given company).[14]

In addition, the survey content has been extensively discussed with various senior procurement and production personnel at several BAE Systems and Rolls Royce sites throughout the UK. Visits were made to British Aerospace at Samlesbury, Stevenage and Warton, as well as visits to Rolls Royce at Derby, Filton and Hillingdon. These visits served two important functions. Firstly, an overall appreciation of the aerospace industry was gained at first hand. BAE Systems plc is one of Europe's biggest aerospace and defence companies and remains the largest single UK manufacturer of fixed-wing aircraft. Rolls Royce plc is one of the world's biggest engine manufacturers with a strong presence in both civil and military aero-engine markets in

[14] Edwards *et al.* (1996: 100) suggest as a method for increasing replies rates of mail-out surveys: 'Keep the survey short (*e.g.* 4 pages or fewer) when possible'. This questionnaire ran to seven pages.

Europe, the Far East and North America. It remains the only aero-engine manufacturer in the UK. Secondly, several personnel at both companies have made detailed comments on the questionnaire and provided general advice on the workings of the aerospace sector. In sum, the guidance was been given without prejudice and has enabled a detailed picture of the aerospace industry to be gained on both production and procurement issues (that is, make-or-buy and contract design).

The final version of the questionnaire was created by a number of methods, including a pilot version, reference to published secondary sources, independent interviews and direct contact with senior personnel in the two major aerospace companies (that is, BAE Systems and Rolls-Royce). The outcome of this approach is that the survey generated meaningful data from the questionnaire. In particular, the key profile data from companies were accurate when checked against published secondary sources. Also, the transaction cost data were generally completed by firms, but this is unique information with no available external sources of data for corroboration. In turn, this situation presents a dilemma for the research, since it is not possible to independently verify the accuracy of the data. Hence, the quality of the pilot work, the questionnaire itself and contact with senior aerospace personnel assumes greater importance in order to establish the consistency of the information.

The questionnaire was divided into three sections, namely company profile; company supply chain and company transactions. A copy of the questionnaire is shown in Appendix II. In the next part, each section is discussed in turn.

Company Profile (Section A)

Section A of the questionnaire is the factual part, which requires company-defining information on characteristics of the firm. That is, confirming known data on firms. Company name and principal areas of business are requested, as well as variables assessing company size, such as turnover and number of employees. The company is similarly categorised in terms of importance of aerospace business and military markets, with the most important customer and the most important suppliers also specified. The final question in this section tabulates the buy component of company business. By definition this will allow the make-or-buy decision to be assessed, along with the marginal make-or-buy decision. The questions are asked for both 1992 and 1997 in order to estimate any differences over time. This longitudinal approach is justified because there had been considerable changes in the aerospace industry in the previous five years. The difference of five years is not an arbitrary figure and allows recent changes over time to be assessed. Otherwise the questions would be almost exclusively cross-sectional in nature. The dates were chosen for the study because 1997 was the last full year of data from when the questionnaires were issued in 1998. A five-year period back was chosen because this was considered a long enough time span to check the changes and any longer may be regarded as too long to compare like with like and have structural break problems with the data.

Essentially, the answers to these questions should reveal considerable information about the type of company, its markets and the position in the supply matrix. The information can be used to establish the sub-groups within the sample, as well as to observe the overall pattern of business in the production of UK aerospace companies.

Company Supply Chain (Section B)

Section B of the questionnaire goes beyond the mainly descriptive approach in assessing the company and attempts to analyse the economic nature of the firm. Section A provides details of the dependent variable, namely the make-or-buy decision. (*i.e.*, percentage of company turnover bought-out (and made in-house)). This approach is based on the measurement of the make-or-buy variables in Masten (1984: 404). The explanatory variables are written as asset specificity, uncertainty, frequency and small numbers, plus scale economies (from Section C). Asset specificity is defined as human, physical, location and dedicated assets. Uncertainty is defined as unexpected changes in supply and demand. Small numbers are specified by companies in terms of low or high numbers in both intermediate (supply) markets and product (demand) markets. Economies of scale are specified in terms of cost advantage. Also, the pilot questionnaire helped define the transaction cost terminology and the questionnaire was designed so that it could be easily understood by aerospace firms.

Company Transactions (Section C)

Section C of the questionnaire attempts to categorise the type and frequency of contracts used by UK aerospace suppliers, with other suppliers and customers. In particular, the competitive nature of contracts is specified together with the duration of contracts and type of contract along with other quality issues, such as names of key suppliers or customers, relating to how companies interact with each other. This provides an extensive range of descriptive analysis of transaction costs to be undertaken especially where certain variables are not easily quantifiable. For example, the type of contract used between aerospace companies and penalty clauses in contracts for late delivery or poor quality as well as discounts for bulk buying. The work by Lyons (1994: 267) is useful in confirming the way to generate data on contracts. The aerospace industry is a highly competitive industry, where quality is assumed to be a vital component of success. *A priori* reasoning suggests that these issues are addressed in the transactional exchange between firms in the supply chain, but this needs to be checked in greater detail to confirm if this is the case developed in Chapter Seven. The next section assesses the sample generated in the survey.

Survey Sample

A total of 187 aerospace companies[15] were sent a copy of the final questionnaire and a copy of this is contained in Appendix II. In the end 82 completed returns[16] were received, which is a response rate of almost 44%. A figure of 44% is considered good, especially as most of the large aerospace firms replied, including BAE Systems and Rolls Royce. To obtain a figure of 44% the questionnaire was sent out three times, in line with conventional practice (Edwards *et al.*, 1998: 92). The first occasion was in July 1998, when all the companies were contacted and 42 completed replies were received. The second occasion was in September 1998, when 24 completed replies were received and the final occasion was in November 1998 when a further 16 completed replies were received. Those replies not returned in the first wave were labelled as 'late' to see if there is a significant difference between the two groups (late accounted for 49% of the sample). However, analysis of the data shows there is no difference between when the questionnaire was received, late or otherwise.

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[15] The original database from SBAC contained 192 companies. Three firms had ceased trading (one of which was in receivership), one firm was not traced and it was not possible to locate a new address and another two firms were found to be one of the same. This left 187 remaining firms.

[16] Another thirteen companies responded by declining to participate. The reasons given actually revealed more information in itself. Whilst most cited the extreme pressures of time, others claimed they would like to respond, but felt unable to do so because the company was restructuring or being taken over. This outcome illustrates the continuing dynamic nature of the industry in terms of merger and exit.

Nevertheless, the technique of 'follow-up until you drop' as advocated by Edwards *et al.* (1996: 100) clearly made a difference. Without the follow-up reminders the response rate would have been only 22.5% and the higher the response rate the more acceptable the survey (Edwards *et al.*, 1996: 91). Edwards *et al.* (1996: 92) considers a response rate of around 50% is acceptable. However, given the length of the questionnaire of seven pages and the fact it was sent unsolicited[17], then a response rate of almost 44% must be regarded as acceptable. Since a majority of the large firms replied then a high proportion of the value of supply chain is captured in the survey. Lyons also received less than 100 acceptable replies in his questionnaire on UK engineering sub-contractors, which represented a response rate of approximately 10%. Lyons considered this result to be acceptable as he captured close to 100 replies, an approach which is repeated in this thesis (Lyons, 1994: 260-261).

In summary, the response rate of completed questionnaires is overall in line with standard procedures of this type (Edwards *et al.* 1996: 100 and Remenyi *et al.*, 1998: 156). The total absolute number of responses is approaching 100 and beyond the problems of small number bias. The response rate is 44% of the total identified population. There are responses from all the major firms, which accounts for over 75% of the direct employment in UKAI. Therefore, the outcome is that the questionnaire survey has been successful since the sample is sufficiently large enough to generate statistically meaningful results. The next section interprets the dependent and explanatory variables in the questionnaire.

Dependent variable

The dependent variable in the transaction cost model is cost of the transacting as shown in equation 4.3. The transaction costs can either be zero or greater than zero. This is a difficult variable to measure consistently across firms and industries. As a result, this variable is measured by the proxy variable make-or-buy. This proxy variable can take one of two forms. Firstly, there is the use of a dummy variable, where 1 is recorded for a decision to make and 0 is recorded for a decision to buy. Secondly, there is a use of a continuous variable where the percentage or proportion of the make-or-buy decisions is recorded.

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[17] A covering letter of introduction was included from Keith Hayward, Head of Research at SBAC.

In fact, there are two measures of the make-or-buy dependent variable in this study. The first measure is a continuous variable, which specifies the percentage of components and sub-components used by the firm in manufacturing that have been bought-out from an external supplier. In other words, this is the extent to which a company will purchase from the market (buy) and the produce in-house (make).
Where:

1. Buy = percentage bought-out; Eq. 5.1
2. Make = (100 minus percentage bought-out). Eq. 5.2

The other measure is a dummy variable in response to the question: if the cost of making a component equals the cost of buying from a supplier do you make-or-buy. The transaction cost literature is very clear on this prediction (Masten, 1984: 405). If the cost to make a component equals the cost to buy, then a firm should always buy. Hence, there is no gain in making, if you can minimise costs by buying. Therefore, to be more specific with the transaction cost prediction, a firm will purchase from the market, if the cost to buy is equal to or less than the costs to make.
There is another dependent variable in the analysis. The variable is the measure of the contract type. This measure is dichotomous variable, which specifies the type of contract. Hence:

Contract with supplier = f (asset specificity, uncertainty, frequency) Eq. 5.3
Where:
Contract with supplier = 1
No contract with supplier = 0

The point of this approach is to analyse if contract type can be modelled using the hostage model (Williamson, 1983: 522). This concept will be developed further in Chapter Nine, but it is important to state at this point that the independent variables are broadly the same in both models, in line with work by Lyons (1994: 262). It is only the independent variables that are different between the two types of model.

Independent variables

The problem of measurement was introduced in Chapter Three and the same issue is revisited in this section. As almost all the independent variables can not be gained from published data then each must be included in the questionnaire. Also, the variables are conceptually difficult to observe and hence need to be measured directly using a Likert scale between 1 and 10. Asset specificity is usually regarded as the most important independent variable and is defined as the particular part of a market relationship, which is special to any given transaction. The different types of asset specificity are covered in the following questions outlined below (Shelanski and Klein, 1995: 340). The actual questionnaire numbers are given in brackets.

There are four direct measures of asset specificity, comprising human, physical, dedicated and site asset specificity.

(i). Human Asset Specificity: (question 10a)

In order to capture human asset specificity, then a detailed question is needed that ranks the human capital of the employees. Hence, the following question is designed to capture asset specificity in terms of the labour input:

"To what extent are the skills, knowledge and experience of your employees specific to your company?"

(ii). Physical Asset Specificity: (question 11a)

To capture physical asset specificity, then a detailed question is needed that ranks the physical capital of the facilities. Hence, the following question is designed to capture asset specificity in terms of the physical input:

"To what extent are the facilities and equipment of your production process specific to your company?"

(iii). Dedicated Assets: (question 12a)

To capture contractual asset specificity, then a detailed question is needed that ranks the legal aspect of the contract. Hence, the following question is designed to capture asset specificity in terms of the contract:

"To what extent are the facilities and equipment of your employees specific to your company?"

(iv). Site Asset Specificity: (question 12c)

Finally, to capture site asset specificity, then a detailed question is needed that ranks the site capital of the employees. Hence, the following question is designed to capture asset specificity in terms of the distance from the point of production:

"How far from your most important customer is your main factory site located?"

In sum, these four direct measures of asset specificity should generate a clear indication of the extent of the inherent transaction costs and in so doing overcome the measurement problems. Indeed, Masten (1984: 407) regarded the make-or-buy choice as central to the whole concept of transaction costs. However, as noted in Chapter Three, the measurement problems of transaction costs must not be ignored. To this end, there has been an attempt to define asset specificity as close to the Williamson original concept as possible. This is because it is necessary overcome the definitional problems of transaction costs and in order to make the concepts operational.

Uncertainty is defined as the degree to which economic agents are unsure about the future or the actions of a third party involved in the transaction. In this study, uncertainty has been measured in terms of the supply of components and the demand for the products.

(i). Uncertainty of the supply of components: (question 14a)

In order to capture the inherent uncertainty of supply the following question is designed to show the changes in the supply of any given component:

"What is the likelihood of unexpected changes in supply of your components?"

(ii). Uncertainty of the demand for products: (question 13a)

To capture the inherent uncertainty of demand the following question is designed to show the changes in the supply of any given product:

"What is the likelihood of unexpected changes in demand for your products?"

Complexity is related to uncertainty and is defined as how complicated the transactional arrangement. This is captured by questions on the extent of formal contract with suppliers and customers:

(i). Complexity of contract with suppliers: (question 19a)

"Do you usually have a formal contract with your suppliers?"

A question of this nature is designed to capture the complexity of the transactions with suppliers. There are additional questions on type of contract, length of contract and the number of suppliers, which generates a detailed picture on the complexity of the contract. These questions are linked to the hostage model and are dealt with in Chapter Nine.

(ii). Complexity of contract with customers: (question 20a)

"Do you usually have a formal contract with your customers?"

This question is designed to capture the complexity of the transactions with customers. Once again there are questions on type of contract, length of contract and the number of suppliers.

Frequency is defined as the regularity with which the transaction occurs. This is more difficult to measure directly. Although a Likert scaling is used again it is possible to design a question that uses absolute levels. However, in order to generate results that can be generalised across firms then the Likert scale was viewed as the preferred measure not least as it was also consistent with the other measures of the independent variables in this study.

(i). Frequency of transactions: (question 15a)

"Is your main business one-off or frequent repeat business?"

This is designed to capture the frequency of the transactions. The range from one-off transactions to repeat business is an attempt to get consistency between firms and use terms that are in common business use in the UK. In particular, these terms were tested on firms in the pilot study and found to be acceptable to the respondents. Nevertheless, conceptually frequency remains a difficult term to make operational, since it can have different meanings to firms in the supply chain.

The main independent variables are measured in such a way that generates continuous variables and links them to the dependent variable. The full descriptions of the variables are shown in Table 5.1 below. Column 1 refers to the question number in the actual questionnaire (see Appendix II); column 2 gives the basis of the question; column 3 gives the variable range and column 4 the link to the relevant aspect of transaction cost theory.

5.1: A summary of the questionnaire variables

Question Number	Question Detail	Variable Range	Transaction Cost Relevance
1	Company name	Descriptive	Firm identifier
2a	Area of business	Descriptive	Core competence
2b	Product price	<£1 to >£1million	Size of firm
3a	Turnover in 1997	£ millions	Size of firm
3b	Turnover in 1992	£ millions	Size of firm
4a	Employees in 1997	Thousands (staff)	Size of firm
4b	Employees in 1992	Thousands (staff)	Size of firm
5a	Aerospace business: 1997	0 to 100%	Type of firm
5b	Aerospace business:1992	0 to 100%	Type of firm
6a	Military business: 1997	0 to 100%	Type of firm
6b	Military business: 1992	0 to 100%	Type of firm
7	Most important customer	Descriptive	Bi-lateral measure
8	Most important supplier	Descriptive	Bi-lateral measure
9	Bought-out value	0 to 100%	Dependent variable
10a	Employee specificity	1 to 10	Measure of k
10b	Change in 10a since 1992	up/down/same	Explanatory change
10c	Examples of 10a	Descriptive	Core competence
11a	Facility asset specificity	1 to 10	Measure of k
11b	Change in 11a since 1992	up/down/same	Explanatory change
11c	Examples of 11a	Descriptive	Core competence
11d	Sub-contract-high demand	yes/no	Boundary of firm
11e	Sub-contract-low demand	yes/no	Boundary of firm
12a	Dedicated specificity	1 to 10	Measure of k
12b	Change in 12a since 1992	up/down/same	Explanatory change
12c	Location asset specificity	number of miles	Measure of k
12d	Proximity to customer	yes/no	Mine-mouth
13a	Demand uncertainty	1 to 10	Explaining variable
13b	Change in 13a since 1992	up/down/same	Explanatory change

13c	Delivery time	day/month/year	Boundary of firm
14a	Supply uncertainty	1 to 10	Explaining variable
14b	Change in 14a since 1992	up/down/same	Explanatory change
14c	Reliability of suppliers	yes/no	Boundary of firm
15a	Frequency of business	1 to 10	Explanatory variable
15b	Change in 15a	Up/down/same	Explanatory change
15c	Change in order size	Yes/no	Boundary of firm
16a	Supplier numbers	1 to 10	Explanatory variable
16b	Change in 16a	Up/down/same	Explanatory change
16c	75% of suppliers	From 1 to > 1	Integration measure
16d	Purchases from firm in Q8	0 to 100%	Boundary of firm
17a	Customer numbers	1 to 10	Explanatory variable
17b	Change in 17a since 1992	Up/down/same	Explanatory change
17c	75% of customers	From 1 to > 1	Integration measure
17d	sales to firm in Q7	0 to 100%	Boundary of firm
18a	Marginal make-or-buy	Make = 1; buy = 0	Dependent variable
18b	Supplier switching	Descriptive	Cost of transaction
19a	Supplier contract	Yes/no/sometime	Firm/market
19b	Contract details	Descriptive	Measure of s
20a	Customer contract	Yes/no/sometime	Firm/market
20b	Contract details	Descriptive	Measure of s
21a	Supplier cost advantage	yes/no sometime	Cost of transaction
21b	size of cost advantage	<5% to 20%+	Cost of transaction
22a	Supplier cost discounts	yes/no/sometime	Cost of transaction
22b	size of cost discounts	< 5% to 20%+	Cost of transaction
22c	Marginal make-or-buy	make = 1; buy = 0	Dependent variable

Where k is a measure of asset specificity and s is a measure of safeguards.

See Chapter Four for details of applying the transaction cost model. The conclusions form the final part of this Chapter and assess the outcome of the pilot study and the questionnaire survey.

Conclusions

In conclusion, the analysis of the population shows that the firms in the survey are broadly representative of the UK aerospace industry and the statistical data generated from the questionnaire is acceptable. The pilot version of the questionnaire and direct interviews with the leading UK aerospace firms confirm that the design of the questionnaire proved successful in generating a large and meaningful set of data, which is capable of assessing the UK aerospace industry in line with the transaction cost model. The response rate of 44% makes the econometric research representative. Moreover, an attempt to make operational the transaction cost approach is consistent with the previous studies in Chapter Three and the model developed in Chapter Four. To this end the methodology and the data draws from a reliable framework and coherent body of work from transaction costs economics.

In sum, the methodology of the questionnaire is an important consideration when assessing the results in the context of the transaction cost approach. It is also very useful for setting the UK aerospace firms in the economic environment of the actual operation of the industry. This Chapter has defined the population of the survey, demonstrated that the pilot is acceptable and shown that the sample meets an acceptable response rate, which is representative of the population as a whole. Also, the Chapter has shown the difficulties of measuring the theoretical variables under the transaction cost approach and offered solutions in order to make the theory become operational for the purposes of the survey. The following Chapters in the thesis will begin to assess the model and empirically test various hypotheses. The next Chapter presents the statistical analysis of UK aerospace at the industry level.

Chapter Six:
Empirical results I: industry level

Introduction

This Chapter begins the empirical testing of the transaction costs approach to the UK aerospace industry. In general, the questionnaire was designed to capture quantitative and qualitative data on the UKAI, which are not published elsewhere. Quantitative and qualitative data are used for two purposes. Firstly, to assess the diagnostics of the data set for robustness and accuracy. This is an important task, since mistakes in data preparation can lead to poor results and incorrect conclusions. Secondly, to assess company profiles of the UK aerospace industry and to develop the empirical themes of the thesis.

There are three sections in this Chapter. The first conducts the diagnostic checks of the dataset from the aerospace questionnaire, since it is vital to establish that the data are robust and statistically sound. The second section assesses the company profiles of the organisations that returned the questionnaire in order to give a clear representation of the participating firms. The final section investigates the qualitative statistics in the dataset and uses cross-tabulations. The next section assesses the data generated from the questionnaire and performs the relevant diagnostic checks on the survey data.

Diagnostic checks on the questionnaire data

The summary statistics for database are shown in Table 6.1 listed by variable codes. The description of the variables by question is listed previously in Table 5.1. In total there are 82 completed questionnaires and 94 variables in each. This gives a maximum 82 by 94 matrix, which has over 7,700 observations. On a descriptive level most of the variables have 82 observations; if there is less than 82 then the specific question was not completed or did not require a response from the firm.

Table 6.1 shows each variable code as listed in the first column and in sequence with the questionnaire itself (see Appendix II). Four parameters are presented for each variable, which are the minimum and maximum value, the mean and the standard deviation. This is the conventional way to report descriptive statistics (Koop, 2000: 18). Overall, the diagnostic checks for the database reveal the data to be satisfactory.

Table 6.1: Descriptive statistics of the key questionnaire variables

Variable Code	Variable Description	Minimum Value	Maximum Value	Mean Value	Standard Deviation
P1	Price Under £1	0.00	1.00	0.01	0.11
P2	Price £1 to £1,000	0.00	1.00	0.34	0.47
P3	Price £1,000 to £100,000	0.00	1.00	0.38	0.49
P4	Price under £1 million	0.00	1.00	0.13	0.34
P5	Price over £1 million	0.00	1.00	0.13	0.34
T97*	Turnover 1997 £ million	1.10	8546	234.76	1074.97
T92*	Turnover 1992 £ million	0.75	11508	270.99	1426.36
E97	Employees in 1997	14.00	43400	1818.53	6866.89
E92	Employees in 1992	5.00	87400	2544.28	11401.53
A97	Aerospace % in 1997	2.00	100	71.52	29.27
A92	Aerospace % in 1992	0.00	100.00	67.03	30.47
M97	Military % in 1997	0.00	100.00	27.51	29.89
M92	Military % in 1992	0.00	100.00	29.81	30.70
BO97*	Bought-out % in 1997	1.00	100.00	53.88	30.81

BO92*	Bought-out % in 1992	1.00	100.00	50.11	29.65
CA97*	Civil Aero % in 1997	1.00	100.00	54.23	31.72
CA92*	Civil Aero % in 1992	1.00	100.00	50.64	31.88
MA97*	Military Aero % in 1997	1.00	100.00	47.95	33.12
MA92*	Military Aero % in 1992	1.00	100.00	47.15	30.83
EMPAS	Employment Asset specificity	1.00	10.00	7.41	1.80
FACAS	Facility Asset specificity	1.00	10.00	6.51	2.83
SUBHIGH	Sub-contract in high demand	0.00	1.00	0.4024	0.49
SUBLOW	Sub-contract in low demand	0.00	1.00	0.1585	0.37
DEDAS	Dedicated Asset specificity	1.00	10.00	6.19	2.86
LOCATION	Location Asset specificity	0.00	7000.00	661.91	1478.89
CLOSELOC	Benefits of close location	0.00	1.00	0.18	0.39
DEMDEL	Demand uncertainty	1.00	10.00	6.21	2.37
TIME	Time between order & delivery	1.00	1000.00	201.34	220.30
SUPDEL	Supply uncertainty	1.00	10.00	4.89	2.36
SUPRELI	Supplier reliability	0.00	1.00	0.84	0.36

ONEOFF	Level of frequency	1.00	10.00	7.00	2.49
ORDER	Changes to order size	0.00	1.00	0.44	0.50
SUPNUM	Small number of suppliers	1.00	10.00	4.91	2.68
SUP75	Number of suppliers	1.00	200.00	18.01	27.62
SUPIMP	% suppliers most important	1.00	98	29.66	22.76
CUSNUM	Small number of customers	1.00	10.00	5.08	2.77
CUS75	Number of customers	1.00	300.00	20.67	37.27
CUSIMP	% customers most important	4.00	100.00	27.98	21.53
MAKE	Make from make-or-buy	0.00	1.00	0.62	0.49
BUY	Buy from make-or-buy	0.00	1.00	0.38	0.49
LOWP	Low price	1.00	4.00	2.62	1.21
HIGHQ	High quality	1.00	4.00	1.96	0.91
DELDATE	Delivery date	1.00	4.00	2.80	0.95
SUPREL	Supplier reliability	1.00	4.00	2.61	1.20
SUPCONYE	Supplier contract	0.00	1.00	0.54	0.50
SUPCONP	Penalties in supplier contract	0.00	2.00	0.69	0.75

CUSCONY	Customer contract	0.00	1.00	0.69	0.46
CUSCONO	No customer contract	0.00	1.00	0.01	0.19
CUSCONP	Penalties in customers	0.00	2.00	1.07	0.71
SUPCAYES	Supplier cost advantage	0.00	1.00	0.21	0.41
SUPCANO	No supplier cost advantage	0.00	1.00	0.44	0.50
CUSCAYES	Customer cost advantage	0.00	1.00	0.31	0.47
CUSCANO	No customer cost advantage	0.00	1.00	0.32	0.47

* Less than 82 responses to this variable.

The majority of the data reported in Table 6.1 are codes or percentages in order to simplify the information. Hence, the minimum and maximum values plus the mean and standard deviation are generally constrained between 0 and 100 if representing a percentage or between 0 and 10 if representing a Likert scale.

The asterisk on 8 of the 53 variables in the first column identifies the number of cases for which there were not 82 responses. In part this confirms the value of a good pilot questionnaire and interviews, which eliminated many difficult questions for the respondents. It also shows that the questionnaire was generally well designed as once a respondent started the questionnaire then it could be completed by almost all those who started. The set of questions with the worst response rate was the questions on the percentage of components bought-out by from external supplier in Section A. Unlike nearly all the other questions, this question did require a certain degree of specialist knowledge or extra time to research the answer. Hence, approximately 83% of the respondents answered this question. In addition, not all of the 82 respondents responded to some of the contract questions in Section C. This is because there were a number of conditional questions, which if answered in the negative as 'no' meant the respondent had to move onto the next question and leave remaining parts of the question blank. Otherwise, the completion rate of the questionnaire by the respondents was generally very good and indeed a perfectly completed dataset is rare in statistical terms. Also, SPSS can cope with limited missing answers in any case.

The second column details the unit of measurement for each of the 53 variables in the dataset. Many of the variables are coded using a binary code (0 or 1) or a Likert scale (1 to 10) with others based on percentages (0 to 100). The detail of each variable is shown in Chapter Five. At this stage is worth stating that the dataset is dominated by two responses, BAE Systems and Rolls-Royce, but the aim of the thesis is to assess the UK aerospace industry as a whole rather than separate these two cases out from the rest of the sample.

The next two columns in Table 6.1 are the minimum and maximum values of the recorded variables. These have been carefully checked for data entry errors and all the variables have the expected range. This is especially relevant for the dummy variables usually between 0.00 and 1.00 and the variables, which register a Likert scale in this questionnaire between 0.00 and 10.00. All these columns conform to the expected values of the data input (Field, 2000: 6).

It is conventional in statistics to present two descriptive measures of the dataset, namely, the mean and the standard deviation (Koop, 2000: 20). These form the final two columns in Table 6.1. The arithmetical mean or statistical average is the sum of the variables divided by the sample size. These results are discussed elsewhere in this Chapter and others. The standard deviation is a common measure of dispersion, which can used as a comparison between more than one standard deviation. The standard deviation of the dependent variable MAKE and BUY are satisfactory and as expected. However, the standard deviation is greater than the mean for BUY, but not for MAKE, which suggests that the BUY variable is more skewed than MAKE. The standard deviation is less than the mean for the main independent variables DEDAS, EMPAS, FACAS, DEMDEL, SUPDEL, ONEOFF, SUPNUM and CUSNUM and hence this result shows the mean to be generally representative of the data. The standard deviations for the variables are mixed showing that many of the mean values are representative of the data and others are not. For example, the turnover figures (T97 and T92) and employee number (E97 and E92) values for standard deviations show the mean not to be representative, but may reflect a wide spread of firms in the supply chain as expected given the concentration ratio reported in Chapter Two. Since these are variables on a Likert scale then another interesting method of analysis is to assess the frequencies, which is discussed elsewhere in this Chapter. The next part of the Chapter assesses the variables in Table 6.1 in greater detail. That is, from the questionnaire, section 1 gains information on the company profile, section 2 on company transactions and 3 on company contracts. The relevant variable code from Table 6.1 is included in the title of the sub-heading. The section to follow is the first in a series that assesses each of the variables in the dataset. Initially, the pricing variables in the survey are analysed.

Pricing Profile (P1, P2, P3, P4 and P5)

The price profile is a descriptive account of the range of the unit price of the most important product by value of sales. Whilst this shows the range of unit price from aerospace fasteners ($p < £1$) to finished aircraft ($p > £1$ million) the main analysis is to be able to differentiate between aerospace suppliers in terms of price and to chart any potential differences. The price profile of the aerospace companies is a way to differentiate between firms in the population by a pricing characteristic of the most important product or service by value of sales. In this particular case it is also a proxy for position in the supply chain, because the supply of aerospace products is highly stratified in price terms and this is one way to identify the structure. The unit price of aircraft is generally in excess of £1 million and major sub-components usually have a cost between £100,000 and £1 million (and occasionally above £1 million). Only the main specialised aerospace assembly companies have a technical and financial ability to supply the more expensive items. *A priori* this helps to explain why transaction costs analysis could be a useful methodology, since it emphasizes asset specificity and uncertainty amongst other features of the transaction. Minor parts and smaller components have a range up to approximately £100,000 and these can be supplied by firms which specialise in aerospace or indeed by more general engineering suppliers, although even relatively minor parts often require highly specialist knowledge, expertise, machinery or tooling. For example, aerospace paint and other coatings require advanced cryogenic properties to withstand extremes of temperature and rapid change in temperature. There tends to be more domestic competition and even limited supplier switching in this part of the supply chain than in the prime contractors. Thereby, even specialist aerospace paint manufacturers face competitive elements in supply. However, this pricing variable is not a continuous variable, as can be seen from the selection of the scale of the price bands, which are not identical, but are designed to be broadly representative. As a result, this variable is not intended as a continuous scale variable, but is it meant to be indicative of the supply chain and to differentiate between firms in terms of a position in the range.

In the questionnaire, the companies were asked to select the unit price of the most important product by sales value. All the 82 companies replied and showed a wide spread of prices from less than £1 to more than £1 million. This is important in the aerospace industry because the unit price of aircraft and spacecraft is relatively high, certainly in comparison with mass production, for example, motor vehicles where unit cost is measured in ten thousands and not millions of pounds sterling. The industry, which is most closely related to aerospace in this respect is shipbuilding, where there is also a wide spread of prices for components and the final product (Masten *et al.*, 1991: 2). Whilst it is difficult to show whether the information gathered is totally reliable it is worth noting that this particular technique is in line with the questionnaire designed by Lyons (1994: 274-278).

Table 6.2 illustrates the diversity of price bands in the aerospace supply chain and differentiates between different characteristics of the suppliers, where all 82 respondents replied to this question. For example, only one in four of the firms have a unit price in excess of £100,000, which confirms that aerospace production is a composite of many parts supplied by many different firms. Approximately, a third of suppliers supply products under £1,000; just over a third supply products between £1,000 and £100,000 million; and fewer than14% over £1 million.

Table 6.2: Unit price profile of most important product by value of sales

Price band	**Number (n)**	**Percentage (%)**	**Example**
Less than £1	1	1.2	Fasteners
£1 to £999	28	34.2	Paint
£1,000 to £99,999	31	37.8	Nacelles
£100,000 to £999,999	11	13.4	Aero-engines
More than £1million	11	13.4	Aircraft
Total	**82**	**100.0**	

In the final column there is an indicative example of the type of product in the given price range. The only company which is located in the range of less than £1 is Hi-Shear and this firm manufactures aerospace fasteners. This is clearly an example of a low unit price product with a well-defined specification where firms buy off-the-shelf from market firms. Transaction cost economics would predict that this type of component would tend to be bought from the market, because asset specificity is low even though frequency is high (see Table 4.3). As expected, firms that assemble aircraft dominate the other end of the scale where the unit price is more than £1 million. This is a good indication of the scale of the cost of aircraft, both military and civilian[1]. These firms include BAE Systems, Britten-Norman, GKN-Westland, Raytheon, and Rolls-Royce, where the latter is a prime contractor for aero-engines. In this category there is limited scope for domestic competition following post-war merger and acquisition activity but other major rivals tend to be from overseas. Major suppliers of sub-components are in the next tier of price profile (less than £1 million, more than £100,000) and include Dowty, Martin Baker, Matra-BAe, Smiths and Vickers. These companies are specific suppliers of equipment, which tend to have a relatively low alternative use, such as weapons. The clear example is Martin Baker that is a manufacturer of ejection seats, mainly for military aircraft. The remaining categories have suppliers of specialist aerospace parts and components such as avionics and metal parts, as well as generic parts that do have alternative uses in other manufacturing industries; hence it is divided into aerospace and general engineering.

Company Turnover (T97 and T92)

The next method to differentiate the sample is company turnover, which can be used as a proxy for firm size. From Table 6.3, the mean figure has declined from £271 million in 1992 to £235 million in 1997 in current prices, which is broadly in line with the SBAC data in Table 2.5. The retail price index (RPI) increased cumulatively by 13.9% between 1992 and 1997[2]. In real terms this is a decrease in the mean annual turnover of 24%, which represents a weak performance relative to previous years, albeit in the immediate aftermath of the end of the Cold War. It is worth emphasising that a proportion of the company turnover for all the firms is not aerospace-related, since other business activity is included in these figures[3]. That is, many firms in the sample are conglomerate organisations and have diversified market interests. Table

[1] As a generalisation, military aircraft tend to be more expensive than civilian aircraft, due to more avionics equipment and higher specifications and engineering calibrations.
[2] Source: Barclays Economic Review, Quarter One, 1998.
[3] Table 7.2 in the next Chapter shows the proportion of aerospace turnover for both 1992 and 1997, which is 67.0% and 71.5%, respectively.

6.3 shows a wide spread of company turnover as the standard deviation is very large relative to the mean (Field, 2000: 7): hence the mean is not fully representative of the data, which at least confirms there is a wide spread of data observations.

Table 6.3: Company turnover of sample 82 companies (£ million) current prices

Type	1992	1997
Total	19,241	18,781
Mean	271	235
Standard Deviation	1,426	1,075

Company Employment (E97 and E92)

Another method to differentiate the sample is company employment, which again is a proxy for firm size. From Table 6.4 the mean figure has declined from 2,544 employees in 1992 to 1,819 in 199 7, which is broadly in line with the SBAC data in Table 2.5. This is indicative of the decline in the aerospace employment in the 1990s, in part as a consequence of the end of the Cold War. This is shown in Table 6.4 below, which illustrates the rapid decline of employment in the sample companies of 28.5% cumulatively over the five-year period from 1992 to 1997 inclusive (see Chapter Two for trends and changes in the UK aerospace industry). Once more, Table 6.4 shows a wide spread of company employees as the standard deviation is very large relative to the mean (Field, 2000: 6). As with company turnover this is indicative of the wide array of data observations. The largest two firms have a large number of employees (*i.e.* BAE Systems and Rolls-Royce) and the remaining firms significantly fewer employees as the sample from the population is heterogeneous.

Table 6.4: Company employees (number of employees) of the sample 82

Type	1992	1997
Total	208,631	149,120
Mean	2,544	1,819
Standard Deviation	11,401	6,867

The employment profile attempts to show the total size of the companies surveyed. This approach captures a proportion of employees who are not involved with aerospace and does not include those employees of aerospace firms not in the survey. However, it does provide an indication of the overall aerospace industry employment in 1992 and 1997. The total sample employment 1992 was 208,863, with mean employment 1992 equal to 2,544. Whereas total employment in 1997 was 149,120 with mean employment 1997 equal to 1,819 employees although approximately 21% of these are indirectly employed in aerospace and not captured by the SBAC figures. In 1997 there were 140,000 people employed in the UKAI using SBAC figures, which confirms that the survey has captured a large proportion of the total industry employment as well as indicating some problems over definitions where large conglomerate firms are also involved with non-aerospace activity (SBAC, 2005). Precisely what proportion is captured is difficult to state with certainty given the conglomerate nature of many firms in the sample that have business interests other than aerospace. It is significant that the total employment difference between 1992 and 1997 is 59,511 or a reduction of 28.5%. The mean employment difference between 1992 and 1997 is 726. The decline in the figures can be explained by a two factors. Firstly, there could be a drop in demand for aerospace output since there is a decrease in turnover identified in the sample of firms as shown in Table 6.3. Secondly, capital may be replacing labour and accounting for some of the productivity gains. Improvements in production processes and company organisation may also account for increases in productivity.

Aerospace percentage of turnover (A97 and A92)

An assessment of company turnover specific to aerospace between 1992 and 1997 reveals a shift away from aerospace business. This can be explained by either an exit strategy from aerospace; or that non-aerospace business is getting larger as a proportion of the total as firms diversify. Given the decline in general aerospace employment, it would appear that the shift is due to a corporate strategy of diversity, because of the overall decline in aerospace activity. In other words, there is a substitution effect in favour of non-aerospace business. If this assertion is correct, then it could indicate relatively low asset specificity in the aerospace industry, because of the transferability of resources: hence, aerospace as a percentage of total business in 1992 was 71.5%, whereas by 1997 it was 67.0%. The non-aerospace business covers an array of activity, which includes many manufacturing and service sector industries. Indeed, aerospace companies could be diversifying into other areas because there is a competitive advantage in logistics or quality. As a strategy to spread risk in a declining market, this could possibly account for the 4.5 percentage-point drop in aerospace activity (expressed as a percentage of total business in the industry as a whole). This result is noteworthy and indicates a shift in the industry.

Finally, from the previous results it is possible to approximate the proportion of the aerospace industry, which has been captured by the sample. In 1997 there were 150,000 directly employed in the UK aerospace industry (SBAC, 1998). The survey captured 149,120 employees, but if only 67% of all business was in aerospace then it is possible to conclude that some 99,910 employees from the UK aerospace industry as a rough order of magnitude were captured by the sample. SBAC also claim that there is an indirect employment multiplier of between 2 and 3 culminating in the total UK aerospace workforce of some 350,000. This complicates the sample somewhat, because although all firms in the same are members of SBAC some of the employment may be actually indirect (*e.g.* British Steel). The employment multiplier employed by SBAC is satisfactory and for the purposes of this thesis it is acceptable to accurately conclude that the sample has captured approaching 70% of the UK aerospace industry. This type of conclusion can be stated with much validity given that all the major firms in the industry as shown in Table 2.8 are represented in the sample.

Military percentage of turnover (M97 and M92)

Similar to the analysis above, an assessment of the percentage of military turnover between 1992 and 1997 reveals a shift away from military business. Once more, this can be explained by either an exit strategy from military; or that civilian business is getting larger as a proportion of the total as firms diversify. It is likely to be the former, reflecting the relative decline in military business since the end of the Cold War. However, concealed within this analysis is the possibility of both exit by some firms and defence consolidation by a few large firms, such as BAE Systems, who will engage in vertical and horizontal merger on the basis of a high-profile business reputation. Military production as a percentage of total business in 1992 was 29.8%, whereas by 1997 the percentage of total business was 27.5%. The relatively small decline in part reflects the long-term nature of military contracts with procurement agencies, although the result is not surprising given the end of the Cold War. This survey is only over five years, where the life cycle of military contracts is over a much longer period often twenty-five years, which may reflect asset specificity and long terms contracts. The following sections will look at the transaction characteristics of asset specificity, frequency, uncertainty, small numbers and also economies of scale in order to link the questionnaire with the transaction cost model.

Asset specificity (Empas, Facas, Dedas and Location)

According to Williamson asset specificity can be measured in a number of ways, namely, human, physical, facility and location asset specificity, which presents research methodology with measurement difficulties (Williamson, 1985: 55). Each way is described detailed below with the appropriate variable response and the relevant make-or-buy prediction.

The measurement of asset specificity is a problem in transaction costs, because the variables are difficult to observe directly. The difficulty was overcome by developing a Likert scaling, which allows the respondent to rank the reply from 1 to 10. This approach was adopted, because there is no other way to directly measure the variables. There is little or no published data on transaction cost variables as the data are invariably below the level of markets and prices usually recorded by firms, industry organisations and government. The transaction cost approach predicts make if the Likert scale is high for human, physical and dedicated asset specificity. Location asset specificity records the proximity of the firm to buyers and customers.

Table 6.5: Asset specificity predictions

Variable Type	Variable Response	Make Prediction	Buy Prediction
Human asset specificity	1 to 10	High	Low
Physical asset specificity	1 to 10	High	Low
Dedicated asset specificity	1 to 10	High	Low
Location asset specificity (buyer)	0 or 1	1	0
Location asset specificity (customer)	0 or 1	1	0

A priori, if there is more asset specificity over the period it should be possible to see if this shows in the data. This remains a problematic feature of the transaction cost approach, as otherwise all data collected will only be cross-sectional in nature. The different types of asset specificity have caused measurement problems in the literature as shown in Chapter Four, which is why the studies have tended to focus on a closed factory system (Masten 1984: 404). The aim has been to measure all aspects of asset specificity directly using a Likert scale, which will build up a composite picture of the interaction between the factors of production across an entire industry. A Likert scale is a response range on the questionnaire and is used when no direct unit measurement is available (Black, 1999: 227).

The relatively high score on employment asset specificity suggests aerospace employees tend to be highly qualified technicians, scientists and engineers, with a very specific skill base. This is why labour hoarding is a continuing issue, since it minimises the costs of search, recruitment and training, although this specific analysis is beyond the scope of the thesis. The costs of hoarding specific labour are less costly than a 'hire and fire' policy with subsequent added training costs. This outcome makes the transaction cost approach highly significant, because an aerospace firm will need to retain staff for long periods due to the high costs of training and recruitment. However, the transaction cost approach as applied here can be criticised as generating a blind hypothesis, in which the results cannot be compared with other sectors or industries. Such evaluation is accepted and hence the results can only be ordinal and intra-group comparisons rather than cardinal inter-group analysis. The results for all the asset specificity variables are shown in Table 6.6, where columns 3, 4 and 5 sum to 100% for employment, facilities and dedicated asset specificity.

Table 6.6: Summary of asset specificity results

Type of Asset specificity	Asset Specificity	Increased (%)	Decreased (%)	Unchanged (%)
Employment	7.4	28.0	11.0	61.0
Facilities	6.5	28.5	3.5	68.0
Dedicated	6.2	44.0	1.2	54.8

The employment asset specificity in 1997 has a mean value of 7.4 on the Likert scale. Over 60% of respondents answered that there had been no change to employment asset specificity since the comparator date of 1992. A significant proportion of 28% answered that employment asset specificity had increased perhaps reflecting increased specialisation in the skills profile of a high-tech industry. As stated above, the employment asset specificity is difficult to compare against other industries, because the relevant data does not exist. However, it is possible to use the data as yardstick evidence and state that on the scale, employment assets specificity for aerospace is greater than both facility and dedicated assets.

Facility and equipment asset specificity has a high score at 6.5 on the Likert scale, but is less then employment asset specificity. This possibly indicates there is slightly more scope for flexibility in the facilities even with aerospace technology. Again some 28% of the respondents answered that there is increased facility and equipment asset specificity. However, 68% answered that facility and equipment asset specificity is unchanged, which is surprising given a prior understanding of technological change in the aerospace industry. Increases in facilities asset specificity are at the same rate as employment asset specificity, but decreases are lower. Dedicated asset specificity is approximately the same as facility and equipment asset specificity. Significantly, there has been a rise in dedicated asset specificity in the five years between 1992 and 1997 possibly as a result of firms attempting to avoid the hold-up problem with vendors. This outcome suggests that there is an increasing willingness between aerospace suppliers to enter contracts with more binding conditions and relates to the issue of contract type and contract design.

Dedicated asset specificity in 1997 is 6.2 with 44% of the answers claiming that there has been increased dedicated asset specificity and just over half answering no change. This is significant for contracts since it is possible evidence that customers are manipulating the supply chains by binding suppliers to the dedicated assets.

As for location asset specificity, aerospace is a national and global industry and therefore location does not appear to be a major factor, as with the 'mine-mouth' location of electricity generation next to coal mines (Joskow, 1987: 170). Hence, the most important export customer is on average 3,400 miles away and the most important UK customer is on average 146 miles away. However, a total of 15 firms (18.3%) would benefit from being closer to the most important customer, but only three of the fifteen companies are where the customer is overseas. For these 15 companies, a close proximity is important, since the majority of these firms are small to medium sized component suppliers. For the remaining firms, location is not a major issue to consider, especially when the most important customer is located in another country. At this level, employment, facilities and dedicated assets are all more important in aerospace than location. Overall, this analysis is further evidence that the transaction cost is relevant to aerospace as it draws out the importance of supply chain management, investment planning and diversity of customers to asset specificity. Whilst this is likely to be true for other industries such as shipbuilding, it nevertheless shows that assets specificity is an important consideration in the UK aerospace industry.

Uncertainty (Demdel and supdel)

The uncertainty variable has been divided into demand uncertainty and supply uncertainty, as shown in Table 6.7. Uncertainty is also a difficult variable difficult to measure and so a Likert scaling was developed similar to asset specificity (see Chapter Four).

Table 6.7: Uncertainty predictions

Variable Type	Variable Response	Make Prediction	Buy Prediction
Demand uncertainty	1 to 10	High	Low
Lead-times	dd/mm/yy	Long	Short
Supply uncertainty	1 to 10	High	Low
Reliability	0 to 1	No	Yes

The main issues of measurement centre on the abstract concept of uncertainty and how it affects the decision-making process. The way this has been interpreted is in terms of supply and demand in order to generate data from both sides of the market. Table 6.8 is a summary of the uncertainty measurements.

Table 6.8: Summary of uncertainty results

Type of Uncertainty	Uncertainty Level	Increased (%)	Decreased (%)	Unchanged (%)
Demand	6.2	35.5	3.7	60.9
Supply	4.9	30.5	6.1	63.4

The demand change is one proxy for uncertainty and appears to be relatively important, since the demand change in 1997 on the Likert scale is 6.2. The figure is towards the higher end of the scale, which suggests that there is a degree of uncertainty on the demand-side. The level of demand uncertainty has increased by over a third (35.4%), whereas it is unchanged in almost 61% of the recorded cases. Decreased demand change is comparatively small at 3.7%. These results are expected given the recent stability following the initial upheavals after end of the Cold War.

Supply change is another proxy for uncertainty and initially appears to be less important than demand as it is under 5.0 on the Likert scale. The level of increased supply change is 30.5% with almost two thirds unchanged (63.4%). Once again the decreased supply change is relatively small at 6.1%.

Similarly, over 84% of respondents regard suppliers as reliable; or alternatively 16% of respondents regard suppliers as unreliable. This result is indicative of a high level of trust and co-operation between firms in the aerospace supply chain, which may not be apparent in other industries, although a 16% response of no trust is not a trivial amount, either.

On a related supply issue, the time difference between order and delivery is 201 days or six and a half months, where the range is from one day to a thousand days. The analysis confirms the relatively long contract length in aerospace and the need for contracts as opposed to spot markets. However, given the high technology status of the aerospace industry it is practical to expect quite long contracts over years and months rather than days or weeks. Even so, aerospace firms still use the spot markets for raw materials such as aluminium on the London Metal Exchange (LME) and oil on the International Petroleum Exchange (IPE). In addition, firms such as BAE Systems and Rolls-Royce hedge using futures and options for commodities (*e.g.* oil and aluminium), currency (*e.g.* £, $ and €) and capital on the global financial markets (*e.g.* UK or US interest rates). Typically 3 to 6 months forward contracts are used to neutralise the risk of price movements, which coincides with contract length identified in the survey.

Frequency (One-off)

The frequency variable is specific in the transaction cost literature, but there are also related measurement problems with the variable. The issue of measurement has been overcome using the standard Likert scale, as with other variables in the survey. If a component or service is required occasionally then the firm is advised to use the market and buy from market firms who generate economies of scale (*i.e.* buy option).

If there is frequent use of a component or service then the firm is advised to internalise the product or process (*i.e.* make option). Otherwise, the firm is exposed to the hold-up problem, where suppliers act opportunistically. According to Worthington, *et al.* (2005: 38) firms are more likely to make if the transaction is frequently occurring, because the firm can generate internal economies of scale in production for the component or part. The predictions of the frequency variable are shown in Table 6.9 below, which are used in Chapter Eight and draw upon the work by Williamson (1985: 52).

Table 6.9: Frequency predictions

Variable Type	Variable Response	Make Prediction	Buy Prediction
Frequency	1 to 10	High	Low
Magnitude change	0 or 1	No	Yes

Table 6.10 shows the frequency level in 1997 is relatively high at 7.0. The transaction cost prediction is for a make decision in this situation. This result would suggest that aerospace firms tend to make in-house, which confirms evidence from the marginal make-or-buy decision and show that firms are more likely to be vertically integrated[4]. In almost 30% of the recorded cases frequency increased, with unchanged frequency at nearly two thirds (64.6%). Finally, the variable of frequency needs to be taken in context with asset specificity as shown in Table 4.3. Transaction costs predicts that if there is significant asset specificity then the firm will make whether frequency is high or low.

Table 6.10: Summary of frequency result

Type of Frequency	Frequency Level	Increased (%)	Decreased (%)	Unchanged (%)
Frequency	7.0	29.3	6.1	64.6

[4] That is, two thirds of firms replied make to the question do you make-or-buy if the costs of make equal the costs of buy, when Masten predicts that in theory the answer should always be buy (Masten 1984: 407).

In a related area to frequency, over 35% of customers change the magnitude of an order at short notice, as opposed to 65% who do not change the magnitude of an order at short notice. One way to interpret this information is to suggest that aerospace supply chain is varied and contains both spot markets as well as more complex contracting along a continuum as suggested in Chapter Four (Williamson, 1985: 20). However, the problem with the frequency result is there are no yardstick comparisons for a single result unlike asset specificity where there are several measures.

Small numbers (Supnum and Cusnum)

The small numbers exchange is related to the concept of opportunism (Williamson, 1975: 47). The issue of small numbers exchange has been modelled in terms of assessing the number of suppliers on the supply-side and the number of customers on the demand-side. There is the possibility of using a hostage model in this context (Williamson, 1983: 520). The implications of this small numbers exchange relate to make-or-buy through the issue of opportunism and the organisational failure framework in Figure 4.3. Williamson also states that when there is a large pool of potential bidders for a contract at the beginning, this situation may be effectively reduced to small numbers supply condition once the contract has been awarded (Williamson, 1975: 10). The situation of small number exchange can be caused by first mover advantage[5] or reputation effects (*ex ante* small numbers) and incumbency effects (*ex post* small numbers). Williamson defines the small numbers problem in terms of the human behaviour of opportunism. Faced with small numbers supply, vendors will use this to an advantage in exchange. This variable is difficult to define and again a Likert scaling was used in an attempt to overcome the problem of measurement. The small numbers variables are composed as follows in Table 6.11 and show the importance of small number to the prediction of make-or-buy and ultimately the production-procurement decision.

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[5] The first mover advantage in game theoretic terms is the battle of the sexes game. In this game the players are non-cooperative, but there is an absence of conflict. In aerospace this has been modelled by Jackson (2003: 87-89) in terms of decision-making between the MoD and the UK DIB.

Table 6.11: Small numbers predictions

Variable Type	Variable Response	Make Prediction	Buy Prediction
Supplier number	1 to 10	Low	High
Single supplier	0 or 1	Yes	No
Customer number	1 to 10	Low	High
Single customer	0 or 1	Yes	No

This section on small number exchange is related to opportunism and there is also a connection with monopoly power. The small number variable could capture the monopoly power in the transaction. If this is the case, then transaction costs can use small numbers exchange as a proxy for monopoly power and thereby eliminate the need to assess the use of monopoly power arguments in this context. In particular, the monopoly power argument could become a special case within the overall transaction cost paradigm, if small number exchange is shown to be significant.

Table 6.12: Summary of Small Number result

Type of Small Number	Level of Small Number	Increased (%)	Decreased (%)	Unchanged (%)
Supplier	4.9	15.8	36.6	47.6
Customer	4.9	25.6	23.2	51.2

Supplier numbers is a proxy for small numbers exchange and the supplier number in 1997 is almost at the mid-point of 4.9 on the Likert scale. The supplier number only increased by 15.8% and over a third there was decreased supplier number change (36.6%) with just under half no change (47.6%).

Customer number is another proxy for small numbers exchange. Again the customer number in 1997 is just under half at 4.9. A quarter of the recorded cases had increased customer number change (25.6%), almost another quarter noted decreased demand change (23.2%), whereas the remaining half of the cases were actually unchanged (51.2%).

In related terms, the mean number of firms that account for 75% of suppliers is 18. This result has implications for the level of indirect employment. Although this aspect of the research is beyond the scope of this thesis the number of firms which account for the remaining 25% of suppliers would be relevant as it would give insight into the indirect employment multiplier of the aerospace industry. On average, the most important supplier accounts for 29.6% of all the purchases made by the firm. This also has implications for purchasing strategy in terms of reliance on a single supplier. It may also suggest that there is monopoly power in certain parts of the supply chain given that some firms have some price leverage in the market.

Similarly, the mean number of firms that account for 75% of customers is 21. On average, the most important customer accounts for 28.0% of all sales, implying there may be a certain degree of monopsony power in the markets. For example, aerospace firms may face a monopsony buyer such as the UK MoD.

Economies of scale (Supcayes)

The issue of economies of scale is developed by Lyons (1994, 1995) and is important to efficient transaction cost minimising. Worthington *et al.*, identify two types of economies identified with the make-or-buy decision (Worthington *et al.*, 2005: 40). The first is production cost economies of scale. This occurs when the firm buys from the market where its demand is small relative to total market. The market can pool the demand from all sources and gain sufficient economies of scale to reduce unit costs for all concerned such as ball-bearings and aerospace fasteners. The second is governance economies of scope, where the firm can generate cost savings through governance of many similar contracts. For example, governance economies may be gained through experience or logistics of multiple project management such as BAE Systems that currently manage projects in land, sea and air systems, but the company heritage is aircraft production. The economies of production scale are considered below, but the economies of scope are also important in aerospace. The latter concept is not included as it is more difficult to measure than the former concept. The economies of scale variables are presented in Table 6.13.

Table 6.13: Predictions relating to economies of scale

Variable Type	Variable Response	Make Prediction	Buy Prediction
Supplier has a cost advantage	1 to 10	High	Low
Core competencies	0 or 1	Yes	No
Supplier offers cost discount	1 to 10	Low	High
Make = Buy	0 or 1	1	0

In more detail, if the supplier has an advantage (over the purchasing firm) then the purchasing firm is more likely to make in order to avoid the hostage problem. Conversely, if the supplier advantage is low then the purchasing firm is more likely to buy from the market as there is reduced scope for opportunism by the supplier. In related terms, if the supplier discount is low then the purchasing firm is likely to make in-house, but if the supplier discount is high then the firm is likely to buy and share the gains from the economies of scale from a supplier that is presumably supplying many different firms with the same or similar component. Also, if the firm has a core competence in producing the component then the firm is more likely to make than buy. The make equals buy variable is the marginal make-or-buy decision. Masten (1984: 405) predicts that if the cost of make equals the cost of buy then the firm should buy. However, as seen earlier in this Chapter (where two-thirds of firms replied make when the predication is buy) this is not always the case, which is an issue developed in the make-or-buy section below (Williamson, 1985: 96).

Sub-contracting (Subhigh and Sublow)

As expected more firms sub-contract work in periods of high demand than in periods of low demand. This situation could simply be an industry-wide custom and practice or reveal that aerospace suppliers operate at or close to full capacity even in periods of low demand. As a result, in periods of high demand firms are forced to sub-contract in order to meet demand. In periods of high demand they do not expand to meet the change, merely use the market in an attempt to minimise transaction costs. Hence, 40% of firms in the sample sub-contract in high demand, whereas only 15% sub-contract in low demand. This can be interpreted in a number of ways. Firstly, there is not the capacity in some firms to expand in periods of high demand, hence 40% of firms sub-contract in high demand. Secondly, some firms do not have the organisational skills to sub-contract in low demand; hence only about 15% of firms still sub-contract in periods of low demand, which has implications for levels of aerospace industry capacity both now and in the future. These results could also contribute in explaining the reduction in the mean number of employees in Tables 6.3 and 6.4. If firms outsource more and more then the size of the aerospace firm will decrease as appears to be happening in the UK aerospace industry.

Make-or-buy (MAKE and BUY)

The marginal make-or-buy decision reveals aerospace suppliers prefer make to buy by a ratio of two to one. This is clearly against the general predictions of the transaction cost framework, which predicts that when make equals buy a firm will always buy (Williamson, 1985: 96). The basis for the logic is why make when you can buy? However, this finding is an original contribution to the empirical transaction cost literature, because firms are not buying when make equals buy. That is, 62% of firms in the sample make (when the costs of make equal the costs of buy); whereas 38% will buy under the same conditions. There are suggestions at Rolls-Royce[6] that the two thirds-one thirds split in favour of make is not surprising given the high levels of sunk costs that aerospace suppliers have to invest. Therefore, given the huge sunk costs, firms are always likely to make rather than buy, implicitly confirming the existence of asset specificity. This could also be linked to the transaction cost relationship between asset specificity and frequency, which predicts that a firm will make when there is significant asset specificity whether or not frequency is high or low. In other words, there may be a predisposition in favour of make in the transaction cost model and in reality.

The transaction cost maxim of why make when you can buy may in fact be inverted in practice, if not in theory. Consequently, some of the results from the dataset may be contradicting elements of the transaction cost predictions. Therefore, whilst there is a trend in aerospace (as with other engineering industries) to outsource there is resistance to the process from within firms. This outcome may result from inertia to change within large organisations; or indeed a realisation that if too much sub-contracting occurs then the 'hollowing-out' of the firm could have serious

[6] These remarks were made in an interview with the author to a senior Rolls Royce procurement director in March 2002.

implications for the aerospace firm in the future (Jackson, 2004: 520). That is, there are concerns about long term security of supply from the original equipment manufacturers (OEM) and problems of switching supply back in-house if suppliers become too expensive or indeed unreliable in the future. This scenario is especially where long product life cycles are involved as with aerospace. The next section explores the use of cross tabulations from the data set.

Cross tabulations

The cross tabulation exercise has two purposes for testing and predictions. Firstly, it shows how respondents have answered on two or more questions at the same time and identifies the joint distribution of variables. Secondly, it presents the data in a straightforward way using a matrix form. There are a number of potential cross tabulations that can be performed from the data, which can be insightful for the remainder of the thesis. The general cross tabulation procedure is to analyse the frequencies in a given data set. It is used to analyse sub-sets of the data, where the variables are organised in rows and columns.

Table 6.14: Cross tabulations for asset specificity and make

Asset specificity	EMPAS: MAKE	FACAS: MAKE	DEDAS: MAKE
1	0 (1)	0 (5)	2 (4)
2	0 (1)	3 (1)	5 (4)
3	1 (1)	3 (5)	3 (2)
4	1 (0)	2 (2)	0 (0)
5	6 (1)	5 (3)	9 (1)
6	2 (1)	5 (0)	3 (6)
7	11 (10)	11 (3)	9 (1)
8	18 (10)	3 (5)	4 (7)
9	5 (4)	8 (3)	10 (3)
10	7 (2)	11 (4)	6 (3)
Total	**51 (31)**	**51 (31)**	**51 (31)**

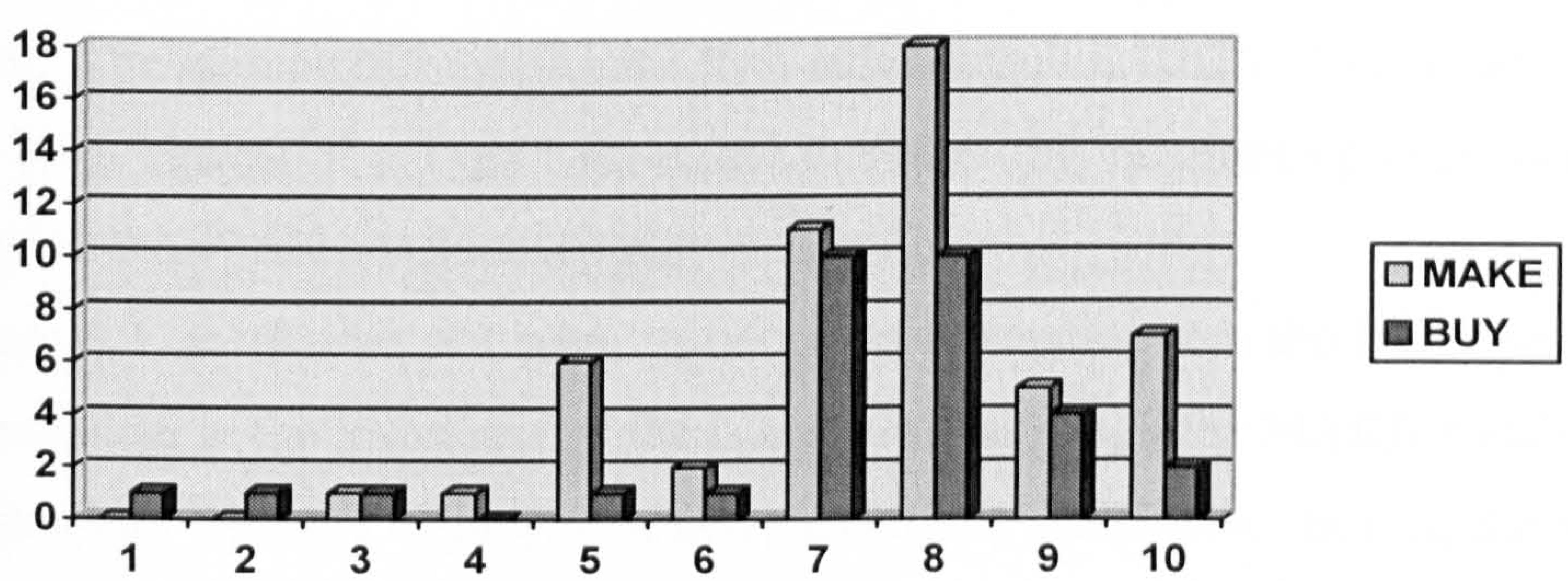
The figures in brackets refer to the BUY variable.

The analysis conducted here uses non-parametric tests, which are concerned with counts for category data (Green, 2000: 845-846). The actual test is the Pearson Chi-square test that generates a decision to accept or reject the null hypothesis of avoiding a Type I error, where a Type I error is rejecting a true hypothesis. By not rejecting a true hypothesis, by definition the decision-maker is accepting a true hypothesis.

The first set of cross tabulations to be reported compare the three main asset specificity explanatory variables (EMPAS, FACAS and DEDAS) with the dependent variable make (MAKE) for the entire sample. The three asset specificity variables have a Likert scale (1 to 10) and the make variable is binary (0 or 1).

The transaction cost approach predicts that the BUY responses should appear proportionately more frequently from 1 to 5 on the Likert scale and the MAKE responses proportionately more frequently from 6 to 10 on the Likert scale. The following diagrams, namely Figures 6.1 to 6.3 attempts to do this for three of the asset specificity variables against the dependent variable of MAKE (and BUY).

Figure 6.1: Histogram of MAKE cross tabulation with EMPAS

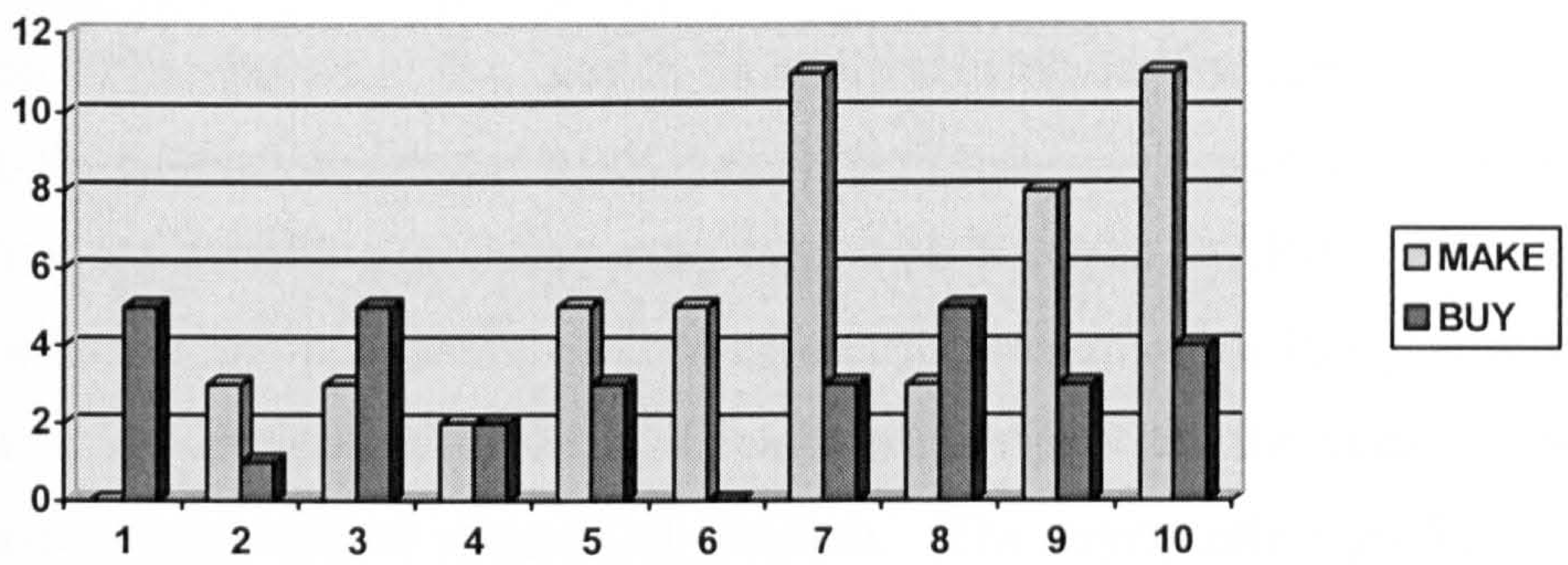


Broadly, there seems to be some confirmation that the BUY variable is more prevalent at the lower end of the Likert scale and the MAKE variable is at the higher end with the employment asset specificity (EMPAS). However, on Figure 6.1 the MAKE variable starts to be larger than BUY at the scale 4.

Using the Pearson Chi-square test of association with the relationship between EMPAS and MAKE, the result is that the value of 7.71 is insignificant with 9 degrees of freedom. The asymptotic significance (two-sided) result is 0.564. This means there is a 56.4% chance of a Type I Error and therefore this relationship is not accepted. This result is surprising since transaction costs would predict a make decision with high asset specificity, in this case employment asset specificity.

In terms of FACAS and the MAKE and BUY variables there seems to be some confirmation that the BUY variable is more prevalent at the lower end of the Likert scale and the MAKE variable is at the higher end with the facility asset specificity (FACAS). However, on Figure 6.2 the MAKE variable starts to be larger than BUY at the scale 5.

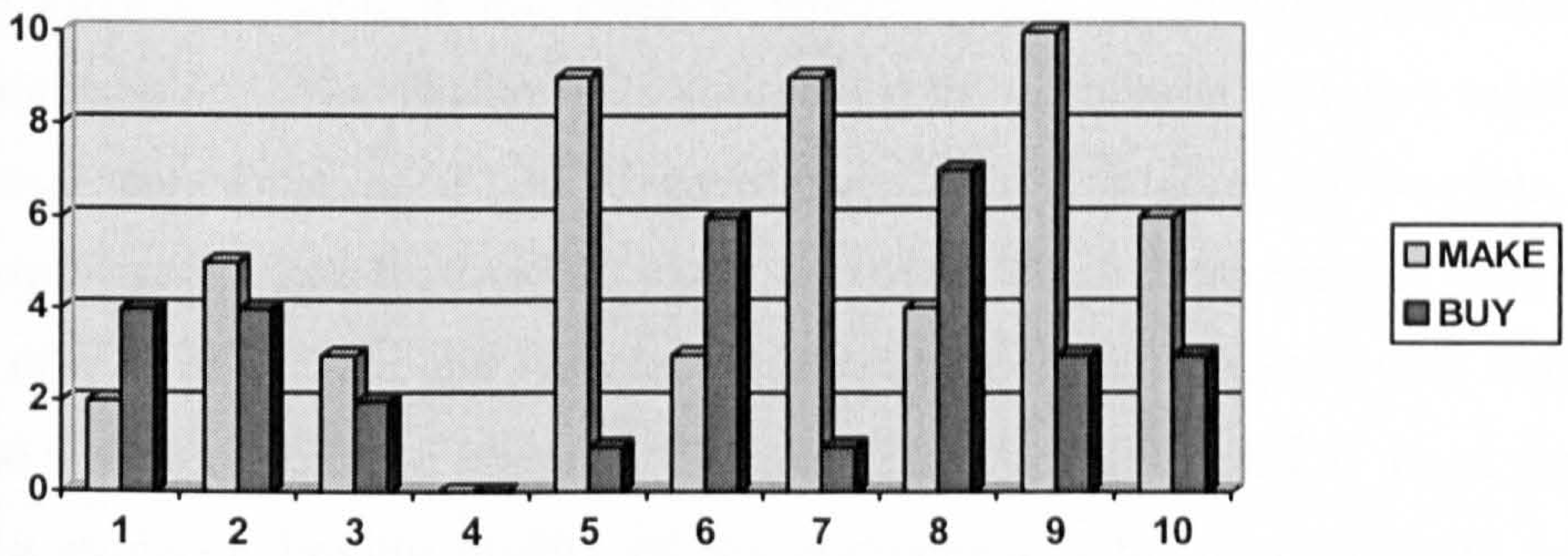
Figure 6.2: Histogram of MAKE cross tabulation with FACAS



Using the Pearson Chi-square test of association with the relationship between MAKE and FACAS the result is that the value of 18.854 is significant with 9 degrees of freedom. The asymptotic significance (two-sided) result is 0.026. This means there is only a 2.6% chance of a Type I Error and therefore this relationship is provisionally accepted at the 97.5% confidence interval.

In Figure 6.3, there does not seem to be any confirmation that the BUY variable is more prevalent at the lower end of the Likert scale although the MAKE variable is at the higher end with the employment asset specificity (EMPAS). In fact, the MAKE variable starts to be larger than BUY at the scale 2 and continues to be throughout the remainder of the scale.

Figure 6.3: Histogram of MAKE cross tabulation with DEDAS



Using the Pearson Chi-square test of association with the relationship between DEDAS and MAKE the result is that the value of 16.467 is significant with 9 degrees of freedom. The asymptotic significance (two-sided) result is 0.036. This means there is only a 3.6% chance of a Type I Error and therefore this relationship is provisionally accepted at a 95% confidence level.

In essence, the cross tabulations have shown visually and statistically that there is a relationship between the dependent variable MAKE and two of the asset specificity variables (EMPAS and DEDAS) in line with the predictions of the transaction cost approach. The next stage is to search for more statistical relationships in the dataset between the dependent variable MAKE and other (generally explanatory) variables.

There is a statistically significant cross tabulation between MAKE and the variable CA97, which is the proportion of civil aerospace production in 1997. The Pearson Chi-square test of association with this relationship shows that the value of 39.864 is significant albeit with 26 degrees of freedom. The asymptotic significance (two-sided) result is 0.040. This means there is only a 4% chance of a Type I Error and therefore this relationship is accepted with a 95% confidence interval. This result can be interpreted to mean that there is strong evidence linking civil aerospace producers with a propensity to make (rather than buy). Such a result is confirmed with MAKE and CA92, which is significant at between the 90% and 95% confidence intervals as there is only an 8.5% probability of a Type I Error. Similarly, MAKE and MA97 is significant at the 95% confidence level as there is only a 4.2% probability of a Type I Error. Significantly, there is also a strong cross tabulation between MAKE and MILCIV where the value is significant at 5.542 with 1 degree of freedom and the Pearson Chi-square test is 0.019. Hence, there is only a 1.9% probability of a Type I Error with between 95% and 99% confidence intervals.

Next, there is a statistically significant cross tabulation between MAKE and the variable HIGHQ, which is the variable where quality is an important reason for switching supplier. The Pearson Chi-square test of association with this relationship shows that the value of 7.130 is significant with 3 degrees of freedom. The asymptotic significance (two-sided) result is 0.068. This means there is only a 6.8% chance of a Type I Error and therefore this relationship is accepted with between a 95% and a 99% confidence interval. This result can be interpreted to mean that there is strong evidence linking quality of the component with the propensity to make (rather than buy).

Finally, Mann-Whitney non-parametric tests were conducted on the four main asset specificity variables (EMPAS, FACAS, DEDAS and LOCATION) for SIZE (dummy variable for firm size), MILCIV (dummy variable for military firm), MAKE (dummy variable for make firm), AERONON (dummy variable for aerospace suppliers) and CUSCONYES (dummy variable for contract with customer). The dummy variables were determined by assigning zero to those firms in the data set which are military and one for those which are civilian and the same procedure for those firms which are large or small, make or buy and aerospace firms or not, respectively. The significant results are reported in Table 6.15.

Table 6.15: Results of wider cross-tabulations: asset specificity

First Variable	Explanatory Variable	Numbers in each category	Asymptotic Significance	Confidence Interval(s)
SIZE	DEDAS	31 Large firms; 51 SME firms	0.015	95% to 99%
MILCIV	FACAS	20 Military firms; 62 Civil firms	0.074	90% to 95%
MAKE	FACAS	51 Make firms 31 Buy firms	0.045	95%
AERONON	FACAS	57 aerospace firms 25 non-aerospace firms	0.014	95% to 99%

The results show that facilities asset specificity is significant in three cases, namely MILCIV, MAKE and AERONON. In other words, facility asset specificity is important to military firms, aerospace firms and firms that make (as opposed to buy). Similarly, Table 6.15 shows that dedicated asset specificity is importantly related to large firms. A parallel exercise was conducted with contract decision. In particular, the variable CUSCONYES, which is the outcome of a formal written contract with a customer (as opposed to a supplier). The results are shown in Table 6.16 below.

Table 6.16: Results of wider cross-tabulations: contract type

First Variable	Explanatory Variable	Numbers in each category	Asymptotic Significance	Confidence Interval(s)
CUSCONYES	TIME	Various, too numerous to specify	0.092	90% to 95%
CUSCONYES	SIZE	31 Large firms; 51 SME firms	0.001	99%
CUSCONYES	MILIV	20 Military firms 62 Civil firms	0.084	90% to 95%

The results show that length of contract is related to whether the firm has a formal written contract with the customer. In other words, those firms with a longer term contracts will tend to have a formal written contract with customers. Similarly, the results show that large firms and military firms will tend to have a formal written contract with customers in an attempt to overcome the hold-up problem.

Conclusions

The results presented in this Chapter are based largely on descriptive statistics and as a consequence there has been a degree of interpretation and benchmarking in the analysis. Nevertheless are a number of conclusions, which can be drawn from the analysis. Firstly, there is evidence to show that asset specificity is relevant to the UK aerospace industry and facilities and employment specificity in particular. Hence, the reason to assess the aerospace industry via transaction cost has gained more credibility, which is also shown in the cross-tabulation results. Secondly, there is considerable evidence to show co-operation between firms in the supply chain, but that there is also a role for competition and 'arms-length' negotiation and contract design. This has potential implications for the assessing vertical integration in the aerospace industry. Thirdly, when make equals buy, UK aerospace firms generally prefer make due to sunk costs and this outcome runs counter to the predictions of transaction costs. The implications for the transaction cost approach are significant, since this may prove there is institutional bias against transaction costs, which are exogenous to the model. That is, the empirical results may actually refute the transaction cost theory. Fourthly, quality and reliability is preferred to cost savings presumably because of huge safety considerations. There is a vital role for suppliers and sub-contracting in the industry that accounts for the linkage and complexity of the supply chain. Finally, there is evidence of tight cost margins, which is reflected in contract design.

The overall findings from the results in comparison to the transaction cost predictions are that asset specificity is significant to military firms that aim to avoid the hold-up problem via long term contracts with customers. Dedicated assets are significant to large firms who also avoid the hold-up problem with long term contracts with customers. Facility asset specificity is significant for aerospace firms and military firms. Finally, contract length is significant when there is a formal written contract with customers. All these conclusions are supported by the results from the cross-tabulations. The next Chapter will begin to assess the qualitative data from the survey and analyse comparative data.

Chapter Seven:
Empirical results II: firm level

Introduction

The plan of this Chapter is to assess UK aerospace transactions in terms of the make-or-buy decision and contract type at the firm level. Make-or-buy and contract type are the two dependent variables in transaction cost economics and this Chapter identifies the features of each within organisations. There are three main parts to be considered. Firstly, there is an assessment of the aerospace chain using qualitative survey data for evidence of the buy decision. Secondly, there is an assessment of aerospace organisations using qualitative survey data for evidence of the make decision. Finally, qualitative survey data is used to assess aerospace contracts. Overall, aspects of transaction costs are addressed in relation to the organisational structure of the firm. The next section uses the survey to look at the aerospace supply chain.

UK aerospace supply chain: evidence of the buy decision

Prior to analysing the results, there needs to be confirmation that the sample is representative of the population as a whole. By taking the SBAC membership list as indicative of the population and then breaking this down into the various parts, it is possible to benchmark the sample generated in the survey with the wider population. Table 7.1 compares the number of companies in various categories for both the sample (total number is equal to 82) and the population as a whole (total number is equal to 187). As a consequence the sample can is viewed as largely representative of the population as a whole and also that each category is represented in the sample. This result is important for the overall pattern of the sample and indicates that there are a robust number of firms in the sample. This result is an important foundation for the rest of the thesis as it shows there is reliability in the data and further evidence of the sample matching the population is presented later in this Chapter.

The UK aerospace supply chain is an important feature of the industry, because of make-or-buy decisions. In an industry with high asset specificity, firms achieve the goal of minimising transaction costs by make and buy, but the latter means a firm is then reliant on other firms where it is financially or logistically advantageous to buy.

Table 7.1: Comparison of aerospace suppliers in the sample and the population

Tier	Supplier Type	Sample (%)	Population (%)
Primary	Aircraft assembly	7.3	5.0
Secondary	Major sub-component	13.4	15.0
Tertiary: Aerospace	Aerospace components	57.3	55.0
Tertiary: general	General components	22.0	25.0
	Total	**100.0**	**100.0**

The supply chain connects many companies, in different locations and with other capabilities and expertise. Table 7.2 shows that there has been an increase in the importance of aerospace to companies in the survey, but a decline in the importance of defence in the post-Cold War period from 1992 to 1997. This may point towards a strategic decision by firms in the UK aerospace supply chain to channel existing expertise and asset specificity towards aerospace and civilian activity and divert away from military activity in view of the declining levels of military expenditure. Indeed, this substitution of military work to civilian aerospace work in general may have been an enforced necessity for the companies involved, as the lagged effect of declining military expenditure began to be a major issue. The increase in aerospace work could be where these firms have established a competitive advantage in supply. In addition, other strategies of exit, merger and a search for completely new markets are likely to be deployed even though the full effects are lagged often longer than a five-year period.

Table 7.2 also confirms the five firm concentration ratio was stable between 1992 and 1997 at around 70% of industry turnover as shown in Chapter Two.

Table 7.2: Types of activity: percentage of industry turnover

Type of activity	1992 (%)	1997 (%)
Aerospace	67.0	71.5
Top five firms	69.4	70.2
Military	29.8	27.5

The identification of the most important customer can be very insightful indeed, because this can identify the structure of the supply chain. Table 7.3 details the most important customer from the survey in rank order, which is a good indicator of how the supply chain is inter-linked with important customers in aerospace. One in four of the suppliers have British Aerospace (now BAE Systems) as the most important customer and one in five have Rolls-Royce. These two companies are at the top of the supply chain although only one produces final aircraft. This situation is indicative of the dominance of the larger firms that are mainly the prime contractors, as well as the make-or-buy policies of the major prime contractors. A possible reason so many firms supply direct to British Aerospace and Rolls-Royce directly is because work is being out-sourced, which has historically been undertaken in one of the many sites of these two companies. Otherwise, the smaller companies would tend to supply to intermediate aerospace firms who in turn would pass on to the big two companies. In the pilot survey, there was further informal evidence of increasing levels of outsourcing by the largest companies had previously been undertaken in-house.

Table 7.3: Most important customer to firms in the UK aerospace supply chain

Name	Number (n)	Percentage (%)
British Aerospace	20	24.4
Rolls-Royce	17	20.8
MoD (including DERA)	12	14.6
Other aerospace firms*	6	7.3
Shorts	5	6.1
British Airways	5	6.1
Boeing	5	6.1
USA DoD	2	2.4
Other firms**	10	12.2
Total	**82**	**100.0**

* Other aerospace firms include Dowty, GKN-Westland and Damlier-Benz.

** Other firms include BNFL, Coventry Press and Thames Water.

One in seven firms supply the UK MoD directly, presumably with items such as spares, maintenance and small engineering work for the RAF. This is because major overhaul work, such as the mid-life update (MLU) for the Tornado tends to be undertaken by the defence manufactures, rather than the RAF itself. The engineering works of the RAF tend to specialise in smaller works programmes and leave the major work to the aerospace DIB. It is worth noting that 20% of respondents state that other aerospace firms and other (non-aerospace) firms account for the most important customer, which indicates there is diversity in the supply chain. Also, organisations in the US figure as well, because this is such a huge destination for global aerospace products. In spite of these markets being very difficult to penetrate the relatively large size and specialist knowledge of UK aerospace firms means there is potential to supply the large North American markets.

Nevertheless, there still remains an interesting array of USA organisations in the list, such as Boeing and US DoD. This reflects the sheer scale of the American market, rather than free and open trade in global aerospace, since the USA markets tends to be supplied mainly by domestic American firms. In other words, industrial and competition policy in the US tends to favour American firms and insist on local content in the supply chain, which is known as the Buy-American Act, 1954.

There are also many other non-aerospace firms that are the most important customer. An indication of the complexity of aircraft production is where expertise from outside the aerospace industry has a positive input. This situation can be viewed in two ways. Firstly, aerospace firms are dealing with such huge conglomerate suppliers that whilst the size of the aerospace contracts is big, they are not the biggest single contract in the portfolio of the supplier. Secondly, aerospace suppliers have developed generic skills of managing vast engineering projects, which are transferable across other areas of business. Indeed, one in eight companies has most important customers who are not aerospace firms. The other non-aerospace firms include a water utility company, a nuclear energy company and car manufacturers.

Also, in the supply chain, the most important supplier in Table 7.4 is much less clear-cut and possibly less important to the aerospace industry. This conclusion is supported by the evidence of contractual relationships in Chapter Nine. So whilst companies were named, only the broad categories of suppliers such as metal suppliers (excluding British Steel) could be identified. There were a significant number of replies showing internal transfer as important, with all the ramifications this has for transfer pricing. Indeed, during the fieldwork for the questionnaire preparation one supplier suggested that they had benefited from competing directly with internal divisions of British Aerospace for work, which had historically been done in-house, hence reducing British Aerospace as the most important supplier.

Table 7.4: Most important supplier to firms in the UKAI supply chain

Name	Number (n)	Percentage (%)
British Aerospace	2	2.4
Rolls-Royce	3	3.7
Boeing	3	3.7
British Steel	3	3.7
Internal transfer	6	7.3
Metal suppliers	14	17.2
Component suppliers	13	15.8
Other (*e.g.* avionics, tyres)	26	31.6
Various (n>1)	12	14.6
Total	**82**	**100.0**

Table 7.5 shows the supply chain as developed in Table 2.6. There are only a few prime contractors, double the number of sub-contractors and four times the numbers of third level suppliers (both aerospace and general). The structure found in Table 7.5 is common in industrial economics and can be found in other industries such as ceramics (Jackson *et al.*, 2000: 8).

Table 7.5: A breakdown of aerospace supply chain from the 82 in the sample

Tier	Supplier Type	Number (n)	Percentage (%)
Primary	Aircraft assembly	6	7.3
Secondary	Major sub-component	11	13.4
Tertiary: Aerospace	Aerospace components	47	57.3
Tertiary: general	General components	18	22.0
	Total	**82**	**100.0**

The primary group of major aerospace assembly companies comprises British Aerospace, Britten-Norman, GKN-Westland, Raytheon, Rolls Royce and Shorts. The secondary group of major suppliers of sub-assemblies comprises Aero and Industry, Airsys, British Airways, Centrax, Dowty, Honeywell, Hunting, Martin-Baker, Matra-BAe, and Marconi. All other firms in the sample are in the third category of aerospace suppliers. For example, Aerospace Metals and Hi-Share supply aerospace components and British Aluminium, British Steel, Smiths and Vega supply generic component and parts, which confirms the pyramid effect.

Table 7.6 shows another aspect of the supply chain. There are twice as many suppliers to airframe contractors, than to engine contractors; and four times as many suppliers to aircraft contractors than to avionics and electronics suppliers. On this occasion there is a sort of inverted pyramid effect on the supply chain, with heavier weighting towards airframe contractors, which is to be expected from a list of firms generated by SBAC. Also, airframe suppliers are ten times the numbers of indirect suppliers, but this underestimates the number of indirect suppliers. There is evidence in Chapter Five that the SBAC membership list captured only 70% of the value of the UK aerospace markets. As a result, the number of indirect suppliers is higher in the population of the aerospace supply chain as a whole, but not in the sample generated by SBAC.

Table 7.6: A breakdown of aerospace supply from the 82 in the sample

Aerospace supply	Product Type	Number (n)	Percentage (%)
Direct	Airframe	43	52.4
Direct	Aero-engine	22	26.8
Direct	Avionics/electronics	13	15.9
Indirect	Other components	4	4.9
	Total	**82**	**100.0**

Table 7.7 compares the sample with the population defined by SBAC in order to compare the two groups. There are similarities between the two groups, but each has different features.

The sample has fewer firms that supply indirect components than the population, which in part may reflect the motivation of the respondents to complete the questionnaire. The next section assesses activity of firms in the aerospace industry. The next stage is to analyse the principal business activity of the aerospace suppliers in order to have a better concept of the industry. In turn this allows a focused transaction cost analysis of the UKAI.

Table 7.7: Comparison of aerospace production between sample and population

Aerospace link	Product Type	Sample (%)	Population (%)
Direct	Airframe	52.4	45.0
Direct	Aero-engine	26.8	25.0
Direct	Avionics/electronics	15.9	20.0
Indirect	Other components	4.9	10.0
	Total	**100.0**	**100.0**

Activity of firms in the aerospace industry: evidence of make

In the questionnaire the firms were asked to list and rank the top three principal activities of the organisation. Principal activity 1 is the primary area of business by type of product, principal activity 2 is the secondary area of business and principal activity 3 is the tertiary area of business. The frequency chart of the results is shown in Table 7.8 below.

Table 7.8: Principal aerospace business activity from the 82 in the sample

General type Of activity	Principal Activity 1	Principal Activity 2	Principal Activity 3
Aircraft	7	2	0
Engine	6	5	3
Avionics*	11	6	0
Sub-assembly	10	8	7
Metalwork	19	17	11
Components/ parts	22	22	20
Maintenance/ services	5	2	13
Jigs/ tools/ logistics	2	4	1
Other work**	0	7	9
Weapons	0	5	4
None	0	4	14
Total	**82**	**82**	**82**

*Avionics, electronics, radar, instruments.

**Nuclear, oil, rail, land, computing, chemical, food processing and motor-sport.

The three main activities are well represented as expected namely aircraft, engines and avionics. There is also a good representation from firms engaged in the fabrication of parts, such as sub-assemblies, metalwork, components and parts. In addition, the machine tool industry is similarly represented, in activities such as jigs and tooling. This area of production is often crucial to the overall success of a manufacturing industry, such as UK aerospace. The category of other work is interesting not only for the variety of work undertaken for example, nuclear, oil, rail, chemical, food-processing and motor-sport, but also because firms are involved in this as principal activity 3. The outcome suggests that aerospace firms tend to fill capacity with other work, but remain as primarily aerospace firms as a result of specialisation. The finding is especially true for the expertise of aerospace firms in industries such as railways and even motor-sports production, such as Formula 1. For example there are spin-offs from the aerospace engine sector to the engines of Formula 1 racing cars.
Also, in Table 7.8, the decreasing share of the category aircraft appears to show that firms tend to be aircraft manufacturers first and foremost or not at all. Indeed, this confirms that many firms are indeed highly specialised and form part of a supply chain such as jigs and tools plus the production of weapons. There is also evidence of a wide array of work being undertaken by firms generally in the supply chain with a great deal of activity. Weapons as an increasing function of principal activity may suggest that firms need expertise in aerospace and defence, in order to maintain a presence in the weapons industry.
Table 7.9 presents the qualitative answers in rank order to the question what are the three occupational groups who have highly specific skills, knowledge and experience in the firm. Asset 1 in the Table is the most specific employee asset at the firm, asset 2 is the second and 3 asset is the third. The aim of this question is to generate an appreciation for the range and type of skilled employees at aerospace firms. For example, specific jobs identified in metalwork include sheet metal workers and metal bonding; and specific jobs in technical support include technical publishers and computer software engineers.

Table 7.9: Employee asset specificity in aerospace

Full job Description	Asset 1 Number (n)	Asset 1 percent (%)	Asset 2 Number (n)	Asset 2 percent (%)	Asset 3 number (n)	Asset 3 Percent (%)
Design/R&D	17	20.7	11	13.4	4	4.9
Engineer various	15	18.3	13	15.9	11	13.4
Moulder/fabricator	11	13.4	4	4.8	4	4.9
Metalworker	10	12.2	7	8.5	7	8.5
Sales/marketing	10	12.2	6	7.3	10	12.2
Machining/CNC	7	8.5	8	9.8	1	13.4
Quality/inspection	4	4.9	10	12.2	4	4.9
Electric/electronics	3	3.7	1	1.2	3	3.7
Technical support	3	3.7	7	8.5	6	7.3
Procurement	2	2.4	3	3.7	2	2.4
Other*	0	0.0	3	3.7	4	4.9
None	0	0.0	9	11.0	16	19.5
Total	**82**	**100.0**	**82**	**100.0**	**82**	**100.0**

* This category includes chemistry, tribology and material stress.

In Table 7.9 another important issue generated by the questionnaire is highlighted namely the exact tasks that are performed by the employees. Firms were asked to list and rank three important groups in the organisation which have highly specific skills, knowledge or experience. For a manufacturing industry such as aerospace it is expected that the various engineering disciplines are important such as metalwork and electronics. The category for design, drawing and R&D is also important. This is partly explained because aerospace is a dynamic and fast-moving industry with huge competitive pressures on the suppliers in terms of design and improvements to specifications and will account for comparative advantage over other nations. Indeed, design and R&D in general are extremely important to aerospace and can be used as a competitive weapon in a fierce market place. There are also a combination of commercial incentives and military imperatives to improve design, so this result whilst not unique to aerospace[1] only serves to confirm the existing impression of the industry as a whole. Metal work, machining and milling is also very important, because this is still a production orientated and metal engineering dominated industry, in spite of the emphasis on design and R&D.

Commercial disciplines such as sales, marketing and procurement also figure prominently in the list. This reflects the real market pressure on aerospace suppliers to reduce the cost of production and maximise the sales of the output. This is not achieved by itself in global markets, hence the need for commercial disciplines in the current aerospace industry. A counter-argument is this high proportion of commercial skills could simply reflect the job title or position of the employee who answered the questionnaire, rather than the importance of this function on the business. There is no evidence in support of the latter explanation and the questionnaires were targeted at those employees who complete the SBAC survey and thereby reduce the likelihood of bias in the responses (see Chapter Five).

In summary, Table 7.9 shows which tasks are complex and taken as a whole are a composite of many sub-disciplines within engineering. There are a large number of skilled workers involved with metalwork and mechanical engineering as expected along-side electrical and technical engineering. Design and R&D features highly as does sales and procurement which all deal with the commercial realities of modern aerospace manufacturing.

Table 7.10 shows the breakdown of the responses still further into individual areas of work associated with UK aerospace supply chain. In particular, the definition of engineer disciplines has been used here in the widest possible sense in order to capture the full magnitude of the skills and technical abilities required in the design, construction and assembly of modern aircraft programmes. In Table 7.10 certain sub-disciplines within the area such as general engineering and metallurgy have the highest number of categories.

Table 7.10 shows the extent of the engineering disciplines in aerospace in alphabetical order. The disciplines range from metallurgy and mechanical engineering to design and R&D. Within these disciplines there is likely to be highly specialist skills and expertise that require expert training and education at both apprentice and university

[1] As previously stated a close comparison to aerospace in this respect is shipbuilding, but this could equally apply to pharmaceutical output as well.

level. This confirms that employee asset specificity will tend to be very high in aerospace in order to fulfil the highly technical functions of the various jobs.

Table 7.10: Analysis of engineering disciplines in aerospace

Engineering General	Metallurgy Disciplines	Mechanical Engineering	Design R&D	Technical Support	Fabrication Moulding
Airworthiness	Bonding	CNC	CAD	Airframe	Braiding
Cell	Boring	Core-makers	CAM	Avionics	Ceramics
Chemistry	Deformation	Fitter	Control	Engine	Forging
Cryogenics	Forging	Forge	Design	Project	Glass
Electrical	Gear-cutting	Furnace	NDT	Service	Moulders
Electronic	Grinding	Machining	R&D	Treatment	Packer
Filtration	Jig-making	Maintenance	System		Operatives
Finite element	Milling	Process	TD		Optimisers
Fluid control	Pipe-bending				
Heat shrink	Pressing				
Mechanical	Sheet-metal				
Pneumatic	Stress				
Radiography	Threading				
Software	Turning				
Tribology	Welding				

Facilities asset specificity is similarly likely to be high as the skilled engineers will also tend to need specialist equipment. The transaction cost approach has an emphasis on asset specificity, which is likely to be an appropriate to assess the industry as a whole given the very specific nature of the jobs and skills identified in the UK aerospace supply chain. That is, this section has found descriptive and qualitative evidence of the specific and complex nature of aerospace activity, which is indicative of facility and employment asset specificity. The next section assesses the role of contracts in the UK aerospace industry.

Contracts in aerospace

This section develops an analysis of the contractual arrangements between aerospace firms in the industry in advance of Chapter Nine. In particular, the analysis will look at the tendency of firms to have contracts with suppliers and customers as well as aspects of incentives and penalties between firms that exchange goods and services. This approach is important because it builds a framework for assessing the transactional arrangements between firms and also allows the research to focus on trust and co-operation in the industry (Williamson, 1983: 537). In particular, contracts help to keep prices on track with long-term relationship between firms and provide safeguards for the parties involved.

In addition, in order to test the transaction cost approach from other approaches the contract design aspect of exchange need to be assessed. The analysis will use the existence of a contract with suppliers and customers as a dependent variable in much the same way as make-or-buy. If a firm has a contract with a supplier, then it is predicted that the firm is protecting against threats; and if a firm has a contract with a customer then it is predicted that the firm is establishing commitments. The following two variables will be considered:

1. Contract with supplier; where 1 = yes and 0 = no.
2. Contract with customer; where 1 = yes and 0 = no.

In general terms a contract with a supplier may be entered into by a firm due to a lack of trust between the exchange partners. The lack of trust may be due to the unreliability of suppliers generally or because the buying firm needs to guarantee a source of supply. In a similar way, a contract with a customer may be desirable for a selling firm as it represents a form of commitment to buy from the customer now and possibly in the future. In other words, there may be a longer-term relationship between firms as opposed to the spot market. In this respect it is the role of the contract which is important not contracts *per se*.

There is a potential paradox in this respect. Any firm in the supply chain will seek a contract with customers, but avoids a formal contract with suppliers as this is a barrier to supplier-switching. However, any supplying firm does not necessarily know if the customer is entering the contracts in order to facilitate long-term co-operation or because there is no trust between the trading partners. Similarly, any buying firm does not necessarily know if the supplier is entering the contract to build links with its customers or because it is aiming to hold its customer to hostage.

Contract with supplier (supcony, supcono and supconp)

A contract with a supplier is only apparent in half the number of firms. From the survey, 53.5% of the firms in the sample had a contract with a supplier, 21.0% did not have a contract with a supplier and 25.5% of the firms sometimes had a contract with a supplier. *Prima facie* the result that only about half the firms in the sample appear to have a contract with a supplier may seem to be a low proportion. However, given the need for supplier-switching policies this is not unsurprising. Hence, aerospace firms may prefer so-called 'arms-length' relationships with suppliers in order to allow quicker supplier switching or to avoid inappropriate or cosy relationships. Although there is evidence elsewhere of trust and co-operation, it will not pay all aerospace firms to do this all the time and hence the desire to trade one supplier off against another on a cost basis and thereby not take out contracts. Asset specificity is important in this respect and also may positively increase the demand for contracts with suppliers in the aerospace industry. This situation is shown in Table 7.11.

Table 7.11: The percentage of firms that have a contract with suppliers

Response	**Percentage**
Yes	53.6
No	21.0
Sometimes	25.4
Total	**100.0**

Contract with customer (cuscony, cuscono and cusconp)

The survey results show that a contract with the customer is more frequent than with the supplier. In the sample 69.5% of the firms had a contract with a customer and only 4% did not have a contract with a customer with 26.5% of the sample sometime entering a contract with a customer. Contracts with customers are different hence the desire to tie-in a customer with a formal written contract is paramount. The implication of these results is that firms have to be realistic about entering into contracts. The greater demand for contracts with customers than contracts with suppliers is straightforward, but there needs to be a great deal of negotiating between firms in the supply chain. That is, not all firms in the supply chain can use spot markets for purchases and contracts with customers, by definition.

Table 7.12: The percentage of firms that have a contract with customers

Response	Percentage
Yes	69.5
No	4.0
Sometimes	26.5
Total	**100.0**

Asset specificity is important in this respect. Where asset specificity is low then spot markets can be used. Where there is high asset specificity then contracts (with incentive and penalty clauses) are advisable.

A comparison between Table 7.11 and Table 7.12 confirms that firms tend to have a contract with customers more than with suppliers. The next section considers the issue of discounting as a form of incentive contracts in the UK aerospace.

Supplier Cost Discount (Supcayes and Supcano)

The extent to which suppliers offer cost discounts for bulk buying is considered in this section. Table 7.13 shows that one in three suppliers offer discounts to customers and over half offer discounts sometimes. This suggests a significant degree of negotiation and bargaining between firms in the aerospace supply chain. Indeed, this is a method for signalling incentives in the market for aerospace parts and components. Also, it is indicative of a highly competitive market structure where discounts are seen as essential to business activity in building-up supplier relationships.

Table 7.13: The percentage of suppliers offering cost discounts

Response	Percentage
Yes	31.7
No	11.0
Sometimes	57.3
Total	**100.0**

If there is little or no scope to offer discounts then this situation could represent a more regulated form of exchange, where prices in contracts are not negotiable between the parties involved. The size of the cost advantage of the 64 firms where suppliers offer discounts tends to be less than 10%, as shown in Table 7.14. The result is that there is only a small margin for cost advantage in the UK aerospace industry due in part to the competitive nature of the industry. Hence, discretion is used, but not for large amounts, as over 80% of the advantages are for 10% and less. This is potentially important for the make-or-buy decision, since large discounts may encourage firms to buy rather than make, but the evidence here is that the size of the discounts are generally not very high (that is, 80% of the discount in the sample are for less than 10%). In all the higher the available discount then the higher the propensity to buy.

Table 7.14: The size of cost discounts offered by suppliers

Cost Discounts	Percentage
Less than 5%	32.8
Between 5% and 10%	48.4
Between 11% and 20%	9.4
More than 20%	9.4
Total	**100.0**

The conclusion to draw from Table 7.14 is that aerospace suppliers are operating in a highly competitive market and as a result these firms are unable to offer significant discounts not least because aerospace is generally a decreasing cost industry.
Table 7.15 shows that one in five suppliers provides a cost advantage and one in three suppliers offer cost advantages sometimes for components previously made in-house. Under half offer no cost advantage, because the internal divisions of the buying firm are competitive. These findings suggest a significant degree of search costs for firms, which need to identify and select firms in the aerospace supply chain to provide the best deal for a component on cost, including other divisions within their own organisation and transfer pricing. This also has implications for both moral hazard and adverse selection in particular, where there is is hidden action and hidden information in the market exchange. The transaction cost approach gives due emphasis to bounded rationality and opportunism, which may be relevant in aerospace, where the scope for the hold-up problem is potentially significant. Full details of the supplier cost discount are shown in Table 7.15.

Table 7.15: The percentage of suppliers with a cost advantage

Response	Percentage
Yes	20.7
No	43.9
Sometimes	35.4
Total	**100.0**

The size of the cost advantage to the firms where suppliers offer cost advantages tends to be less than 10% as shown in Table 7.16. Although a significant proportion of one in four does have a significant cost saving (over 10%) suggesting this type of firm should be considering outsourcing production as a form of cost reduction. Indeed, this type of firm often with sizeable overheads should consider its role in production and concentrate on design, project management or winning contracts from the MoD or large civilian airline companies, such as Boeing or Airbus. This can be assessed in terms of the boundaries for the firm and defining the core competencies for the organisation. Such evidence potentially reflects the small margins and profit in the supply chain, because there is limited scope for supplier cost advantage in spite of 25% of cases where suppliers have a cost advantage over a firm where the component was previously made in-house.

Table 7.16: The size of the cost advantage of the suppliers

Cost Advantage	Percentage
Less than 5%	20.5
Between 5% and 10%	53.8
Between 11% and 20%	20.5
More than 20%	5.2
Total	**100.0**

Mean length of contract with supplier is almost two and a half years. This is less than the mean length of contract for customers, which is over three years and will be assessed later in this Chapter.

The type of contract with suppliers is varied in this industry. Nearly 30% did not know what type of contract the company had with its suppliers, as shown in Table

7.17 below. It is important for the purposes of this research that a fixed price contract allows for price escalation to be incorporated, whereas a firm price contract has no price escalation allowed.

Table 7.17: The frequency and percentage of supplier contract type

Type	Number (n)	Percent (%)
Firm price	19	23.2
Fixed price	31	37.8
Both	8	9.8
Unknown	24	29.2
Total	**82**	**100.0**

Table 7.18 shows the type of contract with customers, where over half of the contracts are a fixed price contract, which suggest the customers have a good degree of bargaining power. It may also result in the organisational structure of the firm as firms with more know-how of bargaining are more likely to procure from the market in order to generate cost savings.

Table 7.18: The frequency and percentage of customer contract type

Type	Number (n)	Percent (%)
Firm price	17	20.7
Fixed price	45	54.9
Both	12	14.6
Unknown	8	9.8
Total	**82**	**100.0**

Finally, from the survey, the mean length of contract with customer is just over three years, which again is further evidence that the suppliers want to have definite contracts with customers as an attempt to build up trust, co-operation and a long term relationship with one another. It could also mean that buyers want to ensure that suppliers do not attempt to hold the firm hostage and engage in opportunistic behaviour. The implications of this for transaction costs are that contract design is important since it recognises the hold-up problem and opportunistic behaviour of suppliers. Another way to assess the implications of long term contracts is as a form of protection between respective parties in the exchange; and this is also a method of risk sharing between partners. If this is the case then it is the role of the contract that is important. Overall, this section has identified the role and types of contracts employed in the UKAI. This is applicable to transaction costs in terms of identifying commitments and threats within the hostage model. The next section assesses supply chain issues in the aerospace industry that have arisen from other responses in the questionnaire survey.

Other supply-side issues

The final section deals with some of the remaining supply-side issues covered in the questionnaire and which relate directly to the make-or-buy decision. Included in this is the level of sub-contracting in the industry, reliability of suppliers and proximity of location to suppliers. These issues are particularly prevalent in the UK and are assessed by industry forum aimed at improving performance, such as the Society of Motor Manufactures and Traders (SMMT) Industry Forum based in the West Midlands. SBAC serves a similar function but there is no industry forum in the UK aerospace industry even though other industries such as ceramics have followed the lead of the car production studies from SMMT. Table 7.19 details the answers to a number of survey questions where a binary response was required, namely yes or no.

Table 7.19: Supplier switching and other issues in UK aerospace

Supplier issue	Yes (%)	No (%)
Do you sub-contract core activity in high levels of demand?	40.2	59.8
Do you sub-contract core activity in low levels of demand?	15.9	84.1
Do you consider your suppliers to be reliable overall?	84.1	15.9
Would you benefit from a closer location to supplier?	18.3	81.7
Do important customers change the magnitude of an order at short notice?	43.9	56.1

In terms of sub-contracting, some 40% of aerospace firms in the survey out-source a core activity in periods of high demand. This figure drops to around 16% in periods of low demand suggesting that out-sourcing remains a sensitive issue to firms during a downturn in business. That is, the make-or-buy plan is an important aspect of firm behaviour during a business cycle. The overwhelming majority of aerospace firms consider suppliers to be reliable, indicating a good and honest inter-firm relationship. Otherwise, transaction costs economics would predict more supplier-switching, if suppliers were not regarded as reliable. In this context, trust is considered as valuable and important. However, one in seven firms does not consider suppliers as reliable. This can be seen as dissatisfaction with the supply chain or an inability of the supply chain to cope with the extra demand as more of the larger aerospace companies continue to outsource.

Less than 20% of suppliers would benefit from closer location to the most important customer. Therefore, it would appear that there is little scope for location asset specificity. However, other evidence contradicts this conclusion since there is a South West Association of aerospace suppliers, which benefit generally from close proximately to the Bristol area sites of Rolls Royce and British Aerospace. Also, there is a Lancashire Association of aerospace suppliers, which similarly benefits from close proximity to the British Aerospace sites at Warton near Preston and Chadderton, near Manchester.

Following other questions, there is also a higher number of customers that change the magnitude of an order at short notice, perhaps reflecting uncertainty in the business relations. Long term planning has always been essential in the production of aircraft, but this may be partial evidence of a change in the nature of the business, which is conforming to the commercial pressures of other manufacturing industries. In the transaction cost literature the issue of switching supplier is considered important since the ability to switch supplier is a proxy for barriers to the make-or-buy decision (Klein *et al.*, 1978: 297). If there are no barriers to switch supplier then there is no hold-up problem or any prospect for opportunistic behaviour by suppliers, which makes the task of minimising transaction costs more straightforward. In the questionnaire the respondents were asked to rank the importance of the decision to switch supplier for any given component, once the decision to switch supplier has been made by the firm. The results are shown below:

1. High quality = 1.96
2. Supplier reliability = 2.61
3. Low price = 2.62
4. Delivery date = 2.80
5. Others include offsets, company strategy, risk share, follow-on contracts and sales, quality assurance, customer relationship and stock control

Where 1 = most important and 5 = least important.

The lower the number the higher the importance attached to the decision to switch supplier. The transaction cost literature would predict that low price would be the most important factor. However, the results confirm that the UK aerospace industry rates quality of suppliers very highly and reliability from suppliers above cost savings and delivery. The results from Supply Chain Relationships in Aerospace (SCRIA) also confirm this conclusion. This is an important finding for UKAI because it suggests that aerospace firms view transaction cost minimisation as one of a number of goals for the firm rather than as the only objective.

There are three remaining issues to emerge from the statistical analysis. Firstly, the typical length of time between customer placing an order and delivery is just over six months. This shows the relatively long lead times in aerospace markets and indeed possible further evidence that co-operation is vital between links in the supply chain. Also, it may indicate that supplier switching may be very difficult for certain components, due to high asset specificity, especially dedicated assets. Whilst six months is not an indefinite tie-in, it is not a spot market either and shows the uncertainty and complexity of the markets. This is because exchange is far from instant and is permeated by times lags in production and delivery.

Secondly, on the supply-side the mean number of suppliers that accounts for 75% of purchases is 18. This is indicative of the wide array of suppliers in the industry and the range for this variable is from 1 to 200, with a standard deviation of 28. However, the most important supplier accounts for 29.7% of purchases, which shows a high level of dependency.

Finally, on the demand-side the mean number of customers that account for 75% of purchases is 21. The range for this variable is from 1 to 300, with a standard deviation of 37. The most important customer accounts for 28.0% of purchases.

Overall, these other supply-side issues indicate that when UK aerospace firms switch supplier it is not only to do with minimising transaction costs, but also supply chain relationships, including reliability and quality performance, where the latter concepts are not necessarily captured in the transaction cost approach.

Conclusions

There are a number of conclusions generated from this Chapter, which relate to the make-or-buy decision and contract design. Firstly, this Chapter confirms that in broad terms the dataset from the survey is representative of the wider population. Secondly, the role of the supply chain is important when testing the make-or-buy predictions; and the interaction between suppliers and customers is important when testing the role of contracts.

The make-or-buy decision is produced within the framework of the UK aerospace supply chain. That is, the firm and the market need to be close substitutes in order for supplier-switching between making in-house and outsourcing to work relatively efficiently. The mere existence of a supply chain is not a sufficient condition for supplier-switching, but it is a necessary condition. Hence, this Chapter shows there is a well-defined aerospace supply chain in the UK capable of determining the make-or-buy decision of firms across various specialist markets, in spite of the dominance of the two main prime contractors (*i.e.* BAE Systems and Rolls-Royce). The Chapter also considers the importance of asset specificity in line with general transaction cost predictions. Employee asset specificity is shown to be important for aerospace firms resulting in both specialist suppliers as well as firms retaining work in-house.

The Chapter also highlights the importance of contractual arrangements between firms and supply-side consideration of sub-contracting in the industry. The conclusions are that a contract will augment the make-or-buy decision-making process. In particular, a contract with a customer is important in order to facilitate co-operation between the parties involved in the exchange, especially with a longer term contract. Furthermore, the contract process is improved if incentives are provided such as discounts. The next two Chapters attempt to use the database to test the central hypothesis of the transaction costs model outlined in Chapter Four.

Chapter Eight:
Econometric analysis of UK aerospace I: make-or-buy

Introduction

This Chapter presents the empirical results from the test of vertical integration in the UK aerospace industry. The paradigm problem of make-or-buy will be examined in detail using econometric modelling techniques. In line with the transaction cost model and using the original data, this Chapter assesses four hypotheses using both a linear regression model and logistical function model. The four hypotheses are that one, UK aerospace firms; two, military firms; three, aerospace-specific firms and four, large firms are all likely to make due higher levels of asset specificity, uncertainty, complexity, frequency and small number. There are at least two dependent variables available for econometric analysis in this study. If the dependent variable is a continuous variable, then the test will use a linear regression and in this study the variable is the percentage of components bought-out by the firm. In the case of binary or dummy variable for the dependent variable, then the test will use a logistic function, which in this study is both a make-or-buy variable and contract. In sum, this Chapter is concerned with make-or-buy as the dependent variable using the transaction cost approach.

The Chapter assesses the organisational form as an equation under the transaction cost approach. The model is presented next and then the central hypothesis and a discussion of the dependent variables. The regression and logit analysis results are assessed and comparisons between the two approaches are made. Finally, there will be a discussion of the results. The next section begins the process by assessing the organisational form of the equation that is the make-or-buy decision.

Organisational form

As developed in Chapter Four, the transaction cost approach in this thesis is a test of vertical integration and attempts to predict when it is advantageous for a firm to use the internal mode of organisation (hierarchy), as opposed to the external mode of organisation (market). It assesses how a firm can minimise the cost of transacting via the make-or-buy decision, using the market (buy) and hierarchy (make), respectively. It also attempts to assess whether the hostage model can be applied to industrial organisation, which follows in Chapter Nine. This approach uses contracts as an important feature of the analysis and shows how relationships in exchange can affect incentives in transactions.

In general, the relationship takes the functional form in equation 8.1, with organisational configuration as the dependent variable (Form) and human and environmental factors as explanatory variables:

$$Form = f(AS, U, F) \qquad \text{Eq. 8.1}$$

Where:

Form = organisational form of the firm

AS = asset specificity

U = uncertainty and complexity

F = frequency

Organisational form can be viewed as vertical integration or the boundary between the firm and the market, which is defined by the make-or-buy decision. This configuration reflects transaction cost minimisation. According to Williamson (1985: 291), the organisational form of the firm depends on environmental factors such as asset specificity and the two behavioural assumptions of bounded rationality and opportunism. Bounded rationality is captured in equation 8.1 through the uncertainty and complexity variable. Opportunism is related to small number exchange, since economic agents will tend to act in a self-interested way that can ultimately result in the hold-up problem and hostage taking. This can be seen as another independent variable, which can be included in the model. As a result, equation 8.1 can be rewritten from the basic form to the form in equation 8.2, which attempts to capture opportunism through the variable for small number exchange (SN), where the predicted sign is positive.

$$Form = f(AS, U, F, SN) \qquad \text{Eq. 8.2}$$

Where:

SN = Small number exchange

As shown in Chapter Four, the organisational form as the dependent variable can be substituted by make-or-buy as an acceptable proxy variable (see equation 4.3) and equation 8.1 and equation 8.2 are tested in this thesis since these equations are the most accurate representation of the transaction cost model (Williamson, 1975 and 1985). The dependent variable can be modelled as a continuous variable[1] or as a dichotomous or binary variable. In the former approach, transaction costs can be seen as an on-going or continuous choice and distinguishes between the percentage of make and buy in an organisation. There are similarities between a linear and a logistic regression, but where the dependent variable is dichotomous, then the assumption of a linear relationship is violated (Field, 2000: 164). The logistic regression has the effect of turning a non-linear relationship into a linear one and thereby overcomes the problem of non-linearity of the observed data in this case the dependent variable.

The dependent variable is the proportion of the components and sub-components used by the firm, which are bought from external suppliers. The latter approach recognises the costs of transacting as a choice between alternative modes of production, that is, the market or the firm. The dependent variable is defined as whether the firm will

[1] It is worth noting that 0 to 100% is a probability, similar to a binary coding of 0 and 1, since both have an upper and lower constraint and are positive, by definition.

make-or-buy if the costs of each option are equal. This results in a model with a limited dependent variable, which in this case is a dummy variable. Both cases have a legitimate statistical foundation; the only empirical difference in this study is that there are 68 observations for the model with a continuous dependent variable that increases to 82 with a limited dependent variable. The relatively lower response rate is due the fact that the percentage bought-out question is more difficult question to answer than the make-or-buy. Nevertheless, this means the organisational form of the firm will be derived from perceived differences between the make-or-buy or contract differences, which will be discussed in Chapter Nine. Transaction cost economics also predicts that if the cost of make equals the cost of buy then the firm will buy, as shown in Table 8.1 with the main predictions for the independent variables. The sign for the variables are correct for the organisation form where make is the dependent variable. However, where buy (or bought-out) is the dependent variable then the signs are reversed, because the more a firm buys from the market then the less transaction costs there are in the exchange.

Table 8.1: The predictions of transaction cost economics

Variable	**Make**	**Buy**	**Sign**
Asset Specificity	High	Low	Positive
Uncertainty / Complexity	High	Low	Positive
Frequency	High	Low	Positive
Small Numbers	Low	High	Negative
Make = Buy	No	Yes	N/A

In turn, Table 8.1 is linked to Table 4.3, which shows the significance of asset specificity in the analysis relative to frequency. Within the organisation structure of the firm, asset specificity plays a central role in the make-or-buy decision because a firm should make when asset specificity is high even if frequency is occasional in order to avoid the hold-up problem.

The Model

The generalised model for make-or-buy is given in equation 8.2 and the model to be tested empirically is shown in equation 8.3. Equation 8.3 links the functional form of the firm with a vector of explanatory variables:

$$\pi_i = \beta X_i + \mu_i \qquad \text{Eq. 8.3}$$

Where:

π_i = the perceived differences between make and buy for firm i.

β = a vector of co-efficients

X_i = a vector of exogenous independent variables, which represent asset specificity, uncertainty, complexity and frequency.

μ_i = an error term

The ultimate algebraic form of the equations to be tested is covered in the next section on the central hypothesis. Nevertheless, it is clear from the previous commentary that there are a number of possible nested models that can be analysed. The first model is where the explanatory variables are the three basic transaction cost dimensions of asset specificity, uncertainty, complexity and frequency, as in equation 8.1, whether using a continuous variable or a dichotomous variable as the dependent variable. The second model is where the small numbers exchange variable is included as in equation 8.2, again whether using a continuous or binary variable. The third model also has dummy variables included to take account of specific features of the UK aerospace industry such as civil-military mix and the extent of the aerospace supply chain. Although these are not explicitly shown in equation 8.3 they appear in equation 8.4 in the next section below. The various models have been formally stated in order to show the development of the model from its theoretical form to operation structure, which takes into account the UK aerospace industry.

In addition, it is worth noting that given the prescriptive nature of the transaction cost paradigm, there should not be any need to question the causality of the model, as long as the dependent and explanatory variables are correctly specified. Statistically however, there is a possibility of some feedback between the continuous dependent variable and explanatory variables. This is because the data are cross-sectional in nature rather than time series and as a result there is also little probability of identifying instrumental variables. The next section will focus on the central hypotheses of the thesis.

Central Hypotheses

The central hypotheses of the thesis focus on vertical integration in the UK aerospace industry and in particular the make-or-buy decision (and contract design in Chapter Nine). This approach will test the organisation form, where there are transaction costs in the null hypothesis (H0) and where there are no transaction costs in the alternative hypothesis (HA). The first hypothesis is presented in H1:

H1: UK aerospace firms are likely to make due to higher levels of asset specificity, uncertainty and complexity, frequency and small numbers.

The central hypothesis tests whether or not these TCE characteristics are dominant in the UK aerospace industry. *A priori* the evidence that this is a worthwhile approach to take is contained in the stylised facts in Chapter Two. There is massive investment in R&D, long life-cycles and a highly specialist products in the UKAI that are indicative of transaction costs.

Subsequent hypotheses can be generated to compare different groups in the database given the nature of the descriptive statistics in previous Chapters. For example, the possible transaction cost differences between military and civilian aerospace firms in the database in H2 may be accounted for by asset specificity (see H2 below). In the dataset a military firm is coded as 1 and a civilian firm is coded as 0, where a military firm has 50% or more of the company activity in defence-related activity. The 50% figure is rather arbitrary and simply reflects the weight of balance for the activity that is 51% is greater than 49%. Whilst it is possible to test what happens if the cut-off point is increased to say 75%, nevertheless the major issue remains that a division exists at all rather than the point of the separation. The second hypothesis is presented in H2:

H2: UK military aerospace firms are more likely to make than counterpart civilian aerospace firms due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers.

Alternatively, the potential vertical integration difference between aerospace firms and general engineering firms that could be explained by transaction cost is contained in H3. An aerospace firm is coded as 1 and a civilian firm is coded as 0, where a firm has 50% or more of the company activity in direct aerospace related activity. Again a figure of 50% could be considered too low and but the effect of a 75% cut-off point is likely to be negligible. The significant issue is the weight of balance where more than 50% is located in one category or another. The third hypothesis is presented in H3:

H3: UK aerospace-specific firms are more likely to make than general engineering firms in the aerospace supply chain due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers.

Moreover, the database is sufficiently specified to differentiate between firms by size in this case the number of employees. The actual employment figures can be used or alternatively a large firm is coded 1 and a small firm is coded 0, where a large firm has 250 employees or more in the company. It is worth noting that size is not measured by turnover, as this was considered too sensitive to the business cycles and exchange rate variations. The fourth hypothesis four is presented in H4:

H4: Large UK firms are likely to make due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers.

The main limitation of the hypotheses is that the results are not comparable over time or with other industries in the UK or elsewhere given the limited survey data available. Also, there may be measurement problems, because there are no standardised ways to measure the key explanatory and dependent variables.

Nevertheless, the previous discussion suggests that the most general form of the model (equation 8.2) could include all the available independent variables. This will take the structure shown in equation 8.4 and incorporates the dummy variables from the aerospace industry, where all signs are expected to be positive. Equation 8.4 is the preferred equation in terms of operational aspects of the model, because it takes into account the many empirical issues of the aerospace industry:

$$Form = f(AS, U, F, SN, MC, AO, SZ) \qquad \text{Eq. 8.4}$$

Where:

MC = Military or civil firm.

AO = Aerospace or general engineering firm.

SZ = Size of firm above or below 250 employees.

In sum, the reported results will use the three main categories of explanatory variables. Namely, model 1 is the basic transaction cost dimensions only (equation 8.1), model 2 is the transaction cost dimension, plus small numbers (equation 8.2) and model 3 is all the explanatory variables, plus the dummy variables for military-civilian differences, aerospace specific distinction and company size (equation 8.4). The predicted sign of the dummy variables is positive.

Table 8.2 shows there are actually two dependent variables, which can be used from this study, namely one for the year 1992 and another for 1997. The questionnaire as a whole is an attempt to draw attention to the changes in the UK aerospace industry over this period. From the 82 completed returns, 61 firms detailed the bought-out figure for 1992, which increased to 68 for 1997 and both periods will be assessed. Table 8.2 also shows that the mean percentage of bought-out has increased by nearly four percentage points over the five-year period 1992-97. This suggests that there has been a rise in outsourcing in the UK aerospace industry in the immediate post-Cold War era. Whether this is due to a general increase in outsourcing since 1992, which has resulted in more firms buying components from the market, rather than making internally is a mute point. Anecdotal evidence from the pilot study shows there has been a greater emphasis on outsourcing in business strategy, but the survey is not sufficiently detailed to fully capture the issue.

Table 8.2: Percentage of components bought-out in 1992 and 1997

Variable	Number (n)	Range (%)	Mean (%)	Std Deviation
Bought-out 92	61	99	50.11	29.65
Bought-out 97	68	99	53.88	30.81

The second measure has the dependent variable as a dummy variable with a binary response, linked directly to the concept of make-or-buy. This is generated by the survey question for 1997, if the cost of making a component equals the cost of buying from a supplier, then do you make or do you buy? Table 8.3 shows that just less than two thirds of the sample replied make and over one third replied buy. These responses are then interpreted as classifying the firm as either a make firm or a buy firm, which in turn can test the prediction of the transaction costs model. The model itself would predict buy if make equals buy on the assumption it is always more advantageous to buy than make. The results included in Table 8.3 are therefore interesting as it suggests the UK aerospace may have other reasons to make rather than buy. For example, sunk costs may be high and prevent supplier-switching. The issue of labour- hoarding may also prevent a perfect switch from in-house to the outsourcing of work by an aerospace firm.

Table 8.3: Make-or-buy profile of the firm in 1997

Response	Make (n)	Make (%)	Buy (n)	Buy (%)
Buy = 0.00	31.0	37.8%	51.0	62.2%
Make = 1.00	51.0	62.2%	31.0	37.8%
Total	**82.0**	**100%**	**82.0**	**100%**

The explanatory variables are an attempt to explain variations in the dependent variable in equation 8.3. The nature of all these variables is shown in detail in Table 8.4, including the dummy variables from equation 8.4, as well as the various types of dependent variables and the range of explanatory variables.

Table 8.4: Dependent and explanatory variable listing

Variable Name:	**Variable Definition:**
Dependent	**Description**
(1) MAKE (Make-or-buy)	The make-or-buy decision at the firm level, that is, the decision when make equals buys.
(2) BO (Bought-out)	The percentage of components bought-out from external suppliers.
(3) CONTRACT (Formal contract)	The decision to have a formal written contract with suppliers and customers.
Explanatory	**Description**
EMPAS: (Employment specificity)	The extent to which skills, knowledge or experience of employees are specific to a firm.
FACAS: (Facility specificity)	The extent to which facilities and equipment used in production is specific to a firm.
DEDAS: (Dedicated assets)	The extent to which facilities and equipment used in production is specific to a customer.
LOCATION: (Location specificity)	The distance of the main factory site located from the most important customer

SUPDEL: (Uncertainty in supply)	The likelihood of unexpected changes in supply for firms components.
DEMDEL: (Uncertainty in demand)	The likelihood of unexpected changes in demand for firms products.
ONEOFF: (Frequency)	The extent to which the main company business is one-off or repeat business.
CUSNUM (Customer small numbers)	The number of UK customers in the main markets.
SUPNUM (Supplier small number)	The number of UK suppliers in the main markets.

Dummy	**Description**
MC (Military-civil dummy)	Dummy variable for the type of company market, where 1 = military and 0 = civilian.
AO (Aerospace dummy)	Dummy variable for the type of company output, where 1 = aerospace and 0 = non-aerospace.
SZ (Size dummy)	Dummy variable for the size of company, where 1 = large firm and 0 = SME.

The predictions of the main variables are contained in Table 8.1. These predictions show that if asset specificity, uncertainty and frequency are high then the model will predict a make strategy and a buy strategy if these variables are low. The dummy variables in Table 8.4 are an aid to understanding the characteristics of the aerospace industry given the nature of H2, H3 and H4. The predicted signs of the dummy variables will be positive if military firms, aerospace suppliers or large firms have greater transaction costs than civilian firms, non-aerospace suppliers or small and medium-sized suppliers, respectively.

Although this is mainly a cross sectional database, it does contain some changes over time as in Table 8.5 below. Table 8.5 tabulates the response to the question on whether the transaction cost dimension, such as asset specificity has increased, decreased or stayed the same over the previous five years. The column headed Likert scale is the mean score from the survey and shows that EMPAS and ONEOFF have the highest transaction cost factors. Also, DEDAS has increased by 44%, which indicates that firms have become increasingly more concerned with specific assets. SUPNUM has the lowest Likert scale and the lowest percentage increase of the explanatory variables, which suggests that the number of suppliers is relatively constant although this is not a main transaction cost issue in any case.

Table 8.5: Descriptive statistics of the explanatory variables

Variable	Likert scale	Increased (%)	Decreased (%)	Constant (%)
EMPAS	7.41	28	11	61
FACAS	6.51	28	4	68
DEDAS	6.20	44	1	55
DEMDEL	6.21	35	4	61
SUPDEL	4.89	30	6	64
ONEOFF	7.00	29	6	65
CUSNUM	5.09	26	22	52
SUPNUM	4.91	16	36	48

In general, the responses in Table 8.5 imply approximately a third of firms in the survey consider the ranking of the transaction dimension to have increased over a five-year period. Approximately two thirds consider the ranking to be constant, with only a few percentage points showing a decrease in the ranking. For the majority of firms the dimensions to the transaction have remained relatively static. However, for a significant minority the ranking has increased pointing to greater potential for the incidence of transaction costs in the industry. An implication of this result is that the parameters of transaction cost economics are possibly becoming more relevant to firms in the UKAI.

Dependent variables

There are two dependent variables used in the analysis, namely make-or-buy and formal contracts (the latter is discussed in Chapter Nine). At this stage, it is worth noting that the matrix of the various models to be tested is shown in Table 8.6 below:

Table 8.6: Matrix of Regression and Logit models

Explanatory variables and model specification	**Dependent variable: bought-out**	**Dependent variable: Make-or-buy**
Explanatory variables: model 1 Model dimension only	AS, U, F	AS, U, F
Explanatory variables: model 2 Model dimension + SN	AS, U, F, SN	AS, U, F, SN
Explanatory variables: model 3 Model dimension + SN + dummy	AS, U, F, SN, MILCIV, AERO, SIZE	AS, U, F, SN, MILCIV, AERO, SIZE

The sequential ordering of the models with or without variables is a useful approach to show the progress of the model-building and the success or otherwise of the model fitting empirical data (Field, 2000: 165). The next section assesses the dependent variable bought-out in more detail.

Dependent variable: bought-out (BO97)

The classic regression method transforms the basic relationship in equation 8.1 and 8.2 then creates the linear correlation in equation 8.3. For the purposes of this work, the dependent variable used is the latest available, since this is the same time period for the limited dependent variable make-or-buy. This allows a better comparison to be drawn between the two models, since both models are cross-sectional by definition[2]. Assessment of the data for 1992 is deemed not possible for this series of models since there are no data for dependent variables for 1992. The number of observation in this model is 68, which are approximately 35% of the SBAC population of aerospace firms. The next section presents the results of the original dataset generated from the survey. The results are divided into two main sections, one where the results are from the classical regression with bought-out as the dependent variable and the other where the results are from a logit regression with make-or-buy as the dependent variable.

(i) Regression Model 1 results

The dependent variable in this model is the percentage of components bought-out in 1997 (BO97), since the date of the study is 1997-98, with the explanatory variables asset specificity (AS), uncertainty (U) and frequency (F). This model contains only the transaction cost dimensions as explanatory variables. The regression results are detailed in Table 8.7.

Table 8.7: Model 1 Coefficients for dependent variable BO97

Explanatory variable	Beta	T statistic	Significance
Constant	N/A	4.328	0.000
EMPAS	(-)0.115	(-)0.884	0.380
FACAS	(-)0.341	(-)2.527	0.014
DEDAS	0.036	0.270	0.788
LOCATION	0.049	0.392	0.696
DEMDEL	(-)0.199	(-)1.473	0.146
SUPDEL	0.268	1.894	0.063
ONEOFF	0.026	0.210	0.835

N/A = not available; where the $R^2 = 0.183$.

[2] A possible improvement to the model would be to use a pooled cross-sectional data set, which is only possible in this study with bought-out (BO92 and BO97) as the dependent variable. However, the survey does not have the values for the explanatory variables in 1992.

The main result is the R^2, which is 0.183 and indicates that 18.3% of the variance in the dependent variable is due to the explanatory variables. This result is relatively low in comparison with previous transaction cost studies in the literature and therefore there is no significant support for the transaction cost approach. Other variables could be included to augment the quality of the results and this approach is attempted in both models 2 and 3, which expands the list of explanatory variables and add dummy variables, respectively. Also, the EMPAS, FACAS and DEMDEL variables all have negative signs. Whilst this is expected for a bought-out, the variables are not relevant when a co-efficient is not significant. Therefore, only FACAS is a significant variable with the correct sign. The only other significant variable with the correct sign is SUPDEL, which is part of the uncertainty dimension. In fact, SUPDEL is close to being significant with a t-statistic equal to 1.89, but is insignificant with a 6.3% probability of a Type I error. There is no need to conduct a one tail test on the significant variables because these have an incorrect sign, but if a co-efficient is significant then the sign has to be assessed.

The analysis of variance in Table 8.8 confirms the R^2 result from regression. Using the F-distribution for 95% confidence intervals with 7 degrees of freedom for the numerator and 60 degrees of freedom for the denominator the critical value is 2.09. Therefore, with the F-test result of 1.95 the model is found to be not significant at 95%. The significance level of 0.083 means there is an 8.3% chance of a Type I error occurring, which means the regression result would be accepted at only a 90% level. In general, the results are unsatisfactory, which provides insufficient support for transaction costs in the UK aerospace industry. Further investigations are required in to the null hypothesis, as these results are from only a limited model.

Table 8.8: Analysis of variance (ANOVA) for model 1

Model 1	Degrees of freedom	F	Significance
Regression	7	1.95	0.083
Residual	60		
Total	67		

Model 1 suggests there is insufficient evidence in favour of the transaction cost approach. The R^2 is relatively low at 0.183, which is significant at between 5% and 10%, that is, the confidence level lies between 90% and 95% and could indicate that a transaction cost explanation is at best not proven and at worst it is not relevant. There is concern about the size and overall worth of some of the asset specificity variables and the sign of EMPAS and FACAS, but there is evidence that uncertainty is important, especially uncertainty with suppliers (SUPDEL). Finally, the frequency variable ONEOFF is highly insignificant. Clearly there is a need for further work on the modelling, which will be attempted next in model 2. In particular, more explanatory variables should be added to see if the explanatory power of the model can be improved.

(ii) Regression Model 2 results

The main result in model 2 is the R^2, which has slightly improved from model 1 to 0.203 and indicates that 20.3% of the variance in the dependent variable is accounted by the explanatory variables.[3] This result remains rather low with 80% unexplained and therefore other variables should be included to augment the results. This is attempted using the dummy variables in model 3, which are specific to the UK aerospace industry.

The supplier small number shows the predicted negative sign and the customer small number is positive, which is expected, but in this regression is not significant and

[3] This will happen *de facto* as variables are added; therefore there is a need to look at the adjusted R^2 which is shown in Table 8.13.

hence the sign is unimportant. In other words, the transaction cost approach predicts a firm will make with supplier small numbers, which is explained by the hold-up problem and monopsony. However, this may not be the case where a firm has a small number of customers, since the hold-up and the monopsony can be exploited by the firm itself.

Table 8.9: Model 2 Coefficients for dependent variable BO97

Explanatory variable	Beta	T statistic	Significance
Constant	N/A	3.429	0.001
EMPAS	(-)0.118	(-)0.898	0.373
FACAS	(-)0.330	(-)2.430	0.018
DEDAS	0.053	0.3827	0.700
LOCATION	0.092	0.708	0.482
DEMDEL	(-)0.161	(-)1.145	0.257
SUPDEL	0.263	1.852	0.069
ONEOFF	(-)0.005	0.041	0.968
SUPNUM	(-)0.005	(-)0.040	0.968
CUSNUM	0.155	1.216	0.229

Where the $R^2 = 0.203$.

The problem of hostage taking is a problem in factor markets for firms, but in goods markets it can be turned into monopoly power. These results in model 2 are an improvement from the previous model 1, but there is concern as almost all variables are not significant and offer very little support for the transaction cost model. Therefore, more proof is needed on the relevance of the transaction cost model when applied to the UK aerospace industry. The analysis of variance in Table 8.10 confirms the relatively weak result from regression R^2. Using the F-distribution for 95% confidence intervals with 9 degrees of freedom for the numerator and 58 degrees of freedom for the denominator the critical value is 2.02. Therefore, with the F-test result of 1.65 model 2 is also not significant at the 5% level. Furthermore, the significance level of 0.124 means there is a 12.4% chance of a Type I error occurring, which means the regression result would be not be accepted even at a 90% level, which prompts the decision to seek ways to further improve the model.

Table 8.10: Analysis of variance (ANOVA) for model 2

Model 2	Degrees of freedom	F	Significance
Regression	9	1.65	0.124
Residual	58		
Total	67		

Model 2 shows there remains only relatively weak evidence for the transaction cost approach. The R^2 remains relatively low at 0.203, which is not even significant at the 90% level. The concern about the significance and sign of the asset specificity variables remain and the small numbers variables introduced in this model are not significant either. The relatively low R^2 could point towards the transaction cost approach being considered insignificant to the UK aerospace industry or at best not proven as significant. If the transaction cost approach were ultimately insignificant then this would lead to concluding the possibility of other approaches as more appropriate. Hence, the next stage is to conduct even more work on the modelling, which is attempted in model 3. Overall, the lack of significant coefficients at this stage is in itself an interesting result as it points to little or no support for the transaction cost hypotheses as specified in H1.

(iii) Regression Model 3 results

Model 3 introduces the dummy variables of MILCIV, AERO and SIZE. In this model, the main R^2 result has significantly improved once again from model 2 to

0.320, showing that 32.0% of the variance in the dependent variable is accounted by the explanatory variables. This still remains low, but it does show the dummy variables in general have augmented the quality of the results, in this case especially the explanatory variable AO.

Table 8.11: Model 3 Coefficients for dependent variable BO97

Explanatory variable	Beta	T statistic	Significance
Constant	N/A	2.989	0.004
EMPAS	(-)0.124	(-)0.977	0.333
FACAS	(-)0.308	(-)2.3230	0.024
DEDAS	(-)0.008	(-)0.057	0.955
LOCATION	0.095	0.751	0.456
DEMDEL	(-)0.228	(-)1.678	0.099
SUPDEL	0.239	1.754	0.085
ONEOFF	(-)0.068	(-)0.508	0.613
SUPNUM	(-)0.043	(-)0.370	0.713
CUSNUM	0.201	1.570	0.122
MC	0.34	0.252	0.802
AO	0.370	2.974	0.004
SZ	(-)0.010	(-)0.079	0.937

Where the $R^2 = 0.320$.

In particular, there is only the dummy variable for the aerospace specific firms that is both the predicted positive sign and significant. This is clear evidence for the alternative hypothesis in H3; that is, aerospace firms are more likely to make than general engineering firms in the aerospace supply chain. However, there is support for the null hypothesis in H2 and H4 for the military-civil split and company size, respectively. These areas operate similar to perfect competition, with little or no effect of transaction costs. Overall, there is a need to consider the possibility of further empirical testing of the model, which can take a number of forms. Firstly, use another dependent variable, such as contract type, considered in Chapter Nine. Secondly, check the measurement of the variables or finally even reject the model and seek an alternative approach. This will be considered in Chapter Ten. Also, as a check for multi-collinearity model 3 is compared without the dummy variables (such as AO) with model 2 and there is little difference in the significance or the sign of the explanatory variables.

The analysis of variance in Table 8.12 confirms the improved R^2 result for model 3. Using the F-distribution for 95% confidence intervals with 12 degrees of freedom for the numerator and 55 degrees of freedom for the denominator the critical value is 1.95. Therefore, with the F-test result of 2.15 the model is significant at the 95% level. In addition, the significance level of 0.028 means there is only a 2.8% chance of a Type I error occurring, which means the regression result would be accepted at a 95% level, but not at a 99% confidence level.

Table 8.12: Analysis of variance (ANOVA) for model 3

Model 3	**Degrees of freedom**	**F**	**Significance**
Regression	12	2.15	0.028
Residual	55		
Total	67		

Model 3 shows there is comparatively limited evidence for the transaction cost approach. The R^2 result has considerably improved to 0.320, which is significant at between 95% and 99% level. However, this result is not a resounding confirmation of the null hypothesis, but nevertheless it provides some evidence in support of the transaction cost approach in the UK aerospace industry. The concern about the significance of the asset specificity variables remain, with only the FACAS and SUPDEL variables in model 3, which is close to significant and the predicted sign.

In summary, the results in the three models show a considerable improvement as the other variables are added from model 1 to model 3. The results for the three models are summarised in Table 8.13. To reiterate, the model in regression 3 is specified the best with a significant R^2 result of 0.320 and an F-test which accepts the null hypothesis at between a 95% and a 99% level. The R, R^2 and significance have all been reported and the adjusted R square takes into account the issue of increasing predicted power that can occur simply by adding variables. The results for the adjusted R^2 are slightly lower than the result for the R^2.

Table 8.13: Summary of the regression model results

Model	R	R square	Significance	Adjusted R square
Regression 1	0.427	0.183	>90% <95%	0.178
Regression 2	0.451	0.203	<90%	0.197
Regression 3	0.565	0.320	>95% <99%	0.310

Overall, using the classic regression methodology, there is very limited evidence in support of the transaction costs approach and there are doubts about whether the dependent variable is suitable for OLS. Notwithstanding, there is support for model 2, as specified in H1, with the R^2 result at 0.203, albeit at a significance level below 90%. There is only very little evidence in support of H2 that there is a difference between civil and military firms in the aerospace supply chain. Indeed, the dummy variable MC is insignificant with an 80.2% probability of a Type I error. Therefore, the null hypothesis is rejected that there is indeed no transaction cost difference between military and civilian firms in the UK aerospace supply chain. There is also no evidence in support of H4 that there is a difference between large and small firms in the aerospace supply chain. Indeed, the dummy variable SIZE is highly insignificant with a 93.7% probability of a Type I error and it is the wrong predicted sign. Therefore, the null hypothesis is rejected in favour of the alternative hypothesis that there is no transaction cost difference between large and small firms in the UK aerospace supply chain. However, there is evidence in support of H3 that there is a difference between aerospace and general engineering firms in the aerospace supply chain. Indeed, the dummy variable AERO is certainly significant with only a 4% probability of a Type I error. Therefore, there is little evidence that the null hypothesis is acceptable and that there is a transaction cost difference between aerospace and general engineering firms in the UK aerospace supply chain. Hence, it is not possible to state that aerospace firms in the supply chain are more likely to be vertically integrated than other general engineering firms in the sample and this result is only partially explained by transaction costs at best.

Overall, the results show little support for the transaction cost model outlined in this thesis. The aerospace supplier is significant but the military-civilian split and size are not significant. The next section presents the MAKE variable as the dependent and uses a logit regression methodology.

Dependent variable: Make

The logit modelling method transforms the basic relationship in equation 8.1 and presents the linear correlation in equation 8.5. The dependent variable is known as the log odds ratio and a maximum likelihood estimation is used as the method of analysis (Green 2000: 860).

$$\ln\left[\frac{prob(make)}{1-prob(make)}\right]=\alpha+\beta_1 X_1+\beta_2 X_2 \dots + \dots \beta_n X_n+\mu \qquad \text{Eq. 8.5}$$

The dependent variable is specified as natural logs and transformed into a log ratio for the make outcome. In this case the dependent variable is MAKE. The mirror image of this variable is BUY. The logistic specification was selected, because the dependent variable is binomial, which makes the classical regression model inappropriate (Greene, 2000: 216). This is because the dependent variable is effectively a dummy variable, where the estimated probabilities are neither negative nor greater than one, which is generally required in classical regression analysis (Gujarati, 1992: 144). In the presence of a limited or restricted dependent variable, then a logit or probit model is appropriate to account for the dichotomous nature of the dependent variable. In sum, this type of model allows for the probability to decline as it approaches the limits of either 0 or 1. There are no guidelines or evidence to suggest whether the logit or probit approach is the most effective and in this study the logit approach will be employed, because it usually accepted as relatively more straightforward than probit (Pampel, 2000: 5). Although the probit regression has not been used in the research, it is acceptable in the literature to use only one method and in the transaction cost literature this tends to be logit (Gujarati, 1992: 423).

(i) Logit Model 1 results

The logit model, given in equation 8.5, has been estimated with the log odds ratio of MAKE as the dependent variable. This is an appropriate method where the dependent variable is non-linear, because the logit regression coverts the truncated or 'ceiling and floor' distribution of the variable into a linear distribution sigmoid shape by transforming the probabilities into logits (Pampel, 2000: 8). Hence, a logistic regression will in effect linearise the non-linear distribution of the dichotomous or limited dependent variable. The explanatory variables of asset specificity, uncertainty and frequency are split into the relevant component parts, as before with OLS. The results from the logit regression for model 1 are given in Table 8.14, which reports beta, standard error (SE), Wald and significance results.

The beta value gives the size of the estimates in the logit equation. In these results, the constant, FACAS and SUPDEL show the largest predicted values. Indeed, both the constant and SUPDEL have a negative sign. This is contrary to the transaction cost prediction for uncertainty in Table 8.1, although it is far less important for the constant. All other variables have a sign as expected *a priori*, but none are significant, which makes it impossible to comment further. The standard error of the regression is defined in terms of the standard error of the deviation of the estimated regression line. It is a summary measure of the goodness of fit (Greene, 2000: 101). The Wald statistic is equivalent to the t statistic within maximum likelihood estimation. In these results, only FACAS and SUPDEL are greater than 2 and can therefore be considered as important. This is a pattern that is repeated elsewhere in the results.

Table 8.14: Logit results for the explanatory variables for model 1

Variable	Beta	SE	Wald	Significance
Constant	(-)1.62	1.38	1.38	0.24
EMPAS	0.07	0.16	0.21	0.65
FACAS	0.17	0.10	2.65	0.10
DEDAS	0.09	0.10	0.78	0.37
DEMDEL	0.09	0.12	0.53	0.47
SUPDEL	(-)0.32	0.14	5.22	0.022
ONEOFF	0.10	0.11	0.84	0.36

All values are at 1% significance.

The significance data for the logit regression shows the probability of making a Type I error, defined as the error of rejecting a correct hypothesis (Gujarati, 1992: 92). The variables FACAS and SUPDEL produce the most important results, because there is only a 10% and 2.2% probability of a Type I error, respectively. All the other variables have a high or very high probability of rejecting a correct hypothesis and are also not significant.

The Cox and Snell $\hat{R}^2$ is relatively low at 0.137 as is the Nagelkerke $\hat{R}^2$ at 0.187, where these type of regression results can be seen as proxy for the R^2 result. This leads to the conclusion that the representation of the transaction cost model given here is not a satisfactory explanation of vertical integration in the UK aerospace industry. On this basis, there is a need to revisit the model and highlight any shortcomings, which may account for the weaknesses in the estimation.

Another method to decide if the model is a good estimation or not is to assess the overall percentage of cases which are predicted as correct. The logit regression results in this case show the BUY variable in the model correctly predicted 38.7% of cases and for MAKE it predicted 86.3% of cases. The overall percentage correct was 68.3%. In order to gain a benchmark for this figure, it is possible to compare against the simple arithmetic mean of make, which is 62.2%. Thus, without the model we would have predicted 62.2% simply by predicting all cases to be the make option. Hence, with the model there is a slight overall improvement to 68.3% as stated above, which is better than no increase at all. This implies whilst there is room to improve the specification of the model, nevertheless there is some predictive power in the model, since it improves overall by 6.1 percentage points, but that this is a small amount. Even so, there is evidence to suggest that FACAS and SUPDEL are important variables in determining make-or-buy and significant at the 90% level. This gives possible weight to the value of asset specificity in particular and transaction costs in general. The additional detail in the model specification will be attempted in model 2 where this model has another explanatory variable. However, at this stage transaction cost analysis in model 1 has failed to explain as predicted by the theory.

(ii) Logit Model 2 results

The explanatory variables of asset specificity, uncertainty and frequency are used in model two as well as the small numbers variable as a fourth explanatory variable. The dependent variable remains MAKE as with model 1. The results from the logit regression in model 2 are given in Table 8.15 and discussion of the results follows.

Table 8.15: Logit results for the explanatory variables for model 2

Variable	B	SE	Wald	Significance
Constant	(-)1.62	1.38	1.38	0.24
EMPAS	0.07	0.16	0.21	0.65
FACAS	0.17	0.10	2.65	0.10
DEDAS	0.09	0.10	0.78	0.37
DEMDEL	0.09	0.12	0.53	0.47
SUPDEL	(-)0.32	0.14	5.22	0.022
ONEOFF	0.10	0.11	0.84	0.36
SUPNUM	0.05	0.09	0.23	0.63
CUSNUM	0.01	0.09	0.02	0.88

Values are at 1% significance.

The beta value in the results indicates that the constant, FACAS and SUPDEL have the largest predicted values. Indeed, both the constant and SUPDEL have a negative sign, as previously in model 1. To confirm, this is contrary to the TCE prediction for uncertainty in Table 8.1, albeit not significant and less important for the constant in any case. All the other variables have a sign as expected *a priori*, except the variable SUPDEL again.

Only FACAS and SUPDEL are greater than 2 and can therefore be considered as significant. This is a pattern, which was initially identified in model 1. The significance data for the logit regression shows the probability of making a Type I error, defined as the error of rejecting a correct hypothesis (Gujarati, 1992: 92). Once again, the variables FACAS and SUPDEL produce the most significant results, because there is only a 10% and 2.2 % probability of a Type I error, respectively. The variables included for small numbers have a high or very high probability of rejecting a correct hypothesis and are therefore considered significant.

The Cox and Snell $\hat{R}^2$ remains low at 0.140 as is the Nagelkerke $\hat{R}^2$ at 0.191, where as in model 1 these type of regression results can be seen as proxy for the R^2 result. This would reinforce the conclusion that the representation of the transaction cost model given provides only a limited explanation of vertical integration in the UK aerospace industry. There is a need to revisit the model and highlight any shortcomings, which may account for the weaknesses in the estimation.

The overall percentage of cases it has predicted as correct has not improved much from model 1. The overall percentage correct is at 70.7% against the benchmark figure; it is possible to compare against the simple arithmetic mean of make, which is 62.2%. Thus, without the model it is possible to have predicted 62.2% simply by predicting all cases to be make. With the model there is a slight overall improvement to 70.7% as stated above. This implies whilst there is room to improve the specification of the model, nevertheless there is potential in the model, since it improves prediction by 8.5 percentage points. Therefore, model 2 is an improvement on model 1 and the explanatory power of the small number variable is significant. The next model will introduce the dummy variables into the logit analysis.

(iii) Logit Model 3 results

The results from the logit regression for model 3 are given in Table 8.16, where the four transactions cost variables are included, plus the three dummy variables. The significant data for the logit regression shows the probability of making a Type I error, defined as the error of rejecting a correct hypothesis (Gujarati, 1992: 92).

Once again, the variable SUPDEL produced the most important results, because there is now only a 2.0% probability of a Type I error, but FACAS now has a 23.3% probability of a Type I error. From the remaining variables, only MILCIV is significant at 4.9% and has a negative sign, which is a reversal of the transaction cost prediction. The result could imply that the variable or the relationship is incorrectly specified in the model..

The Cox and Snell $\hat{R}^2$ has improved to 0.203 as is the Nagelkerke $\hat{R}^2$ is 0.277, where these types of regression results can be seen as proxy for the R^2 result. Once again, this leads to the conclusion that the representation of the transaction cost model is at best only a partial explanation of vertical integration in the UK aerospace industry.

Table 8.16: Logit results for the explanatory variables in model 3

Variable	B	SE	Wald	Significance
Constant	(-)0.79	1.61	0.25	0.62
EMPAS	0.13	0.16	0.67	0.41
FACAS	0.12	0.10	1.42	0.23
DEDAS	0.06	0.11	0.28	0.59
DEMDEL	0.12	0.12	0.91	0.33
SUPDEL	(-)0.35	0.14	5.40	0.020
ONEOFF	0.05	0.12	0.18	0.67
SUPNUM	0.06	0.10	0.29	0.59
CUSNUM	(-)0.01	0.10	0.00	0.96
MILCIV	(-)1.32	0.67	3.8	0.05
AERONON	(-)0.57	0.76	0.55	0.46
SIZE	0.72	0.60	1.43	0.23

Values are at 1% significance.

The overall percentage of correctly predicted results has improved to 72.0%. This is set against the benchmark for this figure of 62.2%. This implies whilst there is still room for improvement in the specification of the model, nevertheless there is potential in the model, since it improves prediction about 10 percentage points.

Summary of the Logit regressions

A summary of the logistic regressions for the three models is show in Table 8.17. This Table shows the full extent of the results from the logit modelling process and helps to compare the various models in terms of significance the $\hat{R}^2$ and the predictive power of the results.

Table 8.17: Summary of the logistic regression model results

Model	Nagelkerke R square	Percentage predicted	Significance	Chi – square
Logit 1	0.177	68.29	>90% <95%	12.1
Logit 2	0.183	70.73	<90%	12.4
Logit 3	0.277	71.95	>90% <95%	18.6

The results of the models have improved to the point where in logistic regression 3 there is a more acceptable Nagelkerke $\hat{R}^2$ of 0.277, or 27.7% of the variance in the dependent variable accounted by the explanatory variables, even though over 70% is unexplained. This result is also significant at a level between 90% and 95%. Importantly the predicted power of the model is 10 percentage points higher than the benchmark, which makes this a potentially worthwhile exercise. The result creates other problems for the research. Whilst the results do not fully support the transaction cost approach it is not possible to reject it either. In any situation of risk such as an investment or even gambling to increase the odds of being successful by 10 percentage points would be seen as an achievement. For example, using a Mote Carlo method of betting odds a method that improves the odds by ten percentage points would be seen as very successful indeed (Vaughan-Williams, 2003: 10). However, in this context it is not sufficient to conclusively prove the transaction cost analysis is correct, not least as the transaction cost approach is time-intensive. The outcome is that transaction cost explanation is not proven by the results.

Conclusions

This Chapter has used a transaction cost approach to assess the organisational form of firms in the UK aerospace industry. Both OLS regressions and Logit regressions were used to test four main hypotheses generated from the transaction cost literature. This approach is necessary because there are two dependent variables with Bought-Out as the dependent (continuous) variable for OLS regressions and MAKE as the dependent (dichotomous) variable for Logit regressions. However, all the four hypotheses presented in this Chapter are rejected, because in every case there is insufficient evidence in the results to accept the null hypothesis.

For the OLS regressions, Model 3 provided the best results with the R^2 result of 0.320, with significance between the 95% and 99% levels. Whilst the R^2 result is comparatively low it does present partial evidence for the transaction cost approach, albeit far from overwhelming. However, this result also begins to cast doubt over the relevance of the transaction cost approach and is compounded by the results using Logit. For the Logit regressions, Model 3 again provides the best results with a Nagelkerke $\hat{R}^2$ of 0.277 with significance between the 90% and 95% levels. Whilst the predicted feature of the regression is improved by almost ten percentage points, the Nagelkerke $\hat{R}^2$ is once more rather low. This may be due to incorrect measurement of the transaction cost variables, in spite of the pilot testing.

The main issue from this Chapter is that a transaction cost approach has realised insignificant results from the data. At best, the results are inconclusive although the models do have some predictive power, especially with the dichotomous make-or-buy dependent variable. The results show there is only partial evidence of transaction cost in the industry and that there is a possible need to find other ways to measure the variables; or even consider an alternative methodological view of the data such as monopoly power.

In summary, the results may lead to rejecting the transaction cost approach as an explanation of the UK aerospace industry. However, there needs to be caution as the results in this thesis may be due to incorrect measurement of the data used in the model or other factors, unknown to the research. In other words, given the evidence of some albeit limited explanatory power in the model, it would be advisable to state that the transaction cost approach is not proven as an explanation of the results. The ten percentage point improvement in the Logit 3 model is significant and would be seen as welcome in the economics of gambling. A cost-benefit analysis of the time to collect and analyse the transaction costs of the UK aerospace industry could also prove that obtaining a ten percentage point improvement in the predictions is worthwhile. However, given the lack of decisive results in this Chapter, the main conclusion is that the transaction cost approach has failed to explain the make-or-buy decision as applied in this thesis. The next Chapter will use similar analysis with the contract type as dependent variable to assess contract design.

Chapter Nine:
Econometric analysis of UK aerospace II: contracts

Introduction

This Chapter presents an econometric analysis of contract design in the UK aerospace industry. The explanatory variables and dummy variables used in Chapter Eight are utilised, but with contract type as the dependent variable. Whilst the previous Chapter used the survey to analyse the make-or-buy decision, this Chapter uses the survey to assess contracts. The aim is to understand the impact of contracts using the hostage model (Williamson, 1983: 522). There are no data available for the dependent variable as a continuous variable and as a result contract type is used as a limited dependent variable. This Chapter addresses the following research question. What potential hold-up problem exists between aerospace firms in the supply chain from the perspective of contract design? The plan of the Chapter is to assess contract design using the hostage model approach. This includes an econometric analysis of contracts using a logit regression. There is analysis of the results and a comparison between the results and those from the previous Chapter. The next section presents the hostage model.

The Hostage Model

The hostage model was first developed by Williamson (1983: 522-523) as an attempt to specify different types of commitments and threats between economic agents in any situation of contractual exchange. In many respects it is simply an extension of the transaction cost model and certainly is not a radical departure from the existing aspects of markets and hierarchies in vertical integration (Williamson, 1975: 8). The work on hostage-taking gives greater emphasis to opportunism and the need to protect against opportunistic behaviour in the design and implementation of contracts. The possibility for opportunism arises from asset specificity. That is, the hostage model closely links commitments and threats to the hold-up problem. According to Williamson (1983: 519):

> "Credible commitments and credible threats share the following attribute: both appear mainly in conjunction with irreversible, specialised investments."
>
> Williamson (1983: 519).

Commitments are defined as "reciprocal acts designed to safeguard a relationship" often through contracts; whereas threats are defines as "unilateral efforts to pre-empt an advantage" known as opportunism (Williamson, 1983: 519). The hostage model is seen as a way to combine the economic analysis of the transaction such as asset specificity and the legal aspect of the contract. A contract is defined as a legal agreement, written or otherwise, that can be enforced and recognised in law (Lyons, 1996: 27). Lyons (1996: 27) asserts that:

> "Economists have adopted a broader definition [of contract] to include agreements enforced by non-legal means...[w]henever anyone buys or sells something, there is a contractual relation established. This may range from a lengthy negotiated document to an implicit agreement..."
>
> Lyons (1996: 27).

Credible threats are when a firm, which fears the possibility of opportunism resulting from asset specificity is exposed to economic risks inherent in market transactions. Any firm which is buying from the market will attempt to enter a formal written contract with its suppliers as a safeguard against the threat of opportunism. Credible commitments are when a firm, which welcomes the legal safeguard against opportunism is covered against the economic risk inherent in the market transactions by entering a contract with its customers. Any firm which is selling to the market will attempt to enter a formal written contract with its customers as a way to develop relationships where there are gains from long term agreements that may involve asset specificity. This has been promoted in UKAI through the Supply Chain Relationships in Aerospace (SCRIA which was introduced in Chapter Five). There is supporting evidence in Chapter Seven that over 50% of aerospace firms in the survey write formal contracts with suppliers (see Table 7.11) and 70% of aerospace write formal contracts with customers (see Table 7.13).

Williamson refers to credible threats as supplier opportunism and credible commitments as protective governance structures (Williamson, 1983: 526-527). The hostage model is identified as follows:

> "The simple hostage model serves to illuminate both unilateral and bilateral exchange, permits the concept of specific capital....and clarifies how costs should be described in assessing exchange."
>
> Williamson (1983: 522).

In other words, contract schemes can replicate "the efficient investment and supply conditions of vertical integration" (Williamson, 1983: 525). Vertical integration has been considered in this thesis within the comparative economic analysis of the make-or-buy issue, but it can also be viewed as legal principles of contract design. Williamson also states:

> "the study of contract is appropriately extended from legal rules to include an assessment of alternative governance structures..."
>
> Williamson (1983: 537).

and furthermore the hostage model:

> "...re-affirms the basic proposition that governance structures need to be matched to the underlying attributes of transactions in a discriminating way if the efficiency purposes of economic organisations are to be realised."
>
> Williamson (1983: 537).

The aim of this Chapter is to re-produce the original Williamson model, whilst including the improvements from the existing body of empirical work. Also, there are further improvements made to the model, which incorporate the features of the aerospace industry, for example, the split between civil and military production.

Applying the hostage model

This section applies the data from the UK aerospace survey to the hostage model. The hostage model has a log odds ratio where contract is the dependent variable (Williamson, 1983: 524). The measure for the dependent variable is similar to dichotomous make-or-buy variable and would generate an outcome of either 1 or 0 for any individual firm, where 1 = contract and 0 = no contract (Lyons, 1996: 30). A figure of between 1 and 0 would be generated by the mean value. In other words, by using a dummy variable as the dependent variable the aim is to capture the contract design and related decisions of the firm. The dependent variable is the log odds ratio of whether or not the firm has a formal contract with either the supplier or the customer. The full form of the equation is shown in equation 9.1 below:

$$\ln\left[\frac{prob(contract)}{1-prob(contract)}\right]=\alpha+\beta_1X_1+\beta_2X_2...+...\beta_nX_n+\mu \qquad \text{Eq. 9.1}$$

The logit regression for contracts will transform the basic relationship in equation 9.1 and present the linear correlation. The approach in equation 9.1 is slightly altered in order to take account of the revised dependent variable. This is because the analysis is focusing on contract type rather than the make-or-buy decision. Hence this will be a test of equation 9.2:

$$\pi_i = \beta X_i + \mu_i \qquad \text{Eq. 9.2}$$

Where:

π_i = the differences between contractual arrangement for firm i.

β = a vector of co-efficients

X_i = a vector of exogenous independent variables, which represent asset specificity, uncertainty/complexity and frequency, derived from survey data

μ_i = an error term

In equation 9.2, the explanatory variables will be the same as the logit model for make, as shown in Equation 8.3, which means comparisons between the two models are relatively straightforward. These comparisons are presented later in the Chapter, which summaries the results. The dependent variable is the differences between the contractual arrangements for any given firm. That is, whether or not the firm has a formal written contract with suppliers or with customers. When there is a dichotomous dependent variable not all the assumptions of linear regression are valid such as linearity, unconstrained and continuous variables. Equation 9.2 transformed the data using logs so that the "form of the relationship is linear whilst leaving the relationship itself as non-linear" (Field, 2000: 165).

Central Hypotheses

There are two main hypotheses relating to the hostage model. The first cluster of hypotheses is based on UK aerospace firms that are purchasing from the market will want to enter into a formal written contract with suppliers in order to reduce or avoid *ex post* opportunism given that there is asset specificity, uncertainty, frequency and small numbers exchange. That is, the customer will offer written agreements to the supplier (or market firm) in return for lessening the effects of *ex post* opportunism as shown in the contracts section of Chapter Seven.

H1(i) (contract with supplier): UK aerospace firms are likely to enter formal written contracts with suppliers due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers.

The second cluster of hypotheses is based on the view UK aerospace firms who are suppliers will want to enter into a formal written contract with customers in order to gain long term relational agreements. That is, the supplier will trade the potential advantage of the threat of *ex post* opportunism for long term agreements by entering a formal written contract with the customer.

H1(ii) (contract wit customer): UK aerospace firms are likely to enter formal written contracts with customers due to higher levels of asset specificity, uncertainty, complexity, frequency and small numbers.

In both cases the supplier has gained by securing a relationship agreement with the customer; and the customer has gained by reducing the threat of *ex post* opportunism by the supplier. It is assumed that the requirement for relational contracts is only apparent in the presence of asset specificity, uncertainty, complexity frequency and small numbers exchange. This assumption is possible because in the absence of such dimension in the transaction then all firms (that is, supplying firms and buying firms) would use spot markets for all transactions. That is:

> "Not every transaction poses defection hazards, and it may not be possible to safeguard all that do."
>
> Williamson (1983: 537).

In the cases where contracts do not work then courts and other forms of arbitration are required, but nevertheless, "contracting institutions arguably start at the beginning" according to Williamson (1983: 537). The hostage model can be specified using the following variables from the survey, including keeping the same dummy variables developed in Chapter Eight.

The evidence from the aerospace survey and reported in Chapter Seven shows there is also economic incentives in the written contracts. Table 7.14 highlights the cost discounts offered by suppliers as an inducement for buyers. Also, Tables 7.17 and 7.18 shows there are number of different types of contracts in the UKAI including firm price and fixed price. The next section assesses contract as the dependent variable in the transaction cost model.

Dependent Variable: Contract

Table 9.1 contains a classification of the various contractual relationships between suppliers and customers taken from the survey. The response coded 0 means there is no formal written contract with the customer or supplier; whereas a response coded 1 means there is a formal written contract. In the case of no formal written contract then the economic relationship is similar to a spot market or at least it can be assumed that supply is readily available. In the case of a formal written contract, the market relationship is different from a spot market or at least it can be assumed that supply is more uncertain. This is because economic agents seek to protect a position with a formal written contract with either a supplier or customer. A formal written contract with a supplier would imply that buyer is relatively unsure about the vendor or at least there is no spot market, where there is an exchange of standard contracts. A formal written contract with a customer may imply that demand is relatively uncertain and/or that a vendor has invested specific or dedicated assets in the transaction.

Table 9.1: Formal contract by aerospace firms

Response	Contract with customer (n)	Contract with customer (%)	Contract with supplier (n)	Contract with supplier (%)
0.00	25.0	30.5%	38.0	46.3%
1.00	57.0	69.5%	44.0	53.7%
Total	**82.0**	**100%**	**82.0**	**100%**

Where contract = 1 and no contract = 0

Theoretically, the dependent variable for contract type is not as close a proxy for organisation form as make-or-buy, but is useful as a comparison. It also has the potential to generate some novel results in terms of linking organisation to law (as opposed to linking governance structure of organisations to make-or-buy). Williamson (1975, 1985) has always claimed that transaction costs is concerned with the combined areas of law, economics and organisation, but there are very few studies that have attempted to systematically test the three aspects.

Explanatory variables

The explanatory variables are taken directly from the transaction costs approach, namely asset specificity, frequency, complexity, uncertainty and small numbers.

Moreover, in the literature there has been a tendency to add a measure relating to economies of scale, as well as a measure of contract type (Lyons, 1994: 264). The latter two variables have been included here in order to test the original model of Williamson (1983) plus recent contributions from Lyons (1994: 260), which directly tests for economies of scale. These are added to this model in order to gain more explanatory power (see Appendix V).

The operational aspects of the Williamson model were considerable as shown in Chapter Four. In sum, the variable listing for the model is detailed below in Table 9.2, including whether the category of variable is dependent or explanatory.

Table 9.2: Variable listing: new variables

Variable name	Category of variable	Measurement of variable
Vertical integration	Dependent	Contract type for both supplier and customer
Small numbers	Explanatory	Number of suppliers and number of customers
Economies of scale	Explanatory	Concentration of suppliers and concentration of customers
Contract type	Explanatory and Dependent	Type and length of contract with suppliers and customers

The predictions for the variables detailed in Table 9.2 are the same as the models used in Table 8.1. The definitions of the variables are the same as the previous Chapter and are in Table 8.4 and the measurement of the variables are in Table 6.1 along with the descriptive statistics.

Dummy variables

As with Chapter Eight, there are a number of dummy variables, which are used to establish the defining characteristics of a firm. These dummy variables are defence or civilian work and whether the firm is primarily involved with aerospace or other engineering work, as specified in Table 9.3. This classification system is important, because it allows the firms in the sample to be compared with one another. The key features of Table 9.3 are that the majority of firms are civilian aerospace and over one in four firms are not specifically aerospace firms, suggesting that the aerospace firms have to search outside the industry for specialist or low-cost suppliers, which is evidence of the make-or-buy decision.

Table 9.3: Dichotomy of the 82 aerospace respondents

	Aerospace (code = 1)	Other (code = 0)	Total
Military (code = 1)	17 (20.8%)	4 (4.9%)	21 (25.6%)
Civilian (code = 0)	43 (52.4%)	18 (22.0%)	61 (74.4%)
Total	60 (73.2%)	22 (26.8%)	**82 (100.0%)**

Summary of results

Using the same logit methodology developed in the previous Chapter, this section presents the results for the percentage predicted correct by the models and the Nagelkerke $\hat{R}^2$, respectively. The dependent variables are contract with supplier and contract with customer. The Logit 1 model has asset specificity, frequency and uncertainty only as the dependent variables, Logit 2 has the explanatory variable small numbers added and the Logit 3 has the dummy variables added for both the contract dependent variables.

Table 9.4 shows the summary results for the percentage predicted correct for the two models, plus the results for Make as the dependent variable from the previous Chapter as a comparison.

Table 9.4: Summary of the percentage correctly predicted by the models

Model	**Make (%)**	**Contract: supplier (%)**	**Contract: customer (%)**
Benchmark	62.20	53.70	69.50
Logit 1	68.29	57.32	71.95
Logit 2	70.73	63.41	67.07
Logit 3	71.95	62.20	80.49
Change	**9.75**	**8.50**	**11.00**

The variables contract supplier and contract customer have a benchmark figure of 53.70% and 69.50% (see Table 9.1), respectively, which is simply the change in the percentage of the sample in the survey that has a formal written contract with the supplier or customer[1]. The research would have yielded these percentages simply by stating that there is a formal written contract. Hence, with the dependent variable as contract supplier the predictive power has increased by 8.50% and with contract customer the predictive power has increased by almost 11%. Therefore, all the various models have improved on the benchmark, in terms of the predictive power, but a formal contract with customer has improved by the largest percentage. However, as with the results in the previous Chapter for Make the improvement in the predictive power represented by the results are modest. There is surprisingly little improvement and whilst this result is better than no improvement at all it casts further doubts over the transaction cost model.

In terms of the proxy R^2 or the Nagelkerke $\hat{R}^2$ the result for contract type are shown in Table 9.5 as well as for Make for comparative purposes.

Table 9.5: Summary of Nagelkerke $\hat{R}^2$

Model	Make	Contract: supplier	Contract: customer
Logit 1	0.177	0.103	0.201
Logit 2	0.183	0.120	0.223
Logit 3	0.277	0.146	0.447

The Nagelkerke $\hat{R}^2$ for contract with supplier does not significantly improve over the three logit models and remains low. A proxy R^2 of only 0.146 or 14.6% at best is too low and the model is rejected. However, the proxy R^2 of 0.447 or 44.7% for contract with customer is modest but acceptable. The result tends to indicate (rather than confirm) that suppliers would prefer to trade the threat of opportunism for the security of a relational contract with their customers. There is some evidence for contracts with customers being explained by the hold-up model, but there is no evidence for

[1] Similarly, the benchmark figure for the MAKE dependent variable is 62.20 %, which means logit 3 has improved the prediction power by 9.75%.

contracts with suppliers, which is further evidence of a lack of support for the transaction cost model as applied in this thesis.

The summary results in Table 9.4 and Table 9.5 are clear that the most effective logistic model is logit 3, which has all the transaction cost explanatory variables, plus all the dummy variables. The most effective model is where customer contract acts as the dependent variable. However, these results do not constitute overwhelming support for the transaction cost model. The proxy R^2 such as Nagelkerke $\hat{R}^2$, which has 44.7% of the variation accounted for by the dependent variables is a good result, but there remains 55.3% unexplained. When taken into account with the 11% increase in the predictive power of this model and with an 8.86% probability of a Type I error occurring, then the model is relatively well specified, but is far from being fully robust. Cumulatively, these results indicate a disappointing lack of convincing support for the transaction cost model as applied in this thesis.

Finally, it is worth noting that the model can be still further improved by having customer contract as the dependent variable, with supplier contract added to the explanatory variable list of logit 3. This result has a Nagelkerke $\hat{R}^2$ of 0.459 and the percentage of correctly predicted results of 82.93, which is an improvement of 13.5 percentage points from the benchmark model for contracts. However, this experiment with the data is not part of the transaction costs approach and is more than likely a result of autocorrelation in any case. In other words, the model can be improved without recourse to the transaction cost theory, which is further evidence of a lack of support in this thesis.

Overall, using a logistic regression methodology, there is insufficient evidence in support of H1 (i) (contracts with suppliers) with the proxy R^2 result at 0.146, at a significance level above 90% and below 95%. Therefore, the null hypothesis is rejected. There is partial evidence in support of H1 (ii) (contracts with customers) with a proxy R^2 result at 0.447 at a significance of between 90% and 95%. The null hypothesis is accepted in this case. The implication for this thesis is that the transaction cost approach can not be fully supported and alternative approaches are needed to explain the data in the survey.

The data can also be used to test hypotheses H2, H3 and H4 developed in the previous Chapter. There is more positive evidence in support of H2 for customer contracts but not supplier contracts. That is, there is a difference between civil and military firms in the aerospace supply chain for customer contracts. Indeed, the dummy variable MILCIV is significant at only a 5% probability of a Type I error with MAKE as the dependent variable. However, the sign is negative, which may require further analysis such as standardised variables to make the result more robust. Nevertheless, the null hypothesis can be accepted (and the alternative rejected) that there is transaction cost difference between military and civilian firms in the UK aerospace supply chain.

There is very little evidence in support of H3 (customer contracts or supplier contracts) that there is a difference between aerospace and general engineering firms in the aerospace supply chain. Indeed, the dummy variable AERO is insignificant with a 45.5% probability of a Type I error. Therefore, the null hypothesis is rejected because there is no transaction cost explanation of the difference between aerospace and general engineering firms in the UK aerospace supply chain.

There is also little evidence in support of H4 (customer contracts and supplier contracts) that there is a difference between large and small firms in the aerospace supply chain. Indeed, the dummy variable SIZE is insignificant with a 23.1% probability of a Type I error, although it is the correct predicted sign. Therefore, the null hypothesis is rejected, because there is no transaction cost explanation of the difference between large and small firms in the UK aerospace supply chain.

Overall, the outcome is that the four transaction cost hypotheses are not proven by the results and at best there is only limited support. The next section compares all the results from Chapters Eight and Nine.

Comparison of results from Chapter Eight and Chapter Nine

The full breakdown of the various models from both Chapter Eight and Chapter Nine, in respect to the four central hypotheses is given in Table 9.6 below. It is evident that model 3 is important to the quality of the results and also that there is a certain amount of evidence in favour of H1. The other hypotheses are less clear cut with only mixed evidence in support, although H3 does have a degree of evidence in its favour. In addition it is also clear that CUSTCON is as important a dependent variable as MAKE. However, SUPCON is considerably less important with little or no evidence in support of the transaction cost approach.

Table 9.6: Matrix of evidence for transaction costs: model 3 by hypothesis

Model 3: The type of Specification	H1: Transaction Costs	H2: Military & Civilian split	H3: Aerospace & Other split	H4: The size of The Firm
Regression: BO Model 3	Partial TC	No TC	Yes TC	No TC
Logit: Make Model 3	Partial TC	Yes TC	No TC	No TC
Logit: Customer Model 3	Yes TC	Partial TC	No TC	Yes TC
Logit: Supplier Model 3	No TC	No TC	No TC	No TC

Where: TC = transaction costs

Table 9.6 shows there is mixture of evidence for the transaction cost approach. In particular, there is considerable evidence for H1 with partial and confirmed evidence of transaction costs from across the models and dependent variables. There is less evidence for H2 of the military-civil split is significant. There is significantly less evidence for H3 aerospace-non-aerospace split and H4 the size of the firm, where evidence of the model significance is confined to only one of the four models.

There are certain patterns in the results that can be identified from Table 9.6. Firstly, reading vertically across models by hypothesis, it is possible to discover that there is some support for H1, but little, if any, significant support for H2, H3 and H4. In other words, there is limited support for the general presence of transaction costs. Secondly, reading horizontally, across hypotheses by model its possible to discover that the logit model 3 using customer contract as the dependent variable is overall the model that best fits the data.

In sum, there is limited evidence of transaction costs and nine of the sixteen models in Table 9.6 show no support for the transaction costs approach at all. The remaining seven models show only mixed support for the transaction cost approach. Therefore, the decision is to reject the transaction cost approach as not proven in this thesis. The next section is a critique of the transaction cost formulae and an analysis of how to improve the results from a theoretical or model-building perspective.

Critique of results

The main findings are a partial support for asset specificity, especially facilities asset specificity. In general, this is in line with the transaction costs predictions and other studies, which support the importance of asset specificity. The results show that it is the facilities and equipment of aerospace production that are the most important in explaining the make-or-buy decision in vertical integration. As can be expected, this is because of the huge capital investment required in both facilities and equipment for aerospace production. However, it is unexpected to find employment asset specificity and dedicated assets not to be important, which casts more doubts about the transaction costs approach. Not unexpectedly for the UK aerospace industry, location asset specificity is considered relatively unimportant for this industry, since it operated in national and international markets. The result has interesting implications for industrial location in the UK as it suggests that location is not important in the UK aerospace industry. This result may reflect the national and international supply chain and special suppliers in the aerospace industry.

There is a possible need to revisit some of the measurement of the variables. Asset specificity is the most straightforward of the explanatory variables to measure in the format of the questionnaire. Uncertainty and complexity are much more difficult to capture and measure even on a likert scale. Similarly, frequency may not be specified correctly and this accounts for the limited success of this explanatory variable in the overall results. This proposal is explored as a suggestion for further research in the next Chapter.

Finally, there is also an issue of sample size, where 82 cases may be considered relatively low, but this is in line with Lyons (1994: 274) who also used a postal questionnaire in the UK and received 91 returns. There are no specific rules on this issue; however, Finch (1994: 268) claims that the number of cases should ideally be at least 100, if not greater than 100, so that there is no small number bias. In the logit study by Finch (1994: 271) on UK aerospace the number of cases was 96 and was considered acceptable. Whilst this survey has a number of cases less than 100, it is worth bearing in mind that a number equal to 82 in this industry does account for nearly 45% of the actual population, which is considerably significant number in itself. In other words, the size of the sample in this thesis is not a major problem in the research.

Conclusions

Chapter Nine has attempted to use the transaction cost framework and use the type of contract as the dependent variable using Logit regressions, since OLS was not possible with this dataset. This approach is using the hostage model as the basis of the Chapter and using commitments rather than make-or-buy to determine relations in the aerospace industry supply chain. Commitments in this context are measured by contract with two types of contracts used, namely contracts with customers and suppliers. The results show that the model has only limited predictive and explanatory power. The Nagelkerke $\hat{R}^2$ results remain low at 0.146 for contract with suppliers, but are improved with contract with customer to 0.447. This shows some support for the hostage model and a possible source of further research in the area. In particular, the use of credible threats and credible commitments between transacting firms may prove fruitful in terms of economic incentives and legal safeguards. Also, the work by Lyons (1994, 1996) has signalled a move away from an exclusive analysis of make-or-buy to research that explicitly takes account of contract design. Finally, the matrix in Table 9.6 highlights some mixed results. There is some evidence for H1 on transaction costs with less support for the other hypotheses H2, H3 and H4. Also, model 3 using customer contract as the dependent variable is overall the model that best fits the data. Overall, there is general rejection of the null hypotheses as applied in this thesis.

The main conclusions to be drawn from Chapter Nine are that transaction costs with contract design as the dependent variable are not proven. Overall, the outcomes from the results in this Chapter are not as expected in advance and disappointing from a transaction cost economics perspective. There are potentially some fruitful areas of analysis for transaction cost using contract as the dependent type in terms of incentives in contract design. Significantly, this Chapter fails to prove that the transaction cost approach is totally useful within the context of the UK aerospace industry and with the level of data generated in the survey. Finally, the lack of support for transaction costs as applied in this thesis can be viewed as an original contribution to economics, because it casts serious doubts about empirically testing the theory using this approach. In the final part of this thesis, there is an assessment of the implications of the survey results and conclusions, as well as the proposals for further research.

Part III

Conclusions

Chapter Ten:
Conclusions and Further Research

"The characteristics of the future aerospace firm might include...new forms of industrial organisation, reflecting efforts to economise on transaction costs (*e.g.* buying rather than making [and] international supplier networks...)"

Hartley and Braddon (2002: 17).

Introduction

The original contribution of this thesis is to examine the make-or-buy decision and choice of contract type in the UK aerospace industry within a transaction costs framework for the first time. However, at best the results show insufficient evidence in support of a transaction costs approach to vertical integration as applied in this thesis. There is a body of opinion in economics that the transaction costs approach is suited to explain the industrial organisation of aerospace firms (Hartley and Braddon, 2002: 17). This thesis has shown there is insufficient evidence in the UKAI to support this belief.

If the transaction costs approach offers little or no explanation then alternative hypotheses must be explored. Whilst the transaction cost approach certainly can be viewed as complementary to other approaches such as monopoly power arguments and game theory, nevertheless further research must establish which approach is the most appropriate, given that the research questions are unsatisfactorily explained by transaction costs in this thesis. The aim of this Chapter is twofold. Firstly, it presents the conclusions to the research questions and secondly it proposes some areas of further research. The next section presents the answers to the research questions.

Thesis conclusions

There are two specific research questions considered by this thesis within the context of vertical integration. Firstly, what determines the make-or-buy decision within the aerospace firm? Secondly, what is the potential hold-up problem between aerospace firms from a contractual perspective?

In answer to the first research question there is little evidence to support the make-or-buy decision in the UK aerospace industry using the transaction cost approach. The questionnaire survey delivered no conclusive proof in favour of the central hypothesis. There is some, but limited, support for H1 (aerospace suppliers make) using both OLS and logit regressions. There is no apparent support for H2 (military aerospace firms make) and H3 (aerospace-specific firms make), with some support for H4 (large firms make) as highlighted in Chapter Eight. In particular, the facilities and equipment asset specificity are important in partially explaining the make-or-buy decision in UK aerospace and overall this justifies the micro-analytical approach. However, a great deal of research effort was required for relatively little explanatory value, not least because transaction cost data are rarely published, if at all, and have to be collected on a case by case basis.

In answer to second research question there is only marginally more support for contract design within the hold-up problem. The results gave qualified support for the central hypothesis, but not sufficient to prove the case for a transaction cost explanation as shown in Chapter Nine. In particular, using logistic regression, there is insufficient evidence in support of H1 (i) (contracts with suppliers) with the proxy R^2 result of 0.15 meaning that the null hypothesis is rejected. There is partial evidence in support of H1 (ii) (contracts with customers) with a proxy R^2 result of 0.45 meaning the null hypothesis is accepted in this case. There is more positive evidence in support of H2 for customer contracts, but not supplier contracts and no significant support for H3 and H4.

Overall, the theoretical discussions in Part One concluded that the transaction costs approach could be applied to the UK aerospace industry. The problems of contracting and make-or-buy in terms of transaction cost economising were highlighted and a case presented for making the theory operational. However, the empirical results from Part Two conclude there is little, if any, support for the four main hypotheses in this study. This result was not expected. A discussion of these findings and related implications follow in the next section.

Interpreting the conclusions

There are a number of potential reasons why the thesis has generated a negative conclusion. Firstly, there are a variety of measurement problems, including the need for better specification of the questions in the questionnaire survey. In particular, there is a need to revisit some of the techniques used to measure the variables. Asset specificity seems to be the most straightforward of the explanatory variables to measure in the format of the questionnaire. Uncertainty and complexity are much more difficult to measure even on a Likert scale. Similarly, frequency may not be specified correctly between different firms and this may account for the limited success of this explanatory variable in the final results. In other words, the measurement of the variables may be causing the weak results rather than the transaction cost model *per se*.

Secondly, the number of returned questionnaires is 82 and this figure may be relatively low. However, given that the percentage of the population that returned a completed questionnaire is 44% and the fact these cases cover a wide array of firms in the UK aerospace industry then this remains an acceptable number.

Finally, there is no consistent or widespread collection of transaction cost data by an authoritative source. This is because the transaction cost data are bespoke and costly to acquire and in any case they may not have any wider commercial value to firms. A possible alternative methodological view would use existing company accounts, which provide data on value added within firms. Company accounts may help to provide an insight into the broader make-or-buy decision through a matriculation of value added. In other words, equate buy with the cost of sales and make with value added (or turnover minus cost of sales). However, this approach was not followed in this thesis, because accounting data are *ex post* by definition and a study of transaction costs requires *ex ante* data, which identifies the thinking behind entrepreneurial choices (see Appendix VI).

In summary, the results from this thesis lead to rejecting the transaction cost approach as an explanation of vertical integration in UK aerospace. However, this outcome may be due to incorrect specification of the data in the model and the need for in-depth interviews with decision-makers. Notwithstanding, the conclusions do indicate that transaction cost economics is limited as a worthwhile theoretical and empirical approach to the study of the UK aerospace industry. The next section considers proposals for further research which arises from these conclusions.

Proposals for further research

Further research arising from this thesis cover two main aspects, namely future directions for transaction cost theory and implications for the UK aerospace industry. The future directions for transaction cost theory centre on other applications of the approach. In particular, decision-makers either create output through the firm (vertical integration) or engage the market (long term contracts). Asset specificity in the context of aerospace as well as defence creates many problems that relate to incomplete contracts, ink costs of contract renewal and even property rights. All of these fall under the scope of transaction cost economics and in fact it is useful that asset specificity can be assessed in such a way. In addition, the single most obvious manifestation of this is the make-or-buy plan, which is actually promoted by the MoD in the area of UK defence aerospace. This is a logical position to hold, because the defence contract in aerospace appears to contain sizeable transaction cost problems. Namely, significant asset specificity exposure, bounded rationality and scope for opportunism, tends to characterise defence aerospace. The transaction cost model does need improving to fully capture transaction costs empirically given the evidence from this thesis. For example, in-depth interviews with key decision-makers who make the relevant choices in firms would augment the quality of the data. Also, the results of this thesis point to the measurement issues that are inherent in the transaction cost approach, which is a factor in the lack of conclusive evidence and suggests that the transaction cost model can not be tested. However, this thesis alone cannot determine whether the transaction cost approach *per se* is incorrect and should be replaced in favour of another approach.

Next are the implications drawn from the conclusions for the UK aerospace industry. There are two major areas where further work on the UK aerospace industry needs to concentrate in spite of rejecting the transaction cost approach of this thesis. First, is the role of procurement contracts in the supply chain, which could be assessed and measured against the make-or-buy decision. Second, is a comparison between aerospace and other industries, for example the motor car industry or shipbuilding would be appropriate, as would comparison between UK aerospace with the aerospace industries of the US and EU (Jackson, 2003: 87-89).

This list is not designed as exhaustive, but it is indicative of the possible areas of further research that might be generated from a transaction cost analysis of the UK aerospace industry. However, before any future research can be undertaken the problems of measurement need to be fully addressed, because the issue of quantifying transaction cost remains the major obstacle to further developments in the area. Whilst this has been an empirical thesis, future developments in the transaction cost approach must address first the theoretical concerns of applied research, namely, the need for improved definitions of the key variables. Attempts to calibrate the transaction cost model and make the approach operational have not worked in this thesis and as such the theoretical foundations of the approach need to be addressed. From an empirical perspective the experience of this work has shown that if the measurement problems can be resolved then the issue of tautology is refuted.

The measurement of transaction costs could be improved by a greater exploration of the data from in-depth interviews as opposed to postal questionnaires. A system of structured personal, in-depth interviews with key decision-makers in an industry may yield more appropriate results compared with an anonymous questionnaire. Also, additional theoretical work on standardising transaction cost variables is required before further empirical testing. In fact, if a yardstick set of transaction cost definitions are established then this could result in the routine collection of the data within firms. In turn, this outcome would overcome many of the barriers to researching in the area and allow a more comprehensive approach to empirical transaction costs research. Eventually, this may facilitate a set of standardised data that could be applied across industries, between countries and over a longer time period than five years.

Overall, there are two related findings from thesis. Firstly, from an empirical perspective, whilst there is a case to suggest that the UK aerospace industry can be assessed through transaction costs, nevertheless the empirical results from this thesis reject the approach. The lack of any conclusive support for transaction costs in this thesis may not necessarily be due to the approach *per se*, but due to incorrect measurement of key variables. In other words, it is not clear if the whole transaction cost approach is at fault (and hence it needs to be replaced with an alternative approach); or the cause of the problem is poor definitions that lead to inconsistent measurement of the variables. Either way, the experience of this thesis is that the transaction cost approach is difficult to make operational and thereby there are no valid results.

Secondly, from a theoretical perspective, if the measurement problems can be fully resolved then this is likely to help overcome the other major criticism of tautology that is often levelled at the transaction cost approach (Dietrich, 1994: 25). Hence, if the variables can be accurately measured by a benchmark method then the criticism of transaction cost as circular in nature may be shown to be false. That is, theoretically it needs to be formally demonstrated that transaction costs are not tautological and can be proven categorically and directly observable. However, this view returns the thesis to the counter-argument that all costs are subjective and the more suitable method of primary research is in-depth interviews focussing on choices. Therefore, transaction costs are a special case within a wider economic literature. Indeed, the research findings in this thesis suggest that transactions costs remain theoretical in nature until fully proven otherwise as far as the UK aerospace industry is concerned.

A priori, the transaction cost approach was predicted to be relevant to aerospace due to asset specificity, make-or-buy, level of outsourcing and the role of contracts. Whilst it is fully accepted that transaction costs are potentially relevant to all industries, the approach seemed particularly appropriate to aerospace because the firm and the market are relatively close substitutes for many of the sub-assemblies and components. However, even though this thesis has highlighted the theoretical importance of the make-or-buy decision in the UK aerospace industry, it has failed to prove this finding empirically within the current transaction cost economics framework.

Appendix I

The Range of Empirical Studies in Transaction Cost Economics

Appendix I: The range of empirical studies in transaction costs economics

Author	Date	Country	Industry	Classification[1]
Goldberg	1976	USA	Various	Case Study
Teece	1976	USA	Petroleum Refining	Industry Study
Williamson	1976	USA	CATV	Case Study
Chandler	1977	USA	Various	Business History
Klein *et al.*	1978	USA	Automobile Suppliers	Case Study
Steer & Cable	1978	UK	Large Firms	Statistical Analysis
Lilien	1979	USA	Industrial Products	Case Study
Williamson	1979	USA	Various	Case Study
Armour & Teece	1980	USA	Petroleum	Statistical Analysis
Klein & Leffler	1981	USA	Various	Statistical Analysis
Teece	1981	USA	Large Firms	Statistical Analysis
Monteverde & Teece	1982 (a, b)	USA	Automobiles	Statistical Analysis
Butler & Carney	1983	UK	Chemical Firms	Case Study
Masten & Snyder	1983	USA	Various	Case Study

[1] Classification devised by Williamson (1989: 173).

Stuckey	1983	USA	Aluminium	Vertical Integration
Alston, Datta & Nugent	1984	USA	Share-cropping	Contractual Vignette
Anderson & Schmittlein	1984	USA	Sales Force	Statistical Analysis
Davidson & McFetridge	1984	USA	Large Firms	Statistical Analysis
John	1984	USA	Marketing Channel	Statistical Analysis
Gallick	1984	USA	Tuna	Vertical Integration
Masten	1984	USA	Aerospace	Statistical Analysis
Palay	1984	USA	Rail Freight	Contractual Vignette
Walker & Weber	1984	USA	Automobiles	Statistical Analysis
Anderson	1985	USA	Electronics	Statistical Analysis
Joskow	1985	USA	Coal	Statistical Analysis
Levy	1985	USA	Manufacturing Firms	Statistical Analysis
MacDonald	1985	USA	Manufacture Firm	Statistical Analysis
Masten & Crocker	1985	USA	Natural Gas	Contractual Vignette
Globerman & Schwindt	1986	Canada	Forest Products	Vertical Integration
Harrigan	1986	USA	Manufacture Firms	Vertical Integration

Hubbard & Weiner	1986	USA	Natural Gas	Contractual Vignette
MacMillan *et al.*	1986	USA	Purchasing Department	Vertical Integration
Mulherin	1986	USA	Natural Gas	Contractual Vignette
Helfat & Teece	1987	USA	CAPM	Vertical Integration
Goldberg & Erickson	1987	USA	Petroleum Coke	Case Study
Joskow	1987	USA	Coal	Statistical Analysis
Walker & Weber	1987	USA	Purchasing	Statistical Analysis
Anderson	1988	USA	Sales Force	Contractual Vignette
Caves & Bradburd	1988	USA	Intermediate Goods	Vertical Integration
Croker & Masten	1988	USA	Natural Gas	Statistical Analysis
Dwyer & Oh	1988	USA	Computer Retailing	Statistical Analysis
Gatignon & Anderson	1988	USA	MNC	Statistical Analysis
Heide & John	1988	USA	Marketing	Statistical Analysis
Hennart	1988	Global	Aluminium & Tin	Industry Study
John & Weitz	1988	USA	Distribution	Bi-variate Analysis
Klein	1988	USA	Automobiles	Case Study

Ellickson	1989	Global	Whaling	Business History
Mitchell	1989	USA	Technology Sun-field	Statistical Analysis
Rogerson	1989	USA	Defence	Statistical Analysis
Tapon	1989	USA	Pharmaceutics R&D	Industry Study
Noordewier, John & Nevin	1990	USA	Purchasing	Bi-variate Analysis
Pisano	1990	USA	Bio-Technology	Statistical Analysis
Crocker & Masten	1991	USA	Various	Case Study
Hallwood	1991	UK	Offshore Oil	Industry Study
Leffler & Rucker	1991	USA	Timber Harvesting	Statistical Analysis
Lieberman	1991	USA	Chemical Products	Bi-variate Analysis
Masten *et al.*	1991	USA	Naval Shipbuilding	Bivariate Test
Mosakowski	1991	USA	Computer Hardware	Statistical Analysis
Pittman	1991	USA	Railroad Side-track	Business History
Walker & Poppo	1991	USA	Single-source Suppliers	Statistical Analysis
Mahoney	1992	USA	Various	Literature Survey
Muris *et al.*	1992	USA	Soft Drinks	Statistical Analysis

Weiss	1992	USA	Mergers	Statistical Analysis
Balakrishnan & Fox	1993	USA	Manufacture Firms	Statistical Analysis
Crocker & Reynolds	1993	USA	Air Force Engines	Statistical Analysis
Lyons & Bailey	1993	UK	Engineering	Statistical Analysis
Pirrong	1993	USA	Bulk Shipping	Business History
Williamson	1993	USA	Various	Case Study
Kaufmann & Lafontaine	1994	USA	Fast Food	Case Study
Levy & Spiller	1994	USA	Telecomm	Statistical Analysis
Lyons	1994	UK	Engineering	Statistical Analysis
Argyres	1995	USA	IBM & GM	Case Study
Krickx	1995	USA	Computer Mainframe	Industry Study
Lyons	1995	UK	Various	Statistical Analysis
Nichols	1995	UK	Leisure Services	Case Study
Argyres	1996 (a, b)	USA	R&D	Statistical Analysis
Abraham & Taylor	1996	USA	Contracting	Statistical Analysis
Foss	1996	Denmark	Fruit and Vegetables	Industry Study

Prencipe	1996	UK	Aero-engines	Vertical Integration
Cameron and Collins	1997	UK	Music Industry	Case Study
Maher	1997	UK	Various	Case Study
Finch	1998	UK	Aerospace	Industry Study
Stephen & Love	2000	UK	Naval shipbuilding	Statistical Analysis

Appendix II

UK Aerospace Supply Chain Questionnaire

Staffordshire University Business School

UK AEROSPACE SUPPLY CHAIN STUDY:
Competition - Contracts - Co-operation

Section A: Company Profile:

Q1 What is the **name** of your company or group of companies?

____

Q2 a. What are your **three** principal **areas of business** by type of product?

1 ____

2 ____

3 ____

b. What is the unit price of the **most important product** by value of sales listed above? (Please ✓ below).

£1 to £999 ☐
£1,000 to £99,999 ☐
£100,000 to £999,999 ☐
£1 million + ☐

Q3 a. What is the **current** value of your company **turnover?**

Turnover: £________ (1997)

b. What was the **1992** total of your company **turnover?**

Turnover: £________ (1992)

Q4 a. What is the **current** number of **employees** at your company?

Employees ________ (1997)

b. What was the number of **employees** at your company in **1992?**

Employees ________ (1992)

Q5 a. What percentage of your **current** annual turnover is **aerospace** business?

Aerospace: ______% (1997)

b. What percentage of your annual turnover was **aerospace** business in **1992**?

Aerospace: ______% (1992)

Q6 a. What percentage of your **current** annual turnover is **military** business?

Military: ______% (1997)

b. What percentage of your annual turnover was **military** business in **1992**?

Military: ______% (1992)

Q7 What is the **name** of your **most important customer** by value of sales? (Including MoD)

____

Q8 What is the **name** of your **most important supplier** by value of purchases?

____

Q9 What percentage of the components and sub-components that you use in manufacturing is **bought-out** from external suppliers?

	1997 bought-out %	1992 bought-out %
1. Total Business		
2. Civilian Aerospace		
3. Military Aerospace		

Section B: Company Supply Chain:

Answer part a of the following questions by using a scale of 1 to 10. Part b requires you to think about whether there have been any changes in the previous five years. Other parts ask supplementary questions. The questions are framed in terms of your company in general.

Q10a. To what extent are the **skills, knowledge or experience** of your employees **specific** to your company? (Please ✓ one).

General	1	2	3	4	5	6	7	8	9	10	Specific

b. In the previous five years has this ranking increased, decreased or stayed the same?

c. Give examples of three occupational groups who have highly specific **skills, knowledge** or **experience** at your company, (if any).

1. ____

2. ____

3. ____

Q11a. To what extent are the **facilities** and **equipment** used in your production process **specific** to your company? (Please ✓ one).

General	1	2	3	4	5	6	7	8	9	10	Specific

b. In the previous five years has this ranking increased, decreased or stayed the same?

c. Give examples of three areas of **core activity** at your company, (if any).

1. ____

2. ____

3. ____

d. Do you sub-contract core activity during periods of **high** demand? (Please ✓ below).

yes ❑ no ❑

e. Do you sub-contract core activity during periods of **low** demand? (Please ✓ below).

yes ❑ no ❑

Q12a. To what extent does your company invest in **facilities** and **equipment** that are **specific** to your most important **customer** listed in Q.7? (Please ✓ one).

General	1	2	3	4	5	6	7	8	9	10	Specific

b. In the previous five years has this ranking increased, decreased or stayed the same?

c. How far from your most important **customer** is your main factory site located?

_____________ miles

d. Would you benefit from being located any closer to your most important **customer**?

yes ☐ no ☐

Q13a. What is the **likelihood** of unexpected changes in **demand** for your products? (Please ✓ one).

Little likelihood	1	2	3	4	5	6	7	8	9	10	Highly likely

b. In the previous five years has this likelihood increased decreased or stayed the same?

c. What is the typical length of **time** between a customer placing an order and delivery for your most important product listed in Q.2 b?

_____________ days / months / years

Q14a. What is the **likelihood** of unexpected changes in **supply** for your components? (Please ✓ one).

Little likelihood	1	2	3	4	5	6	7	8	9	10	Highly likely

b. In the previous five years has this likelihood increased decreased or stayed the same?

c. Do you consider your **suppliers** to be generally reliable? (Please ✓ below).

yes ☐ no ☐

Q15a. Is your main business **one-off** in nature or **frequent** repeat business? (Please ✓ one).

One-off	1	2	3	4	5	6	7	8	9	10	Frequent repeats

b. In the previous five years has this frequency increased decreased or stayed the same?

c. Does your most important **customer** listed in Q.7 regularly change the magnitude of an order at short notice? (Please ✓ below).

yes ☐ no ☐

Q16a. How would you describe the number of UK **suppliers** in your main supply markets? (Please ✓ one).

Low	1	2	3	4	5	6	7	8	9	10	High

b. In the previous five years has this number increased, decreased or stayed the same?

c. How many **suppliers** account for 75% of purchases? _______ number.

d. What percentage of purchases is bought from your most important **supplier** listed in Q.8? ________%

Q17a. How would you describe the number of **UK customers** in your main product markets? (Please ✓ one).

Low	1	2	3	4	5	6	7	8	9	10	High

b. In the previous five years has this number increased, decreased or stayed the same?

c. How many **customers** account for 75% of sales? _______ number

d. What percentage of your annual turnover is sold to your most important **customer** listed in Q.7? ________%

Q18a. Do you **make** or **buy**, if the cost of making a component in-house equals the cost of buying from a supplier? (Please ✓ below).

make ☐ buy ☐

b. If you do switch **suppliers** for any given **component**, rank the following reasons why in terms of importance; where 1 = most important and 5 = least important.

low price ☐
quality of item ☐
delivery date ☐
supplier reliability ☐
other (specify) ______________________________

Section C: Company Transactions:

Part a of the following questions are answered by stating yes, no or sometimes. Part b requires you to choose between various alternative The questions are typically *framed in terms of your company in general.*

Q19a. Do you usually have a formal written contract with your **supplier**? (Please ✓ below).

yes ☐ no ☐ sometimes ☐

b. If you do usually have a formal written contract with suppliers:

i. how many companies compete for the contract? number of companies: ________

ii how long is the contract? number of days/months/years: __________________

iii what type of contract? fixed price (with price escalation), firm price (no price

escalation), cost plus or other please specify: __________________

____

iv. Do you impose penalty clauses on suppliers for late delivery or poor quality?
(Please ✓ below).

yes ☐ no ☐ sometimes ☐

Q20a. Do you usually have a formal written contract with your **customers**? (Please ✓ below).

yes ☐ no ☐ sometimes ☐

b. If you do usually have a formal written contract with customers:

i. how many other companies compete for the contract?

number of companies: ________________________________

ii. how long is the contract? number of days/months/years: _________

iii. what type of contract? fixed price (with price escalation), firm price (no price escalation), cost plus or other please specify:

____

iv. Do your customers impose penalty clauses for late delivery or poor quality? (Please ✓ below).

yes ☐ no ☐ sometimes ☐

Q21a. Do your suppliers have a **cost advantage** over your company for any given component, which was previously made in-house? (Please ✓ below).

yes ☐ no ☐ sometimes ☐

b. If yes, how significant is the cost advantage of your suppliers?

under 5% ☐
5 to 10% ☐
11 to 20% ☐
over 20% ☐

Q22a. To what extent do your suppliers give **cost discounts** for bulk-buying? (Please ✓ below).

yes ☐ no ☐ sometimes ☐

b. If yes, how significant is the cost discount given by your suppliers?

under 5% ☐
5 to 10% ☐
11 to 20% ☐
over 20% ☐

c. Do you make or buy if the cost of making a component equals the cost of buying? (Please ✓ below).

make ☐ buy ☐

Thank you for your assistance.
A full copy of the results will be sent to you in first quarter of 1999.

Please return all completed questionnaires to the following address:
Ian Jackson, Economics Division, Staffordshire University Business School,
Leek Road, Stoke-on-Trent, Staffordshire, ST4 2DF

If you have any questions please contact the following numbers:
Telephone:- (01782) 294211 Fax:- (01782) 747006 E-mail i.jackson@staffs.ac.uk

Appendix III

Pilot Study of UK Aerospace Firms

Appendix III:
Pilot study

Introduction

The central feature of this research is the combination of published data, interviews and self-reported information in order to conduct the analysis. The published data is derived from company reports and accounts as well as listings in specialist business sources. The self-reported information is gathered primarily by a postal questionnaire and also by interviews with key respondents in selected companies. The companies range from large multi-site, multi-nation aerospace companies, which occupy the position of prime contractor in the supply chain, to small and medium-sized suppliers. In order to establish a workable form of the questionnaire, a pilot version was tested on four firms in the North West region of England, which is an important area for aerospace in the UK. The aim of Appendix III is to report the detailed outcome of the pilot and to show the work in progress prior to the issue of the questionnaire. The Appendix reviews the nature of the population for the pilot and then assesses how the pilot study was developed. It will then report the findings of the work with the four firms in the pilot in greater detail than is possible in the main body of the thesis. Finally, there is a discussion on how the pilot improved and informed the final version of the questionnaire in each of the three sections. The next section discusses the development of the pilot questionnaire.

The pilot questionnaire

The pilot study began in June 1998 when fourteen aerospace companies were contacted by letter requesting their participation in the study. The sample was chosen by geographic location, since all the companies, which were contacted, have registered addresses in the North West region of England based on the SBAC membership list of May 1998, which accessed from the SBAC homepage. The North West is a highly strategic region for UK aerospace. British Aerospace defence has sites at Samlesbury and Warton (and until 1993 at Preston), British Aerospace Airbus has sites at Broughton and Chadderton, British Aerospace Regional Aircraft has a site at Woodford, British Aerospace Dynamics has sites at Chorley and Lostock, plus

GEC-Ferranti is based in Oldham. Although British Aerospace has its registered headquarters in Farnborough, it is clear that the North West region is a very important area for the aerospace industry as a whole. In the defence sector alone, Warton is the final assembly point for the Hawk, Tornado and Eurofighter 2000, where defence accounts for 74.6% of the 1997 corporate turnover of British Aerospace, which is the UK's biggest single aerospace company. It is for these compelling reasons that the North West region was chosen for the pilot study. From the fourteen companies that were contacted, four agreed to participate and the remaining seven did not respond to the letter. The latter companies were contacted by telephone, where two more companies agreed to participate, but in the final version of the questionnaire survey only. The response rate was 28.6% and overall the reaction from firms was variable. However, where companies did agree to participate, then the co-operation was excellent and the answers given were meaningful.

The problem of whom to send the pilot questionnaire was overcome by telephoning the companies prior to sending the letter and asking the company receptionist. Whilst the replies given were well meaning, the request to participate in the pilot study may not have been received by the appropriate employee. The issue of finding the appropriate personnel to complete questionnaire surveys is highly significant and in part will determine the final response rate. The person with the appropriate knowledge and expertise needed to complete a questionnaire varies between companies. This was overcome in the final version of questionnaire through obtaining a complete list of companies and direct contact names supplied b SBAC. The list of contact names contained those specific personnel who have responsibility to complete or co-ordinate the company reply to the quarterly SBAC questionnaire. As a result the final questionnaire is accurately targeted against an up-to-date mailing list, which should improve the likelihood of increasing the response rate.

The pilot questionnaire has two primary functions, namely to determine if companies have collected the data required and to establish if companies are willing to disclose the information. The aerospace industry remains a highly competitive environment where UK companies compete in many exacting global markets especially in North America. Therefore, commercial sensitivity is a vitally important consideration for civil markets, in addition to the military secrecy in defence markets. As a result, a meeting was requested with companies to discuss the views to make the questions as meaningful as possible and acceptable for companies to answer in the wider population. The details of the four interviews are given below.

Company One: Aero & Industrial Technology Limited

NAME:	Aero & Industrial Technology Limited
BUSINESS:	Combustion equipment manufacturers for aero and industrial gas turbines.
TURNOVER:	£26 million
EMPLOYEES:	500
AEROSPACE BUSINESS:	95%
MILITARY BUSINESS:	50%
NUMBER OF YEARS TRADING:	55 years
MAKE:	67%
BUY:	33%
MARGINAL MAKE OR BUY:	Make
ASSET SPECIFICITY:	Very high
UNCERTAINTY:	Moderate
FREQUENCY:	Very high
SMALL NUMBERS:	Yes
COMPETITION BETWEEN SUPPLIERS	Medium
COMPETITION FOR BUSINESS:	Medium to high
UNIT PRICE OF TYPICAL PRODUCT:	>£100 - <£100,000

Aero & Industrial Technology Limited (AIT) is a medium-sized company, based in Burnley, Lancashire. It designs, develops, tests and manufactures combustion equipment for use in mainly aero and industrial gas turbines. Turnover is in excess of £25 million with approximately 500 employees. The typical unit price of its products is between £100 and £100,000. It is primarily an aerospace company, with markets in Europe, North America and Australia. Business is divided 50-50 between civilian and military work. AIT is a fully owned subsidiary of Bimeo Industries.

Currently 33% of components are bought-out; five years ago this was 45%. This indicates that AIT is increasingly making a greater proportion of its products. Indeed, the marginal make or buy decision is make. This is supported by very high asset specificity for employees, dedicated assets, facilities and equipment. Location is also important to this company.

Overall, AIT is a highly specialised aerospace component manufacturer, with significant vertical integration. It also forms part of a large number of aerospace suppliers in East Lancashire that is, Blackburn, Burnley, Nelson and Coln. This specific cluster of aerospace firms can be viewed as an industrial district, which benefits from economies of agglomeration and serves the British Aerospace and GEC sites on the Flyde coastline, namely BAe Samlesbury and Warton and GEC Preston. AIT is also a member of the Consortium of Lancashire Aerospace (CLA), which was set up to represent the relatively large number of aerospace suppliers in the Lancashire area. There is a similar organisation in the Bristol area named the West of England Aerospace Forum.

Company Two: Aerospace Metals

NAME:	Aerospace Metals
BUSINESS:	Distribution and stockist of metals mainly for aerospace
TURNOVER:	£20 million
EMPLOYEES:	50
AEROSPACE BUSINESS:	90%
MILITARY BUSINESS:	15%
NUMBER OF YEARS TRADING:	20 years
MAKE:	50%
BUY:	50%
MARGINAL MAKE OR BUY:	Buy
ASSET SPECIFICITY:	Low
UNCERTAINTY:	Low
FREQUENCY:	Low
SMALL NUMBERS:	Yes
COMPETITION BETWEEN	

SUPPLIERS:	Very low
COMPETITION FOR BUSINESS:	Medium
UNIT PRICE OF TYPICAL PRODUCT:	>£100, <£100,000

Aerospace Metals is a small to medium-sized company based in Bury, Lancashire. It is a stockist and distributor of primarily aircraft metals that range from raw material to partially machined metal parts. Approximately £1.5 million worth of stock is held at any given time, subject to world metal availability and prices. Just-in-Time and Total Quality Management policies of many aerospace manufactures, that results in these companies holding little stock, has had a profound effect on Aerospace Metals. It now has to hold more stock and deliver in shorter time periods. There is typically a lead-time of six to twelve months from the mills, but customers can request delivery in a matter of days. Indeed, whilst copper alloy, stainless steel and aluminium require six months, titanium can take up to twelve months to be delivered from the mills. In addition, smart and man-made materials, for example, carbon fibre composites are having an effect on the supply side of this market. As a result Aerospace Metals has been seeking new markets in medical equipment, marine and offshore construction.

Another development is for customers to request certain orders to be part or fully machined. An order can often arrive with a bespoke specification for machining attached. As a result the company has invested in additional cutting equipment including laser, water jet and CNC. The overwhelming majority of this turning and machining is performed in-house. This is because of the large value added involved and the fact that the company is keen to develop a metal service centre. It is clear that for many machine tasks performed on the raw metal, then it is more cost-efficient for Aerospace Metals to undertake this activity, as a metal stockist, than for the aerospace manufacturers themselves.

Another recent development in May 1998 was the acquisition by Aerospace Metals by AM Castle (USA) one of the top three metal distributors in the world. AM Castle has an annual turnover of $750 million and hold $200 million of stock at any given time. The UK operation will be relocated to Blackburn, Lancashire and as a result of this horizontal merger there will be more new business and a further development the value-added areas of work in the metal service centre.

Company Three: Bellhouse Hartwell & Company Limited

NAME:	Bellhouse Hartwell & Co. Ltd.
BUSINESS:	Aircraft equipment manufacturers
TURNOVER:	£15 million
EMPLOYEES:	325
AEROSPACE BUSINESS:	98%
MILITARY BUSINESS:	60%
NUMBER OF YEARS TRADING:	50 years
MAKE:	80%
BUY:	20%
MARGINAL MAKE OR BUY:	Make
ASSET SPECIFICITY:	Low
UNCERTAINTY:	Moderate
FREQUENCY:	High
SMALL NUMBERS:	No
COMPETITION BETWEEN SUPPLIERS:	Medium
COMPETITION FOR BUSINESS:	Medium
UNIT PRICE FOR TYPICAL PRODUCT:	>£100, <£100,000

Bellhouse Hartwell and Company Limited (BHW) is a medium-sized company based in Westhoughton, Lancashire. It is principally an airframe component manufacturer. Turnover is approximately £15 million with 325 employees. The company has a considerable produce range and will bid for a wide variety of work connected with aircraft parts that is, manufacture, overhaul and servicing. As such, it is primarily an aerospace company, which undertakes both military and civilian work. It is currently making 10% profit on turnover, but its export markets are less than 0.5% of turnover. The main customer is British Aerospace: civilian airbus work from Chadderton and various military work from Samlesbury and Warton. Location is very important to BHW, since four British Aerospace sites are within a 20-mile radius, from its factory, which generates a location advantage when bidding for work from BAE-Systems.

BHW endeavours to maintain as much work as possible in-house in order to keep the factory at near full capacity, although the asset specificity is low (other than location). In total, whilst BHW specialise in aerospace, it is essentially a general engineering company. However, it has won some important contracts in recent months from British Aerospace (Airbus and Defence), that has previously been performed by British Aerospace in-house. Therefore, a combination of aircraft expertise and relatively low overheads has given BHW a competitive edge over not only other competitors, but also internal divisions within British Aerospace. Since British Aerospace are finding the global aerospace markets to be even more competitive, they are looking to sub-contract even greater amounts of work to companies further down the supply chain, including some work which has previously been performed in-house. Indeed, British Aerospace are viewing other divisions and sites as simply another source of supply which has to compete for work as indeed they were prior to nationalisation and merger. The beneficiaries of this policy are companies like BHW, who often can produce work using fewer man-hours and at a lower labour rate.

Company Four: Didsbury Engineering Limited

NAME:	Didsbury Engineering
BUSINESS:	Manufacturer of hoists, winches and related equipment for lifting and lowering personnel and equipment
TURNOVER:	£3 million
EMPLOYEES:	36
AEROSPACE BUSINESS:	22%
MILITARY BUSINESS:	57%
NUMBER OF YEARS TRADING:	58 years
MAKE:	20%
BUY:	80%
MARGINAL MAKE OR BUY:	Buy
ASSET SPECIFICITY:	Very low
UNCERTAINTY:	Low
FREQUENCY:	Low to moderate
SMALL NUMBERS:	Yes
COMPETITION BETWEEN	

SUPPLIERS: Medium

COMPETITION FOR BUSINESS: Medium

UNIT PRICE OF TYPICAL
PRODUCT: >£100, <£100,000

Didsbury Engineering is a small sized company based in Levershulme, Manchester. It is a manufacturer of specialist lifting equipment including hoists, winches and safety rope. It serves aviation and public utilities markets as well as the defence industry and defence ministries. The products allow precision handling of materials (including munitions) and personnel from ships, aircraft and armoured vehicles. A quarter of its business is aerospace, but over half its turnover is generated from military markets.

Asset specificity is very low. Most employees have a general engineering background and the factory itself used to produce chocolate before 1940. In general, the frequency is low, and business is conducted through trade fairs and repeat business, but up over many years, plus a good reputation for quality and reliability.

The two main aspects of production are castings and fabrication. Only a small proportion of the fabrication of materials is undertaken in-house and there is a strong network of suppliers. Castings and machining is increasingly being sub-contracted. Approximately 15 to 20 years ago a larger part of the casting and machining was engineered in-house. Since this period less and less is sourced in -house, because it is more economic to procure from more specialist engineering companies. Suprisingly a great deal of the casting and machining could still be achieved in-house, as the facilities still remain. However, this is only used in periods of excess demand and the company has continued with its policy to outsource wherever possible, and whenever it is the lowest cost option.

Overall, the company trades very heavily on goodwill and a strong reputation for branded products such as Minilift, E2i-lift and talking rope. As a result they have only a small sales team. Instead, there is a strong customer support unit, which co-operates very closely with the requirements of the client, who range from haulage companies to the Ministry of Defence.

Finally, to supplement the pilot study contact has been made with personnel at several British Aerospace and Rolls Royce sites throughout the UK. Visits have been made to British Aerospace at Samlesbury, Stevenage and Warton, as well as visits to Rolls

Royce at Derby, Filton and Hillingdon. These visits have served two important functions. Firstly, an overall appreciation of the aerospace industry has been gained. British Aerospace is one of Europe's biggest aerospace and defence companies and remains the largest single UK manufacturer of fixed-wing aircraft. Rolls Royce is one of the world's biggest engine manufacturers with a strong presence in both civil and military aeroengine markets in Europe and North America. It remains the only aeroengine manufacturer in the UK. Secondly, several personnel at both companies have made detailed comments on the questionnaire and provided general advice on the workings of the aerospace sector. In sum, the guidance that has been given without prejudice has enabled a detailed picture of the aerospace industry to be gained on both production and procurement (make or buy) issues.

Conclusions

The pilot has confirmed that UK aerospace firms do tend to hold the relevant information to conduct a transaction cost questionnaire. The statement of purpose for the questionnaire is focused on the make-or-buy decisions of UK aerospace companies. The aim is to establish the reasoning behind production and procurement decisions and to identify the supply chain matrix in the aerospace industry, in addition to those industries, which supply from other sectors. Sub-groups within the population have been specified as military and civil companies, aerospace and non-aerospace companies, plus high technology and heavy-industry groupings. The population is also assessed in terms of company size, company location and number of years the company has been trading.

Appendix IV

UK Aerospace Survey Results

Appendix IV: Descriptive statistics of the key questionnaire variables

Variable Name	Number (N)	Minimum Value	Maximum Value	Mean Value	Standard Deviation
P1	82	0.00	1.00	0.01	0.11
P2	82	0.00	1.00	0.34	0.47
P3	82	0.00	1.00	0.38	0.49
P4	82	0.00	1.00	0.13	0.34
P5	82	0.00	1.00	0.13	0.34
T97	80	1.10	8546	234.76	1074.97
T92	71	0.75	11508	270.99	1426.36
E97	82	14.00	43400	1818.53	6866.89
E92	82	5.00	87400	2544.28	11401.53
A97	82	2.00	100	71.52	29.27
A92	82	0.00	100.00	67.03	30.47
M97	82	0.00	100.00	27.51	29.89
M92	82	0.00	100.00	29.81	30.70
BO97	68	1.00	100.00	53.88	30.81
BO92	61	1.00	100.00	50.11	29.65
CA97	58	1.00	100.00	54.23	31.72
CA92	54	1.00	100.00	50.64	31.88
MA97	55	1.00	100.00	47.95	33.12
MA92	51	1.00	100.00	47.15	30.83
EMPAS	82	1.00	10.00	7.41	1.80
FACAS	82	1.00	10.00	6.51	2.83
SUBHIGH	82	0.00	1.00	0.4024	0.49
SUBLOW	82	0.00	1.00	0.1585	0.37
DEDAS	82	1.00	10.00	6.19	2.86
LOCATION	82	0.00	7000.00	661.91	1478.89
CLOSELOC	82	0.00	1.00	0.18	0.39
DEMDEL	82	1.00	10.00	6.21	2.37
TIME	82	1.00	1000.00	201.34	220.30
SUPDEL	82	1.00	10.00	4.89	2.36

SUPRELI	82	0.00	1.00	0.84	0.36
ONEOFF	82	1.00	10.00	7.00	2.49
ORDER	82	0.00	1.00	0.44	0.50
SUPNUM	82	1.00	10.00	4.91	2.68
SUP75	82	1.00	200.00	18.01	27.62
SUPIMP	82	1.00	98	29.66	22.76
CUSNUM	82	1.00	10.00	5.08	2.77
CUS75	82	1.00	300.00	20.67	37.27
CUSIMP	82	4.00	100.00	27.98	21.53
MAKE	82	0.00	1.00	0.62	0.49
BUY	82	0.00	1.00	0.38	0.49
LOWP	82	1.00	4.00	2.62	1.21
HIGHQ	82	1.00	4.00	1.96	0.91
DELDATE	82	1.00	4.00	2.80	0.95
SUPREL	82	1.00	4.00	2.61	1.20
SUPCONYES	82	0.00	1.00	0.54	0.50
SUPCONP	82	0.00	2.00	0.69	0.75
CUSCONY	82	0.00	1.00	0.69	0.46
CUSCONO	82	0.00	1.00	0.01	0.19
CUSCONP	82	0.00	2.00	1.07	0.71
SUPCAYES	82	0.00	1.00	0.21	0.41
SUPCANO	82	0.00	1.00	0.44	0.50
CUSCAYES	82	0.00	1.00	0.31	0.47
CUSCANO	82	0.00	1.00	0.32	0.47

Appendix V

Abbreviations and Variable Listing

Appendix V: Abbreviations

Abbreviation	Definition
ABI	Annual Business Inquiry
AECMA	European Association of Aerospace Industries
AES	Annual Employment Survey
AIA	Aerospace Industries of America
ANOVA	Analysis of Variance
AWM	Advantage West Midlands
BAE	British Aerospace plc
CAD	Computer Aided Design
CAM	Computer Aided Manufacture
CARAD	Civil Aircraft Research and Technology Demonstration
CNC	Computer Numerically Controlled
DERA	Defence Evaluation and Research Agency
DIB	Defence Industrial Base
DMA	Defence Manufactures Association
DoD	Department of Defense
DPA	Defence Procurement Agency
DTI	Department of Trade and Industry
EU	European Union
EADS	European Aeronautical Defence Space
F	Frequency
FAME	Financial Access Made Easy
FUMA	Future Unmanned Aircraft
GATT	General Agreement on Tariffs and Trade
GEC	General Electric Company
GKN	Guest, Keen, Nettlefolds
GM	General Motors
H0	Null Hypothesis
HA	Alternative Hypothesis
IDDS	International Defence Disarmament Studies
JSF	Joint Strike Fighter

MBDA	Matra, BAE, Dynamics, Aerospatiale
ME	Military Expenditure
MIC	Military Industrial Complex
MLU	Mid Life Update
MoD	Ministry of Defence
NATO	North Atlantic Treaty Organisation
NCE	Neo Classical Economics
NS	National Statistics
OLS	Ordinary Least Squares
PE	Procurement Executive
PSBR	Public Sector Borrowing Requirement
QSE	Qualified Scientists and Engineers
RLFC	Rugby League Football Club
ROF	Royal Ordnance Factory
RR	Rolls Royce plc
SBAC	Society of British Aerospace Companies
SCP	Structure, Conduct, Performance
SE	Standard Error
SIC	Standard Industrial Classification
SMMT	Society of Motor Manufactures and Traders
TSR-2	Tactical, Strike, Reconnaissance
TC	Transaction Costs
TCE	Transaction Cost Economics
TD	Technical Drawing
R&D	Research and Development
RAF	Royal Air Force
SCRIA	Supply Chain Relationships in Aerospace
UKAI	United Kingdom Aerospace Industry
USA	United States of America
USSR	Union Soviet Socialist Republics
VSEL	Vickers Shipbuilding Engineering Limited
VSTOL	Vertical, Short Take-off and Landing

Appendix V: Variable Listing

Variable Name	Variable Definition
A92	Aerospace in 1992
A97	Aerospace in 1997
AERO	Aerospace-Non-Aerospace Split
AS	Asset Specificity
BO92	Bought-out in 1992
BO97	Bought-out in 1997
BUY	Buy Proportion
CA92	Civil Aerospace Proportion in 1992
CA97	Civil Aerospace Proportion in 1997
CLOSELOC	Close Location
CUS75	Top 75% of Customers
CUSCANO	No Customer Cost Advantage
CUSCAYES	Customer Cost Advantage
CUSCONY	Contract with Customer
CUSCONO	No Contract with Customer
CUSCONP	Customer Contract Price
CUSIMP	Customer Importance
CUSNUM	Number of Customers
DEDAS	Dedicated Assets
DELDATE	Delivery Date Criteria
DEMDEL	Change in Demand
E92	Employment in 1992
E97	Employment in 1997
EMPAS	Employment Asset Specificity
F	Frequency
FACAS	Facilities Asset Specificity
HIGHP	High Price Criteria
LOCATION	Location Asset Specificity
LOWP	Low Price Criteria
M92	Military Proportion in 1992

M97	Military Proportion in 1997
MA92	Military Aerospace Proportion in 1992
MA97	Military Aerospace Proportion in 1997
MAKE	Make Proportion
MILCIV	Military-Civil Split
ONEOFF	Frequency of Transaction
ORDER	Order Size of Transaction
P1	Price Category 1
P2	Price Category 2
P3	Price Category 3
P4	Price Category 4
P5	Price Category 5
SIZE	Size of Firm
SUBHIGH	Sub-Contract in High Demand
SUBLOW	Sub-Contract in Low Demand
SUP75	Top 75% of Suppliers
SUPCANO	No Supplier Cost Advantage
SUPCAYES	Supplier Cost Advantage
SUPCONYES	Supplier Contract
SUPCONP	Supplier Contract Price
SUPDEL	Change in Supply
SUPIMP	Supplier Importance
SUPNUM	Number of Suppliers
SUPREL	Reliability of Supply Criteria
SUPRELI	Supplier Reliability
T92	Turnover in 1992
T97	Turnover in 1997
TC	Transaction Costs
TIME	Time in Contracts
U	Uncertainty

Appendix VI

Glossary

Adverse selection: the self-selection of high risk economic agents in a population, which was originally observed in insurance markets.

Aerospace: economic activity where firms are involved in the design, development, production, repair and support services of aircraft and helicopters for military and civil markets, together with missiles and space systems and related equipment, parts and components.

Asset specificity: the degree to which an asset is explicit or definite to any given transaction with little or no alternative use.

Asymmetric information: the situation where economic agents have unequal access to information in an agreement, contract or transaction.

Bi-lateral monopoly: a monopolist and monopsonist co-existing in the same market.

Bought-out: the percentage of components, parts and/or services purchased from the market rather than made in-house.

Bounded rationality: the limit to an individuals ability to gather and process information in a given transaction.

Complexity: the degree to which a transaction is complicated or difficult.

Components: parts or sub-assemblies used in manufacturing.

Contract design: the creation of legal agreements.

Frequency: the extent to which a transaction is repeat or one-off.

Governance structures: the way in which firms are internally organised.

Hold-up problem: where one firm can hold another hostage in the supply chain due to asset specificity.

Idiosyncratic investment: alternative phrase for asset specificity.

Ink costs: the costs incurred from changes in a written contract or agreement.

Make-or-buy: the choice between producing in-house and buying from the market.

Moral hazard: the tendency for economic agents to be less careful when insured.

Outsourcing: another phrase for purchasing from the market.

Opportunism: the chance to take advantage in a transaction, especially where there is asset specificity.

Quasi-rent: the cost of the next best alternative for an asset.

Small numbers exchange: the number of suppliers in any given transaction.

Structure-Conduct-Performance: the paradigm for assessing market concentration, behaviour and operation.

Sub-contractors: firms employed by other firms to perform a task.

Supplier-switching: the extent to which a buyer can swap between suppliers.

Supply chain: a metaphor for business-to-business relationships.

Transaction costs: the costs of using the market, where there are *ex ante* costs (bargaining and search) and *ex post* costs (monitoring and enforcement).

Uncertainty: a situation where there is non-measurable risk.

Vertical integration: the extent to which firms incorporate the production process upstream with distribution and downstream with parts and components.

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