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Transaction Costs and Core Competence Implications of Buyer-Supplier Linkages; the Case of CERN

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Transaction Costs and Core Competence Implications of Buyer-Supplier Linkages; the Case of CERN

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Katholieke Universiteit Brabant, op gezag van de rector magnificus, prof. dr. L.F.W. de Klerk, in het openbaar te verdedigen ten overstaan van een door het college van decanen aangewezen commissie in de aula van de Universiteit op vrijdag 5 september 1997 om 14.15 uur door

Markus Yrjö Nordberg

geboren op 27 april 1960 te Helsinki

Promotors: Prof. dr. S. W. Douma
Prof. dr. A. Verbeke

Abstract

Author of the study	Subject of the study
Markus Nordberg	Transaction Costs and Core Competence Implications of Buyer-Supplier Linkages; the Case of CERN
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This study aims at providing answers to two important research questions. First, what is the most efficient, i.e. transaction cost minimizing, governance structure to organize buyer-supplier relationships, given the presence of specific institutional boundaries, high technological complexity and environmental uncertainty? Second, irrespective of the presence of such an efficient governance structure, what type of impact could technology-oriented government contracts have on supplier core competences?

This research problem is analyzed using CERN- industry relations as a case example. CERN is the European Laboratory for Particle Physics. The study includes the analysis of manufacturing contracts for new project equipment awarded by CERN. The study excludes items which are not considered to be associated with production of advanced, new technologies.

The presented research hypotheses are verified by using collected empirical evidence. The empirical sample of this present study consists of 49 suppliers which have been awarded CERN contracts during the construction period of the latest research project at CERN. The empirical data was gathered in personal interviews with the mid and upper-level management of the supplying companies. In the interviews, a structured questionnaire was used. A conceptual framework was developed to identify contractual friction, supplier benefits, and strategies.

The empirical evidence confirms the key research hypotheses. First, some of the CERN contracts appear to be inefficient and are associated with high transaction costs. Second, inefficient contracts can be identified based on the level of both buyer and supplier-related asset specificity. Third, asset specificity can also be a source of supplier benefits. In this context, competence-driven supplier strategies are associated with higher combined technical and marketing benefits, in comparison with other type of supplier strategies. A competence-driven supplier strategy is defined as behaviour intended to utilize the contracts to tap into complementary assets provided by CERN. Fourth, it appears that the impact of CERN transactions on the supplier can be measured in terms of involvement of the supplier value chain functions. In this context, the level of organizational involvement appears to be an alternative to asset specificity to identify inefficient contracts and supplier benefits.

Dutch summary (Samenvatting)

De economische betekenis van transactiekosten en kernbekwaamheden in de verticale relaties tussen leveranciers en afnemers : een toepassing op het Europees Centrum voor Nucleaire Research (CERN)

Deze verhandeling beoogt een antwoord te verschaffen op twee belangrijke onderzoeksvragen. In de eerste plaats stelt zich de vraag naar de meest doelmatige organisatievorm van de verticale relaties tussen leveranciers en klanten in termen van minimalisatie der transactiekosten, in gevallen waarbij institutionele beperkingen bestaan inzake de selectie van specifieke organisatievormen en tevens sprake is van hoge technologische complexiteit en onzekerheid afkomstig vanuit de omgeving. In de tweede plaats stelt zich de vraag, ongeacht welke organisatievorm vastgesteld wordt voor deze verticale relaties, welke economische effecten uitgaan van technologisch georiënteerde contracten op de kernbekwaamheden van leveranciers.

De twee bovenstaande onderzoeksvragen worden beantwoord op basis van een analyse der verticale relaties tussen het Europees Centrum voor Nucleaire Research (CERN) en haar industriële leveranciers van hoogtechnologische inputs. Een conceptueel kader wordt ontwikkeld en een aantal hypotheses geformuleerd welke dan getoetst worden aan de hand van een analyse van 49 contracten tussen CERN en haar industriële leveranciers. Hierbij wordt via diepte-interviews, afgenomen van zowel de leveranciers als de betrokken CERN-ingenieurs op gestructureerde wijze informatie ingewonnen die toelaat de hypotheses te toetsen.

De verhandeling leidt tot vier hoofdconclusies:

1 de institutionele beperkingen opgelegd aan CERN bij het afsluiten van contracten met leveranciers van hoogtechnologische inputs leiden tot transactiekosten en derhalve inefficiënte contracten, vanuit een comparatief institutioneel perspectief;

2 inefficiënte contracten kunnen geïdentificeerd worden op basis van de 'specificiteit' van de middelen welke ingezet worden om de contracten uit te voeren. Hierbij wordt wel een asymmetrie vastgesteld tussen de specificiteit der ingezette middelen aan de zijde van de afnemer (CERN) en deze aan de zijde van de leveranciers;

3 er blijkt een positief verband te bestaan tussen het niveau van specificiteit der ingezette middelen en de baten gerealiseerd door de leveranciers ingevolge hun contracten met CERN. Deze baten blijken bovendien hoger te zijn wanneer door de leveranciers een intentionele strategie wordt gevoerd met het oog op het ontwikkelen van nieuwe kernbekwaamheden op basis van de contracten met CERN en de uit deze contracten voortvloeiende toegang tot de zogenaamde 'complementaire' know how verschaft door CERN;

4 de graad van betrokkenheid van de diverse functionele afdelingen van leveranciers bij de uitvoering van contracten met CERN blijkt eveneens een parameter te zijn die toelaat om inefficiënte contracten te identificeren (inefficiëntie vanuit een transactiekosten-perspectief) alsook inzichten te verwerven in de baten verworven door de leveranciers, zowel wat het niveau als de types van deze baten betreft.

De studie bestaat uit acht hoofdstukken. Na de inleiding gaat het tweede hoofdstuk in op de literatuur betreffende verticale relaties tussen afnemers en leveranciers. Drie stromingen in de literatuur blijken bijzondere interessant met het oog op een analyse van verticale relaties tussen afnemers en leveranciers:

1 de literatuur inzake transactiekosten. De conventionele benadering bij een transactiekostenanalyse bestaat erin dat de meest optimale organisatievorm wordt geselecteerd op basis van een comparatieve institutionele analyse der diverse alternatieven. Hierbij wordt nagegaan, op basis van de karakteristieken van transacties (bijvoorbeeld hun frequentie en de noodzaak tot het inzetten van specifieke produktiemiddelen die geen alternatieve commerciële aanwending hebben) welke organisatievorm leidt tot de geringste transactiekosten, dit wil zeggen het meest efficiënt is. Deze benadering wordt door onderzoekers meestal gebruikt bij positieve analyses die ex-post worden uitgevoerd, met andere woorden als verklaringsbasis voor effectief gemaakte keuzes van organisatievormen. In het kader van deze studie wordt echter gesteld dat transactiekostenanalyse ook kan gehanteerd worden voor normatieve doeleinden. Indien een bepaalde organisatie bijvoorbeeld verplicht wordt, ingevolge institutionele beperkingen om steeds korte termijn contracten af te sluiten met leveranciers, ongeacht de aard der transacties (in het bijzonder op het vlak van de specificiteit der in te zetten middelen), dan kan transactiekostenanalyse bijvoorbeeld gehanteerd worden om aan te duiden dat contracten op korte termijn wellicht comparatief inefficiënt zullen zijn voor de uitvoering van transacties met een hoge specificiteit van de in te zetten middelen in vergelijking met de

situatie waarbij men op vrije wijze een contractuele vorm had kunnen kiezen die meer aangepast zou geweest zijn aan de karakteristieken van de betrokken transacties;

2 in de literatuur met betrekking tot strategisch management blijkt vooral de stroming die de kernbekwaamheden van ondernemingen analyseert interessant voor een studie van de verticale relaties tussen afnemers en leveranciers. Deze literatuur suggereert dat de betrokken partijen potentieel nieuwe kernbekwaamheden kunnen ontwikkelen dankzij de toegang tot de 'complementaire' know how van de partners bij de contractuele uitvoering. Als gevolg van een leerproces worden derhalve baten bekomen die zich veel verder kunnen uitstrekken dan de directe commerciële baten op het ogenblik van de contractuele uitvoering;

3 een aantal studies werd reeds uitgevoerd inzake de economische impact van publieke hoogtechnologische research organisaties (NASA, CERN, ESA) op macro- en meso-economisch vlak. Deze studies geven aan dat contracten met private industriële ondernemingen leiden tot een substantiële transfer van complementaire know how, welke de mogelijkheid biedt tot de ontwikkeling van nieuwe kernbekwaamheden bij de betrokken ondernemingen en tot een verbetering van hun economisch resultaat op langere termijn.

Het derde hoofdstuk van de studie omvat een korte historiek en beschrijving van de activiteiten van CERN. CERN is de belangrijkste hoogtechnologische research organisatie in Europa. Zij wordt geconfronteerd met een zeer hoge technologische complexiteit en onzekerheid uitgaande van de omgeving. Met het oog op objectiviteit en eerlijke procedures bij de toekenning van contracten aan leveranciers is CERN steeds verplicht een contract af te sluiten met de leverancier die de goedkoopste offerte indient op basis van een openbare aanbesteding, mits deze leverancier aan de technische vereisten voldoet. De aankoopprocedures hebben dus geen enkele flexibiliteit en er bestaat geen garantie van vervolgcontracten, zelfs niet bij de produktie van zeer gesofisticeerde inputs, zodat het ontwikkelen en inzetten van specifieke know how niet op lange termijn kan gevaloriseerd worden bij CERN als afnemer. Dit impliceert eveneens dat CERN grote inspanningen dient te leveren om de telkens nieuwe leveranciers te helpen bij het uitvoeren van gesofisticeerde transacties binnen het keurslijf van korte termijn contracten.

In het vierde hoofdstuk wordt een conceptueel kader ontwikkeld, gebaseerd op de literatuurstudie in Hoofdstuk 2, dat leidt tot de formulering van vier hypotheses:

1 **hypothese 1**: Transactiekostenanalyse kan aangewend worden met het oog op de beschrijving van de contractuele relaties tussen een afnemer zoals CERN en haar leveranciers. In dit kader laat een transactiekostenanalyse eveneens toe om inefficiënte contracten te identificeren. De belangrijkste reden voor het bestaan van transactiekosten, gegeven het gebruik van contracten op korte termijn, is de set van technologische vereisten opgelegd door de afnemer aan de leverancier gekoppeld aan de beperkte rationaliteit van deze leveranciers;

2 **hypothese 2**: In een systeem van verticale relaties waar louter gewerkt wordt met één type van standaard contracten, ongeacht de karakteristieken van de betrokken transacties, kan het niveau van

inzet van specifieke activa gehanteerd worden om inefficiënte contracten te identificeren. Een asymmetrie bestaat tussen het niveau van ingezette specifieke activa vanuit het standpunt van de afnemer en vanuit het standpunt van de leveranciers;

3 **hypothese 3**: De inzet van specifieke middelen in een transactie door zowel de afnemer als de leverancier vormt niet enkel een bron van transactiekosten, maar fungeert tevens als basis voor de baten die te goede komen aan de leverancier. Indien de leverancier bovendien een intentionele strategie voert gericht op het verwerven van nieuwe kernbekwaamheden zullen de baten op marketing en technisch vlak hoger zijn dan wanneer de leverancier een andere strategie zou volgen;

4 **hypothese 4**: De betrokkenheid van de diverse functionele afdelingen van een leverancier bij een transactie kan aangewend worden als een additionele parameter, naast de inzet van specifieke activa, zowel om inefficiënte contracten te identificeren als de baten verworven door de leverancier te beschrijven. Wanneer een leverancier een strategie volgt gericht op de ontwikkeling van kernbekwaamheden bij de uitvoering van een contract met CERN, zal het niveau van betrokkenheid van de technologie- en de marketing-functie hoger zijn dan indien door deze leveranciers een andere strategie zou gevolgd worden.

In Hoofdstuk 5 wordt de empirische onderzoeksmethodologie, welke zal gebruikt worden bij de empirische toetsing van de hypotheses uiteengezet. Met het oog op de identificatie van transactiekosten wordt een enquête opgesteld waarbij aan de leveranciers gevraagd wordt de diverse clausules in CERN contracten te vergelijken met de clausules geldend voor

gelijkaardige transacties in contracten gekenmerkt door een geringe contractuele 'frictie'. Hierbij wordt gebruik gemaakt van een zogenaamde Likert-schaal, waarbij elke relevante clausule uit het CERN contract een score krijgt van de leverancier.

Met het oog op de verklaring van het bestaan van transactiekosten wordt voor elk onderzocht contract ook het niveau van inzet van specifieke activa bepaald vanuit het standpunt van zowel CERN als de leveranciers. De inzet van specifieke activa vanuit het leveranciersstandpunt wordt bepaald op basis van de aard van het produkt van de leverancier (standaard, gewijzigd of uniek produkt) opnieuw gebruik makend van een Likert-schaal. De inzet van specifieke activa vanuit het standpunt van CERN wordt bepaald door na te gaan in welke mate 'engineering en design'-activiteiten werden ontwikkeld door CERN, eveneens gebruik makend van een Likert-schaal.

Met het oog op het verwerven van een grondig inzicht in de baten voortvloeiend uit CERN-projecten ten gunste van de leverancier, wordt een relatie gelegd tussen enerzijds de diverse karakteristieken van de contracten (en transactie-attributen) en anderzijds de diverse functionele afdelingen van de leveranciers die elk verondersteld worden baten te betrekken voortvloeiend uit een specifieke contractuele clausule.

De in aanmerking genomen functionele afdelingen vloeien voort uit de zogenaamde 'value chain' of waardeketen zoals beschreven door M. Porter. Vijftien mogelijke batencategorieën worden onderscheiden, welke via factor analyse kunnen teruggebracht worden tot een kleiner aantal types baten.

Er kan dan nagegaan worden of een statistisch significant verschil bestaat in termen van enerzijds het niveau van transactiekosten en anderzijds

het niveau van baten toekomend aan de leverancier tussen de transacties gekenmerkt door een hoge inzet van specifieke activa door zowel CERN als de leverancier en de transacties waarbij deze inzet laag is.

Ook kan bepaald worden of leveranciers die strategieën volgen gericht op het verwerven van kernbekwaamheden via contracten met CERN effectief hogere baten verwerven. In dit kader kan eveneens worden nagegaan of er leereffecten plaatsgrijpen ingevolge CERN-contracten, namelijk door een gebeurlijke afname van de graad van uniekheid van een produkt, initieel ontwikkeld voor CERN te onderzoeken in de tijd.

De graad van betrokkenheid van de diverse functionele afdelingen van een leverancier bij de uitvoering van een CERN-contract wordt gemeten door middel van een Likert-schaal. Dankzij factor-analyse kan ook hier de betrokkenheid van de vele functionele afdelingen herleid worden tot een meer beperkt aantal types van betrokkenheid.

De bovengenoemde graad van betrokkenheid van specifieke groepen functies kan dan gerelateerd worden aan enerzijds het niveau van transactiekosten en anderzijds het niveau van verworven baten.

Hoofdstuk VI omvat het feitelijke empirische onderzoek, dat de relevantie van de vier onderzoekshypotheses statistisch bevestigt.

Hoofdstuk VII beschrijft de implicaties voor CERN en leidt tot de conclusie dat het onderhavige onderzoek toelaat om:

1 inefficiënties in bestaande contracten te identificeren en gebeurlijk, mits een versoepeling van de institutionele beperkingen, de transactiekosten te reduceren;

2 contracten te beschrijven in termen van hun strategische betekenis voor de leveranciers (hoge of lage inzet van specifieke activa) in plaats van ze op de conventionele wijze te classifiëren als zeer hoogtechnologisch en minder hoogtechnologisch;

3 een inzicht te verwerven in de graad van inzet van specifieke activa door zowel CERN als de leveranciers ;

4 te besluiten dat een hoger niveau van inzet van specifieke activa inderdaad leidt tot hogere baten voor de leveranciers, in het bijzonder wanneer ze intentioneel trachten nieuwe kernbekwaamheden te verwerven.

In termen van industriële strategie dient erkend te worden dat het huidige systeem van korte termijn contracten zeer hoge leereffecten genereert ter gunste van een grote populatie leveranciers. Indien zou worden overgegaan naar een systeem van lange termijncontracten en strategische allianties, zou dit ongetwijfeld de transactiekosten verminderen bij de uitvoering van transacties gekenmerkt door een hoge specificiteit van de ingezette middelen, doch ook de potentiële leereffecten ten gunste van een groot aantal leveranciers zouden in negatieve zin kunnen aangetast worden.

De implicaties van de studie voor de leveranciers zelf zijn enerzijds dat elke leverancier moet beseffen dat een strategie die een bepaald niveau van betrokkenheid van specifieke functies inhoudt ook tot specifieke baten zal leiden en anderzijds dat transactiekosten toch kunnen gereduceerd worden door bijzondere maatregelen te treffen die inspelen op de contractuele clausules opgelegd door CERN.

Het achtste hoofdstuk tenslotte, suggereert dat de onderhavige studie een substantiële bijdrage levert tot zowel de transactiekostentheorie als de theorie van het strategische management inzake kernbekwaamheden. Op het vlak van de transactiekostentheorie wordt in de studie aangetoond dat:

1 de theorie kan gehanteerd worden met normatieve doeleinden bij de analyse van transacties binnen één enkele organisatievorm;

2 de inzet van specifieke activa een goede parameter is om transactiekosten te meten;

3 de sub 2 genoemde inzet niet noodzakelijk exogeen (technologisch) bepaald wordt, maar kan voortvloeien uit de aankooppolitiek van een organisatie als CERN (selectie van de goedkoopste leverancier voor wie het te leveren produkt uniek kan zijn, hoewel het als standaardprodukt kan verkregen worden bij andere leveranciers);

4 de 'specificiteit' van de ingezette middelen kan afnemen in de tijd ingevolge een leerproces voortvloeiend uit de uitvoering van het contract;

5 een hoge specificiteit van de ingezette middelen ook tot hoge baten kan leiden voor de leveranciers;

6 een directe link kan gelegd worden tussen enerzijds de contractuele clausules en anderzijds de impact ervan in termen van baten toekomend aan specifiek functionele afdelingen van de leverancier.

Wat betreft de bijdrage tot de theorie van het strategisch management wordt aangetoond dat:

1 verticale relaties een bron kunnen vormen van complementaire know how voor de leverancier, waarbij een veeleisende klant (in dit geval CERN) aan de basis ligt van een leerproces dat leidt tot de ontwikkeling van nieuwe kernbekwaamheden;

2 de graad van in te zetten specifieke activa voor een transactie kan beschreven worden in termen van betrokkenheid (inspanningen) vanwege de diverse functionele afdelingen van een leverancier;

3 het concept van specifieke activa ingezet voor de uitvoering van een welbepaald contract kan gehanteerd worden als parameter in het strategische denken van de afnemer. Als de afnemer bijvoorbeeld de leverancier kiest met de laagste prijs, moet hij beseffen dat dit kan leiden tot contractuele problemen, namelijk indien de uitvoering een zeer hoge inzet vergt van specifieke activa vanwege de geselecteerde leverancier, hoewel het te leveren produkt mogelijk een standaardprodukt is voor een andere (duurdere) leverancier;

4 leveranciers hun klanten niet enkel dienen te evalueren in termen van economische behoeften die moeten bevredigd worden (vraag), maar tevens als een potentiële bron van complementaire know how;

5 de inzet van diverse functionele afdelingen in de waardeketen van een leverancier expliciet kan gerelateerd worden aan externe contractuele clausules;

6 vooral de simultane betrokkenheid en de interactie tussen de marketing- en de technologie functie bij leveranciers leidt tot hogere baten voortvloeiend uit contracten met CERN.

Tenslotte dient gemeld dat CERN duidelijk de rol van katalysator vervult bij de transfer van hoogtechnologische know how naar de Europese industrie en dat deze transfer in belangrijke mate plaatsgrijpt via haar aankoopstrategie.

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Markus Nordberg

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Glossary

Asset specificity	The degree to which the assets used in a transaction are re-deployable. Highly unique or one-of-a-kind products are typically associated with high asset specificity. See also: transaction attribute
Bounded rationality	Limited capabilities of humans to receive and process information. Its presence implies that the available information is imperfect while carrying out a transaction
CERN	European Laboratory for Particle Physics. It studies the structure of matter using large scientific equipment of industrial scale
Competence-driven supplier strategy	Enhancing the core competences of a firm by tapping into complementary assets through external contracts. See also: core competences
Contract	The economic, organizational and legal framework which binds the transaction
Core competences	A set of distinctive, intra-organizational capabilities which a company developes over time and which transform into economic performance
c-value	Correlation coefficient which varies between -1 and +1. If c is 0, no correlation exists between the studied variables. If c is 1, a perfect linear relationship exists between the variables
Ex-ante	Actions taken before a given milestone
Ex-post	Actions taken following a given milestone
Factor analysis	A method to reduce the number of dependent variables by re-grouping them into factors

Fisher's PLSD	Fisher's protected least significant difference test that makes all pairwise comparisons of the factors between (two) groups
F-ratio	Ratio of the variances of variables when a correlation analysis is carried out. The higher the F-value, the stronger the linear relationship between the variables
Governance structure	Trading interface or the institutional framework within which the transaction is carried out. A spot contract is one form of governance structure. Here, it refers to a fixed contractual relationship
p-value	In linear correlation analysis, the p-value gives the probability that the observed correlation results from pure chance alone. The p-value ranges between 0 and 1. The lower the p-value and higher the F-ratio, the higher the reliability of a linear relationship between the variables
Standard error	The variability of the sample mean. It is equivalent to the standard deviation of the observations (square root of variance) divided by the square root of the number of observations
Transaction	Exchange of a product for some kind of compensation
Transaction attribute	Descriptive element of the transaction. It includes the product features, type of compensation, nature of human interaction and the necessary time-span to carry out the transaction. Asset specificity is one type of transaction attribute
Transaction costs	Presence of contractual friction. Transaction costs are minimized, when the best available governance structure is selected for the given transaction

Opportunism	Self-interest seeking with guile, a conscious attempt to cheat on the other party and to take advantage of its weakened negotiation position. Together with bounded rationality, it is the source of transaction costs
Value chain	Description of a company in terms of its functions. These functions are associated with both costs and value added features. An optimized value chain system results in maximum profits

CHAPTER 1: INTRODUCTION

1.1 Background, scope and objectives of the study

How can buyer-supplier linkages be structured to reduce transaction costs and to develop supplier core competences in an effective way? This question is of crucial importance to suppliers who want to utilize "complementary assets" provided by their customers. It is also important from the perspective of the buyers, such as public, research driven "high tech" organizations. Such organizations exist e.g., in the fields of particle physics, space research, molecular biology and fusion research. They are often used by governments to stimulate innovation by suppliers in order to achieve macro-economic and political goals under tight budgetary constraints.

These types of laboratories are under constant pressure from supporting governments to generate secondary utility such as technology transfer and spin-offs. Examples of the industrial benefits generated by buyer-supplier-linkages include e.g., pace makers, medical body scanners, radiation detectors, high speed computers and new materials such as metal alloys and ceramic compounds.

Public research organizations often work within rigid institutional constraints that prevent them from internalizing the supplier function. This happens even in the case of emerging technologies that are critical to their own operations. The investments for industrial-scale scientific installations run in the multi-billion dollar range and are closely monitored by the funding government agencies. Their main difficulty is that they must operate according to the principles of conventional public tendering, being obliged to use fixed price, short-term contracts. Such contractual frameworks are commonly applied to reduce the risk of financial abuse and costly supplier dependency[1]. However, such fixed-price, short-term contracts could be inappropriate especially when dealing with new and emerging technologies where product development life cycles typically extend beyond 10 years.

This study addresses the question of the design of efficient buyer-supplier contracts within given institutional boundaries faced by the buyer. In particular, the study focuses on vertical buyer-supplier linkages as a source of supplier core competences in a cost and technology driven environment. The buyer-supplier contracts are typically determined by the buyers, who are research and technology (R&D)-driven public organizations. These types of organizations include government institutions such as research labs or technology-oriented scientific centres. The empirical data base, a statistical sample of 49 manufacturing-contracts commissioned by CERN (European Laboratory for Particle Physics) is examined using statistical techniques.

The objectives of the study are to find new ways to analyze buyer-supplier linkages and to use this information to recommend to research organizations how to optimize their trading interfaces. Based on the existing research literature and the analyzed empirical evidence, directions for future research will also be presented.

[1]Stories of past abusive use of public funds are well known, at least in the field of defense contracting. See e.g., Fox (1988).

1.2 Research problem

As stated above, the key question of this study is how buyer-supplier linkages can be structured both to reduce transaction costs and to develop supplier core competences. Within the boundaries of the study, the question can be reformulated into the following two-step research problem:

1 what is the efficient (i.e., transaction cost minimizing) governance structure to organize buyer-supplier relationships, given the presence of institutional boundaries, high technological complexity and environmental uncertainty?

2 irrespective of the presence of such an efficient governance structure in terms of transaction cost minimization, what type of impact could technology-oriented government contracts have on supplier core competences?

1.3 Structure

The structure of the study is as follows. After the introduction, a literature review is carried out to identify the parameters that determine efficient buyer-supplier linkages. Then, in Chapter 3, the research problem is further described using CERN-industry linkages as a case example. In Chapter 4 a conceptual framework is constructed and subsequent research hypotheses are presented. In Chapter 5 the empirical research methodology is discussed. The empirical results are presented in Chapter 6 and the implications of the findings for CERN are dicussed in Chapter 7. Finally, in Chapter 8, the implications of the empirical results are described. The structure of the study is summarized in Figure 1.1.

Chapter 1: INTRODUCTION
- The analysis of buyer-supplier linkages

Chapter 2: LITERATURE REVIEW
- Parameters that determine efficient buyer-supplier linkages

Chapter 3: DESCRIPTION OF THE RESEARCH PROBLEM
- The case of CERN-industry linkages

Chapter 4: CONCEPTUAL FRAMEWORK AND HYPOTHESES
- Transaction costs
- Core competences
- Optimization of buyer-supplier linkages

Chapter 5: EMPIRICAL METHODOLOGY
- Research methodology and definition of key variables
- Reliability and validity of data

Chapter 6: EMPIRICAL RESULTS
- Analysis of field interviews
- Verification of the research hypotheses

Chapter 7: IMPLICATIONS FOR CERN
- Recommendations to CERN on enhanced purchasing strategies

Chapter 8: DISCUSSION AND CONCLUSIONS
- Implications of empirical results for further research

Figure 1.1 The structure of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this Chapter, the importance of transaction costs and core competences in buyer-supplier linkages is reviewed on the basis of the existing literature. The literature review consists of three parts.

In the first part, the literature on transaction cost economics is examined to determine the efficient structure of contracts, given specific critical attributes of transactions.

In the second part, the conclusions of the first section on the design of efficient buyer-supplier linkages are related to the strategic management literature. More specifically, two elements are analyzed. First, the impact of specific buyer-supplier linkages on the different segments or functions of the supplying firm's value chain. Second, the impact of these specific vertical linkages on the network of companies the supplying firm is associated with.

Finally, in the third part, the relevant literature is examined to determine whether technologically oriented, research and development (R&D) intensive customers can contribute to the development of core competences of supplying firms, thus improving their potential to obtain a sustainable competitive advantage.

2.2. A transaction cost analysis of buyer-supplier contractual relationships in a complex and uncertain environment

A myriad of literature exists on buyer-supplier relationships[2] . In this study, a buyer-supplier relationship is viewed as an interaction initiated by either the supplier or the buyer, whereby both parties recognize their mutual interdependence and interest in each other's resources (Cunningham, 1980). This perspective differs from the classical view of analyzing buyer reactions to a supplier's offer as it assumes that "both companies are likely to be involved in adaptations to their own process or product technologies to accommodate each other" (Ford, 1980, p. 340). The buyer-supplier interface can also be complex and may involve many individuals (Spekman and Johnston, 1986).

Transaction cost analysis[3] addresses questions related to the optimal governance structure for transactions (Williamson, 1984). According to transaction cost analysis, there may be hidden risks - and therefore possible transaction costs - involved in a spot contract which can be reduced by choosing an alternative type of contractual agreement or some other type of governance structure[4] such as a joint venture, partnership, coalition or an alliance. Sometimes it is better to carry out the planned activity inside the firm rather than obtaining it from the market (Coase, 1937). When the external market indeed fails to provide economic

[2]For articles on industrial or organizational buyer behaviour and supplier response, see e.g., Webster and Wind (1972); Sheth (1973); Bonoma (1982) Cardozo (1983); Jackson (1985); Reichard (1985); De Bruicker and Summe (1985); MacMillan et al. (1986); Anderson and Narus (1990: 1996); Lyons et al. (1990).

[3]Other equivalent, commonly used terms are "transaction cost economics" or "transaction cost theory". A transaction occurs when a good or service is transferred across a technologically separable interface (Williamson, 1975, p. 1). Transactions costs represent the cost of running the economic system (Arrow, 1969, p. 48).

[4]By governance structure we mean the institutional framework within which the integrity of the transaction is decided (Williamson 1979, p. 235), that is, the contractual format designed to carry out the transaction.

activities efficiently, firms may respond with internalization (e.g., by integrating vertically[5]). This represents a choice between "markets and hierarchies" (Williamson, 1975).

The aim of transaction cost analysis as developed by Williamson is to minimize or economize on the related (buyer) transaction costs by selecting the most suitable governance structure for a given transaction. Transaction costs are the economic equivalent of friction in physical systems (Williamson, 1985) but not similarly directly quantifiable since transaction costs are primarily the consequence of the associated risks before (ex-ante) and during (ex-post) the transaction. Ex-ante contractual costs include costs of drafting, negotiating and safeguarding an agreement; ex-post costs include maladaption costs (transactions drifting out of alignment), haggling costs (correcting ex-post misalignments) and setup and running costs (Williamson, 1985)[6].

According to Williamson (1985), "it is the difference between rather than the absolute magnitude of transaction costs that matters... Empirical research on transaction cost matters almost never attempts to measure such costs directly. Instead, the question is whether organizational relations (contracting practises; governance structures) line up with the attributes of transactions[7] as predicted by transaction cost reasoning or

[5]Vertical integration means managing economic activities within the firm. Porter (1980, p. 300) defines it as "the combination of technologically distinct production, distribution, selling, and/or other economic processes within the confines of a single firm. As such, it represents a decision by the firm to utilize internal or administrative transactions rather than market transactions to accomplish its economic purposes". For transaction cost related studies of vertical integration, see also e.g., Klein et al. (1978); Armour and Teece (1980); Balakrishnan and Wernerfelt (1986); Casson (1986) and Hennart (1988). For cases of vertical disintegration, see e.g., Boone and Verbeke (1991).

[6]From a different perspective, contractual costs can be divided into information, bargaining and enforcement costs (Rugman, 1986).

[7]In this study, transaction attributes are understood as the characteristics of a transaction such as the necessary time-span needed to carry it out, the type of product or service in question, the type of payment or compensation and the type of human interaction necessary to facilitate the exchange.

not" (p. 22). So far, transaction cost analysis has not yet yielded into a formal analysis. However, for special cases, mathematical models for the analysis of transaction costs do exist (e.g., Grossman and Hart, 1986; Kreps, 1990; Milgrom and Roberts, 1988 ; 1990).

Transaction cost analysis is based on an economic and business concept other than simply profit maximizing behaviour by economic organizations intending to carry out a transaction (Williamson, 1985). It shifts attention from considering production functions alone to studying the transaction as the basic unit of analysis (Commons, 1934), using the choice between a contractual relationship (Llewellyn, 1931) and a formal organization (Barnard, 1938) as the basic framework. Here, a firm is seen more as a governance structure than as a production function, but it is also more than just a "nexus of contracts" (Alchian and Demsetz, 1972; Jensen and Meckling, 1976; Fama, 1980). Modern transaction cost analysis is therefore a micro-analytic approach combining theories of economics, law and organization (Williamson, 1985)[8].

Transaction costs result from the way the economic system is run (Arrow, 1969) which in turn depends on both environmental and human factors (Williamson, 1975). Following Williamson's approach (1975; 1985), an environmental factor reflects the uncertainty or complexity surrounding the exchange[9]. This could result, for example, from market development uncertainties, technical difficulties related to the object of the transaction or from some form of unidentified contingency connected to the planned

[8]Transaction cost analysis should be viewed in a broader context, which includes the analysis of different costs such as those of production, the design of goods or services and , social aspects like customs or habits (Riordan and Williamson, 1985; Williamson 1985) or management costs of internalization (Demsetz, 1988).

[9]Williamson maintains that "the distinction between deterministic complexity and uncertainty is inessential" (Williamson, 1975, p. 23) and, referring to Simon (1972, p. 170) points out that "whatever its source, approximation must replace exactness in reaching a decision".

transaction. The human or behavioural factors are bounded rationality and opportunism.

Bounded rationality refers to the "limited capability of individuals to receive, store, retrieve and process information without errors" (Williamson, 1975, p. 21). Bounded rationality means that an individual is "intendedly rational but only limitedly so" (Simon, 1961, p. xxiv). Bounded rationality is closely connected to environmental uncertainty. Together with environmental uncertainty this implies that transactions are governed by incomplete contracts and that unexpected (costly) contingencies may arise. If unbounded (complete) rationality existed, one would be able to identify all possible contingencies and choose right away the best alternative without any costs, whereas bounded rationality only allows to reduce the possible risks, but at a cost.

Opportunism means self-interest seeking with guile. It reflects an incentive to cheat if this will improve one's position in the exchange. Opportunism is a form of strategic behaviour (see e.g., Schelling, 1960; Goffman, 1969) and it plays an important role when choosing among different contractual alternatives. It includes, e.g., strategic manipulation of information, non-disclosure of information even if asked, abuse of the other party's weakened position etc. Williamson (1985, p. 49) identifies opportunism as "a troublesome source of behavioural uncertainty". Both bounded rationality and opportunism can occur ex-ante and ex-post, which implies that the theory of transaction costs goes far beyond the scope of profit-maximizing neoclassical economic theories[10].

[10]Evolutionary theories (see e.g., Nelson and Winter 1982) consider individuals in a society to be behavioural in a specified way without self-interest. In evolutionary economics the behavioural pattern and the evolution of the firm is governed by "routines which are the skills of an organization" (Nelson and Winter, 1982, p. 124) and not by deliberate choice of actions. Nelson and Winter state that "the core concern of evolutionary theory is with the dynamic process by which behaviour and market outcomes are jointly determined

Given the environmental and behavioural factors mentioned above one can identify transaction-specific factors such as asset specificity and the frequency of transactions. Asset specificity reflects the degree to which transactions need to be supported by transaction specific assets which cannot be deployed elsewhere, such as product-specific manufacturing equipment or tools needed to carry out the transaction[11]. It can also refer to the level of required technological and managerial know-how (Teece, 1984).

Williamson (1991a) identifies six types of asset specificity: site specificity (related to inventory and transportation expenses), physical asset specificity (e.g., specialized dies to produce a component), human-asset specificity ("learning by doing"), brand name capital, dedicated assets (discrete investments) and temporal specificity (related to the importance of timely responsiveness). The presence of asset specificity under conditions of uncertainty makes the transaction more complex and conventional trading arrangements associated with non-specific transactions may no longer be suitable. Instead, special transaction-specific arrangements may become necessary to carry out the transaction successfully.

The frequency of the transactions refers to how often the transactions take place. This may be an important factor, since together with asset specificity, it determines whether one should use standard or non-

over time" (p. 18). Evolutionary economics has therefore strong implications for the strategic management of a firm's core competences, see infra.

[11]Asset specificity is a very strong condition in determining transaction costs and efficient economic organizations. Other theories, like contestability theory (Baumol, Panzer and Willig, 1982) acknowledge the existence of asset specificity but do not consider it to be significant. A perfectly contestable market has no entry barriers (extra costs) for entrants which are assumed to have full access to the same technologies with equal costs as the incumbent firms.

standard contracts[12]. Standard spot contracts are efficient in cases where the level of asset specificity is low, irrespective of the frequency of transactions. Here, the market mechanism works sufficiently well and one can use spot contracts. In cases where the level of asset specificity is high and the frequency of the transactions is low, long term contracts may be sufficiently flexible to absorb ex-post contingencies. However, in the case of transactions associated with both a high level of asset specificity and a high frequency, relational contracting within a unified governance structure is the most suitable solution. This implies that a firm needs to internalize the activity and carry it out in-house. Hence, the two polar extremes of "markets" and "hierarchies" (Williamson, 1975).

Zagnoli (1988) has extended Williamson's contractual continuum to study inter-firm agreements in high technology sectors. Such inter-firm cooperation[13] falls between market contracting and internalization and is called "hybrid form" (Williamson, 1991a). Such cooperative agreements include activities such as joint research and development, know-how or manufacturing integration and joint marketing and distribution between firms. Hybrids are associated with a reciprocal, relatively high level of asset specificity whereby both partners need to make an effort to carry out the transaction successfully. Hybrids are therefore efficient for transactions where both parties need to make longer-term mutual commitments and where the level of uncertainty or complexity is

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[12]This is the case when bounded rationality and opportunism are also present. In this study, the importance of frequency is not an issue, because transactions with CERN are typically of the non-recurrent type (see Chapter 3).

[13]Cooperation is understood here as "similar or complementary coordinated actions taken by firms in interdependent relationships to achieve mutual outcomes or singular outcomes with expected reciprocation over time" (Anderson and Narus, 1990, p. 45). For other definitions, see e.g., Ouchi (1980), Axelrod (1984), and Contractor and Lorange (1988), Kotabe and Swan (1995).

relatively high. As an increasing function of asset specificity, hybrids sequentially follow markets before hierarchy (Williamson, 1991a).

Based on the above, one can draw the following conclusions. First, transaction cost analysis suggests three types of governance structures to efficiently carry out transactions. These three modes are market contracting, hybrids and internalization. In this case, transaction cost analysis suggests that spot market contracts may not always be efficient in a high tech environment such as at CERN.

Even though conventional transaction cost analysis has focused primarily on choosing among different possible governance structures, it can also be applied in a normative manner, within a single governance structure. That is, the same philosophy can be extended to study only spot contracts under the assumption that this type of governance structure cannot be altered. The level of asset specificity (and the transaction frequency) then indicates the relative level of transaction costs associated with the contracts for different types of transactions.

2.3. The impact of buyer-supplier linkages on core competences

Strategic management deals with managing change. Teece (1984, p. 87) sees it as managing the need of the firm "to match its capabilities to an ever-changing environment if it is to attain its best performance". The pattern of decisions aimed at achieving a given goal is related to both strategy formulation and implementation and its effectiveness should be assessed over a longer period of time (Andrews, 1971).

Strategic management can therefore be understood as coordinating a set of actions over time which hopefully will lead to an optimal benefit-cost ratio[14]. These actions can be either intentional or unintentional[15].

Two major schools of thought dominate the present literature of strategic management, namely the competitive forces approach and the resource-based view of a firm (Teece, Pisano, Shuen, 1990). The primary purpose of the review below is to study buyer-supplier linkages and their impact on supplier core competences.

The concept of responding to the different competitive forces in a given industry or environment was developed by Porter (1980) following the structuralist paradigm tradition of Mason (1949) and Bain (1959). The competitive position of a firm depends on how well the company can defend itself against five competitive forces in the relevant industry. These five forces are competitors (competition in the industry), potential entrants (threat of new entrants), buyers (bargaining power of buyers), substitutes (threat of substitute products or services) and suppliers (bargaining power of suppliers)[16].

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[14]The cost-benefit analysis is understood here in broader terms than just as a quantitative "decisional balance-sheet" (Janis and Mann, 1971), namely as an approach to limit the number of strategic choices (Ghemawat, 1991).

[15]In fact, de Bono (1984, p. 143) sees strategy as "good luck rationalized in hindsight". Similarly, Mintzberg(1985; 1988) regards strategy as a stream of actions or decisions which originally could have been unintended. The realized strategy would therefore result from either a deliberate or an emergent strategy, the latter referring to set of actions which simply took place, perhaps unrecognized at the time.

[16]In the structuralist paradigm, buyer and supplier conduct (which, in turn, depends on the structure of the relevant market) affect company performance. Porter (1980) further elaborates on the strategic significance of buyer selection or the choice of target customers. The selection criteria include considering the purchasing needs versus company (supplier) capabilities, growth potential, the structural position of the buyer and the cost of serving this buyer. In turn, the key issues in an efficient purchasing policy are stability and competitiveness of the supplier pool, the optimal degree of vertical integration, the allocation of purchases among qualified suppliers and the creation of maximum leverage with chosen suppliers. In another context, Ford and Farmer (1986) link make-or-buy decisions (which are related to vertical integration/disintegration) to the company policy, cost or business approach considering them key strategic issues. See also Venkatesan (1992) for identifying core product components and strategic outsourcing.

Based on this framework, the firm is capable of analyzing both the structure of the industry and its competitors. The areas of competitor capabilities (both strengths and weaknesses) can be in the products, distribution, marketing and selling, operations, research and engineering, overall costs, financial strength, organization, general managerial ability, corporate portfolio, personnel structure, government relations and so on. From analyzing these, the competitive strategy[17] of the firm follows.

Porter (1985) provides an in-depth guide to implement the strategies of cost leadership, differentiation and focus to gain competitive advantage. Porter introduces the concept of value chain to understand the sources of cost reduction and differentiation within a firm. The value chain consists of strategically important company functions or activities which create both costs and customer value. The structure of the value chain differs between companies and industries. It is the optimization of the collective actions and the minimization of total costs in the value chain in comparison to competitors which creates a competitive advantage. Porter calls these activities primary and support activities.

Primary activities include inbound logistics (material handling, warehousing, inventory control, vehicle scheduling and returns to suppliers), operations (machining, packaging, assembly, equipment maintenance, testing, printing and facility operations), outbound logistics (finished goods warehousing, material handling, delivery vehicle operation, order processing and scheduling), marketing and sales (advertising, promotion, sales force, quoting, channel selection, channel relations and pricing) and service (installation, repair, training, parts supply, and product adjustment).

[17]For a general comparison of generic versus competitive strategy, see Rumelt (1980).

Support activities instead include procurement (function of purchasing inputs), technology development (supporting technologies embodied in value activities), human resource management (recruiting, hiring, training and compensating of all types of personnel) and firm infastructure (general management, planning, finance, accounting, legal, government affairs and quality management).

The support activities represent the principal trading interface with external partners in terms of managerial, administrative and legal involvement. Porter points out (1985, p. 48) that "the value chain is not a collection of independent activities but a system of interdependent activities". In addition to linkages within the company value chain, there are also linkages between the company and supplier and channel value chains. The concept of the value chain can be used to study the benefits and costs of coalitions in global strategies (Porter and Fuller, 1986) and the structure of industries to identify the competitive advantage of nations (Porter, 1990).

In contrast, the resource-based perspective on strategy is based on the notion that from its strenghts and weaknesses, the organization creates over time a set of truly distinctive competences which transforms into superior economic performance (Learned et al., 1969; Wernerfelt, 1984; Cool and Schendel, 1988; Peteraf, 1993, Hamel and Prahald, 1994; Hamel, 1996). These are called the core competences of the firm.

The core competences of the firm have three specific characteristics. First, they enable firms to develop new products and participate in diverse businesses. Second, they are difficult to imitate by competitors. Third, core competences should contribute to perceived customer benefits. Developing these core competences within the organization takes a long time and is a complex process (Dierickx and Cool, 1989). This implies that these capabilities cannot be simply purchased on the market (e.g., by vertical integration or diversification) but instead that they can only develop in a context of learning (Hamel, 1991; Slocum et al., 1994). Companies can therefore seldom quickly shift from one attractive industry to another and be successful. Instead, they position themselves in a given industry structure and move incrementally based on their firm-specific assets (Hayes, 1985).

The theoretical foundations of the resource-based perspective lie in evolutionary theories of both innovation (Schumpeter, 1934; 1942) and organizational behaviour of learning or "routines" (Nelson and Winter, 1982), the transaction cost framework of capability-related specific assets (Williamson, 1975; 1985) and the selection of strategic choices based on both complementary assets and technological opportunities (Teece, 1986; 1988; Dosi et al. ,1988).

Teece (1986) discusses the strategic use of contracts as opposed to vertical integration to obtain access to complementary assets. Focusing on technological innovation, Teece argues that imitators and followers can outperform the original innovator in successfully commercializing a new product if they are able to establish an appropriate control structure over necessary assets outside the company. These assets can be for instance competitive manufacturing, complementary technologies, service or specialized distribution channels[18]. Depending on the type of required complementary assets, strategic contractual partnering can be an ideal

[18]In spite of Teece's (1986) contribution, the literature on the strategic management of core competences is more vague about the market feedback and driving mechanisms (e.g., the role of marketing and sales), as compared to R&D or technical skills in the process of enhancing longer-term competitive advantage. Porter (1992) makes a similar comment, warning against adopting a too dominantly technology-driven perspective, while trying to achieve competitive advantage.

solution when the core technology or know-how is well protected and the complementary assets are readily available on the market. In order to keep imitators and followers - possibly existing partners - at bay, one needs to identify, strengthen and keep the core technological know-how inside the company (Teece, 1991).

The issue of complementary assets is a central theme in the literature on cooperative strategies (Hagedoorn and Schakenraad, 1990). Companies engage in cooperative agreements to achieve foreseen benefits through technological complementarity and technology transfer (Mariti and Smiley, 1983) and hybrids (Blois, 1972; 1980)[19]. These interactions, being either formal or informal, can be viewed as an industrial networks approach on the basis of e.g., technology, country or focal organization (Håkansson, 1987; 1989; Håkansson and Johanson, 1988). The industrial network develops over time and contains the history of the interactions within it. The companies therefore need to develop and maintain a strategic identity in the network in order to belong to it.

The concept of network (see e.g., Evan 1966, Schermerhorn 1975; Van de Ven, 1976; Aldrich and Whetten, 1981; Fombrun, 1982; Milward, 1982; Provan, 1983) was originally applied to study inter-organizational relationships within non-profit organizations but is also used in a wider context as a substitute for hybrids (Thorelli, 1986). Jarillo (1988) further developed this concept and views networks as a mode of organization

[19] Hybrids are understood here as vertical quasi-integration which is a form of governance structure between complete vertical integration and out-sourcing. The partners contribute by providing complementary inputs. Other reasons for setting up cooperative agreements (not necessarily based on complementary assets) are to reduce the risks associated with projects, to gain from economies of scale and production rationalization, co-opt or block competition by defensive moves, overcome trade barriers and/or government-mandated investements, or to facilitate initial international expansion (Contractor and Lorange 1988). Cooperative arrangements are not only made by partners, but increasingly by competitors, as well (Fusfeld and Haklisch 1985; Hamel, Doz and Prahalad 1989; Jarillo and Stevenson 1991).

where companies form a relationship with a long-term point of view, consisting of relatively unstructured tasks and unspecified contracts.

The strategic network provides complementary assets to which the associated companies can get access in an economical way and protects them against competitors which are outside the network. The participating companies need not necessarily link all their internal activities to the network. The concept of value chain can be used to distinguish those company activities that are part of the strategic network[20] and those which can be farmed out. The network may be run by a "hub firm" as the centre of activity, introducing a cost discipline. The sustainability of the network (or low transaction costs) is based on building trust among the members to prevent opportunistic behaviour.

The buyer-supplier relationship in cooperative strategies is seen more as a longer-term partnership where the buyer narrows the vendor set to potential partners which have unique complementary skills and share conflict-resolving management skills (Spekman, 1988). Conversely, the supplier can benefit from such a long-term collaboration (Kalawani and Narayandas, 1995). Communication and information sharing form the backbone of the relationship (Konsynski and McFarlan, 1990). In this context, a partnership should be viewed as a dynamic relationship and not as a one-time agreement; it requires a specific governance structure (Doz, 1988). For the partners, the benefits need not be symmetrical (Axelrod, 1984).

[20]In a strategic network, behaviour is assumed to be intentional and a conscious effort is required to keep the network active. But networks need not be understood only as governance structures between markets and hierarchies but instead as structures emerging from and being governed by transactions themselves, these being either intentional or unintentional (Nordberg and Verbeke, 1996).

As a conclusion, it is clear that the literature recognizes the link between longer term effects of firm actions on company core competences. Second, the literature also recognizes the value of cooperative relationships, e.g., in the form of enhanced core competences or performance in a network of collaborating companies. However, these actions resulting in longer term company-specific benefits are viewed in terms of intentional, self-interest seeking behaviour. But in the spirit of Mintzberg (1985), the buyer-supplier relationship, which is the focus of this study, could also lead to outcomes or supplier benefits that simply emerge, are not anticipated or precisely predicted beforehand but which just arise over time and can be utilized at a later stage by the supplier. The question then arises whether such longer term spill-over effects may indeed result from transactions with research and technology-intensive organizations[21]. To answer this question, one needs to turn to the literature on the impact of research and development.

2.4. Supplier impact of R&D-intensive organizations

The literature on the impact of research and development (R&D) can be divided into two segments: one that studies the impact of industrial R&D and one that assesses the effects of government funded R&D[22]. Both micro- and macro-economic methods have been used to assess these effects . Due to the scope of this study, the focus will be on the literature of the economic impact of government-funded R&D-intensive organizations on their suppliers.

[21] Such organizations are assumed not only to be interested in buying products or services but in parallel to transfer knowledge and technology to collaborating companies. A firm may therefore be able to benefit from other research and development work carried out outside the specific transaction.

[22] Obviously, these two effects are closely connected to each other since industrial R&D is also funded by governments.

The impact of non-defense R&D on industry is generally related to basic and applied research and development work carried out by universities and national research laboratories, some of them in collaboration with the industry[23]. Nelson (1959) has identified basic research as the source of significant advances and as a prerequisite to maintain an enterprise based economy. Lederman (1984) has identified profound impacts on society in general, resulting from basic research. Utterback (1971) has found evidence that ideas and successful innovations of new products are most frequently need-stimulated by the scientific community or users, i.e. initiated by the recognition of a need or technical problem rather than by the recognition of exploitable technical information or opportunities.

Von Hippel (1976; 1988) has reported supporting findings concluding that successful innovations in scientific instruments are highly user-dominated processes whereby the university or research institute has been involved in the invention, prototyping, related information distribution and pre-commercial replication of the scientific instrument. The manufacturer, who often is already in that specific market, is often "pushed" by the scientific users to enter a new product line[24].

Rosenberg (1991) has observed that the emergence and diffusion of new technologies of scientific instruments are central to economic growth. He

[23]The National Science Foundation (1990, p. 34) classifies R&D into basic research (directed towards increases in knowledge), applied research (knowledge on how specific needs may be met) and development (systematic use of the knowledge gained from research). For the relationships between basic and applied research in innovation, see e.g., Gibbons and Johnston (1974). For a view of R&D as a function or process, see e.g., Merten and Ryu (1983). For literature on the transfer of knowledge from universities and research laboratories to the industry, see e.g., Reimers (1980); Roberts (1981); Stankiewicz (1986); Dorf (1988); Godkin (1988).

[24]The scientific instruments in question (gas cromatography, nuclear magnetic resonance spectrometry, UV spectrophotometry, transmission electron microscopy) were commercialially introduced between the years 1939 and 1954. Von Hippel (1982; 1988) suggests similar user-developed product strategies for both consumer and industrial markets, as well.

has identified the importance of transfer of scientific instruments among academic disciplines and interdisciplinary collaboration and movement of scientists in the process of generating benefits. This effect can be seen strongly in transfers from fields such as physics and chemistry to fields such as biology, clinical medicine and health care delivery. Rosenberg has also argued that in the absence of university research capabilities both the rate and direction of technological change would have had a smaller economic impact, rather than just causing a time delay in the commercial introduction of new products.

Lederman and Carrigan (1987) have identified transistors, computers, lasers, television, nuclear energy and biotechnology instrumentation as the most important technologies which have resulted from quantum physics research and conclude that these developments have contributed to about 23% of the present U.S. Gross National Product.

Areas where the secondary economic impact of research has been studied periodically are space research and high energy physics, with a focus on the leading centres in these fields[25]. Evans (1975) estimated that increasing the level of NASA's (National Aeronautics and Space Administration) annual expenditures by $1 billion from 1975 onwards would have resulted in an increase of $22 billion in U.S Gross National Product in 1984 and would have created 1.1 million new jobs by that year. Mathematica (1976) measured the transfer of technology from NASA using case studies in cryogenics, integrated circuits, propulsion and software development. This study reported new product developments and substantial cost reductions.

[25] However, most of these studies suffer to some degree of ill-defined research methodologies and inconsistent terminology.

Mathtech (1977) studied a number of innovations resulting from NASA technology and estimated, e.g., a benefit/cost-ratio[26] of 4 for pace-makers intended for cardiac patients. Midwest (1988), concluded that NASA R&D expenditures of $148 billion (in 1982 dollars) have generated an integrated return of more than $ 950 billion to the U.S. economy during the period 1960 - 1986, based on calculations of economic gains of R&D in general in the United States and on an earlier study made in 1971.

Chapman et al. (1989) studied the economic impact of NASA spin-offs, the secondary use of major research and development efforts. Excluding direct NASA-furnished technology amounting to about $12 billion in sales, Chapman et al. report that sales and savings derived from NASA-spin-offs resulted in about $22 billion in total, in addition to roughly 352 000 jobs created or maintained between the years 1978 and 1986. Interviews of 400 suppliers and studies of 441 separate instances of NASA-sponsored or NASA-provided technology led to the conclusion that 83% of the cases resulted in benefits in terms of savings or sales. The highest impacts were in transportation (46% of total sales and savings generated, mostly in aviation), industrial manufacturing and processes (27% of total sales and savings) and medical applications (9%). In about 15% of all cases, a product, process or an entire company would not have come into existence without NASA-furnished technology.

The products having the highest direct sales or savings impact out of 72 technical applications were products such as medical instruments (33% of total sales and savings), musical instruments (15%) and special foams (12%)[27]. In addition to benefits of direct commercial use of NASA-

[26]This was defined as the ratio between the generated secondary sales of the new product in a given market divided by the expenditure by NASA for that product.

[27]It is perhaps interesting to note that products such as Teflon (special coating material), Velcro (adhesive tape) and Tang (breakfast drink), generally attributed to the Apollo-

technology in products or processes, Chapman et al. (1989) identified enhanced markets for other similar products, accelerated product commercialization, distribution or transfer of technology and technical information to other public agencies and users and creation of new companies.

Bezdek and Wendling (1992), using input-output analysis (Leontief, 1966) to measure and analyze the interdependence of all industries in an economy, also included the indirect benefits in their study of economic benefits of NASA. They were thus able to take into account the benefits flowing from the second-, third-, and fourth rounds[28] of subsequent industry purchases from NASA procurement which had been neglected in previous studies (see e.g., National Academy, 1988). Bezdek and Wendling report an input-output multiplier effect[29] of 2.1 on NASA procurement of $8.6 billion in 1987, generating $17.8 billion in total industry sales, $2.9 billion in business profits, $5.6 billion in tax revenues and 209, 000 private-sector jobs in that year. The authors also concluded that the total employment created in various industries does not necessarily correlate with the corresponding sales volume.

The literature on the macro-economic impact of expenditures of R&D-intensive organizations would therefore suggest that there are benefits to the participating industries. The next question is how these benefits relate

space program, were not spinoffs of the space programs but were developed between 12 and 30 years before the first lunar landing (Alic et al., 1992). For periodical reviews on spinoffs from NASA, see e.g., NASA (1990).

[28]These included the indirect, pervasive effects generated by the NASA expenditures (e.g., through cumulative purchases and subcontracting) throughout the country.

[29]This is the ratio between total output and direct output. Total output is the sum of direct and indirect output requirements. Direct output requirement is an industry-specific estimate which indicates the volume of purchases needed to produce one unit of output as defined by the NASA expenditures. The direct output requirements generate subsequent rounds of indirect requirements that can have even fourth-order effects down the supply chain.

to enhancing firm-specific core competences and the value chain functions.

BETA (1980; 1988a) has studied the indirect micro-economic effects of the expenditures by ESA (European Space Agency) for the periods 1964-1976 and 1977-1986. Based on supplier sample sizes of 128 and 67, respectively, BETA concluded that the ratio of indirect benefits (defined as added value and intermediate consumptions) to estimated ESA-payments to the contractors was 2.9 in the first study and 3.2 in the second one[30]. The indirect benefits were divided into four categories: technological, commercial, work factor and organization and methods benefits.

Technological benefits included diversification, new ESA-products and sales of modified or new products based on ESA-technology. Commercial benefits included possible market expansion, the use of the ESA-reference and commercial collaboration with new companies or research institutes. Work factor or labour-related benefits included maintaining qualified personnel ("critical mass" to preserve the necessary technological know-how). Organization and methods benefits included improvements in production methods, quality control, cost savings and in management techniques.

In the later study, the most important effect appeared to be in the area of technological benefits (43% of all indirect benefits), followed by work factor benefits (41%), commercial benefits (9%) and organization and methods benefits (7%). The indirect benefits amounted to 12, 680 million ESA-

[30]The benefit-cost-ratio is calculated here by estimating the impact of the awarded ESA-contracts based on the past and projected company sales, divided by the estimated ESA-payments to the contractors. For literature on the origin of the methodology, see e.g., Schmied (1977; 1987), Balthasar et al. (1978), BETA (1988b).

accounting units[31] (AUs, in 1986 prices), including the sales projections up to 1991. The corresponding cumulative expenditure was 3, 900 million AUs (in 1986 prices) up to 1988. Of the generated indirect benefits, 79% remained in the space sector (mostly in propulsion and telecommunications technologies and in ground facilities) whereas the remaining 21% fell outside space-related activities (mostly in aeronautics and defense).

The contributing technologies in the latter category were onboard electronics, production and test equipment and power supplies. Following the methodology of the first study, a time lag up to five years was assumed before the benefits were fully generated. The findings of the later study confirmed that this assumption was valid. The benefits were highest for equipment developers (benefit-cost-ratio of 3.9), followed by system developers (2.3), prime contractors (2.0) and service providers (1.8) The countries with the highest spinoff coefficient were Sweden (9.8), Denmark (4.5) and Germany (4.4). The countries with the lowest benefit-cost-ratio were Great Britain (1.7) and Italy (2.5)[32].

BETA (1989) reported similar findings for the impact of ESA contracts on Canadian suppliers, as well. Shachar and Zuscovitch (1990) studied in more detail 44 ESA-suppliers from the BETA-sample (1988a) and found that when the companies were seen as members of a technological network, clear learning patterns over a longer time span could be identified.

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[31] An ESA-accounting unit (AU) is linked to the ECU and equals roughly to 1.2 U.S dollars in 1990 prices.

[32] It appeared that the impact was higher for industries applying generic technologies in non-space sectors than for industries operating primarily in the space sector (BETA, 1988a).

Schmied (1975; 1977) and Schmied et al. (1984) studied the secondary micro-economic impact of CERN expenditures during the periods 1955-1973 and 1973-1982. The supplier sample sizes were 127 and 160, respectively. Using a similar methodology as BETA for the ESA-expenditures, benefit-cost-ratios[33] of 4.2 and 3.5 were reported, respectively. Since the two CERN-studies differed to some extent (interviewing techniques, team composition, target groups etc.), one cannot draw conclusions about the apparent decrease in the figures. Schmied (1984, 1987) gives a corrected coefficient of 3.7 (using 1977 constant prices) for the first study.

Both studies identified following types of benefits: turnover increases, new companies created, the use of CERN as a product test-bed, maintaining production capacity, inter-company collaboration, cost savings, product innovations, quality improvements and the use of the CERN-reference for marketing purposes. The distribution of these benefits was not quantified but in the later study they were expected to have a cumulative magnitude of 3, 100 million Swiss Francs[34] by the year 1987 (in 1982 prices). The purchasing expenditures of CERN between 1973 and 1982 amounted to a total of 750 million Swiss Francs (in 1982 prices).

The industrial category of electronics, optics and computers had the highest impact (benefit-cost-ratio of 6.1), followed by steel and welding (5.3), vacuum, cryogenics and superconductivity (3.0), electrical equipment

[33]In the CERN-studies, these are called utility/sales to CERN-ratios. Economic utility is interpreted here as the sum of increased turnover and cost savings which differs slightly from that of BETA (1988a) where utility is understood as the value added expressed in terms of company sales, excluding effects in terms of cost reductions.

[34]One Swiss Franc equals about 0.7 U.S dollars in 1990 prices. Schmied (1982) gives the breakdown of the types of benefits reported in the first CERN-study. Here 46% of the net utility consisted of technological benefits, 45% of commercial benefits and the remaining 9% of cost savings (or organization and methods benefits) and the maintaining of production capabilities (or work factor benefits). On average, it took less than three years to generate the secondary effects.

(2.1) and precision mechanics (2.1). It appeared that 76% of CERN-generated utility spread over diverse commercial and industrial markets, notably in the electrical industry, railways, computers and telecommunications. Of the 160 companies interviewed, 55 reported no utility.

Schmied (1982; 1987) has compared the indirect economic benefits generated by CERN and ESA. Schmied's primary conclusion is that the total utility factors are very close to each other, in spite of the different contract policies. However, at the industrial sector level, the differences in contract policies may have an impact, as is the case in computing, where the utility factor is much higher for CERN[35]. Secondly, in the case of CERN, a major part of the utility is directed outside the physics research market whereas with ESA the major part tends to remain in the space market. Thirdly, CERN's new accelerator projects always become, after their completion, an integral part of the laboratory's existing infrastructure. They need to be operated and maintained for decades to come whereas ESA's space crafts are not accessible to suppliers for repair and maintenance. Fourthly, CERN is geared more towards component-purchasing than ESA, which typically places contracts for complete systems. Since ESA-contracts can be 10 or even 100 times larger than CERN contracts, ESA clearly has a bigger impact on project coordination, management and training benefits. The major differences in the types of benefits generated by ESA and CERN, based on the latter findings above by BETA and Schmied, are summarized in Table 2.1.

[35]According to Schmied (1982), this is because CERN, as opposed to ESA, does not have geographical purchasing restrictions and whenever CERN places an order with a European supplier based on the best price/quality ratio, this will have a considerable impact on future sales. .

Table 2.1 Differences in the types of benefits or utility the European Space Agency and CERN generate for their suppliers.

Characteristics of benefits	Research organization	
	ESA	CERN
Volume of expenditure[a] (in million AU[d])	3, 900	625
Volume of indirect benefits generated by the suppliers[b] (in million AU)	≥ 12, 680	≥ 2, 200
Benefit-cost- ratio	≥ 3.2	≥ 3.5
Major areas of benefits	Technological, work factor	Technological, commercial[c]
Type of technology having a major impact, in volume of benefits	Propulsion, telecommunications	Electronics, optics, computers, electrical equipment
Time-lag in benefits (in years)	≤ 5	≤ 3[c]
Type of market undergoing a high impact, in volume of benefits	Space market	Diverse commercial and industrial markets
Main type of contracts generating the benefits, in volume	System and subsystem deliveries	Component manufacturing

a) European Space Agency 1977-1986 (1986 prices), CERN 1973-1982 (1982 prices).
b) European Space Agency 1977-1991 (1986 prices), CERN 1973-1987 (1982 prices).
c) This data is from the first CERN study but is assumed to apply to the second study, as well.
d) AU refers to European Space Agency Accounting Units (1 AU equals to roughly 1.2 Swiss Francs in 1982 prices).

Given the literature review on the impact of expenditures of R&D-intensive public organizations on suppliers , the following observations can be made.

First, it appears that technology-related purchases have an economic, multi-industrial impact.

Second, it appears that purchases by an R&D-intensive public organization have an impact on supplier value chain functions, notably on technology development, operations and on marketing. Moreover, the impact appears to be higher in cases where the products in question are linked to the core products of the supplier. The fact that the products are nevertheless buyer-specific, suggests that the supplier has been able to tap into some complementary assets provided by the buying organization. This would therefore lead to the conclusion that this process of utilizing complementary assets through vertical linkages further enhances supplier core competences and the long-term economic performance of the suppliers.

2.5. Conclusions and summary

The literature review set out to answer two questions. First, given the institutional boundaries of a high tech-driven public organization, what is the efficient governance structure to manage technology-intensive buyer-supplier transactions? Second, what impact could such transactions have on supplier core competences?

The transaction cost analysis literature was discussed to answer the first question. It identifies high asset specificity as the main reason why both the buyer and the supplier may need to engage in special efforts to facilitate the exchange. Furthermore, it argues that spot market contracts may not be the most suitable governance structure to manage transactions in a cost- and technology driven environment, although this may be required by institutional constraints.

The strategic management literature was then examined to answer the second question. It suggests that, indeed, the buyer can be a source of complementary assets for the supplier. By tapping into these complementary assets, the supplier can enhance his own core competences. However, the literature did not provide details on the exact nature of the core competences that are generated.

The empirical research literature on industrial benefits of R&D-intensive public research centres does provide a description of the benefits that technology-driven customers can generate for their suppliers. It appears that purchases by an R&D-intensive public organization have an impact on supplier value chain functions, notably on technology development, operations and on marketing. Moreover, the impact appears to be higher in cases where the supplier is able to utilize the complementary assets offered by the customer to meet the buyer-specific requirements. Thus, the literature review suggests that buyer-supplier linkages could indeed be a source of core competences to the suppliers.

CHAPTER 3: ANALYSIS OF THE RESEARCH PROBLEM - THE CASE OF CERN-INDUSTRY LINKAGES

3.1 Introduction

CERN is a basic research center whose main research mission is achieved by applying advanced technologies on an industrial scale. This chapter focuses on how CERN interfaces with industry in terms of buyer-supplier linkages. This description is necessary in order to develop the conceptual framework in Chapter 4.

3.2 Mission, brief history and structure of CERN

3.2.1 Mission and the history of CERN

CERN was founded in 1952 in Geneva, Switzerland as a joint European effort to provide research tools for physicists studying the smallest constituents of matter (Hentsch, 1991). At that time, the smallest known particles were the nuclei of atoms and the related research was thus called nuclear physics.

The first CERN-machine accelerated protons and "smashed" them into fixed targets producing showers of new particles. This was the 0.6 GeV[36] Synchro-Cyclotron (SC) which became operational in 1957. The Synchro-Cyclotron was built to study the decay of the carrier particles of the strong force which holds the nucleus of the atom together. The Synchro-Cyclotron provided new information about the electron-decay mode of the charged pi-meson (Ashkin et al., 1959) and the magnetic moment of the muon (Combley, Farley and Picasso, 1981).

[36] 1 GeV equals roughly to the energy a proton has if converted from its mass m to energy E according to Einstein's famous equation $E = mc^2$, c being the speed of light.

The next machine, the Proton Synchrotron (PS), was in operation by 1959 with an energy of 28 GeV. Even though the Proton Synchrotron was a very high energy accelerator, major new discoveries in the 1960's were made elsewhere. These discoveries included particles like the different types of neutrinos (Danby et al., 1962), the Ω^--particle (Barnes et al., 1964) and the CP-violation (Christenson et al., 1964). This was mostly due to less competitive detectors at CERN than elsewhere. Nevertheless, the Proton Synchrotron proved to be a powerful tool in physics. It confirmed the discoveries of the resonances of the S,T,U mesons (Focacci et al., 1966) and provided new physics in resonance formation, shrinking of the diffraction peak and in polarized targets[37].

During the 1960's studying the ultimate structure of matter went beyond nuclear physics to a more fundamental level, called from then on particle physics. The underlying principles of the three experimentally confirmed forces, the electromagnetic, strong and weak force, became the primary focus of research. The manifestation of different particles - amounting by the late 1960's up to more than one hundred - was now of focal interest.

By the early 1970's, CERN was making important contributions again. By advanced bubble chamber detectors and improved performance of the Proton Synchrotron, CERN discovered the neutral currents in 1973 (see e.g., Musset and Vialle, 1978). This provided indirect evidence of carrier particles of the so called electro-weak force, predicted by theoreticians. The electro-weak force was the link between the apparently different electromagnetic and weak forces. It thus simplified the concept of

[37]For an overview, see Jacob (1981, p. 24-29 and 47-51).

different forces and particles. The theory was from then on referred to as the Standard Model[38].

In 1971 CERN's first collider, the Intersecting Storage Ring (ISR) came into operation. The Intersecting Storage Ring provided head-on collisions between proton bunches circulating in opposite directions with beam energies of 31 + 31 GeV.

The Intersecting Storage Ring discovered that the total cross-section for proton-proton collisions rises with energy. It also confirmed the existence of high quantity high transverse momentum events (Giacomelli and Jacob, 1979). This indicated that the protons had some point-like inner structure. This in fact had already been suggested by theoreticians in the early 1960's (Gell-Mann, 1964). The proton-beam collisions at the Intersecting Storage Ring also generated particles with a jet-structure as well as electron and muon particle production (Giacomelli and Jacob, 1981).

In order to study the inner structure of protons called the quarks in more detail, CERN built the 400 GeV Super Proton Synchrotron (SPS). This machine was equipped with sophisticated detectors. Even though major discoveries were again made elsewhere, like the discovery of the dimuons (Aubert et al., 1974; Augustin et al., 1974) and the upsilon-particle (Herb et al., 1977), the Super Proton Synchrotron provided physics with impressive statistical data. In 1980 the decision was taken to transform the Super Proton Synchrotron into a proton-antiproton collider to produce higher energies. This was a new concept at the time (Rubbia, 1977). The first proton-antiproton or p^+p^- collisions were detected in 1981. With

[38]The Standard Model combines the theoretical work of Glashow, S L, Salam, A and Weinberg, S. For a review, see e.g., Aitchison and Hey (1989).

advanced detector systems the carrier particles called Z and W of the electro-weak force were discovered in 1983 (Arnison et al., 1983a; 1983b) The predictions of the Standard Model were thus experimentally confirmed. The discovery of the Z and W-particles, and the use of stochastic cooling for obtaining the dense antiproton beams, led to the award of the Nobel prize in 1984 to C. Rubbia and S. van der Meer. Van der Meer developed the technology necessary to produce the intense antiproton beams (Möhl et al., 1980; van der Meer, 1978).

In the early 1980's, CERN started to construct its latest and biggest accelerator, the Large Electron-Positron collider (LEP). This machine is 27 km long in circumference, obtaining 50 + 50 GeV beam collision energies. The Standard Model had yet another prediction to be confirmed experimentally, namely the existence of the Higgs particle[39] and the top-quark[40]. The Large Electron-Positron collider is well suited for finding Higgs, provided its mass is sufficiently low . It is able to produce thousands of Z-particles a day needed to provide necessary statistics to see their decay into Higgs. Due to the "cleaness" of the point-like particle collisions, concepts beyond the Standard Model could be studied, as well.

3.2.2 Status in 1996

The Large Electron-Positron collider started scheduled operation in late 1989. The four detectors at the Large Electron-Positron collider have collected sufficient data to confirm that there are three neutrino families. While neither the Higgs nor the Top-particle have yet been found at the Large Electron Positron collider, accurate mass limits of the Z-particles

[39]For a description of the symmetry-breaking mechanism generating the Higgs-particle, see Higgs (1966).

[40]For a description of the link between quarks and leptons, see e.g., Aitchison and Hey (1989).

and other properties have been measured (Aarnio et al., 1989; 1990a; 1990b).

The Proton Synchrotron and the Super Proton Synchrotron machines also allow to pursue a wide range of research programmes in high energy and nuclear physics (CERN, 1996).

Attached to the Proton Synchrotron, two major scientific projects are currently in operation. They include the Low Energy Antiproton Ring (LEAR) and the Isotope On-Line Detector (ISOLDE) for nuclear physics (CERN, 1996).

3.2.3 Future

CERN intends to increase the present colliding energies of the Large Electron-Positron collider up to 96 + 96 GeV by the end of 1998. Increasing collision energies beyond this is not feasible from a benefit-cost point of view. Moreover, the Large Electron-Positron collider will be closed down in 2000 to pave way for the next major undertaking, the Large Hadron Collider (LHC).

Following the request made by the European particle physics community, the construction work of the 7, 000 + 7, 000 GeV proton-proton collider started in 1995. The Large Hadron Collider or LHC will be built in the existing Large Electron-Positron collider-tunnel (CERN, 1995). It will be able to study both the Higgs and top-particles in more detail and test the concepts beyond the Standard Model (ECFA, 1992). According to present plans, the Large Hadron Collider is expected to be operational in 2005.

CERN also has other ambitious plans. If the on-going research and development programs for future accelerators proceed as planned, a possible next candidate for the early 21'st century is the CLIC (Compact

Linear Collider). This is a linear accelerator for electron-positron-beams of 1, 000 + 1, 000 GeV collision energy (Schnell, 1992).

3.2.4 Structure of CERN

In 1995, CERN had 19 member states and its annual budget was about 950 million Swiss Francs. These member states are Austria, Belgium, Finland, France, the Czech and Slovak Republic, Denmark, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom. The membership contribution of each country to the CERN budget is proportional to its Net National Income.

The highest decision-making body of CERN is the Council, advised by the Finance Committee and Scientific Policy Committee.

CERN is divided into four sectors. These include the physics research, accelerators, the technical sector and the administrative sector. Within each sector, there are two to four divisions. CERN has about 3, 000 staff members of which roughly 100 are dedicated to physics research only. The rest are either involved in the experiments and accelerators or provide infrastructure services. In addition to the CERN staff, there are about 6, 000 active users on site from physics laboratories and universities. Most of the users come from the member states but some 20% come from other countries (CERN, 1995).

3.3 Role of technology at CERN

3.3.1 Introduction

As physicists want to obtain higher collision energies, the diameter of the accelerator will grow as well. The radius of a conventional accelerator grows as the square of the energy level (see e.g., CERN, 1992) and the size or weight of a detector system as the logarithm of the energy (see e.g., Kleinknecht, 1986). Since the cost of a new accelerator system depends on the required energy level, physics research goals substantially influence the way it is built. It is from this dialogue between physics and engineering that new technological solutions arise and the process of designing new accelerators and detectors starts.

The design and construction of an accelerator system differs from other large-scale projects. Large undertakings such as underground transportation, ship building or high tech-hospital intensive care units also use advanced technologies. However, even though these technologies are advanced, they are embodied in commercially available products with reliable performance levels. In fact, the complexity related to e.g., shipbuilding does not come from technology. Instead, it results from the process through which the financing and insuring of the ship is managed on a global basis (Cho and Porter, 1986).

Yet with large high-energy accelerators, this is not the case. A large accelerator may have less components than a 20, 000 tonnes cargo ship consisting of more than 400, 000 components. However, the related technologies are more unique. The component characteristics are primarily determined by the physics parameters the machine is designed to meet. Furthermore, the design and construction phases extend typically beyond 10 years. Since the number of such machines is very small, well established industrial procedures cannot be readily applied. Accelerator system construction therefore differs from recurrent purchases in project-oriented industries such as electrical engineering.

3.3.2 Technological structure of accelerators and detector systems

The main components in an accelerator are the accelerating elements and, in a circular machine, the bending magnets. The particles are accelerated inside a vacuum. The vacuum system is surrounded by the accelerating elements and magnets. Finally, a control system is needed to operate the machine. The typical features or performance of the major components are shown in Table 3.1.

Table 3.1 The major accelerator components, their functional description and related typical technical parameters.

Accelerator component	Function	Technical parameters
Magnets (normal and superconductive)	To bend the trajectory of particle beams	0.3 - 8 Tesla
Radio-frequency (RF)	To accelerate the beams	0.4 - 5 GHz, 0.1 - 35 MW
Vacuum system	To facilitate the beams	10^{-6} - 10^{-12} Torrs
Control systems	To guide the beams	TCP/IP, UNIX, LANs

Accelerators produce the necessary energies for particles to collide with each other or hit a given target. For detecting and studying the new particles generated by the collision, detectors are needed. They surround the collision point and their size is proportional to the collision energies of the particles in a logarithmic manner. Table 3.2 summarizes the major components a large detector typically consists of (Aarnio et al., 1991).

Table 3.2 The major components of a large multi-purpose detector, their functional description and related technical parameters.

Detector component	Function	Technical parameters
Radiation sensors or sub-detectors	To identify different types of new particles	5µm - 2 mm spatial resolution, energy resolution
Solenoid magnet	To bend the trajectory of the new particles	1 - 3 Tesla
Return yoke	To maintain the homogenous magnetic field	500 - 1, 000 m^3, 2, 500 - 30, 000 tonnes
Vacuum system	To facilitate the detectors	10^{-4} - 10^{-6} Torrs
Gas-distribution system	To facilitate the detectors	Ar, C_4H_{10},CO_2 etc.
Data acquisition system	To transmit and store recorded physics data	200, 000 - 1, 000 000 electronic channels, 20 Mbs - 10 Gbs

The key technology in such detectors is the multi-wire proportional chamber-technique (MWPCs). This technology was developed at CERN (Charpak et al., 1968) and its inventor, Dr. G. Charpak, was awarded the Nobel-prize in Physics in 1992.

Designing and constructing a large-scale accelerator and detector system is a long-term process. In the case of the Large Electron Positron collider, it took about five years to design and eight years to construct it. The overall budget was roughly two billion Swiss Francs. A component break-down of a large accelerator and detector system is displayed in Figure 3.1.

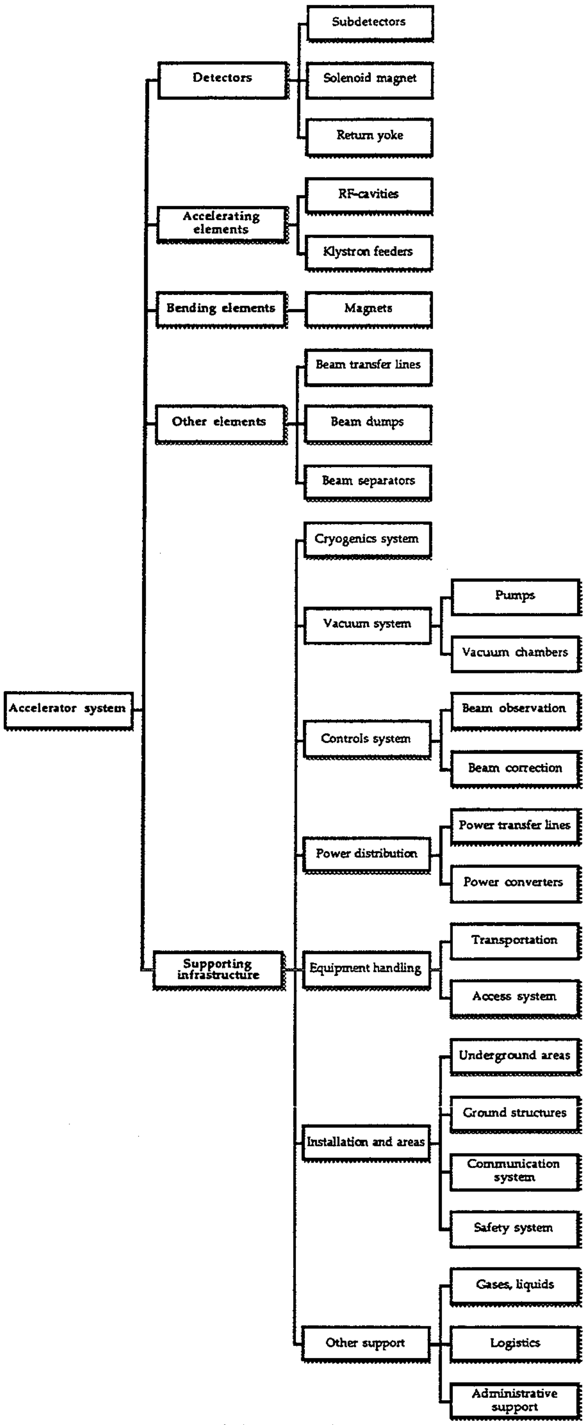

Figure 3.1 A component breakdown of an accelerator system, including the detectors.

3.3.3 Description of the technology domains and examples of product requirements

CERN uses the following classification of technology domains[41] relevant to its operations:

1 Civil engineering (category 100);

2 Electrical engineering (category 200);

3 Electronics (category 300);

4 Data processing (category 400);

5 Mechanical engineering (category 500);

6 Vacuum and low temperature technology (category 600);

7 Detectors (category 700);

8 Miscellaneous; office equipment, standard items (category 800);

9 Technical support on site, design studies (category 900).

The requirements to be fulfilled by the different products vary substantially, even under the same category. This is partially due to the way the classification is set up. The requirements depend on how critical or special the component is in the accelerator or detector system. This reflects the level of in-house expertise at CERN. As a general rule of thumb, it could be argued that the further away one moves from the core of the scientific equipment, the less severe the technological constraints become.

[41] For a detailed description, see Appendix 1.

3.3.4 The different ways CERN interacts with the industry

There are basically four different ways in which CERN interacts with the industry. These are:

1 informal information exchange;

2 short-term collaboration;

3 longer-term collaboration;

4 contract-based transactions.

Informal information exchange

CERN is constantly scanning the market to find new suitable products. Companies are invited to CERN to present their products and they are invited to give technical seminars. CERN organizes on a regular basis industrial exhibitions on-site, together with the member states. The CERN engineers visit companies and attend large industrial exhibitions. In all these cases, the information flow is rather informal, allowing to gain knowledge on both sides as to CERN and industry needs and the available solutions in the market to satisfy these needs[42].

Short-term collaboration

Short-term collaboration is typically geared around testing the suitability of existing industrial products in the CERN-environment. Potential suppliers give their products on loan to CERN and CERN "benchmarks" the performance of the products. Usually, this takes place within the framework of an on-going development programme for accelerator or

[42]One of the best known recent examples of the impact of such free and informal interaction with CERN is the World Wide Web on the Internet.

detector components. This type of collaboration often occurs in the fields of electronics, measurement instruments and in computing. The time-span of the collaboration is usually a few months. The short-term collaboration may represent a rather informal arrangement between the CERN research teams and industry. Typically, it includes little, if any financial involvement. Apart from discussing the results in technical papers, written information seldom exists about the collaboration.

Longer-term collaboration

Longer-term collaboration usually extends beyond a year and takes place during the design phase of a new accelerator or detector project. In most cases, a number of different, promising technological solutions may be available and extensive development work is needed to evaluate them properly. Due to tight budgetary constraints, CERN then turns to the industry to share the costs of the development work. Often the common development work is based on existing, commercially available solutions but without detailed technical specifications. Depending on the outcome of the development projects, they may later turn into final manufacturing contracts. The contexts of such joint development projects are broadly described in formal agreements (Barbalat, 1991). However, they represent less than 1% of the annual purchasing budget and they partly overlap with the general purchasing activities of CERN.

Contract-based transactions

By far the most common format for CERN to deal with the industry is through standardized contracts. Each year, CERN places contracts for about 350 million Swiss Francs. The contracts reflect the financial rules of the Organization and follow well established purchasing rules and procedures. These are discussed in more detail in the following sections.

CERN contracts are based on technical specifications which are prepared by the responsible technical divisions. The specifications usually follow an extensive period of focused research and development work carried out by CERN, in particular for products of strategic importance to CERN. Over the years CERN has developed strong in-house capabilities which enable it to effectively evaluate and compare the technical skills and manufacturing capabilities of the bidders[43]. As the technical specifications are written in a supplier- or industry independent manner, CERN is more interested in the core competences of the bidders than in the standard products they make. For this reason, CERN often attracts bidders from a variety of different industries.

3.3.5 Patents

CERN has no active patent policy. The access to CERN-technology has thus not been restricted by patents. It has been left up to the collaborating industry to decide which CERN-applications may be worth patenting[44]. The suppliers have been permitted to obtain patents for inventions of interest to them, while protecting some exclusivity rights for CERN. Recently, the question of a more active patent policy has been reviewed and a few patent applications have been filed by CERN as a pilot exercise to study the related issues. These patents have been filed in the domain of optical fibres. They include inventions such as scintillating fibres (Destruel et al., 1989), rotating fibre optic drums for controlling remote operated vehicles (Horne, 1989) and the measurement of very short light pulses in a circular fibre (Bovet et al., 1994).

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[43]This does not imply that CERN can always select the best supplier for a particular contract, namely when another supplier who meets the minimum requirements has a lower bid.

[44]It is interesting to note that at least two CERN inventions, the tracker ball or editor mouse and the touch-screen panel, may have contributed to patents obtained elsewhere. See Beck and Stumpe (1973); Design News (1974).

3.4 Purchasing strategy of CERN

3.4.1 Financial considerations

CERN is used here as a case study but, in general, the purchasing policies of most international public organizations in Europe are similar. The European Space Agency (ESA, 1980) and European Synchrotron Radiation Facility (ESRF, 1988) select suppliers based on the lowest bidder and geographic quotas. The Joint European Torus (JET, 1991) and the European Community (CCE, 1989) select their bidders in a similar fashion as CERN. In government defense purchases, contracts are more functionally or systems'-oriented (and are therefore less oriented towards the product process) and require more severe supplier screening. In the United Kingdom, 80% of the value of defense contracts are based on competitive bidding and in most cases, they are maximum- or fixed-price contracts (MoD, 1992). In the United States, suppliers for complex weapon systems are selected based on comparative evaluations of proposals, costs, risk assessment, past performance, contractual considerations and surveys of contractor capabilities (see e.g., Fox, 1988; Gumpert and Timmons, 1982; Turpin 1989).

The purchasing strategy of CERN follows from its mission and from the requirement to meet the research goals within the financial rules set by the Council. Having defined the physics goals of future programmes, the technical solutions and concrete engineering designs follow. These are transformed into technical specifications which represent the starting point of the purchasing procedure. The customers at CERN are either the divisions or external research teams visiting CERN and participating in the major projects. The purchasing procedure is administered by the CERN Purchasing Office.

3.4.2 Aims

The aim of CERN's purchasing strategy is to achieve minimum purchasing costs. It thus considers its strategy as cost-driven. At the same time, the aim is to contract out as much as possible to the member state industries. The suppliers are primarily selected on the basis of the lowest price only (CERN, 1993a). Until recently, there has been no principle of "fair return" or national quotas based on geographical distribution[45].

Through its purchasing strategy, CERN tries to minimize supplier dependence and the risk of being caught up in a too specialized and costly market. This could happen if the market were dominated by too few suppliers. CERN attempts to avoid such dangers by making an effort to invite a sufficiently large number of potential suppliers to bid. This has been possible by utilizing the available engineering resources at CERN. Traditionally, it first designs, constructs and tests the prototypes. Then, a general technical specification is drafted to attract companies from all member states, also from unrelated industries.

Because CERN has had the necessary technical capabilities on site, it has been able to limit suppliers' bargaining power. Due to the heavy competition, suppliers may often change during the follow-up contracts. The well drafted technical specifications have so far made CERN rather immune to the potential hazards of supplier-switching. Whether CERN

[45]It should be noted that the CERN purchasing rules described throughout the text are those applied up to January 1994. Since then, the principle of geographic return has been introduced, similar to that used at ESRF and ESA. This principle aims at an even distribution of contracts over all the member states, each obtaining a share of the total contract volume equivalent to their share to the overall CERN budget. However, the suppliers are still selected based on the lowest bid, either as a result of a geographically more restricted tendering and/or from allowing (within certain limits) a bidder from a less-balanced country to align its bid with the lowest qualified bid from a better balanced country. In any case, the underlying principles discussed in this study remain still the same.

will be able to maintain this position given the present strong reduction in staff numbers[46], remains to be seen.

3.4.4 Procedure

Before the Purchasing Office gets fully involved, the technical divisions typically have already contacted a number of potential suppliers. During these contacts, general information has been obtained and technical discussions have taken place[47]. Typically, the CERN engineers want to talk to technical people rather than to salesmen[48]. Depending on the case, the Purchasing Office may send out a preliminary enquiry to carry out a market survey to measure the interest of potential suppliers. A selected number of these companies may be contacted later on for actual bidding.

Based on the work carried out at CERN and the feedback from the market, CERN drafts the final technical specifications. After this point, the purchasing mechanism is set in motion. Depending on the estimated value of the contract, there are three different procedures. A price information request applies to purchases of less than 5, 000 Swiss Francs and price enquiries[49] to purchases under 200, 000 Swiss Francs. Finally, a call to tenders applies for contract values above 200, 000 Swiss Francs. The first two procedures are relatively straightforward and easy to implement. Due to the scope of this study, they will not be discussed in detail.

According to the purchasing rules (CERN, 1993), calls for tenders need to be sent to at least three potential suppliers in the member states. In

[46]Since 1985, CERN has reduced its staff size by 13% and the size will further be reduced by some 30% by the year 2005 (CERN, 1993b).

[47]This practise, whereby the customer seeks qualified suppliers instead of the other way round, is called "reverse marketing". See Leenders and Blenkhorn (1988).

[48]Ideally, one would like to talk to a "marketing engineer", a phrase coined by Rob Parker at CERN.

[49]A price enquiry needs to be sent to more than one firm whereas an information request can be sent to only one.

practice, the Purchasing Office makes an effort to contact all the member states. Up to about four candidates are approached in each country, depending on the type of product in question. This means that the typical number of companies contacted for a purchase above 200, 000 Swiss Francs ranges between 20 and 70. The list of potential suppliers is drawn from the CERN Supplier Data Base. It covers roughly 15, 000 suppliers, of which some 2, 000 may be dealing with CERN at any one point in time.

CERN does not classify suppliers depending on the size of contracts. This is the case for instance at the European Space Agency (ESA) where a distinction is made among four supplier categories (BETA, 1988a). However, the value of contracts seldom exceeds 20% of the bidders' turnover. In addition, the member states' delegates are invited to provide advice on which firms to contact. The Finance Committee is given advance notice on all future purchases foreseen to exceed 200, 000 Swiss Francs. This information is to be passed on further to the relevant industries.

The closing date for the bids above 200, 000 Swiss Francs is usually about 6 weeks after the date the tenders were sent out. Shortly after the closing date, a formal "opening procedure" takes place including the technical and administrative people involved. CERN requests the bidders to provide a cost breakdown for each item. The bids can thus be compared with each other in a systematic way. In addition, most tenders require the completion of a technical questionnaire that allows to evaluate the capabilities of the bidding firms. Among the bidders able to meet the technical specifications and the delivery date, the firm offering the lowest price is selected. Before a formal announcement is made, the supplier is often visited in order to verify the details in the offer.

CERN will pay only for the items it has specified. In practice, this means that proposing any additional features will penalize the bidder if he increases the price relative to other competitors. The offers also include transportation costs. These are based on Free On Board (FOB) prices, as if delivered to a maritime vessel. In practice, the transportation costs become an issue only if they change the position of the lowest bidder. This may be the case when the difference in the bids is less than 10%. In the case of light or modular products, this margin can be an important factor for more distant suppliers. For selecting suppliers for purchases higher than 750, 000 Swiss Francs, an endorsement of the Finance Committee is required.

The competition for contracts is strong. The two lowest offers are often within 5-20% of each other; sometimes even less than that. The spread in the quotes gives some indication of the type of CERN product in question. The offers made by companies considered as experienced and qualified suppliers by the CERN engineers - that is, firms with prior experience with CERN and who fulfill the technical specifications - are usually very close to each other. However, they are seldom the lowest. The highest offer is mostly approximately twice as costly as the lowest one for non-standard products.

Less experienced but qualified bidders - that is, companies with little or no prior experience with CERN but who fulfill the technical specifications - has a wider spread in their offers. For non-standard products, the most expensive offer may be six times more costly than the least expensive one. A typical spread of offers for a non-standard or modified product is shown in Figure 3.2 where the value of the offers has been normalized; 1 being the lowest and 6 the highest, indicating a price difference of a factor of six. Most of the bids are within a factor of two or three. The circled area represents bids which are close to each other. They are on the "plateau" part of the offer distribution curve and often represent bids from experienced and qualified companies.

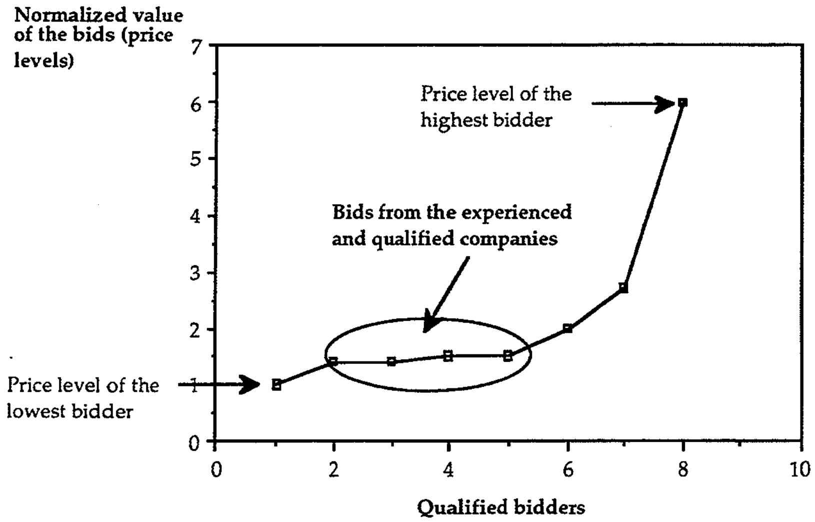

Figure 3.2 Typical price distribution of offers from qualified bidders for non-standard or modified products.

The supplier commits himself to deliver the product for a fixed price. The use of cost-variation indexing is only possible for longer-term contracts. The price cannot be renegotiated unless CERN wants to make changes to the original specification. However, the purchasing history of CERN indicates that this rarely happens, namely in less than 1% of all cases. If the supplier wants to make any changes to the specification, he has to seek prior approval from CERN. Nevertheless, he then still carries the responsibility for any failures the change might lead to. CERN exercises a tight control on the project during the contract. It has the right to visit the supplier for technical inspection whenever deemed necessary. This is to ensure that the project proceeds as planned. If any misalignment takes place, corrective actions can be taken very rapidly.

3.4.5 Structure of contracts

The format of the CERN contracts is standardized and consists of the following elements[50]:

Commercial and legal part

1 value of the contract;

2 duration of the contract;

3 payment conditions;

4 price revisions and options;

5 guarantee period;

6 legal constraints and administration;

7 penalties, legal disputes.

Technical part

1 transportation arrangements;

2 technical description of the product.

Each element is discussed below in more detail.

Value of the contract

As discussed earlier, the lowest bidder who fulfills the technical specifications and the delivery time, wins the contract. The bidder must

[50] The general conditions of CERN contracts are described in Appendix 2.

commit himself to provide the required product for a fixed, non-renegotiable price.

Duration of the contract

The duration of the contract depends on the nature of the product and the delivery time. If the product required is for a major new project[51], the time-span tends to be longer than for urgently needed equipment. Since CERN has only limited on-site storage capacity for larger-volume components, CERN mostly prefers to link the duration of the contract and the delivery dates to the construction and installation schedule of the project in question.

Payment conditions

The normal payment conditions of CERN follow the 10-80-10-rule. That is, 10% of the total value of the contract is paid at the beginning. Eighty percent of the contract value is paid after the delivery has been made. The remaining 10% is paid when the goods have been checked and approved. CERN requires the supplier to give a bank guarantee for the down payment and for the final 10% of the total value of the contract.

Price revisions and use of options

It may be that the length of the contract covers a number of years. Or it may be that CERN wants to keep an option to purchase additional components or products in the future. In such cases, the supplier is allowed to use a special price-revision formula which is based on published indices. The use of the formula is always fixed in the bid. A bidder may try to gain a competitive edge by choosing not to use a price

[51]For larger contracts the duration often extends beyond two years.

revision formula for possible future options. Instead, he could commit to offer the products for the same, fixed price.

An option does not necessarily mean that follow-up contracts or recurrent purchases are automatically awarded to existing suppliers[52]. In most cases, additional purchases are also submitted to open tendering.

Guarantee period

The guarantee period differs from case to case but is normally two years.

Transportation arrangements

In some cases, CERN may require the supplier to package the products in a non-standard way. This is typical, for instance, for some vacuum components which need to be protected from the open air. The size, shape or structure of products may also require special attention during transportation.

Legal constraints and administration

CERN is located at the border of France and Switzerland. Its special status may cause some special constraints as to the way the transaction is carried out. For instance, supplying certain materials related to nuclear technologies to Switzerland may require special permission from both government authorities. CERN has two sites, the Meyrin site on the Swiss side and the Prevessin site on the French side. Due to this double location, some equipment to be installed on both sites may require special administrative procedures.

52 On average, the same supplier is awarded two contracts in five years (Nordberg, 1990).

Penalties, legal disputes

CERN has the right to penalize the supplier for delays in delivery. This is used in cases where serious delays occur despite all the corrective actions CERN has made during the contract implementation. In cases where legal disputes lead to claims, arbitration procedures are used[53]. These issues fall outside the scope of this study and will not be discussed in more detail.

Technical description of the product

As described earlier, the technical specifications define the product, its performance, reliability and other features in a rigorous way. Depending on the case, they may include the manufacturing and testing procedures and equipment to be used. They may also describe the standards that will be used to measure the performance or quality of the product. The specifications may also determine the use of subcontractors and approved raw materials and so on. Suppliers sometimes attempt to gain further cost savings by selecting components of lower quality. It is therefore important to specify what components must be used. Due to a wide variety of other interfacing and inter-dependent equipment at CERN, it is important for suppliers to understand and strictly follow the specified procedures. Technical specifications are in most cases supported by detailed technical drawings.

As mentioned earlier, CERN has the right to visit the supplier whenever this is deemed necessary. In case of technical difficulties, the CERN engineers are obliged to help the suppliers. The technical expertise and support provided by CERN is not defined in the contract components as

[53]So far, legal disputes have taken place in less than 1% of all awarded contracts. This suggests that opportunism (Williamson, 1975) is not dominant in CERN contracts.

such. Nor are the travel expenses of CERN engineers included in the calculations. This is a commitment CERN makes when necessary, taking full responsibility for the technical feasibility of the specified product.

3.5 The need for a conceptual analysis of CERN purchasing contracts

In the previous Chapter, three areas of research literature were reviewed to address the issue of efficient buyer-supplier linkages. They included transaction cost analysis, strategic management analysis of core competences and the analysis of the economic impact of government funded R&D-organizations on suppliers. The relevance of this literature for the analysis of CERN purchasing contracts is described below.

In terms of transaction cost analysis, CERN operates in a context of high technological complexity and environmental uncertainty. The level of asset specificity associated with the purchasing contracts appears to be high. CERN operates within a fixed framework of short-term contracts with limited leverage to choose among governance structures for the various types of buyer-supplier transactions. It would appear that CERN uses a standard contract format for very different kinds of transactions. Moreover, it seems that the complexity of the institutional setting at CERN induces transaction costs for suppliers. The question is whether these transaction costs could be reduced by altering CERN's purchasing practises.

The literature on the strategic management of core competences is helpful in understanding characteristics of cooperative behaviour between CERN and its suppliers. As discussed in Chapter 2, such cooperative relationships are related to the long-term enhancement of firm core competences. Even though the trading interface of CERN is strongly dominated by cost-driven supply-contracts instead of strategic alliances or networks, meeting the technical goals often requires a strong mutual commitment both from CERN and its suppliers. The description of CERN's interaction with industry did not reveal any clear mechanism for generating intentional benefits in the area of enhanced core competences of suppliers. Nevertheless, it does not exclude that these types of benefits may emerge, as an end-result of an interactive process between CERN and its suppliers. In the next chapter, it will be analyzed whether core competences are actually enhanced in practise.

The literature on the economic impact of government funded R&D-organizations suggests that CERN provides complementary assets to its suppliers. These complementary assets are made available to the suppliers as result of a process of building in-house technological capabilities at CERN. Such skills are vital in order to draft technical specifications for products which are of strategic importance to CERN. As discussed earlier, CERN helps its suppliers to meet the specifications set out in the contract. This resource available during the contract_execution could be a source of complementary assets to the supplier. This will also be investigated in the next chapter.

3.6 Conclusions

The description of the CERN purchasing contracts leads to the following conclusions:

1 CERN appears to operate in an environment of high technological complexity and uncertainty. Product life cycles are measured in years. The CERN contracts appear to be associated with a high level of asset specificity in terms of transaction cost analysis;

2 CERN's trading interface is dominated by fixed-price manufacturing contracts. It uses a standard contract format for transactions associated with different levels of asset specificity. Its purchasing rules are not flexible;

3 suppliers are selected primarily on the basis of competitive tendering. In many cases CERN commits itself to help the supplier in order for him to meet the technical specification.

CHAPTER 4: CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

4.1 Introduction

How to reduce transaction costs associated with buyer-supplier linkages and develop supplier core competences in an effective way? This dual question was put forward in Chapter 2 where the relevant research literature was reviewed. The hybrid form with a longer-term time perspective was identified as the most suitable governance structure in the described environment. The impact on supplier core competences appeared to be higher in cases where the supplier was able to utilize the complementary assets offered by the customer.

Given the apparent relevance of transaction cost analysis, strategic management analysis of core competences and economic impact analysis, a conceptual framework is developed in this chapter to further study the research problem.

4.2 Conceptual framework

In order to perform an empirical analysis of buyer-supplier linkages at CERN, one needs to use both transaction cost analysis and strategic management analysis of core competences. The empirical research literature on R&D-intensive buyers is also used to develop the framework. These three components were introduced in Chapter 2.

First, transaction cost analysis can be used to verify the presence of inefficient contracts. Physical asset specificity is expected to be an appropriate indicator of transaction costs associated with transactions that take place in a fixed governance structure and it can be used in parallel to categorize different types of transactions within that governance structure.

Second, the strategic management analysis of core competences can be used to identify "complementary asset-seeking" supplier behaviour. Based on the findings in Chapter 2, such behaviour is likely to be associated with higher levels of asset specificity and benefits as compared to other forms of supplier behaviour. Thus, in this conceptual framework, asset specificity becomes a proxy to measure both transaction costs and benefits of enhanced supplier core competences.

Finally, combining the two research approaches, a relationship between supplier value chain functions and transaction attributes can be proposed. The structure of the conceptual framework, including the research hypotheses, is shown in Figure 4.1.

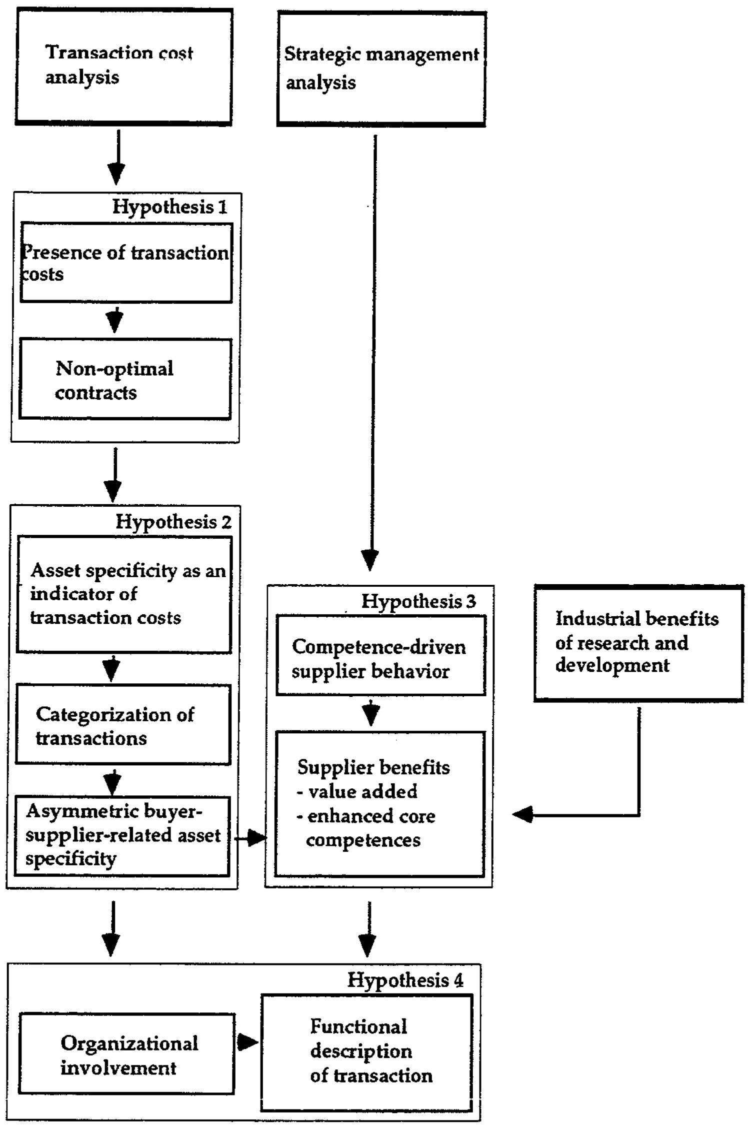

Figure 4.1 Conceptual framework and hypotheses.

4.3 Research hypotheses and key variables

Following the conceptual framework, a set of research hypotheses is now proposed. Each hypothesis has a general and a CERN-specific significance. The general version has implications for the existing research literature discussed in Chapter 2. The specific version represents a special case and is CERN-specific It is the specific version of the hypothesis which will be tested using the collected empirical evidence.

Hypothesis 1

Transaction cost analysis can be used to describe the contractual relationship between a customer like CERN and its suppliers and as a basis to identify inefficient contracts. The dominant source of transaction costs is the set of technological requirements imposed by the customer.

The general version of the hypothesis is that the applicability of transaction cost analysis can be extended to non-profit public organizations. These organizations require and purchase industrial goods while fulfilling their mission. Transaction cost analysis has traditionally dealt with economic organizations (Williamson, 1975; 1985). They are assumed to be in a position to choose and change their governance structures depending on the nature of transactions.

However, a public, inter-governmental organization like CERN is not a profit-seeking organization. It cannot freely choose among different possible governance structures. It follows strict procurement rules determined by a price-driven, contract-based purchasing policy approved by its member states. CERN is obliged to purchase its research instruments from industry using fixed contractual relationships. It has limited freedom to freely select its suppliers or change the structure of the contract after the lowest bidder has been selected.

The specific version of the hypothesis is therefore that transaction cost analysis can be applied to study different CERN transactions that take place within a fixed contractual framework. Transaction costs are usually identified by comparing different types of governance structures with each other. In this case, the presence of transaction costs is measured within a single governance structure.

More specifically, it is argued that the standard contract components can be used as a frame of reference in a normative manner. They can serve as an indicator of the presence of relative transaction costs associated with different types of transactions within a given governance structure[54]. The CERN transactions are compared to other similar contracts where the contractual friction is reported as being low. In cases whereby transaction costs appear to be present, the standard contract-format used for all types of transactions by CERN can be considered as inefficient.

The dominant source of transaction costs is expected to be a form of bounded rationality[55]. This is reflected in the stringent, highly technical requirements imposed by CERN on the suppliers. These requirements are in turn indirectly reflected in the contract clauses and may remain unexplained and unclear to the firms or may, in transaction cost terms, be simply unsuitable or even incorrect. Thus, it is proposed that transaction costs result from information problems related to technological issues

[54]E.g., Joskow (1987) and Goldberg and Ericson (1987) have compared short-term and long-term market contracts with each other and have studied the issue of asset specificity in this context.

[55]Based on Chapter 3, opportunism is not expected to be dominant in the CERN transactions. Transaction costs may also be present in the absence of opportunism, even in a simple framework of promise where the levels of bounded rationality and asset specificity are high but where opportunism is not present (Williamson, 1985).

such as required technical skills, documentation, production and testing equipment etc. It is therefore an institutional matter with managerial implications rather than an issue of measurement of direct production costs.

Hypothesis 2

Based on Hypothesis 1, it is further hypothesized that in a system of fixed contractual relationships, the presence of inefficient contracts can be identified through evaluating the level of asset specificity in the corresponding transactions. Further, asset specificity is asymmetric by nature.

The general version of the hypothesis is as follows. Given the institutional boundaries and the nature of transactions, asset specificity alone is a sufficient indicator to identify inefficient contracts. The presence of inefficient contracts was predicted in Hypothesis 1. Together with the presence of bounded rationality (and opportunism), asset specificity can be a strong source of transaction costs[56]. This proposition is strongly supported by the transaction cost literature (Williamson, 1991b).

It is proposed here that high asset specificity can be partly induced by the buyer's cost-driven purchasing policy, irrespective of whether the product in question is readily available on the market or not. In this case, buyer-induced asset specificity is asymmetric by nature. This proposal extends the scope of the transaction cost literature[57]. The present literature largely

[56]In contrast, it should be noted that high asset specificity does not necessarily imply the presence of both bounded rationality and opportunism.

[57]The question of asymmetric buyer-supplier dependence yielded by transaction specific assets in the presence of both bounded rationality and opportunism has already been discussed in the literature (see e.g., Nooteboom, 1992; Buchannan, 1992). In the present study, it is the behaviour (purchasing policy) of the buyer which generates a breakdown of the symmetry between asset specificity faced by the buyer and the asset specificity faced by the supplier. The issue of hostage situations is not of central concern here.

assumes asset specificity to be symmetrical in buyer-supplier relationships. This is a valid assumption as long as the buyer is free and sophisticated enough to choose from a number of qualified and available suppliers. In such cases, the focus is on the nature of the customer requirements and the extent to which these are specific to a single customer. Further, this is considered as being independent of the skills of the individual suppliers.

As discussed earlier, with CERN this is not necessarily the case since CERN is obliged to select the lowest bidder. In principle, the required products may even exist as completely standard ones in the market. However, whereas the selected firm must obviously fulfill the CERN-requirements, it is not necessarily the most qualified one. Due to this type of purchasing policy, the selected suppliers may not be familiar with the CERN products. The suppliers may not initially have the required products or production technologies available to meet CERN's requirements nor other customers to sell the related products to. Hence, for them the transaction may be associated with high asset specificity. Therefore, from their perspective, asset specificity refers to the degree of specificity or uniqueness of the production and testing equipment and quality control procedures to meet the specific CERN-requirements. It measures the deviation from the assets used to make standard products. This type of asset specificity is defined here as supplier-related asset specificity.

On the other hand, depending on the type of product in question, CERN may need to make an effort to get this product from the industry in the first place. CERN needs in many cases to invest in the design and drafting of the specification for external production. It needs to build, over a long time period, strong in-house capabilities. It needs to monitor and provide technical support during the contract since it cannot always deal with the most suitable and qualified suppliers[58]. The closer the product is to the core competences of CERN, the more it tends to be CERN-specific[59]. This type of asset specificity is defined here as buyer or CERN-related asset specificity. It is independent of the supplier-related asset specificity. It should be emphasized that the level of contractual CERN-involvement does not refer to the level of sophistication of the technology involved. It is not a measure of "high tech" versus "low tech". Instead, it is a measure of the level of CERN-specific technical capabilities and available resources that needs to be deployed to generate an effective transaction[60].

As regards supplier related asset specificity, transactions can be categorized into two major groups; type 1 and type 2. In type 1-transactions the supplier-related asset specificity, environmental uncertainty and complexity are low. The corresponding contracts can be considered as efficient since the related transaction costs are low. The suppliers experience less difficulties in meeting the CERN-requirements. The opposite holds for type 2-transactions where the supplier-related asset specificity, uncertainty and complexity are higher. In these cases, the related contracts require special or new skills on the part of the supplier.

Similarly, the transactions are categorized into two groups, based on the level of buyer-related asset specificity. These groups are labelled as group A

[58]This point was made clear by a CERN purchasing officer who gave the following (fictional) example. "If we want to buy a car and spex it for a Rolls-Royce but Fiat complies with the specifications and is the lowest bidder, we are obliged to give the contract to Fiat". Hence, for Fiat, this contract may be associated with high asset specificity although this would not be the case for Rolls-Royce.

[59]This could also apply to products available in the industry but significantly modified by CERN. They are not necessarily of strategic importance to CERN but nevertheless rely upon strong in-house technical capabilities. In such cases industry often feels it is in a position to offer alternative, closer-to-standard solutions but they seldom comply with the CERN-specifications. One supplier wanted to make a point of this, asking, "Is the lowest price really the best price for CERN?"

[60]For methods to measure the level of sophistication of technology, see e.g., Gordon and Munson (1981); Sahal (1981); Martino (1983).

and B. In group A, the buyer-related asset specificity, environmental uncertainty and complexity are high and in group B they are low. In group A the transactions are very CERN-specific and require extensive involvement and contribution from CERN to manage the transactions. These would also tend to make spot-market contracts less appropriate, given the need of know-how transfer from CERN to the suppliers (which, it shoud be emphasized, does not necessarily imply great efforts for the suppliers themselves). The strongest in-house capabilities are linked to these transactions. In group B, the transactions are less CERN-specific and rely more on the available competences of the suppliers, including their in-house R&D capabilities.

The categorization of transactions based on the level of buyer-supplier related asset specificity is shown in Table 4.1.

Table 4.1 Categorizing the transactions based on the level of buyer and supplier-related asset specificity.

Transaction attribute	**Transaction categories**			
Asset specificity	**1A**	**1B**	**2A**	**2B**
- supplier-related	Low	Low	High	High
- buyer-related	High	Low	High	Low

In Table 4.1, the polar extremes of asset specificity are the cases where buyer and supplier-related asset specificity are both high (cell 2A) and low (cell 1B). Following the transaction cost rationale, it is thus expected that transaction costs associated with transactions of type 2A are higher than with type 1B, given the spot market contracts that need to be utilized by CERN.

Hypothesis 3

Buyer and supplier-related asset specificity do not only constitute a source of transaction costs but also generate supplier benefits. These benefits depend on the level of buyer and supplier-related asset specificity. The transaction benefits linked with competence-driven supplier behaviour include both marketing and technical components and they are higher than the benefits associated with other types of supplier behaviour.

Hypothesis 3 provides an explicit linkage between transaction cost analysis and strategic management analysis. First, extending the present framework of transaction cost analysis, the general version of the hypothesis is that market transactions can also enhance the performance of the suppliers, not only that of the buyer. The suppliers can learn from transactions with their customers and transform this learning experience into economic growth[61]. It is proposed that the level of benefits increases as the level of asset specificity increases. That is, benefits are higher in cell 2A than in cell 1B in Table 4.1. Second, it is proposed that transactions associated with competence-driven supplier behaviour generate higher supplier benefits than those associated with other forms of supplier behaviour.

At first sight, the proposition above would appear to be at odds with the conventional transaction cost analysis. According to present theory (Williamson 1975; 1985) high asset specificity would imply transaction costs and this reduces the efficiency of the fixed buyer-supplier

[61]See e.g., von Hippel (1976; 1988) for examples of new scientific products. In the present study, the supplier benefits are understood more broadly, e.g., new applications based on existing product or manufacturing technologies.

relationship. Thus, such an inefficient governance structure would be unlikely to generate any benefits to the supplier.

This conclusion is correct in cases where the market is static, the buyer is free to choose among a number of suppliers and technology is assumed to be given. However, in this case, none of the assumptions above is necessarily valid (see below). Moreover, in the CERN context, asset specificity is not necessarily associated with the presence of both bounded rationality and opportunism. Conventionally, transaction costs have been identified in terms of contractual inefficiency due to opportunistic behaviour. But here it is expected that in a technology-driven environment such as the one associated with CERN, suppliers tend not to behave in an opportunistic manner even if transactions are associated with high levels of bounded rationality and asset specificity.

Instead, it is proposed here that transactions associated with bounded rationality and high asset specificity can generate a learning process. The customer needs to push the supplier to provide dedicated products. It needs or wants to innovate together with the supplier. The supplier wants to learn new skills or further develop existing ones. In fact, the supplier needs to learn in order to meet the technical specifications. The transformation of the related tacit knowledge into the present production environment takes place in a process of "learning by doing" (Mytelka, 1985). Over time, transaction specific assets can thus be transformed into firm specific assets which may contribute to enhanced core competences.

In conclusion, the market situation is in reality a dynamic one, the technology is constantly developing and the scope of supplier behaviour is not merely driven by individual transactions even though their work with CERN results from individual cost-driven spot market contracts. This long term perspective allows longer-term organizational learning. It is this process which then leads to supplier benefits, even if the governance structure is not efficient from a transaction cost point of view[62]. However, a causal linkage does not necessarily exist between transaction costs and supplier benefits. The presence of high transaction costs does not automatically mean that high supplier benefits are associated with these transaction costs.

The specific version of the hypothesis is that given the fixed contractual relationship, CERN contracts generate supplier benefits. Following the notation in Table 4.1, these benefits are expected to be higher for type 2A- (high-high asset specificity) than type 1B- (low-low asset specificity) transactions[63]. Supplier-related asset specificity and buyer-related asset specificity are assumed to be a joint source of supplier benefits.

Competence-driven supplier behaviour is defined here as the attempt to enhance company core competences by tapping into complementary assets through external contracts. It is based on the concept of complementary assets (Teece, 1986) and core competences of the firm (Hamel and Prahalad, 1994). It was suggested in the literature that buyer-supplier linkages have an impact on supplier core competences in the operations, technology development as well as in the marketing & sales functions (Schmied et al., 1984; Von Hippel, 1988; BETA, 1988a; Chapman et al., 1989).

Based on these research literature findings, the specific hypothesis is that the outcome of dynamic learning processes should be identified in at least the technological domains of improved process, advanced product

[62]Indeed, firms may even consciously choose a non-optimal governance structure to maximize the joint transactional value. See e.g., Zajac and Olsen (1993).

[63]Due also to the size of the sample and to the limitations to the statistical analysis, the focus will be on these two polar extremes. A more substantive reason why no analysis was performed including data on types 1A and 2B is provided in section 6.3.

development and R&D capabilities. It is further proposed that these enhanced technological capabilities will be integrated into the marketing activities of the firm. This process should improve the anticipated customer value of supplier's products as well as the company image. The customers consider a reference like CERN to be an assurance of high-level firm-specific competences, even if the products ordered are completely different.

The strengthened intangible assets are perceived as having a "market value" and should be made visible in the company value chain. This is similar to stock valuation where the trading decisions made by the investor are based on perceptions of the firm's competences and subsequent future performance (Crum and Derkinderen, 1986). The hypothesized effect should thus be observed in terms of technological and marketing benefits which are coupled.

The hypothesis above represents an extension of the present strategic management literature. It suggests a perspective that bridges the gap between the internal, resource-based view of the firm and the external, structuralist perspective of the market. It describes the process which converts the technical competences of the firm into added customer or market value.

Hypothesis 4

The level of organizational involvement is an additional transaction attribute and it can be used as a complement to asset specificity to identify inefficient contracts and supplier benefits. Based on Hypothesis 3, the level of involvement of the technology development and marketing & sales functions should be higher in transactions associated with competence-

driven strategies of suppliers than in those associated with other forms of supplier behaviour.

The general version of the hypothesis is that external transactions with external parties can be described in terms of the firm's value chain functions. The transaction attribute of organizational involvement needed to facilitate the transaction is proposed as a complement to asset specificity to identify inefficient contracts and supplier benefits. So far in this study, transactions have been treated in the Williamsonian (Williamson, 1975) sense as the parameter to select governance structures (at least from the perspective of hypothetical optimization) so as to minimize related transaction costs.

This view implies that a firm can be viewed in the spirit of transaction cost analysis as a "nexus of contracts" (Fama, 1980) described by the nature of its contractual commitments and related transaction characteristics (namely, the type of product in question; form of payment etc.). The view proposed here instead suggests that external transactions are associated with a "nexus of functions" described by the the internal activities of a firm.

The specific version of the hypothesis is that the level of involvement of the supplier support activities is higher for transactions where both buyer and supplier-related asset specificity are high[64] (cell 2A in Table 4.1), in comparison with cases where both are low (cell 1B). The support activities include general firm infrastructure, procurement, human resource management and technology development. They represent the primary

[64]Following from the definitions used in this study, the "Williamsonian " (Williamson, 1991a) concept of human asset specificity overlaps only partly with the concept of organizational involvement. In addition, some forms of human asset specificity may also be embedded in product-related transaction attributes. For the sake of clarity, in this study the concept of asset specificity is used in terms of product features, only.

trading interface to external partners in terms of managerial, administrative and legal involvement. In Hypothesis 1 it was proposed that the principal source of transaction costs - characterized by the level of asset specificity - is bounded rationality linked to overall managerial and institutional limitations. It is thus proposed that the transaction attribute of organizational involvement can be an alternative tool to physical asset specificity to study inefficient contracts and supplier benefits.

Second, it is expected that the level of involvement of the technology development and marketing & sales functions is higher for competence-driven transactions than for other types of transactions. This follows directly from the previous hypothesis that competence-based supplier strategies are linked with higher level of benefits - improved process, advanced product development, R&D capabilities and marketing - than other forms of supplier behaviour. This directly implies that the level of involvement of the technology development and marketing & sales functions is expected to be higher for competence-based transactions.

4.4 Summary

A conceptual framework has been proposed to solve the research problem presented in Chapter 1. The framework is based on transaction cost analysis, strategic management analysis and a number of specific characteristics of the CERN case. The following was hypothesized:

1 transaction cost analysis is applicable to describe and identify inefficient contracts in a cost and technology-driven environment;

2 given the use of standard contracts (irrespective of the nature of transaction), inefficient contracts can be identified based on the level of both buyer and supplier-related asset specificity;

3 the transaction-specific attributes are not only a source of transaction costs but in addition, they can also generate supplier benefits. These benefits depend on the level of asset specificity. Furthermore, benefits associated with competence-driven transactions are expected to be higher than those associated with other types of transactions;

4 external transactions can be described in terms of the supplier value chain functions. Instead of using asset specificity as an indicator of inefficient contracts and supplier benefits, the level of organizational involvement can also be used. Moreover, involvement of the technology development and marketing & sales functions is expected to be higher in transactions associated with competence-driven supplier strategies.

CHAPTER 5: EMPIRICAL RESEARCH METHODOLOGY

5.1 Introduction

The conceptual framework was presented in Chapter 4. This chapter discusses the empirical research methodology developed to study the different types of transactions and supplier benefits.

The empirical research methodology was conducted in three stages as follows:

1 exploratory or research planning phase;

2 explanatory research phase;

3 data collection and analysis phase.

5.2 Exploratory research phase

In order to solve the research problem, several traditional scientific methods were used.

Development of the method - drafting key hypotheses and designing the questionnaire

The first step was to draft the key research hypotheses. To find experimental evidence to support them, a questionnaire[65] for the suppliers was designed.

[65]The model questionnaire is in Appendix 3.

The key design parameters about which information was gathered, included:

1 target population; who will provide the data;

2 what information should be asked and how;

3 how to obtain the information: by mail, personal interview, over the telephone or by some other way;

4 how to process and interpret the data.

Two different versions of a draft questionnaire were given to 30 CERN suppliers during a conference (see Fernandez and Jarlskog, 1989), none of them being included in the final sample. The questionnaires explored the perceived interest in the proposed research problem. The suppliers were asked to fill in the questionnaires later and return them by mail. Based on the replies and further discussions with experts, the following conclusions were reached:

1 a statistical analysis appeared more appropriate for the purposes of the study since the existing literature could already give some indication as to the effects one would expect to observe in addressing the research problem;

2 it would be necessary to carry out the interviews personally and in an interactive way since the replies from the test mail inquiry clearly indicated many different perceptions of the original questions. Moreover, a Gallup-type of traditional approach with pre-coded yes/no/cannot say -replies would not be appropriate for the purposes of this study since they tend to measure more the attitudes of the

respondent rather than the attributes of the subject matter themselves;

3 a questionnaire with pre-determined questions appeared optimal for the following reasons

- the scope of the study does not require going into intimate financial details or highly emotional issues, where informal interviewing is more appropriate (Moser and Kalton, 1989);
- it is necessary to obtain comparable data;
- interviewer bias can be minimized in a controlled way.

After reviewing the literature on field interview techniques (see e.g., Oppenheim, 1966; Warwick and Lininger, 1975; Moser and Kalton, 1989; Singer and Presser, 1989) and incorporating the feedback from the previous steps, the structure of the questionnaire was re-designed.

In order to assure data reliability and validity, that is, quality of measurement and meaningful interpretation of the measured variable (Carmines and Zeller, 1979; Kirk and Miller, 1986), two precautions were taken:

1 key questions needed to be multidimensional, consisting of a number of different variables. Furthermore, it was decided not to include "high bias" items which everyone would be bound to answer exactly in the same way nor neutral items which are difficult to scale;

2 discussions were held with CERN engineers and purchasing officers responsible for contracts prior to visiting the firms.

Implementation of the method. The pilot test

The second step in the exploratory research phase was to study one case perceived as highly beneficial and one non-beneficial on the basis of initial discussions during the conference mentioned above. The aim was to test the tentative hypotheses and the draft questionnaire. Information was gathered from both the CERN engineers and the company representatives. Based on the findings, the hypotheses were further developed and the questionnaire revised. The help of an external expert[66] was used during this phase. Neither of these cases were included in the final sample.

Extended implementation of the method

The third and last step of the exploratory research phase was to extend the sample to four suppliers and to test the key hypotheses. In addition, the aim was to generate a final test for the revised questionnaire with pre-determined questions. The information was gathered from interviews carried out both in the companies and at CERN. For the CERN engineers, a separate questionnaire was used. The companies interviewed were included in the final supplier sample. For practical reasons, the four companies were from the same country, namely from the United Kingdom.

5.3 Explanatory research phase

The deductive phase of the study concentrated on supplier interviews. The objective of this explanatory research was to verify the method, namely the hypotheses and relationships. These were proposed earlier during the exploratory research phase.

[66]This person was Dr Erkko Autio from the Helsinki University of Technology.

The explanatory research phase consisted of four parts:

1 finalizing the questionnaire(s);

2 selecting the suppliers;

3 preparing for the supplier interviews;

4 interviewing the selected suppliers.

Finalizing the questionnaire(s)

A five-point Likert-scale was used to measure the key issues. In most cases, the Likert-scale was used in a comparative mode. This meant using statements like "lower than ..." and "higher than ... " .

Likert-scales are commonly used in these types of studies. For example, Ansoff and Stewart (1967) drafted a technological profile for companies, Prahalad and Doz (1987) used the Likert-scale to measure the types of market, competitive situation and technologies companies use. Ansoff and McDonnell (1990) measured company strategic performance in turbulent and uncertain environments. The scale typically varied between four and seven points.

Reviewing the literature (see e.g., Andrews, 1989), it was concluded that the difference between using four, five or a seven-point Likert-scales would be insignificant within the scope of this study. The different scales would lead to similar outcomes in terms of data validity, methods effect and residual errors. Based on feedback from test interviewees it was decided to use five-point Likert-scales, given that the interviewees considered that a seven-point Likert-scale would not result in higher accuracy.

Selecting the suppliers

Because of manpower and financial constraints, a target sample size of 50 industrial suppliers was chosen. The selection criteria were as follows:

1 only manufacturing contracts for new projects were included;

2 supply categories 100 (civil engineering), 800 (miscellaneous) and 900 (industrial support) and standard infrastructure items were excluded because they do not include manufacturing activities;

3 the time period 1985 - 1988[67] was selected as the period within which the contract started (it was the heavy construction phase of LEP);

4 research institutes and national laboratories were excluded;

5 companies that were no longer in the same business, or cases where the key people had left and could not be traced, were excluded;

6 the selected contractors were from CERN member states;

7 contract size was above 200, 000 Swiss Francs;

8 only the primary contractors were considered. Subcontractors were excluded;

9 contracts were to be selected in a random manner;

[67]The literature on the European Space Agency (BETA, 1980; 1988) and CERN benefits (Schmied, 1975; Schmied et al., 1984) suggests that it takes between two and four years to see the benefits resulting from the contracts. However, events extending beyond six or seven years are hard to recollect due to the "memory effect" (Ibidem.). Given that the interviews were conducted in the period 1991-1993, the whole of the time period mentioned above guarantees that benefits, if any, would have been generated during the research period.

10 only one contract per company was included. If the supplier was a member of an industrial group, one contract per physical manufacturing site was allowed;

11 if the supplier had follow-up contracts, only the first, original one was included.

After all the selection rules up to number nine above were applied, the size of the supplier data base was reduced from 1328 down to 279 contracts. A random sample of 49 contracts was selected This sample of 49 contracts and suppliers was considered sufficient for the purposes of this study (see section 5.4).

Preparing for the supplier interviews

Prior to contacting the selected 49 suppliers, the following preparatory work was carried out. The contractual histories of all 49 cases were examined with the help of the Purchasing Office and CERN engineers.

Interviewing the selected suppliers

All the interviews were carried out by the author himself. This was done for the following reasons:

1 familiarity with the technical and scientific vocabulary and products in question[68];

2 confidentiality issues. Access to confidential documents at CERN would have been difficult to arrange for an external team;

[68]The author has participated in the instrumentation phase of the DELPHI-detector (Aarnio et al., 1991) at the Large Electron Positron collider (LEP) and in initiating R&D efforts for future linear colliders (Orava, Eerola and Nordberg, 1992). Furthermore, he was involved in setting up industrial collaboration in areas such as satellite-based telecommunications (Altaber et al., 1991), teleoperated robotics (Horne, 1989) and high-speed electronics.

3 data quality. In order to estimate the quality of the data given by the suppliers, it was important to hear the "inside-story" from the CERN engineers prior to the visit. The engineers would have been reluctant to share contractual details with outsiders;

4 limitations in terms of available human and financial resources.

In three cases, the interviews took place at CERN. In four cases, the actual questionnaires were completed by telephone, following the visit.

5.4 Data analysis phase

Once all the data had been collected, they were entered into three separate data bases or files, two including the supplier data and one including the CERN data. These files were processed by using standard program libraries of statistical analysis. The major tools used are descriptive statistics[69], regression or correlation and factor analysis.

The data collected in this study were assumed to approximate a normal distribution. This allowed to use the powerful standard program libraries available on PC's. In cases of serious doubt, unpaired nonparametric tests were carried out (Hollander and Wolfe, 1973). In the nonparametric tests, one does not have to make assumptions on the shape of the distribution. However, there were certain practical limitations in using the nonparametric tools and the observed differences in results were not significant. This led to the conclusion that for the purposes of this study, linear approximations were sufficient. In addition, the literature suggests that the analysis of data which is not normally distributed but does not have outliers, should result in reliable conclusions about the statistical significance of the findings (see e.g., Milliken and Johnson, 1984). This is

[69]These include the mean, standard deviation and standard error.

the case in this study due to the fixed measurement scales, using a confidence level above 95%. This minimum confidence level is maintained consistently throughout this study.

Among other things, correlations between different variables were studied. Linear relationship analysis was considered sufficient for the purposes of this study. The correlation measures the extent to which two variables can be considered linearly dependent on each other. Correlation analysis obviously assumes implicitly some form of causality between the variables. The level of correlation is given in this study as a c-value. The c-value ranges between -1 and +1, the first value indicating a negative correlation and the second a positive, respectively. A c-value of 0 would mean that there is no correlation at all. A c-value of +1 would indicate a perfect linear relationship between the two variables. Simple regression analysis was used to calculate, in addition to the c-values, the p- and F-values describing the relationship between variables.

Throughout this study, the F-test was used while analyzing correlation relationships between different variables (see e.g., Wilcox, 1987). The F-ratio is the ratio between the variances of the two variables. The variance gives the average squared difference between the observations and the mean. The values of the F-ratio thus depend on the size of the sample. A high F-value is an indication of a high degree of correlation between the two variables.

The F-ratio is associated with the probability p value which gives the probability that the observed correlation could result from pure chance, only. In order for the observed correlation to be of statistical significance, the p-value should be below 5% or 0.05. The confidence level is then 95% or above. P-values below 5% are defined as being of high statistical significance and p-values below 1% as of very high statistical significance. The lower the p-value, the higher the F-ratio.

In cases where several variables were hypothesized to be grouped together, factor analysis and Fisher's protected least significant difference or PLSD-test, were used. Factor analysis reduces the number of original variables by re-grouping them into factors. These factors are linear combinations of the original variables and are in a sense new "metavariables". In applications such as the ones in this study, factor analysis typically reduces the initial number of correlated variables down to about one third. These new "metavariables" should explain at least 50% of the calculated variance.

The factor analysis was carried out as follows:

1 selecting the variables to be analyzed, making sure the number of cases exceeds the number of variables;

2 by using Cattell's scree test, extracting the factors with the highest variance proportion. In this study, the selected factors with eigenvalues above 1 should cover more than 50% of the variance to ensure their explanatory power;

3 applying an orthogonal varimax transformation to the rotated uncorrelated factor structure, followed by an additional oblique orthotrans-transformation. The latter transformation releases the restriction of orthogonality, thus providing a better view of the underlying factor structure;

4 from the oblique solution, extracting those original variables which have loading factors or weights below 0.35 in all factors or above 0.35 for multiple factors. The selection of this threshold value is based on

practical experience. Using some other arbitrary threshold value does not affect the end results;

5 repeating the analysis procedure until no additonal variables can be eliminated.

As in the case of correlation analysis, factor analysis is associated with a p-value. This approach circumvents the question of accuracy of the original data. In factor analysis, it is also assumed that the data is normally distributed.

Following the factor analysis, the hypothesized differences between groups of variables was verified using Fisher's PLSD-test. The test uses the multiple t-statistic method to evaluate all possible pairwise comparisons of the factorial "metavariables" for each group. Fisher's PLSD-test assumes a normal distribution of data and assumes initially that the sizes of the groups are the same. However, the latter assumption is not rigid and does not cause a problem as long as the number of variables is below the size of the smallest group.

Fisher's PLSD-test is a post-hoc procedure following the factor analysis. Thus, it assumes that the F-ratio or p-value exists for the factors. The test then calculates the mean difference of the coupled variables between the two groups, the critical difference value, the F-ratio, and the p-value.

A simple t-test was performed to measure the mean difference between two or more variables. The t-value indicates the difference between the measured mean difference and the hypothesized mean difference in terms of standard error. Unless otherwise stated, the hypothesized difference is zero. The t-test also gives the F- and p-values[70].

5.5 Description of the sample companies

The final sample consisted of 49 equipment manufacturers from technological industries such as electrical engineering, computing, telecommunications, electronics, mechanical engineering, and vacuum technologies. The list of suppliers, the nature of the CERN product and their major business areas are represented in Table 5.1. The suppliers are listed in a random order. The details related to the CERN products and main business areas have been omitted to ensure supplier anonymity. The business area refers to that of the physical location responsible for the CERN product in question.

Table 5.1 The description of the CERN products delivered between 1985 and 1988, and the main business areas of the suppliers.

Supplier	Product sold to CERN	Main business
1	Electronics for temperature measurement instrumentation for a radio-frequency (RF) system	Electronics design and manufacturing
2	Superconducting prototype magnet	Magnet technologies (power generation and distribution)
3	Trunked underground radio telephone system	Radio communication systems
4	Ultra-high vacuum flanges	Mechanical equipment
5	Off-line computers for an experiment	Computers
6	Special multicore transmission cables	Special cables
7	Aluminum gaskets for vacuum system	Vacuum components
8	Automated cartridge storage facility	Computers
9	Electronics crates and modules for power converters	Telecommunications
10	Audiovisual communication and switching equipment	Communications and security
11	Power cables	Power and communications cables
12	Busbars for electrical supply of the monorail vehicle	Busbars for production lines
13	Power cables	Power cables
14	Switched-mode AC/DC power supplies	Power supplies

[70]The F-value is calculated in unpaired comparisons where the measurement does not include the same variable taken at different times.

Table 5.1 (cont'd) *The description of the CERN products delivered between 1985 and 1988, and the main business areas of the suppliers.*

Supplier	Product sold to CERN	Main business
15	Collimators	Beam-line technology (Energy production)
16	Super-heated water temperature controllers for vacuum chambers	Heaters and coolers
17	Superconducting cable for prototype magnet	Special alloys
18	Extruded aluminum tubes for vacuum chambers	Aluminum extrusion products
19	Intercavity vacuum chambers	Vacuum components
20	High-voltage alumna-ceramic feedthroughs	Insulation ceramics
21	Wiggler magnets	Electromechanical equipment
22	Oil-immersed power transformers	Power transformers
23	Superconducting magnet prototype	Electricity power generation
24	Electrical metal-ceramic feedthoughs	Metal-ceramic vacuum feedthoughs
25	Low-voltage switchgear	Low-voltage switchgear
26	Capacitor banks	Capacitors
27	VME-electronics for driving power converters	VME-electronics manufacturer
28	Thyristor-controlled air-core reactors for power distribution	Power transmission and distribution services
29	Thyratrons	Power tubes
30	Heating jackets for electrostatic separator tanks	Heating elements
31	Radio-frequency (RF) storage cavities	Security devices
32	Emergency diesel generator sets	Diesel generators
33	Radio-frequency cavity tuning electronics	Electronics
34	Cryogenics plant for radio-frequency cavities	Cooling plants
35	Power cable	Power and communications cables
36	Vacuum chambers	Vacuum components
37	Magnetic access card readers	Security and control systems
38	Diodes for power converters	Power electronics devices
39	Electrodes for detector calorimeter	Metal components manufacturer
40	Larger-size mechanical feedthrough for detector	Special projects for paper machines
41	Bellows and assemblies for vacuum system	Vacuum components
42	Mechanical structure for a detector	Power plant equipment
43	Digital telephones and exchange	Telecommunications
44	Power transformers	Power transformers
45	Multicore cable	Telecommunications cables
46	Mechanical racks	Enclosures and accessories
47	High-voltage resistors for beam separation	High-voltage insulators for power industries
48	Power transformers	Power transformers
49	Special stainless steel bolts, nuts and washers for vacuum system	Stainless steel fasteners for nuclear industries

Table 5.2 gives the distribution of suppliers based on the industrial categorization used by CERN. All electromechanical devices like heaters, transformers, magnets, cavities, and products directly related to power generation and distribution are grouped in the category of electrical engineering. Mechanical engineering includes passive mechanical parts where no direct electrical functions are incorporated. The detector-related mechanical structures are also included in mechanical engineering, thus limiting the number of different categories to five. Some CERN products listed in Table 5.1 are not within the main business area of the supplier. However, with only one exception, they were within the same industrial category.

Table 5.2 Distribution of sample suppliers by industrial categories.

Industrial category	Number of companies	% of sample
Electrical engineering	24	49
Electronics	8	16
Computers and telecommunications	4	8
Mechanical engineering	7	15
Vacuum technologies	6	12
Total	49	**100**

The distribution of suppliers by member states is given in Table 5.3. The country of origin was defined as the geographic site where the major part of the manufacturing or assembling took place. While determening the selection rules, it was decided not to insist on a minimum number of suppliers for each member state, as the random selection process was unlikely to guarantee such an outcome. For this reason, countries like Greece, Portugal, and Spain are not represented in the study. However, one of the two suppliers who declined to participate in the study was from one of these countries, namely Spain.

Table 5.3 *The geographical distribution of the sample companies in the CERN member states.*

Country	Number of suppliers	% of the sample
Austria (A)	2	4
Belgium (B)	2	4
Switzerland (CH)	6	12
Germany (D)	8	16
France (F)	7	15
United Kingdom (UK)	9	19
Italy (I)	8	16
Norway (N)	3	6
Netherlands (NL)	2	4
Sweden (S)	2	4
Total	**49**	**100**

The distribution of the sample companies in terms of size (annual sales in millions of Swiss Francs in 1992 prices), is given in Table 5.4. The annual sales refer to that of the physical company unit or division responsible for the CERN contract. In 47 cases, the annual sales referred to the total annual sales of the company in that specific geographic location. In the other two cases the CERN activity could not be associated with a single production site and thus the global annual sales were used. In 24 cases, the supplier was well established in Europe and North America. Furthermore, half of these 24 firms could be considered as multinationals. The distribution of supplier sizes has been scaled in such a way as to eliminate possible interpretation problems relating to a unit or division annual sales.

Table 5.4 *Distribution of sample companies by their annual sales (S) in four ranges; less than 10 million Swiss Francs (MCHF), between 10 and 50 MCHF, between 50 and 250 MCHF and above 250 MCHF.*

Annual sales (S) range (million Swiss Francs)	**$S \leq 10$**	**$10 < S \leq 50$**	**$50 < S \leq 250$**	**$S > 250$**	**Total**
Number of sample companies	9	20	16	4	**49**
Distribution (%)	18	41	33	8	**100**

Table 5.5 gives the annual distribution of CERN contracts awarded to the sample companies between 1985 and 1988. In four cases the original

contract had in fact already started before 1985. In three cases, the contract had started in 1983 - 1984 and in one case, the original contract dated back to the mid-1970's. In one case, a new project was started within the framework of an existing contract in 1988 but the contract in question was officially signed in early 1989.

Table 5.5 Annual distribution of CERN contracts awarded during the time period 1985 and 1988.

Start of CERN contract (year)	1985	1986	1987	1988	Total
Number of contracts	18	14	10	7	**49**
Distribution (%)	37	29	20	14	**100**

5.6 Definition and measurement of the key variables

5.6.1 Hypothesis 1: Identifying the presence of transaction costs and inefficient contracts

The literature review conducted in Chapter 2 has suggested that inefficient contracts are associated with high contractual "friction" or transaction costs. Furthermore, the literature has suggested that the efficient governance structure of a trading interface for a customer like CERN would be a hybrid structure. Such a structure would fall between spot contracts and complete internalization of functions. The first task is therefore to identify possible transaction costs related to the CERN contract format itself to determine if there are indeed inefficient contracts for specific types of transactions.

Based on empirical studies using transaction costs analysis (Monteverde and Teece, 1982; Anderson and Schmittlein, 1984; Masten, 1984; Walker and Weber, 1984; Walker and Poppo, 1991) it was decided to proceed as follows:

1 the components of a CERN contract were compared to components of an other, standard contract associated with low contractual friction to determine whether transaction costs were present;

2 assuming that transaction costs were present, the origins of these costs were identified in order to separate efficient contracts from inefficient ones.

Comparing the format of CERN contracts to other contracts associated with low contractual friction

Modifying Walker and Poppo's definition of transaction costs used in their empirical study[71], transaction costs are defined here as difficulties in carrying out the CERN contract to meet CERN's requirements. Here, the perspective is that of the supplier. The transaction attributes are the source of transaction costs which can be measured by studying the contract components. Therefore, it is necessary to establish a link between transaction attributes and the contract components. This link is established in Table 5.6. For the sake of simplicity, each contract item is assumed to be generated only once. The compensation reflects the customer's direct contribution to the transaction. The product attributes refer to physical asset specificity. The time-span of delivery refers to the length of time of the transaction. The organizational involvement refers to the technical support provided by CERN and the form of communication with CERN. The terminology used is based on the structure of standard CERN contract components[72].

[71] Walker and Poppo (1991) defined transaction costs as the difficulty expressed by an assembly division in reaching agreement with its suppliers on the allocation of adjustment costs. In the CERN contracts, however, contractors must commit to their original bids (price-wise) unless CERN wants to change the specifications. Due to the stringent contract monitoring and control practises of CERN during contract execution, engineering or product changes can be common. According to the purchasing rules, the contractor cannot transfer these costs to CERN even if he wanted to do so. Such situations occur also when e.g., CERN does not accept the raw materials already bought - and included in the bid - by the purchasing division of the firm. This happens when the bidder does not strictly follow the CERN-specs during the execution of the contract. Even though Walker and Poppo studied intra-firm relationships, their view of transaction costs is similar to the one adopted here.

[72] For a more general but yet practical approach to the structure of contracts, see IPS (1986).

Table 5.6 Identifying contract components and possible transaction costs based on transaction attributes.

	Transaction attributes	Corresponding components in a CERN contract	Quantification of the contract component
1	Compensation	Contract value Payment conditions Price revisions and options for additional quantities	Price of the contract Fixed-price, distribution of payments Price-index if an option is used for repeat orders
2	Product attributes - description related to the components	Specified in-house skills Technical documents; level of details Use of subcontractors	Product or production experience in years Length, attached technical drawings etc. Identification, specific purpose like for raw materials or components
	- description related to production and quality assurance	Production equipment and methods Testing procedure Standards used	Type of used machines and equipment Testing sequence to ensure required performance and quality ISO, DIN, MIL etc.
	- description of the transportation and installation and commissioning	Transportation arrangements Guarantee period Legal constraints and administration	Packaging, means of transportation etc. Time in months or years Transportation of strategic materials, customs formalities etc.
3	Time-span of the transaction	Duration of the contract	Time in months or years
4	Organizational involvement	Technical support provided by CERN, form of communication, involvement of supplier functions	Equipment, procedures managed by CERN, means of communicating, involvement of technical and commercial individuals

A five-point Likert-scale is used to measure the relative transaction costs associated with the CERN contracts as compared to other, low-friction contracts (i.e., non-CERN transactions with similar attributes). Each interviewee was asked to use as a frame of reference either the business area or products closest to the CERN product in question. The comparison was asked to be made for a specific contract occurring at the same time as the CERN contract. If the CERN contract in question was efficient, the interviewee was still asked to compare it to a "typical" low-friction contract in a business area closest to that of CERN.

For each contract component, the following scale is used:

-2 = CERN contract component is very much less... than in a low-friction, non-CERN contract;

-1 = somewhat less;

0 = same or standard;

+1 = somewhat more;

+2 = very much more.

If the total sum of the components in a CERN contract is negative, transaction costs are considered to be present. For the sake of clarity and convenience, each interviewee was asked to compare each CERN contract component to the equivalent components in a non-CERN contract associated with low contractual friction. The consequence of this approach is that the presence of transaction costs is measured as a negative sum of the comparative components. In principle, the sum of the comparative components could be positive, as well. This would occur if the scores for many items would be on the positive side of the scale. In that case, it is the CERN contract that would be "very" efficient (i.e., even more efficient than non-CERN contracts). In other words, if the sum of the scores for the various contract components is less than 0, transaction costs are present. If the sum of the scores of the various contract components is equal to or greater than 0, transaction costs are considered to be neglible.

The analysis of the contract components is performed here in terms of perceived contractual difficulties resulting from buyer behaviour. There appear to be two major sources of contractual difficulties. The first source is the standardized contract format, which may be ill-adapted to specific types of transactions. It should be emphasized that this type of contractual difficulty is entirely unrelated to production costs. All production cost implications of transactions with CERN are obviously taken into account when submitting a bid that fully conforms with CERN specifications (this is a condition that must be met in any case in order to be selected for a contract).

The second source is the insufficient explanation of specific clauses in the contract to suppliers. Although these clauses may be necessary to execute the contract in a satisfactory manner, they may still be considered as inappropriate by the suppliers and therefore result in contractual ineffectiveness. This obviously reflects a bounded rationality problem whereby the buyer does not understand the need for information dissemination and the supplier does not understand the buyer requirements, given the lack of information received[73].

From this perspective, the contract components are unrelated to production costs per se. For example, if CERN were to require specific packaging and means of transportation, it could be argued that a supplier may view this as ineffective because it would increase his production

[73]For example, if specific purchasing and transportation requirements are imposed by CERN, this may be a reasonable demand but to the extent that suppliers do not receive sufficient information about the rationale for such demands, they may again view the transaction as inefficient. The production cost issue is also secondary here, as suppliers would have been well aware of the requirements when submitting a bid.

costs. However, in this study it is assumed that such a perception by the supplier would not result from production costs per se but from the fact that CERN inefficiently explained why the specific type of packaging and means of transportation are required. Therefore, the perceived inefficiency is caused by insufficient CERN communication which is transaction cost-related.

5.6.2 Hypothesis 2: Classification of transactions

The testing of Hypothesis 2 is performed in two steps. First, the origins of transaction costs are determined. Second, the transactions are classified based on the level of asset specificity.

Determining the origins of transaction costs

Based on Williamson (1991b) and Walker and Poppo (1991), asset specificity is defined here as the primary indicator of transaction costs in the CERN contracts. As discussed in Chapter 2, asset specificity is a relevant parameter, given environmental and behavioural factors such as uncertainty and complexity, bounded rationality and opportunism[74].

In this study, the supplier-related asset specificity is defined as the degree of deviation from the standard products of the supplier. It is measured in terms of the uniqueness or specificity of the CERN product to the supplier[75]. The variables defined above will be used to measure the attributes of different types of CERN transactions.

[74]As mentioned above, the frequency of transactions with CERN is typically low and within the scope of this study, frequency is therefore not viewed as an important parameter to measure.

[75]This is expected to be closely coupled to the specificity of the manufacturing process which is also measured. The manufacturing process refers to the manufacturing technologies and steps used to produce the CERN product.

Classification of transactions

The supplier-related asset specificity is defined as the uniqueness or specificity of the CERN product to the supplier. The variable used here is defined based on Roberts and Berry (1985), Hagedoorn and Schakenraad (1990), and Walker and Poppo (1991).

In order to measure the supplier-related asset specificity, a five-point Likert-scale is used:

1 = standard product;

3 = modified product;

5 = unique product.

It should be emphasized that supplier-related asset specificity is not necessarily linked to any design or engineering efforts by the buyer. Extensive design and engineering efforts required from the buyer may not lead to any particularly difficult work from the supplier.

The second primary variable for classifying the transactions then needs to be defined. This is the buyer-related asset specificity which is determined based on Walker and Weber's (1984) definition of buyer experience. It is similar to the classification of innovations (Roberts, 1991) as a function of the type of market (base versus unfamiliar) and product technology entered (base versus unfamiliar).

The buyer-related asset specificity is linked here to the level of CERN-involvement in the preparation and monitoring of the contract. It is measured as the amount of original design or engineering work involved

(Monteverde and Teece, 1982)[76]. The level of CERN-involvement indicates to what extent the product in question has a high level of CERN-related asset specificity and how much original design and engineering effort has been made at CERN in order to draft a technical specification for the supplier[77].

To measure the CERN-related asset specificity, a five-point Likert-scale is used:

1 = very low CERN-related asset specificity. More a functional description of the product. CERN has performed very little or no design or engineering work;

5 = very high CERN-related asset specificity. Highly detailed specification, all details fixed. CERN has performed all necessary design or engineering work.

Factor analysis is then applied to the CERN contract components to reduce the number of transaction cost variables. A Fisher's PLSD-test is carried out to verify that transaction costs are higher in the cell where both buyer- and supplier-related asset specificity are high (cell 2A in Table 4.1), in comparison with the cell where both are low (cell 1B).

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[76]For specialized equipment which is less familiar to the firms, CERN has tended to concentrate the pre-contractual technical efforts in-house (Zilverschoon, 1974).

[77]Since the CERN-involvement is a measure of the level of CERN or buyer-related asset specificity, this is inversely proportional to the volume of required engineering on the part of the supplier. The higher the CERN-involvement, the less the supplier needs to engage in engineering activities to meet the CERN-specifications. In cases where the product is not available on the market, CERN-related asset specificity is by definition high. It was decided to measure CERN-related asset specificity by asking the CERN engineers how much design or engineering was still required from the supplier. In this way, a possible bias was avoided since had a direct question been asked to the engineers about their efforts in the transactions, their answers might have been exaggerated. In their answers, the CERN engineers actually responded in terms of volume of work that needed to be carried out by the suppliers but from CERN's viewpoint, i.e., assuming that suppliers would have capabilities similar to CERN. In other words, a perception by a CERN engineer of substantial engineering activities still to be performed by a supplier, really constitutes a statement of about buyer and not supplier-related asset specificity.

5.6.3 Hypothesis 3: Types of generated supplier benefits

In this study, it is hypothesized that contracts with a customer like CERN may generate supplier benefits.

In order to identify the major supplier benefits, the general framework of strategic management (Porter, 1985; Teece, 1986) discussed in Chapter 2 and the benefit findings of research centers (Schmied, 1975; Schmied et al., 1984; BETA, 1988a) are combined. Establishing a link similar to the one between transaction attributes and contract components in Table 5.6, the expected benefits are identified in Table 5.7.

The product attributes refer to primary functions of the value chain. The organizational involvement refers to the support activities which provide the principal contractual interface with external parties. For the sake of simplicity in the presentation, the different types of transaction attributes are assumed to generate a specific type of benefit only once. However, it is well possible that a given transaction attribute is linked to more than one type of benefit. Nevertheless, the benefit analysis itself is not affected by the classification presented in Table 5.7 even if a given type of benefit is associated with more than one transaction sub-attribute. Due to the scope of the study, the focus is on the commercial and technical attributes describing the transactions.

Table 5.7 Identifying possible benefit variables linked to the CERN contracts, based on corresponding transaction attributes.

	Transaction attributes	Corresponding possible supplier benefits
1	Compensation (money)	- Profit
2	Product attributes - description related to the components	- Improved process or manufacturing methods: new or modified production equipment, improved production efficiency - Advanced product development: accelerated innovation process or product introduction due to the needs of CERN, entry into new or related markets, modified products - Marketing benefits: image, credibility, export reference - Commercial collaboration: useful business relationships with new subcontractors found due to the CERN transactions - Other customers: identification of new customers thanks to the CERN transactions
	- description related to production and quality assurance	- Improved quality; new or modified testing equipment or methods - Production capacity utilization; filling available production capacity at the time of bidding for contract - Improved contract control: monitoring the cost-impact of possible changes or modifications during the contract, strengthening of the balance sheet, improved cost consciousness, efficiency etc.
	- description of transportation, installation and commissioning	
3	Time-span of the transaction	- Long-run operational efficiency with a customer such as CERN
4	Human interaction	- Improved technical skills: learning new technical skills - Improved subcontracting (purchasing) practices: enhanced procurement performance due to the CERN transactions - Research and development (R&D) benefits: new ideas, design concepts, developments etc. - Employee motivation: feeling of having accomplished something significant

In Table 5.7, no generic benefits are assumed to be generated by the sub-attributes of transportation, installation and commissioning. However, a mix of benefits such as advanced product development, commercial collaboration, new skills and motivation could be expected.

The differences between benefits regarding technical skills, research and development (R&D) and advanced product development are the following.

Improved technical skills are defined as a benefit that can result from the manufacturing process of the CERN product. They are therefore understood to be primarily linked to supplier operations but may naturally have connections to other functions, as well.

Benefits in research and development refer in this context to enhanced knowledge which is more tacit by nature. This knowledge is more abstract than needed in the manufacturing process to make the CERN product. It extends beyond the immediate production environment but is nevertheless related to development work for identifiable products. Depending on the supplier, the definition includes development work for modified, but existing products, or unique customer-oriented research. Therefore, research and development is not intended here to be understood in the broadest sense of the meaning, as a support function having a direct impact on all the primary value chain activities.

Benefits in advanced product development are understood here as resulting from the product requirements imposed by CERN. The supplier may have been able to identify similarities between the CERN product and its own, possibly independent, product development ideas. The CERN transactions was then used as a tool to introduce a product to the market faster. The benefits in advanced product development are not necessarily linked to research and development capabilities. A supplier may be able to accelerate the product introduction period and yet have no research and development capability in-house.

The foreseen supplier benefits are categorized in this study as follows:

Commercial benefits

1 direct profit;

2 production capacity utilization;

3 other customers due to the CERN contract;

4 long-run operational efficiency with a customer such as CERN;

5 commercial collaboration;

6 improved subcontracting practises;

7 improved contract control;

8 marketing benefits.

Technical benefits

1 improved process or manufacturing methods;

2 improved quality;

3 advanced product development;

4 research and development (R&D) benefits;

5 improved technical skills; learning new skills, streamlining technical operations;

6 employee motivation;

7 other[78].

Factor analysis is carried out to reduce the number of independent benefit-variables. Using Fisher's PLSD-test, the values of the "metavariables" are compared between the cases where both buyer and supplier-related asset specificity are high (cell 2A in Table 4.1) and where they are both low (cell 1B). Comparing the differences between cells 2A and 1B is considered as sufficient for the purposes of this study, given the statistical limitations of the sample size.

The last test in this section is made to verify whether the proposed effect of organizational learning results from the CERN transactions. This is achieved by measuring the level of uniqueness associated with the process technologies used to make the CERN product. Two measurements are performed: the level of process-related uniqueness at the time of the contract and the level of uniqueness at the time of the interview. A five-point Likert-scale similar to the measurement of product uniqueness is used. A paired t-test is then carried out to detect any difference of statistical significance.

Identification of competence-driven supplier strategies

Competence-driven supplier strategies were defined in Chapter 4. These referred to suppliers enhancing their core competences by tapping into complementary assets through external contracts. The primary aim is to broaden the core competences upon which the existing key products of the firms involved are based. Supplier intentions are based on the existing manufacturing technologies for present core products (Wernerfelt, 1984; 1993). Based on Table 5.7, competence-driven supplier strategies can be

[78]This variable is used to identify any hidden variables. If no effect is observed, it is automatically omitted from the analysis.

viewed as being linked to benefits generated by product component-related transaction attributes.

In this study, competence-driven supplier strategies could be viewed as a subset of diversification strategy. No generally accepted definition of diversification strategy exists (Rumelt, 1974). Rumelt (1974) bases his view of diversification strategy on Chandler's (1962) notion of entering a new market-product area, expanding upon the available competences of the firm. In the strictest sense, diversification strategy implies entering a new market area with a new product. Due to the scope of the study, it was decided to adopt a resource-market-based view of diversification as described by Wernerfelt (1984). Here, the emphasis is on applying the firm's resources to markets or products which are similar in terms of required capabilities. Thus, both the products and the markets are not necessarily new to the firm. For this reason, and to avoid any confusion, the concept of competence-driven strategies is used in the study instead of diversification strategies.

For practical reasons, the word "diversification" was nevertheless used in the final interviews. There were three reasons for this. First, it could not be assumed that the companies were familiar with the theoretical framework regarding core competences. Second, the concept of diversification already became well established in the industry in the 1960s, even if a common definition does not exist. Third, it was feared that using some other term including the word "strategy" or "core competence" could be misunderstood.

Therefore, the word "diversification plan" was used to identify competence-driven supplier strategies. This was achieved by asking whether the CERN project was linked to plans in the company to further develop existing core products.

As discussed earlier, a competence-driven supplier strategy is based on utilizing present skills and products. In order to verify that this indeed is the case, it was also asked whether the identified diversification plan was product-related or not.

Further, it was checked whether the diversification plan was not merely an internal activity. It was asked whether the CERN project was related to any backward or forward integration plan in the company. As in all the other previous cases, an option was left to answer "cannot say".

In this study, the definition of competence-driven supplier strategy is a rather narrow one. First, it is defined in the spirit of the literature that adopts a core competence-based view of the firm. Second, it reflects a shared view inside the firm, not only a judgment the top management would be able to make. This results from the selection of the target group, where emphasis was put on interviewing people who were personally responsible for carrying out the CERN contracts. Despite this set of priorities, in eight cases out of the 13, or in 60% of all cases involving competence-driven strategies, senior- or top management was interviewed. In comparison, the corresponding figure for other cases was 45%.

A Fisher PLSD-test is carried out to verify the hypothesis that benefits are higher in transactions associated with competence-based strategies, in comparison with other types of supplier behaviour.

5.6.4 Hypothesis 4: Description of transactions by value chain functions

The fourth research hypothesis proposes that the level of organizational involvement can be used instead of asset specificity to identify inefficient contracts and supplier benefits. This is tested by measuring the level of organizational involvement in the transactions and comparing the difference between cases of high-high and low-low level of buyer and supplier-related asset specificity, respectively.

The functional involvement, or in cases of small suppliers, the participation of the key people representing corresponding functions, is measured using a five-point Likert-scale as follows:

1 = no participation;

5 = very high level of participation.

The functions involved are defined here in terms of Porter's value chain functions (Porter, 1985) as follows:

1 general management (firm infrastructure);

2 research and development (technology development);

3 production division, including planning and testing (operations);

4 marketing (marketing and sales);

5 purchasing (procurement);

6 service and installation (services).

Inbound and outbound logistics are not included due to the scope of the study. It should be noted that profit or margin in the value chain is obviously not an activity. The value chain functions may overlap with each other, e.g., process and technology development functions. However, this is considered as a marginal effect within the scope of this study.

Factor analysis is applied on the involvement-variables and a Fisher PLSD-test is then carried out on the reduced variables to verify the hypothesized difference between competence-driven transactions and the other transactions.

5.7 Identifying possible hidden variables and minimizing their effect

An effort was made to design the variables in such a way that "background noise" would be minimized. That is, an attempt was made to make sure that the intended signal was identified and registered. Furthermore, an effort was made to explain the findings, even if these findings deviated from what was expected. In general, the issue of undetected, hidden variables was approached in two ways:

1 by giving the interviewee a choice to reply "cannot say" if the closed format questionnaire did not offer appropriate alternatives;

2 giving the interviewee an option to create a new, additional variable which would be more appropriate while addressing the specific question.

An effort was made to minimize the effect of the following potential hidden variables:

1 distorted or otherwise unsuitable supplier sample for the purposes of the study: see section 5.3;

2 interviewing the wrong person(s): the interviewees were suggested by CERN engineers and found in the related technical documents;

3 misunderstanding the questions: the questions were explained and examples given during the interview;

4 receiving misleading answers: when this was expected, the answers were verified with the CERN engineers;

5 the forget-factor: the time-period within which contracts were awarded, was limited (see section 5.3).

The research methodology was further specified to prevent the effect of hidden variables. Similarly, the questionnaire was further improved and its clarity tested, using people who were not involved in the study.

5.8 Description of reality and estimation of error limits

Two major questions can be asked at this stage. First, to what extent can it be expected that the presented results reflect reality? Second, what can be said about the accuracy of the measurement scales used?

This study adopts a hypothetico-deductive method following the positivist view of Popper (1959). An intellectual risk is taken in terms of presenting a set of hypotheses which are then tested, based on empirical evidence. The empirical measurement is understood here as a process which links abstract concepts to empirical indicators (Carmines and Zeller, 1979). If the hypotheses cannot be confirmed, they do not reflect reality. On the other hand, if the hypotheses are confirmed, they still require the consensus of the scholarly community in order for them to be considered as reflecting reality (Blumer, 1968).

In order to answer the second question above, three simple tests were carried out.

The first measurement test took into account the level of participation of the production division. All the contracts included production and in all cases CERN provided the technical specifications for manufacturing. The level of participation of the production division was therefore expected to be on the high side of the scale. The mean and standard error were calculated and found to be 3.8 ± 0.16 on a five-point Likert-scale. On the other hand, only one quarter of the cases included installation on-site. The level of participation of service and installations could be expected to be on the lower side of the scale. Indeed, its level of participation was calculated at 1.9 ± 0.23. These results would tend to support the assumption that different degrees of scales ranging from "very high" to "very low" or "no significance" can be associated with a meaningful measurement of reality.

A second simple test was performed to study the relationship between the five-point Likert scale and the range of physically measurable "real" values it could have. The extent of the use of subcontractors was compared with the level of subcontracting in terms of percentage of the manufacturing costs. The five-point scale measuring the level of involvement had values running from -2 to +2, from "very much less" to "very much more", in comparison with other, similar contracts. The percentage values ranged between 5 and 60. The mean value was 27.9% ± 4.1%. Subcontractors were used in 53% of all the cases. A linear regression analysis was carried out and the results are shown in Table 5.8.

Table 5.8 Linear correlation analysis between the amount of subcontracting as % of manufacturing costs and the use of subcontractors on a five-point Likert-scale.

Amount of subcontracting (%) versus	F-ratio	Correlation coefficient	p-value	Conclusion
Use of subcontractors	4.370	0.415	0.049	Significant

As seen from Table 5.8, the probability for such a linear relationship to take place by chance alone, is less than 5%. This would tend to give further confidence to the assumption that the Likert-scales behave in a linear fashion and that they can be associated with meaningful, physical values.

A third test was carried out to verify the reliability of the key measurements, namely those of the benefits. The test was performed by first asking the CERN engineers what benefits they thought the supplier gained from the contract. These answers were then compared with those from the suppliers. It is assumed that the supplier did not make an effort in advance to find out what the CERN engineer had replied. In fact, the suppliers were not informed of the prior discussions with the CERN engineers.

A paired t-test was then performed. The t-test measures the likelihood that the mean values of two measured sets of benefits are the same. The key indicator is the probability value p. The higher the p-value, the higher the likelihood that the mean values are indeed the same. If p is 1, the mean values are identical with 100% probability. The results are shown in Table 5.9 where the first column represents each type of benefit. The second column represents the mean difference, the third the number of cases considered and the fourth the t-value. The fifth column represents the probability value p. The higher the p-value, the more likely it is that the two means are the same.

Table 5.9 Comparison of the differences between the mean values of the anticipated key supplier benefits, as scored by CERN engineers and as scored by the suppliers themselves.

Benefit	**Mean difference**	**Number of cases (max.47)**	**t-value**	**p-value**
Marketing benefits	-.029	33	-.102	.919
Process improvements	.081	30	.291	.773
Improved skills	.083	29	.299	.767

From Table 5.9 it can be observed that the maximum difference between the means was about 0.08. This test would suggest that the key measurements are sufficiently reliable. Thus, the status of the interviewee does not appear to cause a major bias in the results.

Obviously, the possible margins of error depend on the type of question. For instance, estimating the benefits may be more difficult than estimating the contractual difficulties. However, based on the experience gained during the pilot interviews, the analysis above and on earlier studies (Schmied, 1975; Schmied et al., 1984; BETA 1988a) it is concluded that the expected accuracy of the answers lies between 10 and 20% on the five-point Likert-scale.

This would also include the scaling effect, where some interviewees tended not to use the full scale but instead the low or high end only. Furthermore, the time spent on the interview was also included in the error analysis. Any possible interviewee bias was further monitored by studying the correlation between the specific divisional involvement and the position of the interviewee.

5.9 Summary

In this chapter, the empirical research methodology was discussed. This included describing the exploratory and explanatory research phases, followed by the data analysis phase.

Based on the research hypotheses presented in Chapter 4, the corresponding key variables were defined and their measurement principles were explained. Then, the possible hidden variables were described as well as the efforts made to minimize their impact. Finally, the chapter ended with a discussion about the descriptive accuracy of the method and the error estimates.

CHAPTER 6: EMPIRICAL RESULTS

6.1 Introduction

Following the empirical research methodology which was discussed in the previous chapter, the proposed hypotheses are tested in this chapter. This chapter is structured as follows. Hypothesis 1 on the presence of transaction costs and inefficient contracts, is tested in section 6.2. Hypothesis 2 regarding the classification of transactions based on asset specificity, is tested in section 6.3. Hypothesis 3 on the relationship between asset specificity and supplier benefits, is tested in section 6.4. Hypothesis 4 related to the description of transactions by value chain functions, is tested in section 6.5.

6.2 Hypothesis 1: Identifying the presence of transaction costs and inefficient contracts

The first question was whether contracts used by CERN were associated with any transaction costs. That is, given CERN's institutional limitations to freely choose among different possible governance structures for carrying out transactions with industry, whether all the contracts were efficient or not. The literature review in Chapter 2 suggested that for many transactions, an efficient governance structure would be a longer-term hybrid form, at least when viewed from the perspective of a customer such as CERN. Indeed, hybrids are most suitable for transactions associated with mixed levels of asset specificity, given that the environmental and behavioural uncertainty is high.

However, in reality the CERN transactions are all carried out within a fixed-price, standardized contract format. The literature would thus suggest that some CERN contracts, especially those associated with high a level of asset specificity, are inefficient. Here, transaction costs can be expected. These transaction costs can be identified by comparing contract components with similar components prevailing in non-CERN contracts considered by suppliers as having low friction.

As discussed in Chapter 4, the expected differences between low friction contract components and CERN contract components are not measurements of direct production costs. The dominant source of transaction costs is a form of bounded rationality which originates from stringent, inappropriate CERN requirements and inadequately explained or unclear contract clauses.

In Chapter 3 the CERN contract format was analyzed and the following contractual components were identified:

1 value of the contract;

2 duration of the contract;

3 payment conditions;

4 price revisions;

5 use of options;

6 guarantee period;

7 legal constraints and administration;

8 transportation arrangements;

9 technical description of the product: level of details (technical specification), specified in-house skills, equipment, related technical documents, testing procedures, technical support from CERN, use of standards and use of subcontractors.

Following the definition of measurement variables introduced in Chapter 5, the suppliers were asked to provide a score for each of the components of the CERN contract. This was done by using a five-point Likert scale ranging between values -2 ("very much less...") and +2 ("very much more ... than in a non-CERN, low-friction contract).

The results are shown in Figure 6.1. where positive values indicate that CERN contract components were associated with less contractual "friction" than non-CERN contracts. This would imply that CERN contract components were efficient. Conversely, negative values indicate that CERN contract components were considered as inefficient by the suppliers. The variables in Figure 6.1 are from left to right: value of the contract, duration of contract, payment conditions, price revisions, use of options, guarantee period, legal constraints, transportation arrangements, level of details (technical specification), specified skills, equipment, related documents, testing procedures, support from CERN, use of standards, use of subcontractors. The T-line gives the corresponding standard error for each variable.

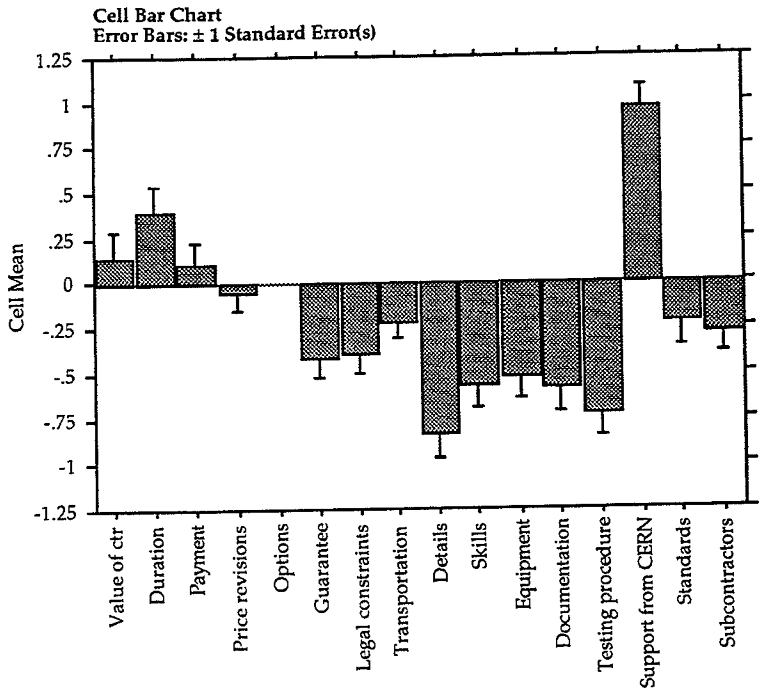

Figure 6.1 *The mean of each CERN contract component compared to other contracts considered by the suppliers to be associated with low transaction costs.*

From Figure 6.1 one can see that the total integral of deviations is negative, even if the values above zero are included. The dominant negative-value contract components included clauses linked to required technical supplier skills, production or testing equipment, extent of contractual documentation, level of details of the technical specifications, and testing procedures.

In 50% of the cases, the suppliers expressed difficulties in understanding why CERN imposed certain contractual requirements related to the technical parameters of the products. They perceived the CERN-specifications as unconventional and difficult to implement. The suppliers would have preferred more functional specifications giving them more freedom to implement the production phase in detail. It was not always clear to the suppliers why such a detailed specification was necessary in the first place. This resulted in additional work to clarify and interpret the exact meaning of the specified contract clauses, often extending long into the execution phase of the contracts.

Other inefficient contract components included transportation arrangements, required special manufacturing or testing standards, subcontractor selection, guarantee period and legal clauses. For example, in 20% of the cases, special transportation arrangements were requested which suppliers did not understand or did not want to agree to. These included, e.g., the packaging and transportation of vacuum components to CERN under very specific conditions (temperature, humidity, physical contact etc.). The suppliers considered themselves as experienced in the business and had not been forced to respect such requirements before by other customers buying similar or identical products.

Another example is related to legal constraints. Due to the specific geographical location of CERN (established physically both in France and in Switzerland), special safety measures linked with installation procedures were indirectly imposed in 25% of the cases by both the French and Swiss government authorities. This required the suppliers to get well acquainted with the safety regulations of both countries. These requirements had in turn contractual implications which obviously were not clearly explained to suppliers and resulted in a need for substantial clarification efforts during the project execution.

Based on the findings in this section, it can be concluded that in a number of the studied cases, contract components related to CERN transactions appeared to be inefficient to the suppliers. It can further be concluded that the empirical evidence did indicate the presence of transaction costs.

In order to verify the dominance of technological requirements as the source of transaction costs, a factor analysis was carried out. As described in Chapter 5, factor analysis reduces the number of original variables by creating new variables based on a linear combination of the original ones. The results, after applying the oblique transformation, are summarized in Table 6.1 The original variables are given in the first column in Table 6.1. The reduced new variables are marked as Factor 1, Factor 2, and Factor 3. The factors cover 74% of the total calculated variance. The highest weights or loading factors in the three different factors are given in bold. The factor analysis included 41 cases.

Table 6.1 Summary results of the factor analysis on transaction costs after applying an oblique transformation.

Original variables	**Factor 1**	**Factor 2**	**Factor 3**
Price revisions	-.114	**.917**	-.057
Use of options	-.004	**.928**	.063
Specified in-house skills	**.661**	-.117	.180
Equipment	**.788**	-.212	.051
Level of details (technical spec)	**.869**	.056	-.023
Testing procedures	**.871**	.066	-.147
Guarantee period	.020	-.128	**.830**
Legal constraints	.002	.138	**.842**

Three factors were sufficient to cover a dominant share of the total calculated variance in Table 6.1. Eight original variables were eliminated during the transformation process. These variables included value of the contract, support from CERN, use of standards, transportation arrangements, use of documents, use of subcontractors, duration of the contract, and payment conditions.

The highest loading factors in Factor 1 were associated with transaction cost variables such as specified technical skills, equipment, level of details of the specifications and the description of the testing procedures. Factor 1 covers 36% of the total variance. It would appear that Factor 1 was dominated by production and quality-related transaction attributes as described in Table 5.6 in Chapter 5. This factor was named "Production and quality".

The highest loading factors in Factor 2 were associated with price indexing and the use of options for futher contracts[79]. Factor 2 covered 20% of the total calculated variance. It appeared to correspond with the transaction attribute of compensation as described in Table 5.6. This factor was named "Compensation".

Factor 3 included two original variables with high loading factors, namely the contract component guarantees and legal constraints. Factor 3 covered 18% of the total calculated variance. Based on Table 5.6, Factor 3 seemed to correspond with transaction attributes describing the transportation, installation and commissioning aspects. This factor was named "Customer delivery".

It would thus appear that Factor 1, including the product and quality-related issues, was the dominant source of transaction costs as proposed in Hypothesis 1. This confirms what was suggested by the literature review in Chapter 2. The neoclassical contractual format is not an efficient trading interface for transactions in a cost and technology- driven purchasing environment.

[79]This means that CERN withholds the right to place additional orders, applying a price revision formula.

Therefore, the first research hypothesis appears to be supported by empirical evidence.

6.3 Hypothesis 2: Classification of transactions

The second research hypothesis proposed that in a system of fixed contractual relationships, the presence of inefficient contracts can be identified through evaluating the level of asset specificity. It was further proposed that this asset specificity is asymmetric by nature.

More specifically, it was proposed that the concept of asset specificy can be further divided into buyer (CERN) and supplier-related asset specificity. In Chapter 5, the CERN-related asset specificity was defined as the level of CERN-involvement in the transaction. Supplier-related asset specificity was defined as the level of product uniqueness.

The second hypothesis was tested by:

1 studying the relationship between buyer and supplier-related asset specificity and the characterization of transactions;

2 verifying the relationship between asset specificity and transaction costs.

The first step was to verify to what extent the buyer and supplier-related asset specificity were dependent on each other. This linear dependence is shown in Table 6.2.

Table 6.2 Correlation between buyer and supplier-related asset specificity measured in terms of the level of CERN-involvement and product uniqueness , respectively.

Product uniqueness vs.	F-ratio	p-value	Corr. coeff.	Conclusions
CERN-involvement	.154	.697	.071	Not significant

Based on Table 6.2, it was concluded that the proposed two forms of asset specificity were not dependent on each other on a level of statistical significance. It was therefore appropriate to classify the various transactions using these two variables.

The distribution of the 49 contracts is shown in Figure 6.2. The two axes represent the buyer and supplier-related asset specificity on a Likert-scale ranging from 1 to 5. The buyer or CERN-related asset specificity is shown on the horizontal scale. On the horizontal axis, the value 5 means high commitment and 1 low commitment from CERN during the preparation and execution of the contract. The small squares indicate the number of contracts related to the corresponding level of asset specificity associated with the transaction. The full lines represent the means of the variables. In cell 2A, both types of asset specificity are high and in cell 1B both are low.

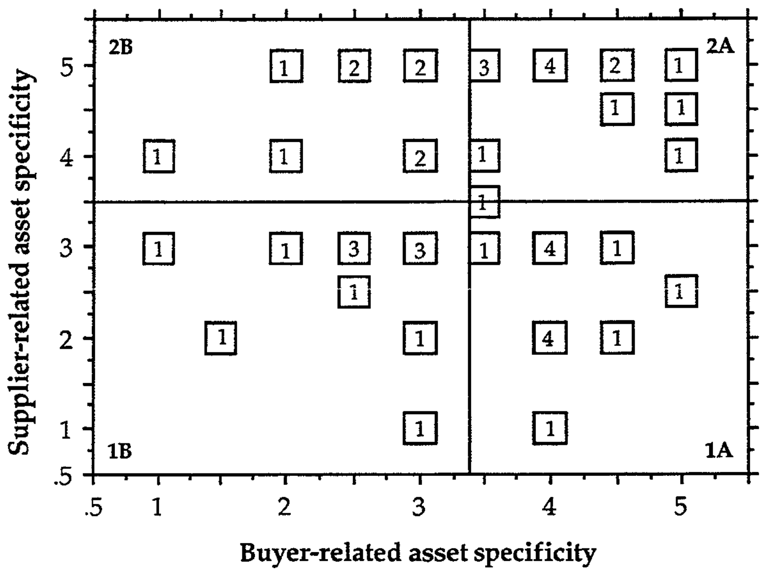

Figure 6.2 Characterizing the different types of CERN transactions on a five-point Likert scale.

A low level of CERN-related asset specificity means that no engineering effort was performed by CERN. The product in question may have been a well established product thus requiring limited technical involvement from CERN. In such cases, it was sufficient for the supplier to respond to a functional, more general specification. Conversely, a high level of CERN-related specificity means that the level of technical involvement of CERN in the transaction was high. This is a reflection of the necessary development efforts in areas of CERN's core competences. In such cases, CERN had already carried out the necessary research and development effort and had specified the product in more detail. Thus, there was no need for the supplier to undertake any engineering activities. Typically, this type of transaction took the form of a contract focused on production.

The supplier-related asset specificity on the vertical scale measures to what extent the CERN product in question deviated from the standard products of the supplier[80]. The value 1 means that the CERN product was a standard product for the supplier and 5 that it was unique. As discussed in Chapter 4, the level of product uniqueness was supplier-specific. In this context, it could result primarily from the purchasing policy of CERN. Thus, product uniqueness rated by a given supplier as 5 did not necessarily mean it was unique in a general sense. In principle, it is possible that the CERN product existed as a standard product of a non selected supplier.

The two lines dividing Figure 6.2 into four cells reflect the mean values of the variables. The mean value of the level of supplier-related asset specificity was 3.5 ±.18 and the mean value of the buyer-related asset

[80]This also measured the degree to which the assets linked to the manufacturing of the CERN product deviated from those associated with manufacturing standard products. The manufacturing process refers to the manufacturing technologies and steps used to produce the CERN product.A correlation of statistical significance was observed between product uniqueness and process technologies ($p = .0009$, $F = 12.63$ and correlation = .48).

specificity was 3.4 ± .14, respectively. The transactions were thus divided into two major sub-sets. Those in the two lower cells of supplier-related asset specificity were defined as type 1-transactions and those being in the two upper cells are type 2-transactions. The numbers in the small squares in each cell give the number of the transactions with the same values for the parameter of asset specificity.

Table 6.3 describes the nature of CERN transactions in each cell. Individual transactions were not presented in any particular order. In cell 1B, both buyer-related asset specificity (BAS) and supplier-related asset specificity (SAS) are low and in cell 2A both are high.

Table 6.3 Description of the nature of the CERN transactions in terms of different levels of asset specificity.

2B: BAS low, SAS high	2A: BAS high, SAS high
Metal-ceramic feedthroughs	Beam separators
Thyristor-controlled reactors	Multicore transmission cables
High-voltage feedthroughs	Superconducting magnets (2)
Detector electrodes	Electrical heating jackets
RF storage cavities	RF electronics (2)
Intercavity vacuum chambers	Vacuum chambers
Cryogenics plant	Access cards
Vacuum tubes	Feedthrough rings for detectors
Automated cartridge storage	Ultra-high vacuum flanges
	Mechanical detector structure
	Emergency diesel generator sets
	Power cables
Power transformers (2)	Superconducting cable
Power cables (2)	Power cables
Power supplies	Bolts, nuts for vacuum systems
Bellows and assemblies	Off-line computers
Mechanical racks	Busbars
Radio telephone system	Collimators
Temperature controllers	Electronics for power converters
Thyratrons	Wiggler-magnets
VME-electronics	AV-communications equipment
Digital exchange system	Gaskets for vacuum system
	Capacitor banks
	Power transformers
	Low-voltage switchgear
	Diodes
1B: BAS low, SAS low	**1A: BAS high, SAS low**

Similar transactions extending beyond more than one cell were typically border line cases (for example, the power cables in cells 2A and 1A). The distribution of transactions was partly determined by the level of individual supplier familiarity and could thus have been very different even for identical products if other suppliers had been involved. Therefore, the cells do not represent an absolute measure of product or transaction features. They are related to the capabilities of the individual selected suppliers.

The next step was to test whether high asset specificity was linked to a strong presence of transaction costs. That is, whether transaction costs were higher in cell 2A than in 1B. As discussed in Chapter 2, in the presence of bounded rationality, asset specificity is a good indicator of transaction costs. In this study, the level of bounded rationality associated with the CERN contracts was not measured directly. However, based on Chapter 3, bounded rationality was expected to be present to a high degree in CERN contracts[81].

Thus, buyer and supplier-related asset specificity were expected to be associated with high transaction costs as determined by the transaction attributes proposed in Hypothesis 1. The dominant source of transaction costs was the factor "Production and quality", including product attributes such as specified technical skills, equipment or testing procedures. In order to verify the connection between transaction costs and asset specificity, Fisher's protected least significant difference or PLSD-test was

[81]This was also supported by other empirical findings. The level of complexity was used as a proxy measurement for bounded rationality problems. Complexity was defined as the number of product components and critical linkages between them (Lambert, 1989). The level of complexity linked to the CERN transactions was 30% higher than complexity linked to standard product transactions. The observed complexity was $+.85 \pm .12$ on a five-point Likert-scale from -2 (much lower) to +2 (much higher) and 0 (the same) in comparison with other, similar contracts.

applied to the transaction cost factor "Production and quality" between cells 2A and 1B. The results of the test are given in Table 6.4 where Factor 1 describes production and quality-related transaction attributes. It includes the original variables: skills, equipment, level of details and testing. The notations 2A and 1B refer to cells where the level of both buyer and supplier-related asset specificity are high and low, respectively. The lower the p-value, the more unlikely it is that the observed difference is due to coincidence alone. A p-value having high statistical significance is indicated in bold.

Table 6.4 Summary results of the Fisher's PLSD-test applied to the transaction cost variable Factor 1.

Statistics	**Factor 1**
Mean difference (2A, 1B)	-.452
Critical mean difference	.325
p-value	**.007**
F-ratio	5.210

Table 6.4 shows a statistically significant difference between the level of transaction costs in cells 2A and 1B[82]. This implies strong support for the second hypothesis that the presence of inefficient contracts can be identified through evaluating the level of asset specificity.

In empirical tests, not included in this study, the transaction costs associated with the cases in cells 1A and 2B were compared with the transaction costs prevailing in cells 1B and 2A. No statistically significant results were obtained, probably because it is the joint occurrence of new products manufacturing by the supplier and extensive new know-how transfer by the buyer that leads to friction in the spot-market contracts

[82]For the sake of comparison, the mean difference between cells (2A+2B) and cells (1A+1B) was -.318, p= .009 and F= 4.51.

execution. This implies that in the CERN context, the dual presence of high supplier-related asset specificity and high buyer-related asset specificity leads to the presence of high transaction costs.

6.4 Hypothesis 3: Types of generated supplier benefits

The third hypothesis proposed that buyer and supplier-related asset specificity not only constitute a joint source of transaction costs, but also generate supplier benefits. These benefits depend on the level of buyer and supplier-related asset specificity. The supplier benefits linked with competence-driven supplier behaviour include both marketing and technical aspects and are expected to be higher as compared with the benefits associated with other types of supplier behaviour.

The supplier benefits were measured using a five-point Likert-scale. On the scale, 1 meant "no significance at all" and 5 "very significant" to the supplier. In 85% of all the cases, suppliers considered the transactions as beneficial[83]. The reported benefits are shown in Figure 6.3 where the vertical axis gives the mean value of each variable and the T-line the corresponding standard error[84]. The different benefits are from left to right; direct profit, extra available capacity utilization, other similar customers, long-run operational efficiency with a customer such as CERN, commercial collaboration with new companies, improved subcontracting practices, improved contract control, marketing benefits, improved process equipment, improved quality, advanced product development, research and development (R&D) benefits, improved technical skills, and improved workforce motivation.

[83]In comparison, only 70% of the transactions were considered as beneficial by the suppliers in the previous study on CERN contracts (Schmied et al., 1984).

[84]Since in practise, all the values are between 1 and 4, the upper end of the vertical scale in Figure 6.3 has been adjusted accordingly.

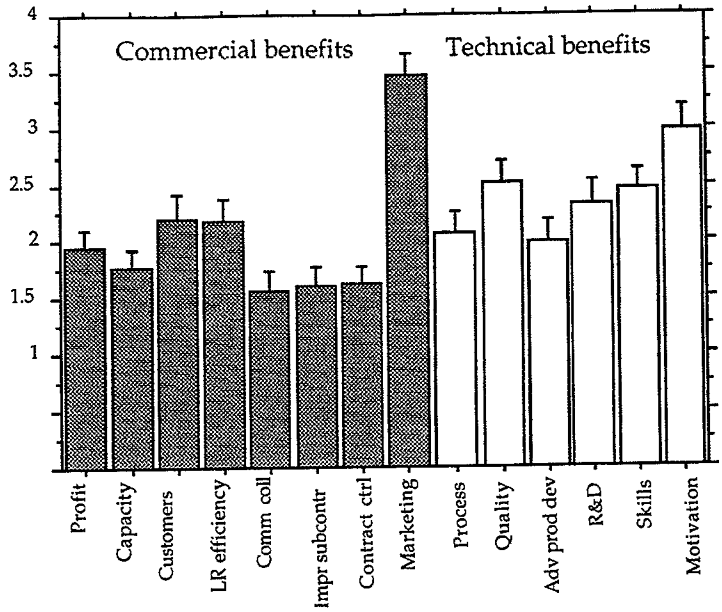

Figure 6.3 Benefits from CERN contracts to suppliers.

From Figure 6.3 it can be observed that the highest benefits were found in the areas of marketing, improved motivation, improved quality, research and development (R&D) benefits and improved technical skills.

Factor analysis was applied to reduce the number of original variables and to compare the benefits at different levels of asset specificity. The results, after applying the oblique transformation, are summarized in Table 6.5. The original variables are given in the first column in Table 6.5. The reduced new variables are marked as Factor 1, Factor 2, and Factor 3. The factors cover more than 50% of the total calculated variance. The highest weights or loading factors in the three different factors are given in bold. The corresponding p-value was less than 0.0001. The factor analysis included 45 cases.

Table 6.5 Summary results of the factor analysis after applying an oblique transformation.

Original variables	Factor 1	Factor 2	Factor 3
Profit	**.753**	-.370	-.285
Capacity utilization	-.247	**.792**	-.151
Other customers	-.077	.040	**.891**
Long-run operational efficiency	**.729**	-.331	.054
Improved subcontracting practises	**.672**	.001	-.061
Contract control	-.050	**.822**	-.035
Marketing benefits	.252	.206	**.423**
Improved quality	.100	**.484**	.189
Advanced product development	-.241	-.202	**.943**
Research and development benefits	.161	.020	**.733**
Improved technical skills	**.636**	.178	-.002
Increased employee motivation	**.539**	.221	.173

Three factors shown in Table 6.5 were sufficient to cover more than 50% of the total calculated variance. Two original variables, commercial collaboration and process benefits, were eliminated during the transformation process.

The highest loading factors in Factor 1 were associated with benefit variables such as profit, long-run operational efficiency, improved subcontracting practises, improved technical skills, and motivation. Factor 1 covered 30% of the calculated variance. It appeared that Factor 1 described supplier benefits which were linked to a sustainable (long-run) improvement of operational activities. The companies were able to improve their operational efficiency (longer term business relations with clients such as CERN, improved subcontracting, improved technical skills and increased employee motivation). Based on Table 5.7 in Chapter 5, these benefits appeared to be generated by three of the four different types of transaction attributes[85]. Thus, this factor was named "Mixed benefits".

The highest loading factors in Factor 2 were associated with variables such as capacity utilization, contract control, and improved quality. Factor 2 covered 15% of the calculated variance. Factor 2 appeared to describe benefits linked to short-term, capacity-driven supplier relationships. As a result of the CERN contracts, the suppliers were able to use their production capacity and learned to monitor contract costs. In addition, stringent quality requirements from CERN had a positive impact on overall quality. Based on Table 5.7, these benefits appeared to be generated mainly by production and quality-related transaction attributes. Thus, this second factor was named "Production and quality benefits".

While testing Hypotheses 1 and 2, it was observed that the dominant reduced factor associated with transaction costs was linked to production and quality-related transaction attributes. Moreover, the magnitude of the factor called "Production and quality" was higher in cell 2A than in 1B (see Figure 6.2). The benefits generated by the same transaction attribute were expected to be higher in cell 2A as compared to cell 1B. In order to test this, Fisher's PLSD-test was carried out on benefit factor "Production and quality benefits" between cells 2A and 1B.

The results of the test are given in Table 6.6 where Factor 2 describes production and quality-related transaction benefits. It includes the original variables: capacity utilization, contract control and quality. The notations 2A and 1B refer to cells where the levels of buyer and supplier-related

[85]The four general transaction attributes were defined as: compensation (money), product attributes, time-span of the transaction, and human interaction.

asset specificity are both high or both low. The lower the p-value, the more unlikely it is that the observed difference is due to coincidence alone. A p-value having high statistical significance is indicated in bold.

Table 6.6 Summary the results of the Fisher's PLSD-test applied to the benefit variable Factor 2.

Statistics	**Factor 2**
Mean difference (2A, 1B)	.818
Critical mean difference	.529
p-value	**.003**
F-ratio	5.106

Table 6.6 provides strong empirical support to the first part of Hypothesis 3, namely, that supplier benefits were higher in transactions associated with a high level of buyer and supplier-related asset specificity.

The remaining Factor 3 appeared to be a combination of both commercial and technical benefits. The highest loading factors in Factor 3 were associated with variables such as advanced product development, other similar customers, research and development (R&D) skills, and marketing benefits. Factor 3 covered 12% of the calculated variance. Based on Table 5.7 in Chapter 5, Factor 3 seemed to be dominated by product component-related transaction attributes. Thus, it was called "Product component benefits". As discussed in Chapter 5, these types of benefits are expected to be associated with competence-driven strategies. Competence-driven supplier strategies were defined as conscious plans to enhance the core competences of the firms by tapping into the complementary assets provided by the customer. The knowledge gained would then be used to develop new products or enter new markets.

In 13 cases evidence of competence-driven supplier behaviour was identified. In each case, the focus was on utilizing the knowledge gained as a result of delivering products to CERN.

Fisher's PLSD-test was applied to test whether product component-related benefits were higher in transactions associated with competence-driven supplier strategies in comparison with the other types of supplier behaviour. The results are shown in Table 6.7 where Factor 3 describes product component-related transaction benefits. It includes the original variables: advanced product development, other similar customers, research and development (R&D) skills, and marketing benefits The abbreviation "CB" refers to competence-driven supplier strategies. The lower the p-value, the more unlikely it is that the observed difference is due to coincidence alone. A p-value having high statistical significance is indicated in bold.

Table 6.7 Summary of the results of the Fisher's PLSD-test applied to the benefit variable Factor 3.

Statistics	Factor 3
Mean difference (CB-strategies, other)	.858
Critical mean difference	.465
p-value	**.003**
F-ratio	13.251

From Table 6.7 it can be observed that a difference of statistical significance exists between the benefits associated with competence-driven supplier strategies as compared to other forms of supplier behaviour. Thus, the presented empirical evidence gives strong support to Hypothesis 3.

An additional consistency test was performed to verify the findings. The presence of an organizational learning process was studied. This effect was proposed to be present in the studied transactions, explaining the apparent absence of opportunism. A reduction in the level of uniqueness of the manufacturing or process technologies was expected between the time of the CERN contract and the time of the interview. That is, one expected the level of process uniqueness to decline over time as the suppliers learned how to manufacture the CERN products and possibly utilize these new skills for other purposes. A five-point Likert-scale was used (1= "standard", 5= "unique") to measure the level of process uniqueness, followed by a paired t-test analysis (at the time of the contract, at the time of the interview). A difference of statistical significance was observed[86], thus confirming the presence of organizational learning.

In conclusion, sufficient empirical evidence was found in support to the third research hypothesis.

6.5 Hypothesis 4: Description of transactions by value chain functions

The fourth and last research hypothesis proposed the following. The level of organizational involvement is an additional transaction attribute as a complement to asset specificity to identify inefficient contracts and supplier benefits. Based on Hypothesis 3, the level of involvement of the technology development and marketing & sales functions should be higher in transactions associated with competence-driven strategies of suppliers than in those associated with other forms of supplier behaviour.

First, the organizational involvement of the supplier in the CERN transactions was analyzed. Figure 6.4 shows the involvement of different supplier functions in the CERN transactions. For each variable, a five-point Likert-scale was used. The variables shown in Figure 6.4 are from

[86]The mean difference was +.55 (at the time of the contract; at the time of the interview) and the probability p was .0001 that the mean difference was 0. The corresponding t-value was 4.14. The elapsed time between the start of contract and the interview was on average 6 ± .18 years.

left to right; general management, research and development (R&D), production, marketing, purchasing, service and installation and other form of involvement. The bars give the mean value of each variable and the T-line the corresponding standard error[87].

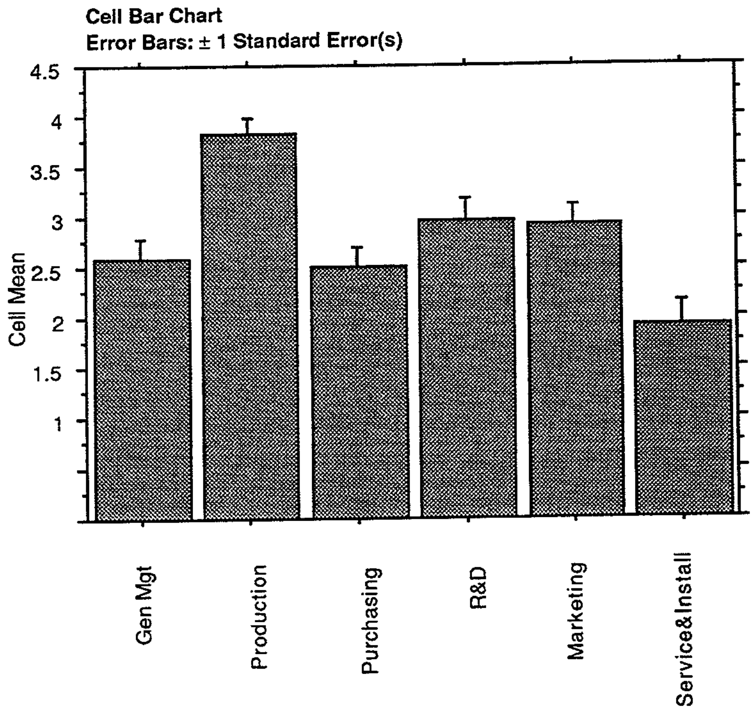

Figure 6.4 *Organizational involvement of the supplier divisions in the CERN transactions.*

As can be seen from Figure 6.4, the involvement of production, not surprisingly, was highest. Then, research and development and marketing followed.

Other types of supplier involvement were reported in 13 cases, nine of which were directly linked to quality assurance and construction

[87]Since in practise, all the values are smaller than 4, the upper end of the vertical scale in Figure 6.4 is adjusted accordingly.

functions. These could be included as production functions which were already found to be dominant.

Factor analysis was applied to reduce the number of comparable variabes between cases of high and low level of asset specificity. The results, after applying the oblique transformation, are summarized in Table 6.10 where the original variables are given in the first column. The reduced new variables are marked as Factor 1 and Factor 2. The factors cover more than 65% of the total calculated variance. The highest weights or loading factors in the two different factors are given in bold. The corresponding p-value was less than 0.0001. The factor analysis included 47 cases.

Table 6.10 Summary results of the factor analysis on the level of involvement of supplier divisions in the CERN contracts, after applying an oblique transformation.

Original variables	**Factor 1**	**Factor 2**
General management	**.637**	$-5.108\ 10^{-5}$
Production	**.904**	-.321
Purchasing	**.760**	.215
R&D	.036	**.794**
Marketing	-.207	**.923**

Factor 1, with the highest loading factors for the original variables of general management, production and purchasing, covered 39% of the total variance. Based on the description of the value chain functions in Chapter 2, Factor 1 seemed to be dominated by support activities, namely firm infrastructure (general management) and procurement (purchasing). Since production activities of the suppliers concerned were also partially related to the support functions of the firm value chain, Factor 1 was called "Support activities-involvement".

The second factor, Factor 2, included two original variables with high loading factors. These variables were R&D and marketing activities, which primarly corresponded to the value chain activities of technology development and marketing & sales, respectively. Factor 2 covered 27% of the total variance. Factor 2 appeared to include the two hypothesized strong components of competence-driven supplier strategies, namely R&D and marketing. As hypothesized in Chapter 4, within the dynamic learning process technological capabilities were expected to become integrated into the marketing activities of the firm thus resulting in enhanced core competences. Factor 2 was thus called "R&D and marketing involvement".

Fisher's PLSD-test was then applied to verify the hypothesized difference between the level of involvement of the support activities in cases of high and low buyer and supplier-related asset specificity. The results of the test are shown in Table 6.11 where 2A refers to high buyer and supplier-related asset specificity and 1B low buyer and supplier-related asset specificity. Factor 1 includes the following original variables: general management, purchasing and production. A p-value having high statistical significance is indicated in bold.

Table 6.11 Summary the results of the Fisher's PLSD-test applied on the level of involvement of supplier activities between cases of high and low buyer and supplier related asset specificity.

Statistics	Factor 1
Mean difference (2A, 1B)	.601
Critical mean difference	.606
p-value	.052
F-ratio	7.115

From Table 6.11 it can be seen that the difference between the level of involvement of support activities in cases of high and low levels of asset specificity was close to becoming statistically significant[88].

The second part of the last hypothesis was also verified using Fisher's PLSD test. The level of involvement of R&D and marketing divisions was compared between transactions associated with competence-driven strategies and other types of supplier behaviour. The results of the test are shown in Table 6.12 where the abbreviation "CB" refers to competence-driven supplier strategies. A p-value having high statistical significance is indicated in bold.

Table 6.12 Summary of the results of the Fisher's PLSD-test applied on Factor 2 linked to competence-driven and other transactions. Factor 2 includes original variables: R&D and marketing.

Statistics	**Factor 2**
Mean difference (CB, Others)	.621
Critical mean difference	.653
p-value	.062
F-ratio	3.557

Table 6.12 shows that the difference between involvement of technology development and marketing & sales functions in competence-driven and other transactions was close to becoming statistically significant[89].

In conclusion, limited empirical evidence was found in support of Hypothesis 4, even though the findings were not of statistical significance at the 95% level.

[88]The observation would be statistically significant at a confidence level of 94.8% instead of the default value of 95%.

[89]The observation would be statistically significant at a confidence level of 93.8% instead of the default value of 95%.

6.6 Summary

The four research hypotheses were tested in the light of the collected empirical evidence. The key results are as follows:

1 transaction cost analysis allows to describe and identify inefficient contracts in a cost and technology-driven environment;

2 in a fixed contractual environment, inefficient contracts can be categorized based on the level of both buyer and supplier-related asset specificity;

3 asset specificity is not only a source of transaction costs but also of generated supplier benefits. The supplier benefits are higher in the case of competence-driven supplier behaviour when compared with other types of supplier behaviour;

4 the level of organizational involvement is an additional transaction attribute as a complement to asset specificity to identify inefficient contracts and, more importantly, supplier benefits. Based on Hypothesis 3, the level of involvement of the technology development and marketing & sales functions should be higher in transactions associated with competence-driven strategies of suppliers than in those associated with other forms of supplier behaviour.

Except for the fourth hypothesis, statistically significant empirical evidence was found in support to all the propositions. Support was found for the fourth hypothesis at a confidence level higher than 93%.

CHAPTER 7: IMPLICATIONS FOR CERN

7.1 Introduction

In the previous chapter, empirical evidence was found in support of the proposed research hypotheses. In this Chapter, the implications for CERN are discussed.

7.2 Implications for the present CERN purchasing strategies

As discussed in Chapter 3, the nature of the interactions with industry is primarily determined by the mission and research strategy of CERN. The purchasing strategy of CERN needs to take into account four elements:

1 the focused mission and scientific strategy of CERN;

2 the implications of national science and technology policies in the Member States and CERN's expected role in them;

3 the goal of maximizing financial and technological returns to the Member States industries;

4 the best use of the available resources at CERN.

As discussed earlier, CERN operates in a cost and technology-driven environment. On the one hand, it aims to achieve high performance and high reliability of its scientific installations. On the other hand, it is obliged to operate its facilities at the lowest possible cost. These two and sometimes contradictory goals are discussed further below, based on the research findings.

The **first** contribution of this study to CERN's purchasing strategy is that it provides a planning tool to identify contractual components that may not be efficient for a given transaction. The presence of such inefficient components may result in contractual difficulties. For example, ill-explained or mis-interpreted requirements could induce indirect costs to CERN in terms of additional efforts in contract monitoring and control. In order to prevent this from happening, the contract format could be adjusted to reduce the related transaction costs and increase the supplier benefits. This could be achieved, e.g., as follows:

1 estimating the total costs of a product and evaluating the bidder capabilities, taking into account the required level of CERN support;

2 relaxing the criterion of selecting the lowest bidder to concentrate on suppliers whose offers are closest to each other, namely on the "plateau" part of the distribution curve represented in Figure 3.2 in Chapter 3. These suppliers are not the lowest bidders but in most cases are the most experienced ones. Based on transaction cost analysis, this would imply that they are characterized by the lowest overall costs (including transaction costs), as well[90];

3 reducing the risk of opportunistic supplier behaviour (which, it should be recognized, was neither analyzed nor even identified in the present study) by involving both the purchasing office and legal support early on in the tender-preparation phase.

The **second** contribution of this study is the suggestion of a new way to characterize different types of contracts based on their transaction attributes. Traditionally, contracts have been described in terms of their

[90]CERN engineers are convinced this is indeed the case. One engineer explained. "We select the lowest bidder. He may be good but usually quite new in the game. So we help him; we visit the firm often, help in the testing, provide perhaps some small back-up in terms of equipment, teach the staff to make the product, check everything ... After the contract the firm knows what it's all about and makes a more realistic offer for the possible follow-up contract. But then there is someone else who is cheaper, less experienced, and we start all over again".

specific technical content. They describe the specific product in question, the volume of the contract, the type of supplier and so on. In this study, the common denominator in all the contracts is the nature of the transaction. That is, whether the product in question is unique or not; whether the supplier is familiar with the CERN product or not; whether the related manufacturing technology is special or not and so on.

The focus shifts from the technological details of the products to describing the type of transaction itself. It is not necessarily linked to the supplier size, its level of export activity or research and development expenditures. Nor is it necessarily linked to the business areas or some other traditional indicator of supplier categorization. The detailed product description becomes therefore secondary in nature. For instance, electric heating jackets and emergency diesel generators share the same transaction features and belong to the same class of contracts. Yet they are obviously totally remote products from a technical description point of view.

The **third** contribution of this study is based on the previous ones and it goes a step further to describe the nature of asset specificity related to CERN transactions. As discussed earlier, the level of asset specificity does not measure the level of technological sophistication nor does it define "high tech" versus "low tech". It is an indicator of the levels of specificity the transaction has for both the buyer and the supplier.

The level of uniqueness associated with a transaction has two components, namely the levels of CERN-related asset specificity and supplier-related asset specificity. These concepts reflect the extent to which the product described in terms of the transaction attributes is CERN-specific and/or supplier-specific. This approach can be used to identify activities which are linked to the core competences of CERN. More specifically, if both the CERN-related asset specificity and supplier-related asset specificity are high, this implies that CERN has made a significant effort in designing and developing prototypes and in drafting detailed technical specifications before launching the tenders. In addition, the products concerned are, in these cases, unfamiliar and unique to the suppliers selected based on the lowest bid.

The opposite case would hold for transactions where both the CERN-related asset specificity and supplier-related specificity are low. In this case, the related products or technologies are most likely associated with knowledge which is complementary to the in-house capabilities available at CERN. These types of transactions do not represent an important source of complementary assets to the suppliers since, technologically speaking, CERN has little to offer to the suppliers. In addition, they only include products with low level of product uniqueness.

The **fourth** contribution of this study is to provide a tool to identify different types of supplier benefits. The study showed that in more than 85% of the cases, the CERN contract generated benefits to the suppliers. Moreover, the benefits were higher in transactions where both the CERN-related asset specificity and supplier-related asset specificity were high as compared with cases where both were low. When competence-driven supplier strategies led to utilizing CERN-specific assets, the associated benefits were higher than the ones resulting from other forms of supplier behaviour.

7.3 Improving CERN's goal achievement in the area of industrial policies

Identifying the types of supplier benefits associated with different types of transactions could support CERN's goal achievement in the area of industrial policies. The contribution of CERN to the industrial policy goals of member states could be viewed in two alternative ways.

First, if CERN wants to put emphasis on its role as a catalyst and a teacher of industry, it is clear that the present purchasing strategy supports this role. At present, CERN selects the lowest bidder without any commitment to establish a longer-term contractual relationship. From the point of view of CERN, suppliers operate in an "open" network. Suppliers change frequently and their identity is less important. The commercial benefits to the suppliers may be low but the technological benefits are high. This results from CERN's independent in-house research and development and design capabilities and the fact that CERN performs the role of a trend-setter in core technologies.

However, from the perspective of transaction cost analysis, this solution is inefficient because the associated transaction costs are high. Furthermore, in terms of strategic management theory, from the perspective of existing suppliers, such an approach is not to be recommended as it prevents longer-term partnering and strategic alliances, networking and alike. In addition, this practice requires maintaining strong and expensive in-house capabilities at CERN. It is necessary to draft the technical specifications in a supplier-independent way, to re-train new suppliers and to carefully monitor and control the contracts.

Second, if CERN aimed instead at emphasizing the full exploitation of assets available in the industry, the present purchasing strategy would need to be modified. According to theory, larger contracts with longer-term commitments would be required. In addition, one should concentrate on fewer but better qualified suppliers[91]. Design, prototype and series production contracts would be more closely linked as sequential contracts would be granted to the same suppliers. The implications of such a strategy are the following.

First, this option would attract other qualified suppliers who presently do not bid, fearing that they would only be awarded the first contract. Their fear is that the investments made in designing a special prototype for series production would bring no return on investment. Their argument is that many manufacturing-oriented suppliers could carry on from there, once the major technical problems are solved. They hardly see an incentive to make an effort to win a contract with CERN.

Second, the commercial benefits would be higher due to reduced contractual difficulties. The technological benefits, however, would likely be reduced in comparison with the model of an "open" supplier network where the suppliers are typically less familiar with the CERN products in question.

Restricting the tendering to fewer suppliers would lead to a more closed supplier network. Over time, suppliers could develop sufficient capabilities to run CERN-specific activities at CERN. The present in-house resources at CERN could then be reduced accordingly. This implies that the suppliers would become more familiar with CERN-activities and would gain higher commercial benefits at the same time. However, the technological benefits could be less significant. From a conceptual point of view, such an approach, albeit contractually efficient, could be vulnerable

[91] It should be reminded that the revised purchasing rules (CERN, 1994) have permitted CERN to reduce the number of firms contacted for tendering. Whether this has resulted in obtaining more qualified suppliers, remains to be studied.

to possible opportunistic behaviour from the key suppliers. To safeguard against such behaviour, long-term contracts would be necessary.

7.4 Implications for CERN-supplier strategies

The contributions of this study, as regards CERN-supplier strategies, are discussed below.

The **first** contribution is the insight that suppliers should select a specific strategy to gain specific benefits. Three main types of supplier benefits were identified, each of them associated with specific value chain functions:

1 benefits in the area of long-run operational efficiency (mixed benefits);

2 short-term, capacity-driven benefits (production and quality benefits);

3 competence-based supplier benefits (product component benefits).

Benefits in the area of long-run operational efficiency were associated with a higher profitability, improved purchasing practises and technical skills. The shorter-term production and quality benefits included better capacity utilization, contract control and improved quality. Competence-driven supplier strategies were associated with finding other similar customers, marketing benefits, advanced product development and improving skills in research and development.

The **second** contribution to supplier strategies is the following. The tools developed permit to identify transaction costs related to the contracts. Thinking of ways on how to reduce these transaction costs could further help suppliers while preparing their offers.

How could the supplier reduce transaction costs and increase the benefits related to CERN contracts in practice? Given the institutional boundaries of CERN, the findings of this study suggest that the following measures could be taken:

1 making sure the product is fit for purpose; bidding for only what is specified - nothing more, nothing less;

2 making sure to know what to expect from CERN; making sure to fully understand the CERN purchasing rules. The scope is only one contract at a time without any guarantees of follow-up contracts. Verifying in detail what type of help CERN is able to provide during the contract, if any;

3 setting up a contract team: including people from operations, technology development, procurement and marketing functions;

4 making sure there is sufficient technical supervision: nominating an experienced project leader, in particular when there is installation work involved;

5 managing subcontractors: extending the imposed CERN requirements to the subcontractors, as well;

6 linking the contract to strategic concerns: using CERN contracts to improve the firm's core competences; tapping into the complementary assets provided by a customer such as CERN;

7 using the contract to increase personnel motivation: suggesting to the personnel that they are able to do more demanding, special tasks, as well; rewarding them by allowing them to join such non-routine "odd-jobs".

7.5 Summary

The implications of the research findings for CERN were discussed. These included aspects linked to improving CERN's present purchasing strategies and improving its goal achievement in the area of industrial policy. Finally, the supplier-specific strategies were discussed. The key conclusions were as follows:

1. the conceptual framework provides a tool to identify inefficient contracts and potential contractual difficulties. This tool can be used to further strengthen the contract policies of CERN, given its institutional boundaries;

2. when using the buyer and supplier-related asset specificity as a measurement tool, it is possible to monitor longer-term shifts or trends regarding both CERN and supplier core competences over time;

3. through using the buyer and supplier-related asset specificity as a measurement tool, it is possible to analyze supplier benefits and to further strengthen CERN's industrial policies;

4. the linkage between transaction attributes and supplier value chain functions helps to enhance supplier core competences in terms of recommended functional involvement in CERN contracts.

CHAPTER 8: CONCLUSIONS

8.1 Introduction

How can buyer-supplier linkages be structured to reduce transaction costs and to develop supplier core competences in an effective way? This research problem was described in the introduction to the present study. In this chapter, each major research finding is discussed in terms of its contribution to the research literature. Six contributions to the transaction cost economics literature and six contributions to the strategic management literature are identified. Based on the findings of this work, an agenda for future research is drafted.

8.2 Results and contribution to the present research literature

8.2.1 Transaction cost analysis

The **first** contribution of the present study to the research literature on transaction cost economics is that it has extended the literature's scope beyond a simple comparative analysis between different governance structures. Instead, the focus is on transaction cost differences within one governance structure, namely short-term spot-market contracts. This was achieved by designing a parameter which measures the difference in contractual "friction" (Williamson, 1985) between a given contract and a contract perceived as having low friction by a supplier. The latter refers to an existing reference contract whereby the associated transaction costs are perceived as low from a supplier perspective. For empirical research in the area of transaction cost economics, such indicators of contract structure can be used to detect the presence of transaction costs. Thus, inefficient contracts can be identified.

The **second** contribution is the characterization of transactions within one governance structure based on asset specificity. The literature acknowledges asset specificity as an important source of transaction costs, in the presence of both bounded rationality and opportunism. But asset specificity, together with the presence of small numbers bargaining, the frequency of transactions and information impactedness, is usually treated as a selection factor for efficient governance structures. In this study, however, asset specificity alone is shown to be an adequate determinant and measure of transaction costs, within a fixed governance structure. Asset specificity can therefore be used as an operational tool to analyze spot-market contracts.

The **third** contribution, linked to the second one, is the observation that asset specificity is not a transaction attribute which is necessarily only exogenously determined. That is, asset specificity associated with a given transaction can be induced by buyer behaviour: the buyer may purchase a standard product but it may be a special product for a supplier who has never produced it before. Here, the supplier may have no prior experience or appropriate production facilities. Thus, asset specificity is not generated by external conditions alone such as environmental complexity.

The implications for theory are the following. Asset specificity is a transaction-specific factor which is asymmetric by nature. It has two components, buyer and supplier-related asset specificity. These are independent of each other. Transactions can be further categorized and analyzed based on these two components. This type of analysis is not restricted to fixed contractual relationships only. It can be applied to other forms of governance structures, as well.

The **fourth** contribution is that the levels of both buyer and supplier-related asset specificity may change during the transaction. Transaction-related asset specificity which was high for the supplier ex-ante, may be low ex-post. The potential to redeploy resources (the definition of asset specificity) therefore becomes a time-dependent parameter. Its value depends on the moment in time one chooses to analyze the transaction. The asymmetric nature of asset specificity can therefore be used as a tool to analyze the dynamics of individual transactions and the associated costs.

The **fifth** contribution of the study is the observation that asset specificity not only constitutes an important source of transaction costs, but may also generate benefits to the supplier. The implications for the theory are the following.

First, a link can be established between the attributes of individual transactions and the occurrence of supplier benefits. Second, high asset specificity may imply higher supplier benefits. However, as discussed earlier, the presence of high transaction costs is not necessarily linked to higher supplier benefits. High asset specificity may be a source of benefits to the supplier when the transaction is associated with a learning process. Third, the asymmetric nature of asset specificity can be used as a tool to analyze subsequent supplier benefits as transactions associated with different levels of buyer and supplier-related asset specificity are sources of different types of supplier benefits. For example, high buyer-related asset specificity generates benefits because suppliers can tap into the complementary assets provided by a customer such as CERN. High supplier-related asset specificity generates benefits as suppliers make efforts to overcome contractual difficulties due to the special or unfamiliar nature of the transactions.

The **sixth** contribution is that transaction attributes can be linked to supplier value chain functions in a deterministic way. The level of organizational involvement can be used as an alternative to asset specificity to identify inefficient contracts and supplier benefits. The literature, notably contributions by Williamson (1985) and Jarillo (1988) recognizes that transactions are linked to company functions. However, a more in-depth analysis of this interdependence, especially for external transactions, had not yet been performed. To facilitate an exchange or transaction requires human interaction in terms of organizational involvement. Optimizing this organizational effort can reduce ex-post transaction costs.

8.2.2 Strategic management

The **first** contribution of this study to the strategic management literature is that buyer-supplier linkages can be a source of complementary assets. A demanding customer such as CERN pushes the supplier to develop and manufacture products. This may start a process of enhancing firm-specific technical capabilities. If this process is consciously linked to competence-based strategies of the firm, it can significantly contribute to creating a sustainable competitive advantage.

The **second** contribution of this study is that the level of asset specificity in transactions can be described in terms of functional capabilities of the firm. Asset specificity may therefore become a common source of both anticipated benefits and unanticipated functional efforts.

The **third** contribution to the literature is related to the use of the concept of asset specificity in strategic management thinking. Two areas of application can be identified. First, asset specificity may be influenced by the buyer's own behaviour. Selecting a supplier (e.g., based on the lowest bid, only) who is less familiar with the product could result in a high level of supplier-related asset specificity thus increasing the risk of contractual difficulties which otherwise could have been avoided. Second, the occurrence of high buyer-related asset specificity can be used to identify the buying firm's core technologies and products. High buyer-related asset specificity likely reflects market failure. In such a situation, the buyer needs to make in-house efforts to design, build prototypes and specify the product for volume production. In addition, if the transactions are associated with both high buyer and supplier-related asset specificity simultaneously (in particular when the supplier is technically very competent), they are most likely linked to the core capabilities of the buying organization.

The **fourth** contribution to the strategic management literature is the following. As discussed earlier, a firm can enhance its core capabilities by tapping into the complementary assets provided by its customers. It can achieve this by a deliberate strategy. The implications of such a strategy are consistent with the resource-based view of the firm. Customers should not only be characterized in terms of their product needs but also in terms of capabilities. These may be complementary to those of the supplying firm and enhance the economic performance of the supplier, as well. Furthermore, it is the transaction attributes which count, and not the detailed technical description of the product itself. Thus, a supplier can operate in a number of seemingly unrelated industries, building upon the complementary assets provided by the customer.

The **fifth** contribution results from linking the value chain functions to external transactions. The value chain has traditionally been used to identify cost drivers, assuming that the functions are given. In this study, the benefits associated with individual transactions are viewed in terms of the generation of value added in various value chain functions of the firm. This approach allows to extend the use of the value chain concept beyond the scope of internal functions within the firm. It is now possible to study the interactions between the value chain system and its external environment.

The **sixth** and last contribution to the strategic management literature is the extended use of the value chain concept. Marketing and sales functions turn the enhanced technical capabilities gained from external transactions into customer value and sustainable competitive advantage. Marketing and sales alone are obviously not sufficient to generate value added. But when they allow to create external visibility for the incorporated tacit knowledge or other intangible assets, they may generate high customer value. This would imply that it is the interaction between technology development and marketing functions which generates value added from transactions with customers such as CERN.

In conclusion, this study has aimed at bridging the existing gap between the strategic management literature and transaction cost economics. It has shown that asset specificity is the common denominator in both approaches.

8.3 Agenda for future research

The presented empirical evidence raises a number of challenges that future research should address.

The **first** challenge is to analyze the presence of transaction costs within a fixed governance structure in an individual or more homogeneously defined industry. In this present study, a multi-industry analysis was carried out. Single-industry studies would shed more light on the issue of buyer-supplier linkages in specific industries. This could lead to new insights in the area of vertical buyer-supplier linkages in given industries.

The **second** challenge is to study transaction attributes in terms of anticipated or encountered contractual efforts. As discussed, contracts are understood in this study in the broadest possible sense. They include agreements ranging from spot contracts to internal transactions. In the spirit of the present study, they could be analyzed using a functional description, as well. For instance, what are the tasks and efforts involved when carrying out transactions? How can individual transactions be described in terms of core competences?

The **third** challenge is to study different types of governance structures in terms of buyer and supplier-related asset specificity, with a focus on the asymmetry between the two and on their differential evolution over time.

The **fourth** challenge is to identify supplier benefits generated within various governance structures. Can buyer-supplier governance structures be designed in such a way that supplier benefits are maximized?

In this context, a fundamental question should be addressed. In this study, the generation of supplier benefits was analyzed within the framework of strategic management theory, not transaction cost analysis. Nevertheless, asset specificity was identified as the common source of both transaction costs and potential supplier benefits. Is this approach correct? Could supplier benefits be explained by extending the transaction cost paradigm itself? If so, what then is the relationship between the transaction costs themselves and the generated supplier benefits? Are high tech transactions in general associated with a low level of opportunistic behaviour, therefore precisely allowing supplier benefits?

The **fifth** challenge is to study innovation or technology transfer processes in terms of buyer and supplier-related asset specificity within different governance structures. How can innovations result from specific buyer-supplier linkages? What is the best governance structure for a given type of process? What is required from both parties to successfully facilitate such a process?

Recalling the findings of empirical research on industrial benefits of research and development, a related suggestion can be made. Longer-term effects of individual contracts with customers such as CERN should be studied. In other words, a number of high tech suppliers should be monitored over a long period of time and in a systematic way. The economic performance of the suppliers in connection with the foreseen decrease in supplier-related asset specificity would be periodically measured over time.

8.4 Summary

Table 8.1 summarizes the findings of this study and their impact on CERN, the suppliers, the literature and on the future research agenda.

Table 8.1 The impact of each major research finding on the theories and the research agenda for the future.

Major research findings	Contribution to theory	
	Transaction Cost Analysis	Strategic Management
Description and identification of inefficient contracts in a cost and technology-driven environment.	Analysis of transaction cost differences within one governance structure.	
Categorizing of contracts based on the level of buyer-related asset specificity and supplier-related asset specificity.	Asset specificity as an adequate measure of transaction costs within a fixed governance structure.	
	Asset specificity generated by buyer behavior (not only exogenously determined). Buyer and supplier-related asset specificity may change over time.	
Buyer and supplier-related asset specificity as sources of supplier benefits.	Asset specificity also generating supplier benefits.	Buyer-supplier linkages as a source of complementary assets and enhanced supplier core competences. Identification of areas of buyer core competences in terms of buyer and supplier-related asset specificity.
Use of the level of organizational involvement as an additional transaction attribute next to asset specificity.	Transaction attributes linked to supplier value chain functions in a deterministic way.	Linkage between value chain functions and external transactions. Description of the level of asset specificity in terms of the functional capabilities of the supplier. Characterization of customers in terms of both product needs and complementary capabilities. Extended use of the value chain concept in creating sustainable competitive advantage.

Major research findings	Contribution to CERN purchasing strategy	Contribution to supplier strategies	Implications for future research
Description and identification of inefficient contracts in a cost and technology-driven environment.	Identification of inefficient contractual components.	Identification of transaction costs related to the contracts.	Single-industry analysis of transaction costs in vertical buyer-supplier relationships.
Categorizing of contracts based on the level of buyer-related asset specificity and supplier-related asset specificity.	Characterization of contracts based on transaction attributes. Use of buyer and supplier-related asset specificity as a determinant to identify areas of CERN's core competences.		Study of governance structures in terms of buyer and supplier-related asset specificity.
Buyer and supplier-related asset specificity as sources of supplier benefits.	Identification of different types of supplier benefits.	Selection of contracts to generate targeted benefits.	Identification of supplier benefits generated within various governance structures. Study of innovation and technology transfer processes in terms of buyer and supplier-related asset specificity within different governance structures.
Use of the level of organizational involvement as an additional transaction attribute next to asset specificity.			Study of transaction attributes in terms of anticipated contractual efforts.

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APPENDIX 1.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ACTIVITY CODES

CERN/FI

1995/01

CIVIL ENGINEERING AND BUILDINGS

BUILDING WORK

111 Buildings and public works
112 Minor building work, flooring
113 Concrete shielding blocks
114 Cladding, roofing, waterproofing
115 Paint work
116 Huts and temporary buildings
117 Metal framing and minor metalwork
118 Timber joinery
119 Glazing, blinds

ROADWORKS

121 Roads and car parks
122 Road marking
123 Gardening
124 Fencing
125 Earthworks and piling
126 Soil sampling - Surveying
127 Road signs

INSTALLATION AND SUPPLY OF PIPES

131 -
132 Steel pipes
133 Stainless steel pipes
134 Sanitary pipes
135 Heating pipes
136 Lagging of pipes
137 Supply of steel pipes
138 Supply of stainless-steel pipes
139 Supply of non-ferrous pipes
13A Miscellaneous

ELECTRICAL INSTALLATION WORK

141 Cable-laying
142 Lighting - Power
143 Telephone, telex, telefax

HEATING AND AIR-CONDITIONING EQUIPMENT (SUPPLY AND INSTALLATION)

151 Boilers
152 Heat exchangers
153 Ventilation installations
154 Air-conditioning installations
155 Air-conditioning units
156 Ventilation and air-conditioning trunking
157 Air filters
158 Miscellaneous

HOISTING GEAR

161 Manual
162 Light- and medium-duty overhead travelling cranes
163 Heavy-duty overhead travelling cranes
164 Handling and fork-lift trucks
165 Accessories
166 Lifts, service lifts
167 Derricks, pulleys
168 Platforms, lifting tables

WATER SUPPLY AND TREATMENT

171 Pumps
172 Heat exchangers
173 Cooling plants
174 Demineralizers - Water softeners
175 -
176 Valves, cocks, etc.
177 Flexible tubing
178 Accessories
179 Flowmeters for installations and water treatment
17A Water treatment

CIVIL ENGINEERING AND BUILDINGS

181 Compressed air - Compressors
182 Fire-fighting, prevention and detection
183 Fuel oils
184 Lubricating oils
185 Building materials
186 Fireproofing materials
187 Building equipment - Scaffolding
188 Heat and sound insulation for buildings
189 False floors
18A Storage equipment

MAINTENANCE - CLEANING

191 Cleaning of buildings
192 Site cleaning
193 Maintenance of pipe installations
194 Maintenance of electrical installations
195 Maintenance of heating and air conditioning.
196 Maintenance of hoisting gear
197 Handling work
198 Cleaning of pipes and tanks
199 Waste disposal

ELECTRICAL ENGINEERING

SWITCH GEAR AND SWITCHBOARDS

211 Very-high-voltage switch gear (380-220-110-66 kV)
212 HV switch gear (18-10-6-3 kV)
213 LV switch gear (low voltage)
214 -
215 HV switchboards
216 LV switchboards
217 Cubicles, boxes (electrical engineering)
218 Electrical engineering accessories
21R Maintenance and/or repair of switchgear

POWER TRANSFORMERS

221 Very-high-voltage transformers
222 HV transformers
223 LV transformers
224 Reactances
225 HV pulse transformers
226 Variable-ratio transformers
227 Special transformers

POWER CABLES AND CONDUCTORS

231 HV cables
232 LV cables
233 Radiation-resistant cables
234 Coaxial cables
235 Water-cooled cables
236 Cable accessories
237 Wire
238 Non-insulated conductors
239 - (see 663)
23A Bus bars

CONTROL AND COMMUNICATION CABLES

241 Multicore cables
242 Coaxial cables
243 Telephone cables
244 Radiation-resistant signal cables
245 Optical fibres
246 Instrument wires, measurement cables
247 Flat cables
248 Accessories

POWER SUPPLIES AND CONVERTERS

251 Diesel sets
252 No-break power supplies and converters
253 Pulsed power
254 Switch-mode power converters
255 HV power rectifiers
256 LV power rectifiers
257 DC power converters
258 Chargers
259 Reactive power compensators
25R Maintenance and/or repair of power supplies and converters

MAGNETS

261 Complete large (> 50 tons) magnets
262 Complete small- and medium-sized magnets
263 Yokes/Magnets
264 Coils/Magnets
265 Superconducting coils/Magnets
266 Permanent magnet systems
267 Accessories for magnets

MEASUREMENT AND REGULATION

271 Measuring instruments
272 Recorders
273 Measuring transformers
274 Processors for networks controls
275 Programmable processors
276 Miscellaneous
27R Maintenance and/or repair of measuring and regulating instruments

ELECTRICAL ENGINEERING

281 Filters/Electrical engineering
282 Power capacitors
283 AC motors
284 DC motors
285 Accumulators
286 Industrial fittings
287 Lighting equipment
288 Motor reduction gearing
289 Cable trays
28A Ceramics
28B Insulation materials and gases
28C Dielectric liquids
28R Maintenance and/or repair of motors and miscellaneous components

ELECTRICAL ENGINEERING COMPONENTS

291 Resistors (braking, starting)
292 High-power resistors
293 Fuses, protective devices
294 Protection relays
295 Encoders (see also 384)
296 Connecting equipment
297 Miscellaneous electrical engineering components

ELECTRONICS

ACTIVE ELECTRONIC COMPONENTS

311 Electronic tubes
312 Discrete solid-state devices
313 Integrated circuits
314 Microprocessor chips
315 -
316 Optical transmitters and receivers (see also 486)
317 Hybrid circuits
318 Quartz
319 Crystals
31A Gas-discharge devices

PASSIVE ELECTRONIC COMPONENTS

321 Capacitors
322 Resistors, potentiometers
323 Inductances
324 Connectors
325 Switches, buttons, fuses
326 Relays
327 Indication and display devices
328 Filters
329 Delay circuits

ELECTRONIC MEASURING INSTRUMENTS

331 Panel meters
332 Frequence generators
333 -
334 -
335 Oscilloscopes
336 Data analysers
337 Multimeters
338 Spectrum analysers
339 Specialised measuring stations
33A Miscellaneous electronic measuring instruments
33R Maintenance and/or repair of measuring instruments

POWER SUPPLIES - TRANSFORMERS

341 LV power supplies - general
342 HV power supplies - general
343 NIM power supplies
344 CAMAC power supplies
345 Constant-current power supplies
346 EUROBUS power supplies
347 Transformers
348 Pulse transformers
349 Variable transformers
34A FASTBUS power supplies
34R Maintenance and/or repair of power supplies and transformers

FUNCTIONAL MODULES AND CRATES (see also 440 and 480)

351 Analogue - general
352 Digital - general
353 NIM modules and crates
354 CAMAC modules and crates
355 EUROBUS modules and crates
356 FASTBUS modules and crates
357 Telecommunications - analogue
358 Telecommunications - digital
359 Video
35A Radio communication
35B VME modules and crates
35R Maintenance and/or repair of modules and crates

RF AND MICROWAVE COMPONENTS AND EQUIPMENT

361 Components below 100 MHz
362 Components above 100 MHz
363 Ferrite cores
364 Low-level amplifiers
365 Power amplifiers
366 Wave guide components
367 Coaxial components
368 RF tubes and klystrons
369 Miscellaneous RF and microwave components and equipment

CIRCUIT BOARDS

371 Printed circuits
372 Multi-layer printed circuits
373 Manufacturing machines
374 Electrolytic treatment
375 Accessories
376 Printed circuit substrates
377 Printed circuit films
378 Multiwire circuits
379 Wire-wrap circuits

ELECTRONICS

381 Bays, racks / electronics
382 Casings, boxes, chassis
383 Fans
384 Servo-motors, tachos, synchros (see also 275)
385 Batteries
386 Heat exchangers
389 Electronics documents

ELECTRONIC ASSEMBLY AND WIRING WORK

391 Assembly and wiring without off-site testing
392 Assembly and wiring with off-site testing
393 Assembly and wiring with technical design study and testing
394 As 393, for specialised fields (e.g. Multiplex)
395 Off-site multiwire assembly and wiring
396 On-site multiwire assembly and wiring

DATA PROCESSING

COMPUTERS AND WORK-STATIONS

411 Mainframe computers
412 Minicomputers
413 Servers
414 Work-stations
415 Personal computers
416 Single-board computers
417 Calculators
418 Office automation, text processing systems
41L Hire of data-processing equipment
41R Maintenance and/or repair of computers and workstations

STORAGE SYSTEMS

421 Memory boards
422 Cartridge discs drives
423 Fixed discs
424 Magnetic tape drives
425 -
426 Diskette drives
427 Cartridge tape drives
428 Optical discs drives
429 Automated storage systems
42A Miscellaneous data-processing storage systems

DATA-PROCESSING PERIPHERALS

431 -
432 Terminals (alpha-numeric)
433 Printers
434 Graphic displays
435 Plotters
436 Equipment for microfiches, micro-films
437 Miscellaneous data-processing peripherals
43R Maintenance and/or repair of peripherals

INTERFACES (see also 350)

441 CAMAC process interfaces
442 -
443 VME process interfaces
444 G64 process interfaces
445 High-energy-physics interfaces (CAMAC, VME, FASTBUS)

SOFTWARE

451 Operating systems
452 Programming language processors
453 DBMS
454 Software for office automation
455 CAD/CAM and engineering software
456 Network software, electronic mail
457 Application packages
458 Miscellaneous software
45R Software maintenance

CONSUMABLES ITEMS FOR DATA-PROCESSING

461 Magnetic tapes and cassettes
462 Cartridges (tape and disc)
463 -
464 Printer paper
465 -
466 -
467 Microfiches
468 Data-processing cards (consumable)
469 Diskettes
46A Optical discs
46B Other consumable items
46C Miscellaneous: consumable items

STORAGE FURNITURE (DATA-PROCESSING) (see also 350)

471 Information storage vaults
472 Storage (tapes, diskettes, cartridges)

DATA COMMUNICATION (see also 350)

481 Local-area networks (hardware)
482 Wide-area networks (hardware)
483 Network gateways, bridges
484 Modems
485 Multiplexers
486 Fibre-optics interfaces (see also 316)
48R Maintenance and/or repair of data transmission equipment

MECHANICAL ENGINEERING
(SUPPLIES AND MANUFACTURING TECHNIQUES)

RAW MATERIALS (SUPPLIES)

511 Iron, steel (see also 137)
512 Stainless steel (see also 138 and 679)
513 Copper, copper alloys
514 Aluminium, aluminium alloys
515 Nickel, nickel alloys
516 Special metals and alloys
517 Metal powders
518 Non-metal products
519 Miscellaneous other raw materials
51A Hardware (nuts, bolts, etc.)

MACHINE TOOLS, WORKSHOP AND QUALITY CONTROL EQUIPMENT

521 Sheet metal equipment
522 Machining equipment
523 Welding and joining equipment
524 Heat treatment equipment
525 Surface treatment equipment
526 Quality control equipment
527 Assembly equipment
528 Machine tool accessories
52R Maintenance and/or repair of manufacturing and control equipment

CASTING AND MOULDING (MANUFACTURING TECHNIQUES)

531 Grey iron
532 Steel
533 Stainless steel
534 Copper, copper alloys
535 Aluminium, aluminium alloys
536 Refractory metals and alloys
537 Gravity, pressure die casting
538 Lead
539 Plastic injection

FORGING (MANUFACTURING TECHNIQUES)

541 Iron, steel
542 Stainless steel
543 Copper, copper alloys
544 Aluminium, aluminium alloys
545 Refractory metals and alloys
546 Powder metallurgy

BOILER METAL WORK (MANUFACTURING TECHNIQUES)

551 Mild steel (≤ 5 mm)
552 Mild steel (> 5 mm)
553 Stainless steel (≤ 5 mm)
554 Stainless steel (> 5 mm)
555 Copper, copper alloys
556 Aluminium, aluminium alloys
557 Other non ferrous metals

SHEET METAL WORK (MANUFACTURING TECHNIQUES)

561 Stainless steel ≤ 1 mm)
562 Stainless steel (1 - 3 mm)
563 Copper, copper alloys (≤ 1 mm)
564 Copper, copper alloys (1 - 3 mm)
565 Aluminium, aluminium alloys (≤ 1 mm)
566 Aluminium, aluminium alloys (1 - 3 mm)
567 Other non ferrous metals

GENERAL MACHINING WORK

571 Small sizes (≤ 5 kg)
572 Medium sizes (5 - 100 kg)
573 Large sizes (100 kg - 5 tons)
574 Very large sizes (> 5 tons)
575 Welding

PRECISION MACHINING WORK

581 Very small sizes (≤ 100 g)
582 Small sizes (100 g - 5 kg)
583 Medium sizes (5 - 100 kg)
584 Large sizes (100 kg - 1 ton)
585 Very large sizes (> 1 ton)
586 Welding

SPECIALISED TECHNIQUES

591 Combined technology assemblies
592 Beryllium machining
593 Working of special metals and alloys
594 High-technology welding
595 Fibreglass
596 Plastic materials
597 Ceramics moulding and machining
598 Laser machining
599 Spark-erosion machining
59A Heat treatment
59B Vacuum heat treatment
59C Component cleaning
59D Surface treatment
59E Composite materials

VACUUM AND LOW-TEMPERATURE TECHNOLOGY

VACUUM PUMPS

611 Mechanical
612 Diffusion
613 Getter
614 Cryopumps
615 Turbo-molecular
616 Ion
617 Sublimation
618 Accessories for vacuum pumps
61R Maintenance and/or repair of vacuum pumps

REFRIGERATION EQUIPMENT

621 Air-separation plants
622 Linde-cycle systems
623 Claude-cycle systems
624 Sterling-cycle systems
625 Various systems
626 Accessories for refrigeration equipment

GAS-HANDLING EQUIPMENT

631 High-pressure reservoirs
632 Medium-pressure reservoirs
633 Gas holders and balloons
634 Recovery pumps and blowers
635 Compressors
636 Driers and purifiers
637 Miscellaneous gas-handling equipment
63R Maintenance and/or repair of gas-handling equipment

STORAGE AND TRANSPORT OF CRYOGENS

641 Tanks insulated at atmosph. pressure
642 Vacuum-insulated tanks (dewars and cryostats)
643 Vacuum-insulated tanks with reflecting layers
644 Tanks insulated with cooled screens
645 Pipework insulated at atmospheric pressure
646 Vacuum-insulated transfer lines
647 Pumps
648 -
649 Miscellaneous

MEASUREMENT EQUIPMENT (VACUUM AND LOW-TEMPERATURE TECHNOLOGY)

651 Gauges
652 Residual-gas analysers
653 Leak detectors
654 Thermometers
655 Liquid-level gauges
656 Mass-flow meters
657 Mass spectrometers
658 Miscellaneous items for measurement
65R Maintenance and/or repair of vacuum measuring instruments

LOW-TEMPERATURE MATERIALS

661 Metals and alloys of low normal resistivity
662 Superconducting metals and alloys
663 Superconducting wires and cables
664 Dielectric materials
665 Thermal insulating materials
666 Thermal radiation reflectors
667 Cryogens
668 Special metals and alloys
669 Special adhesives

VACUUM COMPONENTS AND CHAMBERS

671 Flanges, seals, clamps
672 Bellows
673 -
674 -
675 Valves
676 Bakeout equipment
677 Optical windows
678 Feedthroughs
679 Tubes
67A Large-size vacuum chambers (≥ 1 m)
67B Small- and medium-size vacuum chambers (< 1m)

LOW-TEMPERATURE COMPONENTS

681 Valves
682 Joints
683 Seals
684 Connectors
685 Feedthroughs
686 Coaxial cables
687 Low-temperature insulated wires
688 Miscellaneous other low-temperature components

VACUUM AND LOW-TEMPERATURE TECHNOLOGY

691 Lubricants
692 Climatic test chambers
693 Ovens
694 Evaporators

PARTICLE DETECTORS

FILMS AND EMULSIONS

711 Films
712 Nuclear emulsions
713 Developers
714 Miscellaneous films and emulsions for particle detectors

SCINTILLATION COUNTER COMPONENTS

721 Scintillators
722 Light-guides
723 Photon detectors (photomultipliers)
724 Bases for photomultipliers
725 Photodiodes
726 Optical fibres
727 Miscellaneous components for scintillation counters

WIRE CHAMBER ELEMENTS

731 Frames
732 Special wires
733 Special insulators
734 -
735 Gas control systems
736 Electrode planes
737 Miscellaneous other components for wire chambers

SPECIAL DETECTOR COMPONENTS

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742 Lead glass, crystals
743 Quartz, CaFl fish-eyes
744 Special mirrors, optical components
745 Lithium films
746 Miscellaneous other components for special detectors

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752 Ionisation chamber liquids
753 Electrode structures
754 Purification systems
755 Miscellaneous other components for calorimeters

APPENDIX 2.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Conditions générales des contrats du CERN

General Conditions of CERN Contracts

CERN / FC / 1814 - II

GENÈVE - GENEVA
1975

CERN — Organisation européenne pour la Recherche nucléaire
Conditions générales des contrats du CERN

CERN — European Organization for Nuclear Research
General Conditions of CERN Contracts

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CERN - Organisation européenne pour la Recherche nucléaire

Conditions générales des contrats du CERN

I. DISPOSITIONS GÉNÉRALES

1. Champ d'application

Les présentes Conditions générales s'appliquent aux contrats passés par le CERN, sauf dispositions contraires dans le contrat. Par « contrat du CERN », on entend tous marchés, contrats ou commandes passés par lui. Par « fourniture », on entend l'objet d'un contrat ainsi que tous travaux, services ou prestations s'y rapportant.

2. Acceptation des Conditions générales

L'offre ou la soumission, de même que la signature du contrat, comportent l'acceptation des présentes Conditions générales, sauf dispositions contraires dans le contrat.

3. Observation des lois et règlements

Le contractant et/ou son mandataire sont censés avoir agi conformément aux lois et règlements qui leur sont applicables. Ils supportent seuls toutes les conséquences en cas d'infraction.

II. DOCUMENTS CONTRACTUELS - SIGNATURE - MANDATAIRES

4. Documents contractuels

4.1 Les contrats passés par le CERN comprennent le texte du contrat, ses annexes éventuelles (spécifications, plans, dessins, etc.) et les présentes Conditions générales.

4.2 Dans le cadre du contrat, l'ordre de priorité des documents contractuels est le suivant :

1. le texte du contrat ;
2. l'appel d'offres, et, en particulier, sa spécification technique;
3. les présentes Conditions générales ;
4. l'offre ou la soumission du contractant.

Le document portant le numéro le moins élevé a toujours, en matière de force obligatoire, la primauté sur le document portant un numéro plus élevé.

5. Signature du contrat

5.1 Un contrat n'est formé que lorsque son texte a été signé par le contractant et par un ou deux représentants habilités du CERN. La date de signature du CERN est la date de formation du contrat. Seuls des accords écrits lient le CERN. Faute d'un tel accord, chaque partie est en droit de se retirer sans encourir aucune responsabilité, notamment de caractère financier.

5.2 Tous les documents annexés au contrat et fournis par le contractant ou par le CERN doivent être couverts par un document authentique daté et signé par des représentants habilités de ceux-ci.

5.3 Toute modification de contrat, de quelque ordre qu'elle soit, ne prend effet qu'après signature d'un avenant, ainsi qu'il est dit au paragraphe 12.1.

6. Mandataires

Tout mandataire ou représentant d'un ou de plusieurs contractants du CERN doit être préalablement accrédité par celui-ci ou ceux-ci auprès du CERN, qui se réserve le droit de vérifier l'étendue et la validité de ses pouvoirs.

III. EXÉCUTION DES CONTRATS

7. Conduite du contrat - Représentation

7.1 L'exécution du contrat sous tous ses aspects est assurée par le contractant conformément aux règles de l'art, sous sa seule direction et sa seule responsabilité. Il attire l'attention du CERN sur tout élément susceptible de nuire à la bonne exécution du contrat, notamment en donnant à tout moment au CERN toutes informations utiles à cet effet.

7.2 A sa demande, tout contractant a libre accès au domaine du CERN pour toutes questions liées à l'exécution d'un contrat avec l'Organisation. Il est réputé connaître, tant pour lui-même que pour son ou ses éventuels sous-traitants, les conditions d'approvisionnement des matières ainsi que la nature des difficultés spéciales qu'il est possible de prévoir, inhérentes à l'exécution du contrat. Il s'interdit de ce fait toute réclamation à ce sujet sauf cas de force majeure.

7.3 Le contractant fait connaître par écrit, au plus tard un mois après la signature du contrat, son représentant accrédité pour toute la durée d'exécution du contrat.

CERN - European Organization for Nuclear Research

General Conditions of CERN Contracts

I. GENERAL PROVISIONS

1. Scope

The General Conditions shall apply to CERN contracts except when otherwise specified in the contract. The term " CERN contract " shall signify all contracts and orders placed by CERN. The term " supplies " shall be deemed to mean the subject of a contract, including all work and services connected therewith.

2. Acceptance of the General Conditions

The submission of any bid or tender and the signature of a CERN contract shall constitute acceptance of the General Conditions, except to the extent that they may be modified in the contract.

3. Observance of Laws and Regulations

The contractor and/or his representative shall be deemed to have complied with all relevant laws and regulations. The said contractor and/or his representative shall alone be liable in the event of their infringing the said laws and regulations.

II. CONTRACT DOCUMENTS - SIGNATURE - AUTHORIZED REPRESENTATIVES

4. Contract Documents

4.1 Contracts let by CERN shall consist of the text of the contract, together with any annexes (specifications, plans, drawings, etc.), and the General Conditions.

4.2 In contractual matters, the following order of priority shall apply to the contract documents:

1. the text of the contract;
2. the invitation to tender and in particular the relevant specification;
3. the General Conditions;
4. the contractor's bid or tender.

A document higher on the priority list shall always take precedence over a document lower on the list.

5. Signature of Contract

5.1 A contract shall be deemed to be constituted only after it has been signed by the contractor and by one or two duly authorized representatives of CERN. The date of signature by CERN shall be the date of constitution of the contract. Agreements in writing only shall be binding. Failing such written agreement, either party may withdraw without incurring any liability, in particular of a financial nature.

5.2 All documents supplied as annexes to the contract by the contractor or by CERN shall be covered by an authenticated document dated and signed by duly authorized representatives.

5.3 All modifications of whatsoever kind to the contract shall take effect only after the signature of an amendment, as specified in paragraph 12.1.

6. Authorized Representatives

Any person empowered to act as a representative of one or several contractors shall first be accredited to CERN by the said contractor or contractors. CERN reserves the right to verify the extent and validity of his powers.

III. PERFORMANCE OF CONTRACTS

7. Contract Management - Representation

7.1 The contractor shall be solely responsible for the performance of the contract in every respect, in accordance with the normal customs of the trade. He shall draw CERN's attention to any element which could impede a good performance of the contract, especially by giving at any time any suitable information for this purpose.

7.2 Every contractor shall be granted, on request, free access to the CERN site for all questions relating to the performance of a contract with the Organization. He shall be deemed, both for himself and on behalf of any of his sub-contractors, to be fully conversant with the conditions for the supply of materials and with the nature of any foreseeable special difficulties inherent in the performance of the contract. He shall therefore refrain from making any claims in respect of such matters, except in circumstances beyond the contractor's reasonable control.

7.3 One month after the signature of the contract at the latest, the contractor shall inform CERN in writing of the name of his accredited representative for the duration of the performance of the contract.

8. **Cessions - Sous-traitances - Sous-commandes**

8.1 Toute cession ou toute sous-traitance totale d'un marché, même sous forme d'apport en société, fait l'objet d'une autorisation préalable que le contractant est tenu de demander par écrit au CERN. Le CERN se réserve le droit de demander spécifiquement que toute cession ou toute sous-traitance d'une partie importante d'un contrat fasse l'objet d'une autorisation préalable présentée par écrit. Si dans un délai d'un mois à compter de la présentation de la demande le CERN n'a pas répondu, sa non-réponse est interprétée comme un accord. Dans tous les cas le contractant reste seul responsable vis-à-vis du CERN de l'exécution du contrat et prend toutes mesures nécessaires à la poursuite satisfaisante de son exécution.

8.2 Quand ils nécessitent un accord préalable, le CERN peut demander au contractant de lui faire parvenir copie des accords de sous-traitance et/ou de sous-commande passés par lui, ainsi que de leurs modifications ultérieures, à l'exclusion des dispositions financières.

8.3 Le contractant est tenu d'informer ses sous-traitants de toutes dispositions du contrat pouvant s'appliquer à leurs obligations.

9. **Livraisons - Programme d'exécution - Délais**

9.1 Les fournitures objet du contrat sont livrées en conformité avec les stipulations du contrat, à la date, à l'endroit et de la manière prescrits par ce dernier.

9.2 Si le contrat prévoit une exécution échelonnée dans le temps, le contractant remet au CERN, dans les délais fixés dans le contrat ou à défaut dans un délai d'un mois à dater de la signature de ce dernier, un programme prévisionnel définissant l'échelonnement dans le temps des opérations d'exécution du contrat. En fonction des examens périodiques auxquels il est soumis par les parties au fur et à mesure de l'exécution du contrat, ce programme est tenu régulièrement à jour par le contractant après approbation du CERN. Ce programme et ses mises à jour ne sont établis que pour information et à titre indicatif ; seuls les délais fixés dans le contrat lient le contractant. Dans le cas particulier de travaux de construction, le contrat stipulera les plannings et programmes prévisionnels que le contractant doit strictement respecter.

9.3 Si l'exécution du contrat est susceptible d'être retardée par un cas de force majeure, et si le contractant justifie qu'il s'est efforcé de limiter les conséquences du retard, les délais contractuels sont prolongés sans que cette prolongation de délais puisse entraîner obligatoirement des modifications de prix stipulés au contrat.

9.4 Tout événement dont les conséquences peuvent retarder l'exécution du contrat est signalé par lettre recommandée au CERN par le contractant au plus tard dans les quinze jours après qu'il en a eu connaissance, sous peine de forclusion.

10. **Documents à fournir**

10.1 Le contractant communique au CERN tous documents et informations techniques paraissant à ce dernier raisonnablement utiles à l'exécution du contrat.

10.2 La non-communication des documents stipulés dans un contrat, dans la forme et aux dates prescrites, peut entraîner la suspension des paiements.

10.3 L'accord donné par le CERN sur un document technique ne dégage en rien la responsabilité du contractant quant à la bonne exécution du contrat.

11. **Approvisionnements en provenance du CERN**

11.1 Le contractant est responsable des matériaux, des pièces, du matériel et/ou des appareils appartenant au CERN, qui sont remis à sa garde en vue de l'exécution du contrat. Au cas où ces approvisionnements sont achetés d'ordre et pour le compte du CERN par le contractant, celui-ci prend toutes mesures, et notamment conserve tous documents nécessaires à la preuve de la propriété du CERN, laquelle inclut tout document du CERN.

11.2 Le contractant dont le contrat est résilié pour quelque cause que ce soit est tenu de restituer immédiatement au CERN tout ce qui appartient à ce dernier, y compris les exemplaires de tout document du CERN. Réciproquement, le CERN restituera les biens dont le contractant est propriétaire.

12. **Droit de modification et pouvoir de mettre fin au contrat**

12.1 Toute modification au contrat fait l'objet d'un avenant établi préalablement à tout commencement d'exécution.

12.2 Pour tout contrat, le CERN peut, si l'état d'avancement de l'exécution du contrat le permet, exiger toutes modifications qui peuvent lui paraître souhaitables. Il ne saurait résulter d'une modification un amoindrissement des garanties techniques auxquelles le contractant s'est engagé. En conséquence le contractant attire au préalable l'attention du CERN sur toute conséquence d'une modification sur la garantie. Si le CERN fait usage de son droit de modification, un avenant au contrat constate les modifications techniques apportées et leur incidence sur les délais et le montant du contrat ainsi que, s'il y a lieu, sur la garantie.

8. **Assignment - Sub-contracts - Sub-orders**

8.1 The contractor shall request prior authorization from CERN in writing for the complete assignment or sub-letting of any CERN contract, even if the contractor joins or forms a company for the performance of the contract. CERN reserves the right to specify that prior authorization shall be sought in writing for the assignment or sub-letting of any important part of a contract. If CERN fails to reply to an application for such authorization within one month of receiving such an application, it shall be deemed to agree to the said application. In any event the contractor shall remain solely responsible to CERN for the performance of the contract and shall take all necessary steps to ensure that the remaining work is satisfactorily performed.

8.2 Where prior authorization is called for, the contractor may be required by CERN to provide a copy of any sub-contracts and/or sub-orders which he has placed, together with copies of any subsequent modifications thereto, except for their financial clauses.

8.3 The contractor shall be required to inform his sub-contractors of any clauses of the contract which might be applicable to their obligations.

9. **Deliveries - Performance Schedule - Time Limits**

9.1 The supplies specified in the contract shall be delivered in compliance with the provisions of the contract, at the date and place and in the manner stipulated therein.

9.2 If the contract is to be performed by stages, the contractor shall send to CERN, within the time limit laid down in the contract, or, if no time limit is laid down, within one month from the date of signature of the latter, a time-table indicating the projected completion dates of the stages in the performance of the contract. In conformity with the periodic examinations made by the parties to the contract as it is being performed, the time-table shall be regularly kept up to date by the contractor after CERN's approval has been obtained. This time-table and the amendments thereto shall be drawn up solely for purposes of information and as an indication; the only time limits binding on the contractor shall be those specified in the contract. In the particular case of construction work, the contract will contain provisions for detailed schedules and time-tables with which the contractor shall strictly comply.

9.3 Where the performance of the contract is likely to be delayed by circumstances beyond the contractor's reasonable control and where the contractor can show that he has made every effort to limit the consequences of such delay, the contractual time limits shall be extended, provided that such extension does not necessarily lead to an alteration of the prices stipulated in the contract.

9.4 The contractor shall, within fifteen days of its coming to his notice, notify CERN by registered letter of any occurrence likely to delay the performance of the contract, failing which he shall be precluded from making any claim in this respect.

10. **Documents to be Provided**

10.1 The contractor shall supply CERN with all the documents and technical information which CERN may reasonably deem necessary for the performance of the contract.

10.2 Failure to supply documents stipulated in the contract, by the dates and in the form prescribed, may entail the suspension of payments.

10.3 CERN's approval of a technical document shall in no way relieve the contractor of his responsibility for the proper performance of the contract.

11. **Material Supplied by CERN**

11.1 The contractor shall be responsible for the safe keeping of all materials, parts, equipment and/or apparatus belonging to CERN which are entrusted to him for the performance of the contract. If such items have been purchased by the contractor for and on behalf of CERN, he shall take all necessary measures and, in particular, retain all documents required to prove CERN's ownership, including any CERN documents.

11.2 A contractor whose contract is cancelled for any reason whatsoever shall immediately return to CERN all property belonging to CERN, which property shall be deemed to include all copies of CERN documentation. CERN for its part shall return to the contractor everything which is his property.

12. **Right to Modify and Power to Terminate the Contract**

12.1 Any modification to a contract shall be set out in an amendment, which shall be drawn up before the performance of such modification is begun.

12.2 In any contract, provided the stage reached in the performance of the contract so allows, CERN may call for any modifications that may appear to it desirable. No modification should entail a reduction in the extent of the technical guarantees which the contractor is committed to provide. The contractor shall therefore draw CERN's attention beforehand to any consequences for the guarantee which a modification may entail. Should CERN exercise the right of modification, an amendment to the contract shall be drawn up stating the technical modifications involved and their effect on the completion dates, price of the contract and on the guarantee.

12.3 Toute réclamation du contractant relative à des modifications effectuées à la demande du CERN est présentée à ce dernier au plus tard dans les trente jours qui suivent la demande du CERN, sous peine de forclusion.

12.4 Le contractant peut proposer au CERN des modifications de nature à améliorer les conditions d'exécution du contrat ou la qualité de la fourniture. Si cette proposition est acceptée, les modifications et leurs incidences sont constatées par avenant au contrat.

12.5 Le CERN peut à tout moment, par lettre recommandée, mettre fin, en tout ou partie, à tout contrat, moyennant pleine indemnisation du contractant, laquelle ne peut excéder le montant du contrat.

13. Inspection - Contrôles

13.1 Le CERN peut faire exercer, par telle personne qui lui convient, toute surveillance, tout contrôle, toute inspection qu'il juge opportuns, tant dans les établissements du contractant que dans ceux de ses sous-traitants ou des titulaires de sous-commandes. L'exercice de ce droit ne préjuge en rien les décisions du CERN lors de la recette ou de la réception des fournitures et ne saurait en aucun cas porter atteinte à ses droits en matière de garantie, ni diminuer en rien la responsabilité du contractant quant à l'exécution de ses obligations.

13.2 Le contractant prend toutes mesures pour faciliter aux représentants accrédités du CERN les contrôles ou inspections que le CERN juge utiles, à tout moment raisonnable. Le contractant facilite également la surveillance exercée par le CERN sur l'exécution du contrat. Les présentes dispositions s'appliquent de plein droit aux sous-traitants et/ou aux titulaires de sous-commandes ; le contractant les leur signifie en temps utile.

13.3 Les représentants du CERN peuvent s'assurer, par toutes vérifications utiles, de la bonne exécution technique du contrat et demander la suspension de tout travail, de toute exécution jugés non conformes, que ce soit en vertu des stipulations du contrat ou du non-respect des règles de l'art.

13.4 Le CERN s'engage, tant pour lui-même que pour ses représentants, à exercer son droit d'inspection et de contrôle en respectant le secret professionnel et en s'efforçant de réduire au minimum les inconvénients que l'exercice d'un tel droit pourrait éventuellement comporter pour les activités du contractant.

13.5 Le contractant présente au CERN, chaque fois que ce dernier le requiert, toutes informations et tous documents techniques, tous rapports sur l'exécution des contrats, aux dates et dans les formes prescrites ; de tels rapports ne sont soumis qu'à titre d'information et leur acceptation par le CERN ne préjuge en rien les décisions ultérieures du CERN quant à l'exécution du contrat, ni n'altère en rien ses droits, notamment en matière de garantie.

14. Acheminement des fournitures - Transport - Emballage

14.1 L'expédition, le transport, l'acheminement et le déchargement des fournitures au lieu prévu dans le contrat sont à la charge du contractant et pendant toute la durée du transport, y compris le déchargement au lieu de destination, le contractant reste responsable des fournitures qu'il est tenu de livrer en vertu du contrat.

14.2 Le CERN se réserve le droit de changer à tout moment raisonnable le lieu de livraison des fournitures, sous réserve d'adaptation des prix contractuels.

14.3 Si, à la demande du CERN, l'expédition de tout ou partie d'une fourniture est retardée, le contractant est tenu d'en assurer gratuitement, sous sa responsabilité, la garde et la conservation pendant une durée de deux mois à compter de la date à laquelle la livraison avait été prévue. Si cette durée se prolonge au-delà de deux mois, le contractant est tenu aux mêmes obligations moyennant une indemnité fixée d'un commun accord.

14.4 Aux fins de transport et de manutention, le contractant fournit tous emballages, caisses, boîtes, récipients divers, lesquels sont, à l'exception des conteneurs de fret ISO, considérés comme perdus et non retournables. Leur prix est réputé inclus dans le montant du contrat.

15. Réception provisoire

15.1 Lorsque toutes les fournitures ont été livrées, ont satisfait aux conditions du contrat, et que le contractant a exécuté toutes ses obligations à cet effet, la réception provisoire est prononcée. Le cas échéant, un certificat de réception provisoire est établi contradictoirement.

15.2 Si la réception provisoire n'est pas prononcée dans les trois mois de la date de la notification par le contractant qu'il a exécuté toutes ses obligations à cet effet, le CERN, à la demande du contractant, procède au paiement et au transfert de la propriété en réservant tous ses droits quant à la garantie. Le délai de garantie fait l'objet d'une négociation compte tenu des conditions de conservation du matériel.

15.3 Les fournitures ne sont considérées comme propriété du CERN qu'après la réception provisoire ou à telle autre date convenue entre le CERN et le contractant.

12.3 Any claim which the contractor may have with respect to modifications made at CERN's request shall be submitted to CERN at the latest within thirty days following such request, failing which the contractor shall be precluded from making any such claim.

12.4 The contractor may propose to CERN modifications such as to improve the conditions of performance of the contract or the quality of the supplies. Should this proposal be accepted, such modifications and their implications shall be recorded in an amendment to the contract.

12.5 CERN may at any time, by registered letter, terminate any contract in whole or in part, with payment of full compensation to the contractor, the amount of which shall not exceed the value of the contract.

13. Inspection - Supervision

13.1 CERN may carry out through a representative of its choice any reasonable supervision, check or inspection it may consider desirable, both on the contractor's premises and on those of sub-contractors and of holders of sub-orders. The exercise of this right shall in no way prejudice CERN's decision when taking delivery of or accepting any supplies and shall in no circumstances affect CERN's right in the matter of guarantees or lessen in any way the contractor's responsibilities regarding the due fulfilment of his obligations.

13.2 The contractor shall take all necessary measures to permit the accredited representatives of CERN, at any reasonable time, to make such checks or inspections that CERN may consider necessary. He shall also facilitate CERN's supervision over the performance of the contract. The above provisions shall equally apply to sub-contractors and/or recipients of sub-orders, who shall be notified thereof in good time by the contractor.

13.3 Representatives of CERN may carry out any verification needed to satisfy themselves of the proper technical performance of the contract, and may call for the suspension of any work they may judge unsatisfactory because it fails to comply either with the terms of the contract or with the normal customs of the trade.

13.4 CERN undertakes, on its own behalf and on that of its representatives, to observe normal commercial secrecy when exercising its rights of inspection and supervision, and to strive to reduce to a minimum any inconvenience which the exercise of these rights might cause to the contractor's activities.

13.5 Whenever so requested, the contractor shall, by the dates and in the form prescribed, supply CERN with all technical information and documents and all reports concerning the performance of the contract. Such reports shall be submitted solely for purposes of information, and acceptance by CERN of any such report shall in no way prejudice CERN's subsequent decisions regarding the performance of the contract, or affect any of CERN's rights, particularly in the matter of guarantees.

14. Routing - Transport - Packing

14.1 The costs relating to despatch, transport and routing of supplies and their unloading at the place specified in the contract shall be borne by the contractor who shall, throughout the entire duration of transport, including unloading at their destination, retain responsibility for the supplies which he is required to deliver under the terms of the contract.

14.2 CERN reserves the right to change at any reasonable time the place of delivery of the supplies, subject to adjustment of the prices specified in the contract.

14.3 Should CERN request the postponement of despatch of the whole or part of an item to be supplied, the contractor shall provide free storage and maintenance under his own responsibility for a period of two months dating from the stipulated date of delivery. If this period exceeds two months, the contractor's obligations shall continue, subject to agreement between the parties concerning payments to be made.

14.4 Packing required for transport and handling, including crates, cases and receptacles of any type, shall be supplied by the contractor and, with the exception of ISO freight containers, be regarded as non-returnable. The cost of such items shall be deemed to have been included in the contract price.

15. Provisional Acceptance

15.1 Provisional acceptance shall be granted after all supplies have been delivered and have satisfied the conditions of the contract, and provided that the contractor has fulfilled all his obligations for this purpose. A certificate of provisional acceptance may be drawn up jointly.

15.2 If the provisional acceptance has not been granted within three months of the date on which the contractor has notified that he has fulfilled all his obligations to this end, CERN, when the contractor so requests, shall effect payment and acquire property in the supplies, whilst reserving all rights in respect of the guarantee. The expiry date of the guarantee period shall be subject to negotiation taking into account the requirements of safe keeping of the supplies.

15.3 Property in the supplies shall pass to CERN on the date of provisional acceptance or on such other date as may be agreed between CERN and the contractor.

16. Garantie

16.1 Le délai de garantie est de deux ans pour toute fourniture livrée par un contractant, sans préjudice des délais de garantie habituels en matière de construction. Les délais de garantie courent à compter de la date de la réception provisoire.

16.2 Le contractant est tenu d'exécuter à ses frais toutes opérations, notamment modifications, mises au point, réglages, réparations, nécessaires pour satisfaire aux conditions du contrat, ou de remplacer à ses frais tout ou partie de la fourniture qui s'avérerait non conforme pendant la période de garantie. Le CERN peut, après mise en demeure, agir d'ordre et pour le compte du contractant en cas de défaillance de la part de ce dernier.

16.3 Les fournitures rebutées pendant la période de garantie sont, sur proposition du contractant, au choix du CERN, soit remplacées gratuitement par le contractant, soit remboursées par lui au prix du remplacement, soit réparées ou modifiées par lui à ses frais. Pour les articles remplacés, le délai de garantie court à nouveau en totalité à compter de la date de remplacement. Pour les articles réparés ou modifiés, le délai de garantie est prolongé d'une durée égale à celle de l'indisponibilité du matériel.

16.4 Toutes fournitures défectueuses sont tenues, à ses risques et périls, à la disposition du contractant pendant une durée d'un mois à compter de l'avis écrit qui lui a été donné par le CERN. Passé ce délai, elles restent gratuitement à la disposition du CERN qui en fait tel usage qui conviendra.

16.5 Si, au cours de la période de garantie, la fourniture est indisponible pour des causes imputables au contractant, notamment en cas d'usure anormale, de rupture ou de vice de fonctionnement d'un ou de plusieurs de ses éléments, le délai de garantie de l'ensemble de la fourniture est augmenté de toutes les périodes d'indisponibilité.

16.6 Le contractant supporte tous les débours occasionnés découlant de ses obligations de garantie, y compris les frais de transport. Sont exclus les débours résultant d'une détérioration due soit à une négligence, à un défaut de surveillance ou d'entretien, soit à une fausse manœuvre, imputables au CERN. Sans préjudice des dispositions du paragraphe 16.2, la responsabilité du contractant n'est pas engagée si des éléments ont été remplacés, modifiés ou réparés par le CERN sans l'accord écrit du contractant.

16.7 Des dommages-intérêts pour préjudice indirect ne sont réclamés qu'en cas de faute lourde ou de négligence grossière de la part du contractant.

16.8 Si le défaut constaté au cours de la période de garantie provient d'une faute technique systématique, le contractant doit remplacer ou modifier, à ses frais, sur toutes ses fournitures susceptibles d'être altérées par le défaut, toutes pièces identiques objet du contrat, même si elles ne donnent lieu à aucun incident.

17. Réception définitive

17.1 La réception définitive prend effet à compter de l'expiration du délai de garantie, si le contractant a satisfait à toutes ses obligations.

17.2 Si le contractant demande par écrit qu'il soit procédé à la réception définitive, le CERN se prononce dans les quinze jours suivant la demande. Le CERN peut dans tous les cas exiger qu'il soit procédé à un examen général de la fourniture et de son comportement depuis la réception provisoire, et dressé procès-verbal contradictoire, à l'issue duquel la réception définitive est prononcée, le cas échéant rétroactivement, à la date de la demande écrite s'il y a lieu.

17.3 S'il y a lieu à rebut et si celui-ci ne porte que sur une partie de la fourniture, la réception définitive est prononcée pour le matériel non rebuté dans la mesure où ce matériel peut être utilisé indépendamment du matériel rebuté.

17.4 Si au cours de la période de garantie il a été nécessaire de remplacer un élément pour usure anormale, rupture ou vice de fonctionnement, la prolongation du délai de garantie appliqué à cet élément ne fait pas obstacle au prononcé d'une réception définitive partielle par le CERN.

IV. PRIX - PAIEMENTS - DISPOSITIONS FINANCIERES

18. Prix

Les prix sont, sauf dispositions contraires, toujours réputés être fermes et non révisables. Les fournitures destinées à l'usage du CERN sont exonérées de droits de douane. Pour les impôts et taxes, le CERN bénéficie d'un régime particulier, dont le contractant est tenu de prendre connaissance. A cet effet, les prix sont nets et hors taxes. Lorsqu'il y a lieu à application soit de l'ICHA (Suisse), soit de la TVA (France), ces taxes sont facturées de manière apparente. En dehors de la non-application éventuelle de l'ICHA ou de la TVA du fait du régime fiscal du CERN, ce dernier n'entraîne pour le contractant aucune dérogation aux impositions de droit commun.

19. Révisions de prix

Les révisions de prix, s'il y a lieu, ne jouent pas au-delà des limites des délais contractuels si le retard est le fait du con-

16. Guarantee

16.1 The guarantee period shall be two years for all supplies furnished by a contractor, provided however that the guarantee period for construction work is that usually applicable to such work. The guarantee period shall begin on the date of provisional acceptance.

16.2 The contractor shall carry out, at his own expense, all work, such as modifications, adjustments, settings and repairs, necessary to comply with the terms of the contract, or replace at his own expense all or any part of the supplies which turn out not to comply with these terms during the guarantee period. If the contractor fails to comply with the above requirements, CERN may, after serving due notice on the contractor, take the necessary action in his stead and at his expense.

16.3 If supplies are rejected during the guarantee period, CERN shall decide, after receiving the contractor's proposals, whether such supplies shall be replaced free of charge by the contractor, whether their cost shall be reimbursed by him at replacement prices, or whether they shall be repaired or modified by him at his expense. For items replaced, the guarantee period shall recommence on the date of replacement. For items repaired or modified, the guarantee period shall be prolonged by a period equal to that during which they were unavailable.

16.4 All defective supplies will be held by CERN on the contractor's behalf, but at the contractor's risk, for a period of one month following CERN's notification thereof to the contractor in writing. Thereafter, such supplies shall be at the disposition of CERN without charge, to use as it thinks fit.

16.5 If, during the guarantee period, supplies become unusable for reasons ascribable to the contractor, in particular as a result of abnormal wear, breakage or defective functioning of one or more parts of the said supplies, the guarantee period for the whole of the supplies concerned shall be extended by all the periods during which the said supplies as a whole were unusable.

16.6 The contractor shall meet all costs arising in connection with his obligations under the guarantee, including those of transport. He shall not be responsible for costs resulting from deterioration attributable to CERN by reason of negligence, inadequate supervision or maintenance, or mishandling. Except as provided for in paragraph 16.2, the contractor shall not be held liable if components have been replaced, modified or repaired by CERN without the contractor's written consent.

16.7 Compensation for indirect damages may be demanded only in the event of gross negligence or misconduct of the contractor.

16.8 If the defect observed in the course of the guarantee period is found to be due to a technical error of a systematic nature, the contractor shall replace or modify at his expense all identical components covered by the contract which are liable to suffer from this error, even if these components are functioning correctly.

17. Final Acceptance

17.1 Final acceptance shall be granted with effect from the expiry of the guarantee period, provided that the contractor has met all his obligations.

17.2 If the contractor makes a written request for final acceptance, CERN shall give its reply within fifteen days following such request. In every case, CERN may require a general examination to be made of the supplies and their history since provisional acceptance, and the findings to be recorded in a document signed by both parties, whereupon final acceptance shall be granted and, where appropriate, backdated to the date of the written request, if such a request was made.

17.3 In the event of rejection affecting only part of the supplies, final acceptance shall be granted for all supplies not rejected, in so far as they can be utilized independently of the rejected portion.

17.4 If, during the guarantee period, it is necessary to replace part of the supplies by reason of abnormal wear, breakage or defective functioning, the extension of the guarantee period relating to such part shall not preclude the granting by CERN of partial final acceptance.

IV. PRICES - PAYMENTS - FINANCIAL PROVISIONS

18. Prices

Unless otherwise stated, prices shall at all times be deemed to be firm and not subject to revision. Supplies for the use of CERN are exempt from customs duty. With regard to taxes and levies, there are special arrangements for CERN and the contractor is required to become conversant with such arrangements. Accordingly prices shall be quoted net and free of tax. Where ICHA (Switzerland) or TVA (France) is applicable, these taxes shall be shown clearly on the invoice. Save in respect of possible exemption from ICHA or TVA arising from the special fiscal conditions which apply to CERN, the contractor shall in no way be released from his obligation to pay any taxes which may normally be due.

19. Price Revisions

Price revisions, if applicable, shall not be effective beyond the contractual time limits if the delay is due to the contractor.

tractant. Les indices des formules de révision doivent être tirés de publications officielles gouvernementales. Les données émanant d'organisations privées ne sont acceptées qu'en l'absence de données d'origine officielle. Les conséquences de l'application d'une formule de révision sont en tout état de cause limitées au maximum à la hausse effective des prix.

20. Paiements

20.1 Aucun paiement n'est effectué sans remise d'une facture libellée conformément aux dispositions contractuelles, accompagnée de toutes pièces justificatives.

20.2 Si la facture est acceptée, les paiements sont effectués dans les trente jours suivant la réception de la facture selon les formes et conditions contractuelles.

20.3 Le paiement des fournitures n'est effectué que lorsque celles-ci ont été réceptionnées.

21. Dispositions financières diverses

21.1 Il n'est versé aucune avance si le contractant ne souscrit en faveur du CERN, auprès d'un établissement bancaire agréé par lui, une garantie bancaire conjointe et solidaire, d'un montant égal à la somme qu'il demande. Il peut y avoir lieu à acompte dans la mesure de l'exécution du contrat.

21.2 Jusqu'à la réception définitive, le CERN peut, jusqu'à concurrence de dix pour cent du prix du contrat, procéder à une retenue de garantie, laquelle peut être remplacée par une garantie bancaire conjointe et solidaire de mêmes validité et montant.

V. SÉCURITÉ

22. Obligations du contractant

Outre l'observation de toute législation nationale qui lui est applicable en matière de sécurité et d'hygiène, le contractant sur le domaine du CERN doit respecter les règles de sécurité qui y sont en vigueur et dont il est tenu de prendre connaissance. Il prend toutes mesures utiles à cet effet. Le contractant tient compte de ces obligations dans l'établissement de ses offres et pour l'exécution du contrat.

VI. PROPRIÉTÉ INTELLECTUELLE ET PROPRIÉTÉ INDUSTRIELLE

23. Propriété intellectuelle

La Convention ayant créé le CERN met l'Organisation dans l'obligation de publier ou de rendre accessibles de toute autre manière les résultats de ses activités. Aucune publication, aucune communication ou aucun usage de quelque connaissance acquise du CERN à l'occasion d'un contrat du CERN et qui est brevetable ou peut être considérée comme relevant de la propriété intellectuelle ne doit, en conséquence, être fait sans un accord préalable écrit entre les parties. Le CERN s'interdit de refuser son accord pour des motifs non fondés et agit avec diligence pour signifier sa décision.

24. Usage de droits de propriété industrielle appartenant à des tiers

24.1 Le contractant s'engage à garantir le CERN contre toute réclamation en matière de propriété intellectuelle ou industrielle connue et publiée dans son pays ou enregistrée au Bureau Européen des Brevets lors de la signature du contrat, relative à la fourniture faite par le contractant au CERN. Le contractant répond de toutes conséquences, notamment juridiques ou financières, résultant de l'exercice de ses droits par le CERN, en particulier de tout recours, à moins qu'il n'ait agi sur instructions formelles du CERN.

24.2 Les droits et redevances afférents à la propriété industrielle de tiers sont compris dans le prix contractuel.

25. Droit de réparation

25.1 Les droits de propriété industrielle et intellectuelle du contractant ne font pas obstacle au droit du CERN de réparer ou de faire réparer par qui il veut, à l'expiration de la garantie, toute fourniture, et de se procurer toutes pièces à cet effet. Le CERN donne néanmoins la préférence au contractant pour autant que ses prix et ses délais d'exécution de la réparation soient raisonnables.

25.2 Le CERN notifie aux tiers qu'ils ne peuvent user des connaissances mises à leur disposition qu'aux fins de réparation. Il ne communique que les informations nécessaires à la réparation, et veille à ce que celles-ci ne soient utilisées qu'à cet effet.

26. Perfectionnement

Le contractant offre au CERN, selon des conditions à définir par accord mutuel, la possibilité de faire appliquer à un contrat du CERN tout perfectionnement, brevetable ou non, qu'il peut réaliser pendant l'exécution dudit contrat, même en l'absence de lien avec celui-ci. Il informe le CERN à cet effet.

27. Inventions - Brevets

27.1 Le dépôt d'un brevet par un contractant, relatif à une invention résultant de travaux réalisés ou de documents, d'instructions ou d'informations obtenus de quelque manière que ce soit à l'occasion d'un contrat passé avec le CERN, fait l'objet d'un accord préalable entre le CERN et le contractant, par lequel le contractant cède au CERN une licence gratuite et irrévoca-

The indices used in the price revision formulae must be those of official government publications. Information from private sources shall be accepted only when such official sources are not available. The consequences of applying price revision formulae shall in any case be limited to the increase in prices which has effectively taken place.

20. Payments

20.1 No payment shall be effected without receipt of an invoice drawn up in the form prescribed in the contract and accompanied by all relevant supporting documents.

20.2 Provided that the invoice has been accepted, payments shall be effected within thirty days following receipt of the invoice in the form and under the conditions laid down in the contract.

20.3 Final payment for supplies shall be made only after acceptance by CERN.

21. Miscellaneous Financial Provisions

21.1 No advance shall be paid unless the contractor has obtained from a bank approved by CERN a joint and several banker's guarantee in CERN's favour for an amount equal to the sum demanded from CERN. Payment may be effected by instalments for each completed part of the contract.

21.2 Up to the final acceptance, CERN may withhold the payment of up to ten per cent of the contract price as security ; this security may also be provided by a joint and several banker's guarantee for the same duration and amount.

V. SAFETY

22. Contractor's Obligations

In addition to observing all relevant national legislation in safety and health matters, the contractor shall, when on the CERN site, comply with the safety regulations in force thereon, with which he is required to become conversant. He shall take all necessary measures to this effect. These obligations shall be taken into account by the contractor when drawing up his tenders and performing the contract.

VI. INTELLECTUAL PROPERTY AND PATENT RIGHTS

23. Intellectual Property

The CERN Convention places upon the Organization the obligation to publish or otherwise make available the results of its activities. No publication, communication or use of any piece of knowledge which is acquired from CERN in relation to a CERN contract and which is patentable or may be considered intellectual property shall therefore be made without prior agreement in writing between the parties. CERN shall not withhold its agreement unreasonably, and shall act with due diligence in notifying its decision.

24. Use of Patents Belonging to Third Parties

24.1 The contractor shall undertake to indemnify CERN and hold CERN harmless against any claim for infringement of intellectual property or patent rights, known and published in the contractor's country or registered by the European Patent Office at the date of signature of the contract, by the transfer or use of any equipment or component supplied by the contractor to CERN. He shall be liable for all the consequences, in particular legal and financial, of the exercise of its rights by CERN, and shall guarantee CERN against any claim, except if he has acted on formal instructions given by CERN.

24.2 The contract price shall be deemed to include any fees and royalties for the use of patent rights.

25. Right of Repair

25.1 The contractor's patent and intellectual property rights shall in no way preclude CERN from repairing any equipment, or having it repaired by whomsoever it chooses, on expiry of the guarantee period, and from obtaining any parts for this purpose. Preference is nevertheless given to the contractor provided his prices and repair or delivery times are reasonable.

25.2 CERN shall notify third parties that they may use the information communicated to them only for the purpose of the repair. CERN shall communicate to third parties only such information as is necessary for the repair, and shall ensure that such information is used only for that purpose.

26. Developments

The contractor shall, in accordance with conditions to be defined by mutual agreement, ensure that CERN is offered the possibility of application to the contract being performed of any development, whether patentable or not, which may arise during the performance of the CERN contract, even if the development has no connection with the said contract. He shall inform CERN of any such development.

27. Inventions - Patents

27.1 A patent application by a CERN contractor in respect of an invention resulting from work performed or from documents, instructions or data obtained in any manner whatsoever as a result of a contract concluded with CERN shall be subject to prior agreement between CERN and the contractor, whereby the contractor shall undertake to grant to CERN an irrevocable

ble, utilisable par les fournisseurs travaillant pour le compte du CERN ; ladite licence étant librement transmissible aux universités et aux établissements scientifiques gouvernementaux œuvrant dans le même domaine que le CERN dans les Etats Membres de l'Organisation. Le CERN s'interdit de refuser son accord pour des motifs non fondés et agit avec diligence pour signifier sa décision.

27.2 Si donc une demande de brevet est ainsi déposée par un contractant, le CERN respecte le secret d'usage jusqu'à établissement du titre de propriété industrielle.

28. Nom et emblème du CERN

Un contractant ne peut utiliser le nom ou l'emblème du CERN ni mentionner sa qualité de fournisseur de celui-ci s'il n'en a obtenu l'autorisation préalable écrite.

VII. RETARD - RÉSILIATION

29. Pénalités de retard

29.1 En cas de dépassement des délais contractuels d'exécution, éventuellement prolongés selon les présentes Conditions générales, le contractant est passible de pénalités, sous réserve des dispositions des paragraphes 9.3 et 9.4, sans mise en demeure préalable. Leur montant est stipulé au contrat.

29.2 D'une manière générale, les pénalités sont calculées sur le montant total du contrat.

29.3 Si le contrat prévoit des livraisons périodiques, par tranches ou par lots, pour autant que le retard d'une telle livraison, d'une telle tranche ou d'un tel lot ne porte pas atteinte à l'exécution générale du contrat, la pénalité applicable est calculée sur la valeur de chaque livraison, tranche ou lot.

29.4 Le montant des pénalités est déduit des paiements à effectuer sans préjudice du recours direct du CERN en cas de besoin.

29.5 L'application des pénalités ne fait pas obstacle au droit de résiliation du contrat pour cause de retard, laquelle n'est prononcée qu'après mise en demeure par lettre recommandée. Les pénalités sont applicables dans ce cas jusqu'au jour où expire le délai extrême d'exécution fixé dans la mise en demeure.

30. Résiliation du contrat

30.1 Outre les dispositions du paragraphe 12.5, le CERN peut, par lettre recommandée, résilier en tout ou partie tout contrat sans indemnité d'aucune sorte, pour toute faute grave du contractant, et notamment en cas de :
- inexécution totale ou partielle du contrat après mise en demeure ;
- inobservation répétée ou inobservation grave des mesures de discipline et de sécurité applicables sur le domaine du CERN ;
- corruption ou tentative de corruption de fonctionnaire du CERN ;
- fraude, tromperie, falsifications concernant les qualité, quantité, consistance des fournitures.

30.2 La résiliation prononcée dans ce cas par le CERN lui donne le droit de se procurer, aux frais du contractant, auprès de tel fournisseur qui lui conviendra, tout ou partie des fournitures non livrées ou rebutées. Nonobstant les dispositions du paragraphe 32.4, au cas où un nouvel appel d'offres entraînerait des prix supérieurs à ceux du contrat résilié, le CERN peut demander au contractant de lui rembourser la différence entre les nouveaux prix et les anciens, sans préjudice des dommages-intérêts que le CERN peut réclamer au contractant pour inexécution du contrat.

30.3 Nonobstant les dispositions du paragraphe 30.2, si le contractant peut de bonne foi invoquer le fait qu'il a été victime de circonstances extérieures et inévitables quant à l'inexécution totale ou partielle du contrat et apporte la preuve qu'il a, dans la mesure de ses moyens, tenté néanmoins de faire face à ses obligations contractuelles, les parties pourront se rapprocher en vue de procéder équitablement à la liquidation du contrat.

VIII. DISPOSITIONS DIVERSES

31. Faillite - Poursuite pour dettes - Séquestre - Saisie - Liquidation

31.1 En cas de poursuite pour dettes, de faillite, de séquestre, de saisie ou de liquidation dont le contractant serait l'objet, le CERN se réserve le droit de prononcer, par lettre recommandée, la résiliation du contrat, sans indemnité et sans préjudice des droits de recours du CERN.

31.2 Le CERN dispose du même droit de résiliation au cas où un contractant conclut un concordat ou tout autre arrangement avec ses créanciers ou à leur bénéfice, ou opère à leur profit un transfert de ses biens; ou leur consent un acte fiduciaire.

32. Responsabilité civile - Protection sociale - Responsabilité contractuelle - Assurances

32.1 En matière de responsabilité civile, le contractant répond de tous dommages survenus de son fait ou du fait de ses préposés, dont lui-même ou ses préposés pourraient être rendus responsables selon le droit applicable.

free licence, which CERN may make available to the suppliers engaged in work on its behalf. Such licence shall be freely transferable to universities and to governmental scientific institutes working in the same field as CERN in the Member States of the Organization. CERN shall not withhold its agreement unreasonably, and shall act with due diligence in notifying its decision.

27.2 If a patent is being taken out by a contractor, CERN shall observe normal secrecy until the patent has been officially granted.

28. CERN's Name and Emblem

A contractor may not use CERN's name or emblem, or indicate that he is a CERN supplier, unless he has first obtained CERN's permission in writing.

VII. DELAYS - CANCELLATION

29. Penalties for Delays

29.1 If the contractor fails to observe the contractual time limits, prolonged if necessary in accordance with the General Conditions, he shall be liable to penalties, subject to the provisions of paragraphs 9.3 and 9.4. Prior warning by CERN shall not be necessary. The amounts of the penalties shall be set out in the contract.

29.2 As a general rule, penalties shall be calculated on the basis of the total amount of the contract.

29.3 Where the contract provides for delivery by stages, instalments or lots, and if the delay in delivery of such a stage, instalment or lot does not impede the general performance of the contract, the penalties shall be calculated on the basis of the value of each stage, instalment or lot.

29.4 Penalties shall be deducted from the payments due, without prejudice to CERN's right to claim the sum directly.

29.5 The enforcement of penalties shall not detract from CERN's right to cancel the contract for reasons of delay, such cancellation taking effect only after CERN has given the contractor formal notice by registered letter. In such cases, the penalties shall be applicable up to the latest time limit stipulated in the letter of notice.

30. Cancellation of Contracts

30.1 In addition to the provisions made under paragraph 12.5, CERN may at any time cancel a contract in whole or in part by registered letter, without any compensation whatsoever, in the event of gross negligence or misconduct on the part of the contractor, and in particular in case of:
- failure to complete all or part of the contract, after receiving a formal letter of notice;
- repeated or serious disregard of the disciplinary or safety regulations applicable on the CERN site;
- corruption or attempted corruption of a CERN employee;
- acts of fraud, misrepresentation and falsification concerning the quality, quantity or composition of supplies.

30.2 Cancellation by CERN in such cases shall automatically give CERN the right to obtain, at the expense of the contractor, all or part of the undelivered or rejected supplies from any supplier it may consider suitable. Notwithstanding the provisions made under paragraph 32.4, if, as a result of a new invitation to tender, the prices quoted are higher than those of the cancelled contract, the contractor shall, on request from CERN, pay to CERN the difference between the new and the old prices, without prejudice to the compensation that CERN may claim from him for non-completion of the contract.

30.3 Notwithstanding the provisions of paragraph 30.2, if the contractor can, in good faith, claim that he has been the victim of external and unavoidable circumstances preventing him from completing the contract and can provide proof that he has nevertheless taken all reasonable steps to fulfil his obligations under the contract, the parties may cooperate in seeking a way of terminating the contract equitably.

VIII. MISCELLANEOUS PROVISIONS

31. Bankruptcy - Prosecution for Debt - Sequestration - Distraint - Liquidation

31.1 Should a contractor become involved in bankruptcy proceedings, prosecution for debt, sequestration, distraint or liquidation of assets, CERN reserves the right to cancel the contract by registered letter without compensation and without prejudice to CERN's right to seek legal redress.

31.2 CERN has the same right of cancellation if a contractor makes a composition or other arrangement with his creditors or for their benefit, or effects a transfer of his property to their advantage or signs a fiduciary agreement in their favour.

32. Liability in Tort - Social Security - Contractual Liability - Insurance

32.1 With regard to his liability in tort, the contractor shall be liable for all damages arising from his action or that of his agents, of which he or his agents could be rendered responsible under the applicable laws.

32.2 Le contractant supporte seul toutes les conséquences pécuniaires de toutes atteintes matérielles ou corporelles dont lui-même, ses préposés, le CERN ou ses agents, ou des tiers pourraient de son fait être victimes à l'occasion de l'exécution du contrat, tant sur le domaine du CERN qu'à l'extérieur de celui-ci.

32.3 Le contractant est tenu d'être en règle avec le droit social qui lui est applicable et supporte seul les conséquences de toute infraction.

32.4 En matière contractuelle, la responsabilité du contractant est limitée au montant du contrat.

32.5 Le contractant est tenu d'assurer auprès de compagnies notoirement solvables sa responsabilité civile et sa responsabilité contractuelle.

IX. CONTESTATIONS - STATUT - DROIT APPLICABLE

33. Arbitrage

Tout litige non réglé à l'amiable est soumis à arbitrage dans les conditions définies ci-après :

Les parties désignent chacune un arbitre, dans les trente jours à compter de l'avis donné par lettre recommandée, avec accusé de réception, par la partie la plus diligente à l'autre de son intention d'avoir recours à un arbitrage. Ces deux arbitres choisissent d'un commun accord, dans un délai de trente jours à dater de la désignation du dernier d'entre eux, un tiers arbitre qui ne peut en aucun cas être choisi parmi les personnes étant ou ayant été, de quelque manière que ce soit, au service du CERN ou du contractant et pour ce dernier être ou avoir été au service de ses sociétés filiales ou affiliées. Le tiers arbitre ainsi désigné préside le Tribunal arbitral.

Si un des arbitres désignés est empêché, après avoir accepté sa mission, d'accomplir celle-ci pour une raison quelconque, il est pourvu à son remplacement dans un délai de trente jours selon les conditions ci-dessus.

Au cas où l'une des parties n'a pas désigné d'arbitre et/ou si le tiers arbitre n'a pu être désigné d'un commun accord par les deux arbitres, la désignation en est faite par le Président du Tribunal Administratif de l'Organisation Internationale du Travail, à la demande de la partie la plus diligente.

L'arbitrage est organisé à Genève, sauf accord des parties.

Les arbitres ont le droit de se faire assister par des conseillers juridiques, des experts ou d'autres personnes de leur choix, dans les conditions qui leur semblent convenables, de procéder à des mesures d'instruction, à l'audition des parties, séparément ou contradictoirement, assistés par des conseils juridiques et/ou des experts s'ils le désirent, et plus généralement aux enquêtes, investigations et interrogatoires propres à les éclairer dans l'accomplissement de leur mission.

Les parties apportent d'elles-mêmes aux arbitres l'aide qu'elles sont en mesure de leur fournir.

La sentence est rendue dans les trois mois qui suivent la désignation définitive du tiers arbitre. Toutefois ce délai peut être prolongé d'un commun accord des parties.

La décision des arbitres interprète fidèlement les termes du contrat. Cependant, pour toute question de procédure qui n'y est pas stipulée, elle se réfère, par analogie, au code de procédure civile du canton de Zurich.

La sentence est définitive et lie les parties qui, par avance, renoncent à tout recours possible.

Néanmoins, chacune des parties en cause a le droit, dans les quinze jours de la notification par les arbitres de leur décision, de leur demander d'interpréter conjointement leur sentence. Cette interprétation est donnée dans les trente jours suivant la date où ladite sentence a été rendue.

Pendant ce temps, l'exécution de la décision est suspendue.

Les frais et honoraires de l'arbitrage seront fixés et répartis par le Tribunal arbitral.

La clause d'arbitrage définie dans le présent article s'applique de plein droit à tous les avenants, amendements et additifs à un contrat, même si elle n'y est pas expressément incluse, sous réserve de dispositions contraires formellement inscrites dans lesdits avenants, amendements et additifs.

34. Statut du CERN

Le CERN est une organisation intergouvernementale créée par la Convention du 1er juillet 1953, ayant son siège à Genève (Suisse). Elle est établie sur les territoires suisse et français, où elle bénéficie d'un statut international, défini dans les Accords de Statut passés entre elle-même et ses Etats-hôtes. A ce titre elle jouit notamment tant en Suisse qu'en France d'un régime civil, douanier et fiscal particulier. Le contractant est informé de l'effet de ce régime particulier et prend en conséquence les mesures qui lui incombent en relation avec les services compétents du CERN.

35. Droit applicable

35.1 Les contrats du CERN sont régis par la réglementation mise en vigueur par celui-ci du fait de son statut international et subsidiairement par le « Code suisse des obligations ».

35.2 Les contrats du CERN sont faits et exécutés à Genève.

32.2 The contractor shall bear the full financial consequences of any material damage or personal injuries which, through his action, may be suffered by himself, his agents, CERN or its agents, or any third party during the performance of the contract, either on the CERN site or outside it.

32.3 The contractor shall at all times comply with the social legislation which applies to him and shall be solely liable for the consequences of any infringement.

32.4 In matters concerning the contract, the contractor's liability shall be restricted to the price of the contract.

32.5 The contractor shall take out insurance cover with companies of reputed solvency for third-party liability risks connected with the contract.

IX. DISPUTES - STATUS - APPLICABLE LAW

33. Arbitration

Failing an amicable settlement of any dispute, the parties shall resort to arbitration under the following conditions:

Each party shall appoint an arbitrator within thirty days after notice has been given, by registered letter with acknowledgment of receipt, by either party to the other, of its intention to resort to arbitration. The two arbitrators shall, by joint agreement and within thirty days of the appointment of the second arbitrator, select a third arbitrator, who may in no case be drawn from amongst persons who are or have been in any way in the service of CERN or of the contractor, or of any subsidiary or affiliated company of the latter. The third arbitrator thus selected shall preside over the Arbitration Tribunal.

Should one of the parties fail to appoint an arbitrator and/or vented for any reason from fulfilling it, a replacement shall be selected within a period of thirty days in accordance with the above procedure.

Should one ot the parties fail to appoint an arbitrator and/or the two arbitrators fail to agree on the selection of a third, the choice shall be made by the President of the Administrative Tribunal of the International Labour Organization, at the request of the first party to do so.

The arbitration proceedings shall take place in Geneva, unless otherwise agreed by the parties.

The arbitrators shall be entitled to be assisted, in such manner as they see fit, by legal advisers, experts and other persons selected by them, to undertake investigations, to hear the parties either separately or in each other's presence, assisted if they so desire by legal advisers and/or experts, and generally to carry out any enquiries, investigations and hearings which may provide them with information for the performance of their task.

The parties shall spontaneously provide the arbitrators with such assistance as they are capable of providing.

The award shall be made within three months of the final appointment of the third arbitrator. This time limit may, however, be extended provided the parties agree.

The arbitrators' award shall faithfully interpret the terms of the contract. With regard to matters of procedure not dealt with in the contract, the award shall be based, by analogy, on the common law procedure of the Canton of Zürich.

The award shall be final and binding upon the parties, who shall in advance undertake not to resort to any form of appeal.

Nevertheless, either party to the dispute may, within fifteen days of announcement of the arbitrators' award, request them to provide a joint interpretation of their award. This interpretation shall be given within thirty days of the award.

During this time execution of the award shall be suspended.

The costs and fees of arbitration shall be determined and apportioned by the Arbitration Tribunal.

The arbitration clause set out in the present Article shall be applicable to all amendments, modifications and addenda to a contract, even if this clause is not specifically mentioned therein and provided that there is no formal provision to the contrary in such amendments, modifications or addenda.

34. Status of CERN

CERN is an intergovernmental organization set up by the Convention of 1 July 1953, and has its seat at Geneva, Switzerland. It is established on Swiss and French territory, where it enjoys international status as defined in the Status Agreements between CERN and the host countries. Special legal, customs and fiscal conditions therefore apply to CERN both in Switzerland and in France. The contractor shall be deemed to be conversant with the effect of these special conditions and shall accordingly, in conjunction with the appropriate CERN services, make such arrangements as may be required.

35. Applicable Law

35.1 CERN contracts are subject to the regulations adopted by CERN by virtue of its international status and subsidiarily to the "Code suisse des obligations".

35.2 CERN contracts shall be deemed to have been drawn up and to be performed in Geneva.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Conditions générales des appels d'offres et des soumissions

1. **Appels d'offres**
En règle générale les appels d'offres ne sont adressés qu'à des fabricants ou entrepreneurs établis sur le territoire des Etats Membres. Ils sont lancés sous forme d'appels restreints. Le CERN prend le cas échéant l'avis des autorités compétentes et des associations professionnelles pour le choix des soumissionnaires éventuels à consulter.

2. **Offres ou soumissions**

2.1 Toute offre doit être datée et signée par le soumissionnaire ou par son mandataire dûment habilité.

2.2 Sa signature doit être précédée d'une formule d'engagement indiquant sans équivoque possible que le soumissionnaire manifeste son intention de soumissionner. Une offre engage son auteur pendant un délai de cent vingt jours de calendrier qui court à compter de la date limite fixée dans l'appel d'offres. Le soumissionnaire ne peut revenir, pendant cette période, sur les prix ni sur les conditions de l'offre.

2.3 Il doit être répondu aux appels d'offres lancés par le CERN en tenant strictement compte des formes qui y ont été prescrites. Toute offre modifiée ou non complétée peut être rejetée sans autre motif. Si l'appel d'offres prévoit plusieurs éléments, postes ou lots, le soumissionnaire doit remettre un prix séparé pour chacun. Il est autorisé à indiquer en outre la réduction de prix qu'il consentirait au cas où il lui serait attribué tout ou partie de la commande. Il peut également subordonner la validité des prix remis à l'attribution de tout ou partie de la commande.

2.4 Toutes les clauses de l'offre et notamment celles qui concernent les prix proposés doivent être écrites très lisiblement ; toute rature ou surcharge doit être confirmée et paraphée par le signataire, faute de quoi la soumission ne peut être prise en considération.

2.5 Le CERN se réserve le droit d'attribuer les marchés de fournitures en fonction des objectifs qu'il poursuit dans chaque cas particulier et peut passer des contrats séparés pour chacun des éléments, postes ou lots avec tel contractant qui lui conviendra, même s'il n'est pas le moins disant. Le CERN se réserve le droit de rejeter le cas échéant toutes les offres. L'auteur d'une offre non retenue ne peut en aucun cas émettre une quelconque réclamation ou prétendre à quelque indemnité que ce soit.

2.6 Si plusieurs soumissionnaires désirent faire une offre conjointe ou collective unique pour tout ou partie du marché, ils doivent, dans leur offre, désigner un représentant dûment habilité à traiter avec le CERN et lui consentir un mandat dont l'étendue soit telle qu'en traitant avec lui seul le CERN soit réputé traiter avec eux tous. Néanmoins, le CERN conserve ses droits dans leur totalité à l'égard de chacun des fournisseurs. Le CERN est en droit, avant d'accepter une telle offre, d'exiger des soumissionnaires qu'ils soient tenus envers lui conjointement et solidairement.

General Conditions Governing Invitations to Tender and Tenders

1. **Invitations to Tender**
As a general rule invitations to tender shall be issued only to manufacturers or contractors established in the territory of Member States. Invitations to tender are issued in the form of selective invitations. In establishing lists of firms to be approached, CERN may seek advice from the relevant authorities and professional associations of the Member States.

2. **Offers or Tenders**

2.1 Every offer shall be dated and signed by the bidder or his duly authorized agent.

2.2 Above his signature the bidder shall insert a form of commitment showing without any possible ambiguity that he is expressing his intention to submit a bid. An offer shall commit the bidder for a period of one hundred and twenty calendar days from the closing date for the despatch of bids, as specified in the invitation to tender. The bidder shall be debarred during that period from modifying the prices or conditions of the offer.

2.3 Bids in reply to an invitation to tender issued by CERN shall conform strictly to the forms prescribed therein. Any offer which has been altered or left incomplete may be rejected without further reason. Where the invitation to tender provides for several elements, headings or lots, the bidder shall submit a separate price for each. He may indicate what price reduction he would agree to if he were awarded the whole or part of the order. He may also specify that compliance with the prices quoted shall be subject to his receiving the whole or part of the order.

2.4 All clauses of the bid, and particularly those concerning the proposed prices, shall be clearly legible and any erasure or addition shall be confirmed and initialled by the bidder, failing which the bid or offer will not be taken into consideration.

2.5 CERN reserves the right to place orders for goods in the manner appropriate to its aims in each particular case and to award separate contracts for each element, heading or lot with such suppliers as it sees fit, even where the said supplier may not be the lowest bidder. CERN may also decide not to accept any offer. A bidder whose offer has not been accepted may in no circumstances either raise any objection or claim any compensation whatsoever.

2.6 If several bidders desire to submit a single joint or collective offer for all or part of a contract, they shall in their bid appoint a duly accredited agent to negotiate on their behalf with CERN and shall delegate to the said agent such authority that, in negotiating with him alone, CERN shall be deemed to negotiate collectively with all the bidders. Nevertheless, CERN shall retain all its rights in relation to each of the suppliers. CERN shall be entitled, before accepting such an offer, to require that the bidders be bound to CERN jointly and severally.

2.7 Du seul fait qu'il a soumis une offre, son auteur reconnaît implicitement qu'il est capable d'exécuter la totalité des obligations du contrat susceptible d'être passé avec lui, sans aucune exception, et avoir pris toutes informations nécessaires à cet effet.

2.8 Toutes offres ou soumissions doivent être expédiées au plus tard à la date limite stipulée par l'appel d'offres. En conséquence, tous les envois doivent être faits sous pli recommandé et être expédiés par la poste exclusivement, le cachet de la poste faisant seul foi de l'expédition des documents en temps utile. Toute offre expédiée après la date limite stipulée dans l'appel d'offres peut être rejetée.

2.9 Les documents de l'appel d'offres mentionnent les noms des interlocuteurs du CERN pour les questions techniques et administratives ainsi que l'adresse à laquelle les offres doivent être envoyées.

3. Prix

3.1 Les prix doivent être libellés en francs suisses.

3.2 Les prix sont, sauf dispositions contraires, toujours réputés être nets, fermes et non révisables. Les fournitures destinées à l'usage du CERN sont exonérées de droits de douane. Pour les impôts et taxes, le CERN bénéficie d'un régime particulier, dont le contractant est tenu de prendre connaissance. A cet effet, les prix sont nets et hors taxes. Lorsqu'il y a lieu à application soit de l'ICHA (Suisse), soit de la TVA (France), ces taxes sont facturées de manière apparente. En dehors de la non-application éventuelle de l'ICHA ou de la TVA du fait du régime fiscal du CERN, ce dernier n'entraîne pour le contractant aucune dérogation aux impositions de droit commun.

3.3 Si le CERN accepte des clauses de révision de prix, les conditions qui leur sont applicables sont stipulées dans les conditions particulières de l'appel d'offres.

3.4 Les indices des formules de révision doivent être tirés de publications officielles gouvernementales. Les données émanant d'organisations privées ne sont acceptées qu'en l'absence de données d'origine officielle. Les conséquences de l'application de formules de révision sont en tout état de cause limitées au maximum à la hausse effective des prix.

3.5 L'assurance couvrant les pertes et dommages-intérêts relatifs au personnel, aux matériaux et aux marchandises en cours de fabrication, de construction et de vérification est à la charge du fournisseur.

4. Livraisons tardives
Tout marché passé par le CERN peut être affecté d'une pénalité pour livraison tardive. Le montant de cette pénalité est fonction de l'importance du marché et est fixé dans le contrat.

5. Droit applicable et arbitrage
Tout litige entre le CERN et un offrant ou soumissionnaire sera réglé par arbitrage selon la clause établie par le CERN. Les contrats du CERN sont régis par la réglementation mise en vigueur par celui-ci du fait de son statut international et subsidiairement par le « Code suisse des obligations ».

2.7 The submission of a tender shall be deemed to be an implicit acknowledgement by the bidder that he is in a position to fulfil every obligation, without exception, under the contract which may be concluded with him and that he is in possession of all the necessary information to that effect.

2.8 All offers or tenders shall be despatched, at the latest, by the closing date stipulated in the invitation to tender. Accordingly all communications shall be sent by registered mail and by post only, the postmark providing the sole proof of the despatch of the documents in due time. Any offer despatched after the closing date stipulated in the invitation to tender may be rejected.

2.9 The documents of the invitation to tender shall give the names of the persons to be approached at CERN for technical and administrative questions, and the address to which offers are to be sent.

3. Prices

3.1 Prices shall be quoted in Swiss francs.

3.2 Unless otherwise stated, prices shall at all times be deemed to be net, firm and not subject to revision. Supplies for the use of CERN are exempt from customs duty. With regard to taxes and levies, there are special arrangements for CERN and the contractor is required to become conversant with such arrangements. Accordingly prices shall be quoted net and free of tax. Where ICHA (Switzerland) or TVA (France) is applicable, these taxes shall be shown clearly on the invoice. Save in respect of possible exemption from ICHA or TVA arising from the special fiscal conditions which apply to CERN, the contractor shall in no way be released from his obligation to pay any taxes which may normally be due.

3.3 If CERN accepts price revision clauses, the conditions applicable to such clauses shall be laid down in special conditions of the invitation to tender.

3.4 The indices used in price revision formulae must be those of official governmental publications. Information from private sources shall be accepted only when data from such official sources are not available. The consequence of applying price revision formulae shall in any case be limited to the increase in prices which has effectively taken place.

3.5 The supplier shall bear the cost of insurance cover for loss and damages in respect of personnel, materials and goods in course of manufacture, construction and testing.

4. Late Delivery
Every sale to CERN may be subject to a penalty for late delivery. The amount of this penalty shall vary in accordance with the value of the goods and shall be specified in the contract.

5. Applicable Law and Arbitration
Any dispute between CERN and a bidder shall be settled by arbitration in accordance with the clause drawn up by CERN. CERN contracts are subject to the regulations adopted by CERN by virtue of its international status and subsidiarily to the "Code suisse des obligations".

PhD STUDY ON INDUSTRIAL BENEFITS OF CERN AND THE INFLUENCE OF CRITICAL FACTORS

The aim of the study is to identify different kinds of industrial benefits resulting from CERN contracts and the critical factors which generate the benefits.

The basic hypothesis is that CERN generates benefits to its suppliers and that by optimizing the present contract format these benefits can be further increased.
The results may help bidders to evaluate the potential benefits of future CERN-contracts.
The study will be written in English and distributed to the interviewed companies.

QUESTIONNAIRE

CONFIDENTIALITY

All information given in this questionnaire will be treated as strictly confidential. The information will be used for statistical purposes only, omitting the name and subsequent nationality of the company thus prohibiting identification of individual companies. Should a need arise to use this information in the form of an illustrating case study, written permission will be sought.

---

1. GENERAL INFORMATION ABOUT THE COMPANY

1.1. Name of the company ______________________

1.3. Telephone ______________________

1.4. Person interviewed ______________________

1.5. CERN-contract in question ______________________

1.6. Year and volume of the contract ______________________

1.7. Position at the time of the contract ______________________

1.8. Position at present ______________________

1.9. Role in the CERN-contract ______________________

1.10. Type of business ______________________

1.11. Branch/division responsible for the CERN-contract ____________

____

1.12. Main products of this branch/division ____________________

____

1.13. Annual turnover ($) of this branch/division at present (±10%)

____

1.14. Annual turnover at the time of the CERN-contract ______________

1.15. Number of employees at the time of the contract (± 10%)________

1.16. Number of employees at present ____________________________

1.17. Amount (%) of sales from standard products coming from export at the time of the contract______________________________

1.18. ... and at present ____

1.21. Number of those standard products at the time ________________

1.22. ... and at present ____

1.23. Market share (%) of the product (family) closest to the CERN-product at the time __________________________________

1.24. ... and at present ____

1.25. From a manufacturing point of view, which standard product(s) was/were closest to the CERN-product? ______________________

____

1.26. How long had this/these product(s) been on the market at the time of the CERN-contract? ____________________________

1.27. The extent of subcontracting of the standard product(s); % of manufacturing costs ______________________________

1.28. R&D expenditure (% of turnover) at the time of the contract ______

1.29. ... and at present ________________________________

2. ABOUT THE CONTRACT

2.1. Did you know about this specific CERN-tender before it was sent out?

A no ☐
B yes how? ______________________ ☐

____

C cannot say ☐

2.2. Has your company had regular contacts to CERN prior the contract?

A no ☐
B yes how? ______________________ ☐

____

how often? (visits/telephone calls per month) ________

____

who/which division initiated the contact? ____________

____

C cannot say ☐

2.3. What was your key competitive advantage in winning the contract with CERN?

2.4. What were the reasons you decided to do business with CERN?

2.5. Compared to some other, possibly more optimal types of customer-specific projects ("minimum friction" from your company point of view), how would you estimate the CERN-contract?
Please mark all relevant choices

Contract items	**the CERN-contract was**
1 duration of the contract (incl. repeat orders)	**very much shorter — same — very much longer** <-------|-------|-------|-------|------> **-2 — 0 — +2**
cannot say	❑
2 size ($) of the contract	**very much smaller — same — very much larger** <-------|-------|-------|-------|------>
cannot say	❑
3 transportation arrangements	**very much less flexible — same — very much more flexible** <-------|-------|-------|-------|------>
cannot say	❑
4 payment conditions	**very much less flexible — same — very much more flexible** <-------|-------|-------|-------|------>
cannot say	❑
5 price-indexing of future deliveries	**very much less flexible — same — very much more flexible** <-------|-------|-------|-------|------>
cannot say	❑
6 option for repeat orders	**very much less flexible — same — very much more flexible** <-------|-------|-------|-------|------>
cannot say	❑

7 specified necessary in-house skills

very much less demanding — same — very much more demanding

<-------|-------|-------|-------|------>

-2 0 +2

cannot say ❑

8 specified necessary production equipment and/or methods

very much less demanding — same — very much more demanding

<-------|-------|-------|-------|------>

cannot say ❑

9 technical documentation

very much less extensive — same — very much more extensive

<-------|-------|-------|-------|------>

cannot say ❑

10 technical specifications (tolerances, product performance etc.)

very much less demanding — same — very much more dmding

<-------|-------|-------|-------|------>

cannot say ❑

11 testing procedures

very much less demanding — same — very much more dmding

<-------|-------|-------|-------|------>

cannot say ❑

12 availability of help from the customer in case of technical problems

very much less specified — same — very much more specified

<-------|-------|-------|-------|------>

cannot say ❑

13 product/process standards imposed by the customer

very much less conventional — same — very much more cvtional

<-------|-------|-------|-------|------>

cannot say ❑

14 use of subcontractors

very much less extensive — same — very much more xtensive

<-------|-------|-------|-------|------>

cannot say ❑

15	quarantee period	**very much shorter** — **same** — **very much longer** <-------|-------|-------|-------|------> **-2** **+2**
	cannot say	❑
16	legal constraints and administration	**very much less demanding** — **same** — **very much more dmding** <-------|-------|-------|-------|------>
	cannot say	❑
17	other, what? ________________	<-------|-------|-------|-------|------>

2.6. Please identify (up to) three most important changes you would like to impose on the present CERN-contract format to make them more compliable to those of other, more optimal ones?

3. BENEFITS OF THE CERN-CONTRACT

3.1. How significant were the CERN-benefits compared to other, possibly more optimal ("minimum friction") contracts? Please mark all relevant choices

A Direct benefits

1 direct profit

CERN	Other, possibly more optimal contracts
of no significance — **of very high significance** <-------|-------|-------|-------|------> **1** **5**	**of no significance** — **of very high significance** <-------|-------|-------|-------|------> **1** **5**
cannot say ❑	cannot say ❑

2 existing capacity utilization (free production capacity at the time)

<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ❑	cannot say ❑

3 other, what? ________________

<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>

B Indirect benefits

1 other similar customers for the same kind of product (same product for other customer groups)

CERN	Other, possibly more optimal contracts
of no significance … **of very high significance**	**of no significance** … **of very high significance**
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
1 … **5**	**1** … **5**
cannot say ❑	cannot say ❑

2 longer term profitable business terms with the client (new contracts with the same client)

CERN	Other, possibly more optimal contracts
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ❑	cannot say ❑

3 commercial collaboration with previously unkown companies (e.g. subcontracting, sourcing)

CERN	Other, possibly more optimal contracts
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ❑	cannot say ❑

4 improved purchasing practises (e.g. raw materials supply cost savings)

CERN	Other, possibly more optimal contracts
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ❑	cannot say ❑

5 improved contract control (monitoring cost-impact of possible changes in contract)

CERN	Other, possibly more optimal contracts
of no significance ... **of very high significance**	**of no significance** ... **of very high significance**
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
1 ... **5**	**1** ... **5**
cannot say ❑	cannot say ❑

6 marketing benefits (export reference, image etc.)

<-------|-------|-------|-------|------>   <-------|-------|-------|-------|------>

cannot say ❑   cannot say ❑

7 improved process methods (e.g. new/modified equipment)

<-------|-------|-------|-------|------>   <-------|-------|-------|-------|------>

cannot say ❑   cannot say ❑

8 improved quality assurance (e.g. new/modified testing equipment or methods)

<-------|-------|-------|-------|------>   <-------|-------|-------|-------|------>

cannot say ❑   cannot say ❑

9 accelerated development of a new (other) product

CERN	Other, possibly more optimal contracts
of no significance — of very high significance	of no significance — of very high significance
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
1 … 5	1 … 5
cannot say ☐	cannot say ☐

10 R&D benefits (new ideas, skills etc.)

CERN	Other
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ☐	cannot say ☐

11 improved technical skills due to technical support provided by the customer

CERN	Other
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ☐	cannot say ☐

12 employee motivation (feeling of doing something important)

CERN	Other
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>
cannot say ☐	cannot say ☐

13 other, what? ____________________

CERN	Other
<-------|-------|-------|-------|------>	<-------|-------|-------|-------|------>

3.2. Please identify (up to three) most important types of benefits generated by CERN (1 - 3)

3.3. Were there some other results of the CERN-contract which were utilized by your company? How?

3.4. All in all, do you think that the CERN-contract was beneficial to your company?

A yes ☐
B no ☐
C cannot say ☐

4. FACTORS CONTRIBUTING TO THE BENEFITS

4.1. In what way did the CERN-product differ from your standard product(s)?

1 Product
Was the CERN-product a standard, off- the- shelf-product or was it a specially designed for a special purpose?

product — **standard** <-------|-------|-------|-------|------> **unique**; **1** … **5**

cannot say ☐

2 Process technology
Was the manufacturing technology used for the CERN-product standard as well, or was a special process line/facility set up for the job?

process technology — **standard** <-------|-------|-------|-------|------> **unique**; **1** … **5**

cannot say ☐

3 Product performance
Was the required performance of the CERN-product higher than those of the standard products of the company?

product performance — **standard** <-------|-------|-------|-------|------> **very high**; **1** … **5**

cannot say ☐

4 Product complexity
Was the complexity (number of components ; component linkages) of the CERN-product higher or lower than those of the company's standard products?
(STD = Standard complexity)

product complexity — **very much lower** <-------|-------|-------|-------|------> **very much higher**; **-2** … **STD 0** … **+2**

cannot say ☐

4.2 ... and what is the situation at present?

1 product
standard ... unique
<-------|-------|-------|-------|------>
1 ... 5

cannot say ☐

2 process technology
standard ... unique
<-------|-------|-------|-------|------>
1 ... 5

cannot say ☐

3 product performance
standard ... very high
<-------|-------|-------|-------|------>
1 ... 5

cannot say ☐

4 product complexity
very much lower ... STD ... very much higher
<-------|-------|-------|-------|------>
-2 ... 0 ... +2

cannot say ☐

4.3 Which divisions were involved in carrying out the contract? Please mark all relevant choices

1 general management
no participation ... very high level of part.
<-------|-------|-------|-------|------>
1 ... 5

cannot say ☐

2 R&D division(technology development) <-------|-------|-------|-------|------>

cannot say ☐

3 production division (operations; product planning included) <-------|-------|-------|-------|------>

cannot say ☐

4 marketing division (marketing & sales) <-------|-------|-------|-------|------>

cannot say ☐

5 purchasing division (procurement) <-------|-------|-------|-------|------>

cannot say ☐

		no participation	very high level of part.
6	service & installations divisions (services)	<-------|-------|-------|-------|------> 1	5
	cannot say	❑	
7	other, what? ____________________	<-------|-------|-------|-------|------>	

4.4. Please identify (up to three) most important divisions above in their order of importance (1 - 3)

4.5. What measures were taken before the manufacturing started? Please mark all relevant choices

		no effort was made	a very big effort was made
1	technical product suitability evaluation (e.g. product configuration)	<-------|-------|-------|-------|------> 1	5
	cannot say	❑	
2	market research study	<-------|-------|-------|-------|------>	
	cannot say	❑	
3	investments in new process equipment and/or tooling	<-------|-------|-------|-------|------>	
	cannot say	❑	
4	investments in new testing equipment	<-------|-------|-------|-------|------>	
	cannot say	❑	
5	finding suitable component suppliers/subcontractors	<-------|-------|-------|-------|------>	
	cannot say	❑	
6	training and re-allocating present employees	<-------|-------|-------|-------|------>	
	cannot say	❑	
7	visit(s) to CERN	<-------|-------|-------|-------|------>	
	cannot say	❑	
8	hiring new people	<-------|-------|-------|-------|------>	
	cannot say	❑	

9 other, what? ___________ <-------|-------|-------|-------|------>

cannot say ❑

4.6. How did the preparations differ from other customer projects?

4.7. Did you subcontract any components of the CERN-product? (raw materials excluded)

A no ❑
B yes; how much (%) compared to manufacturing costs? ___________ ❑
C cannot say ❑

4.8. At the time, what size total (market) volume were you aiming to achieve with the CERN-product?

A higher than the value of the final CERN-contract; how much and in which time? (e.g. compared to the contract in 3 successive years) ❑

____

B about the size of the final CERN-contract ❑
C lower than the size of the final CERN-contract ❑
D cannot say ❑

4.9. Was the CERN-project related to any diversification plan in your company?

A no ❑
B yes;
1 product-related diversification ❑
2 unrelated diversification ❑
C cannot say ❑

4.10. Was the CERN-project related any backward/forward integration plan in your company (e.g. buying suppliers/selling larger system-level concepts)?

A no ❑
B yes, in what way?___________ ❑

____

C cannot say ❑

5. PROBLEMS ENCOUNTERED AND HOW THEY WERE SOLVED

5.1. Was there anything special in the manufacturing/testing procedure?

A no ❑
B yes, what? ________________ ❑
C cannot say ❑

5.2. What kind of problems were faced during the contract? Please mark all relevant choices

A During the design phase

1 <u>Design work;</u>
1.1. designing the product for manufacturing

not a problem at all **a very big problem**
<-------|-------|-------|-------|------>
1 5

cannot say ❑

B During the process phase

1 <u>Process equipment;</u>
1.1. modifying present process line and/or tooling

not a problem at all **a very big problem**
<-------|-------|-------|-------|------>
1 5

cannot say ❑

2 <u>Quality control;</u>
2.1. unfamiliar test procedure <-------|-------|-------|-------|------>

cannot say ❑

2.2. unfamiliar testing equipment <-------|-------|-------|-------|------>

cannot say ❑

3 <u>Human resources;</u>
3.1. lack of personnel familiar with CERN-requirements or specifications ("language") <-------|-------|-------|-------|------>

cannot say ❑

3.2. lack of manpower <-------|-------|-------|-------|------>

cannot say ❑

4 Other:

	not a problem at all		a very big problem
4.1. communication problems	<-------|-------|-------|-------|------>		
	1		5

cannot say ☐

4.2. problems with the subcontractors (quality, sourcing etc.) <-------|-------|-------|-------|------>

cannot say ☐

4.3. other, what? __________ <-------|-------|-------|-------|------>

C During installation and acceptance test-phase at CERN

1 Integration work;

	not a problem at all		very big problem
1.1. difficulties in the installation of the system	<-------|-------|-------|-------|------>		
	1		5

cannot say ☐

1.2. difficulties in commissioning the system <-------|-------|-------|-------|------>

cannot say ☐

2 Quality control;

2.1. difficulties in testing the system <-------|-------|-------|-------|------>

cannot say ☐

3 Human resources;

3.1. lack of manpower on site <-------|-------|-------|-------|------>

cannot say ☐

4 Administration;

4.1. legal problems (delivering the goods etc.) <-------|-------|-------|-------|------>

cannot say ☐

5 Other;

5.1. what? ________________<-------|-------|-------|-------|------>

5.3. Please identify (up to three) most difficult problems in their order of importance

5.4. How were the problems solved?

5.5. Could the solution(s) be applied to other products, as well?

A no ❑
B yes, how? ____________________ ❑

____

C cannot say ❑

6. IMPACT OF THE CONTRACT ON COMPANY FUNCTIONS

6.1. Do you think the CERN-contract has contributed in the growth of your company/market share since the time of the contract?

A no ❑
B yes ❑ how much (%)?

____

C cannot say ❑

6.2. What was the level of satisfaction with the outcome of the CERN-contract compared to other, possibly more optimal ("minimum friction") contracts?
Please mark all relevant choices

A Support activities — **very much lower** / **same** / **very much higher**

1 general management (firm infrastructure)
<-------|-------|-------|-------|------>
-2 **0** **+2**

cannot say ❑

2 R&D division
A. technology development
<-------|-------|-------|-------|------>

cannot say ❑

B. human resources
<-------|-------|-------|-------|------>

cannot say ❑

		very much lower	same	very much higher
3	purchasing division (procurement)	<-------|-------|-------|-------|------>		
		-2	0	+2
	cannot say	❑		
4	other, what? ____________	<-------|-------|-------|-------|------>		

B Primary activities

1 production division
(operations)

1.1. technology development (product planning included) <-------|-------|-------|-------|------>

cannot say ❑

1.2. human resources <-------|-------|-------|-------|------>

cannot say ❑

2 marketing division (marketing and sales) <-------|-------|-------|-------|------>

cannot say ❑

3 service division (installation and services) <-------|-------|-------|-------|------>

cannot say ❑

4 other, what? ____________ <-------|-------|-------|-------|------>

6.3. Since then, have you made other bids to CERN?

A no ❑

B yes ❑

have you won contracts? no ❑

yes ❑ how much ($) in total? ____________

how many contracts? ________

how often? ____________

____

C cannot say ❑

Why have you/have you not bid to CERN since?

6.4. How many times did the CERN-engineers visit your company during the project?

6.5. How many of your people were working on the project?

6.6. Did you apply for some state support (R&D or equivalent) for the project?

A no ☐
B yes ☐
C cannot say ☐

6.7. Did you get funding?

A no ☐
B yes ☐
C cannot say ☐

7. COMPANY PROFILE

7.1. How important are the following typical customer needs to your company?

a customer typically needs	our company puts emphasis on
	of no importance … **or very high importance**
1 new products	<-------|-------|-------|-------|------> **1** … **5**
cannot say	☐
2 tailor-made (customized) products	<-------|-------|-------|-------|------>
cannot say	☐
3 comparatively short delivery time	<-------|-------|-------|-------|------>
cannot say	☐
4 continuous after-sales	<-------|-------|-------|-------|------>
cannot say	☐
5 other, what? ____________________	<-------|-------|-------|-------|------>

7.2. Please identify (up to three) most important customer needs to your company

THANK YOU VERY MUCH!