Supply Chain (Logistics) Environmental Complexity

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Supply Chain (logistics) Environmental Complexity

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for the degree of Doctor of Philosophy

by

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PhD School LIMAC

PhD programme in Technologies of Managing
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Abstract

The spatial scope of organisations has recently been reemphasised in the context of supply chains and supply chain management. This scope is usually accompanied by uncertainty to organisations, especially for the extended supply chain with geographically dispersed operations and activities, thus posing environmental complexity in the form of risks and costs that organisations need to contend with. The main purpose of this dissertation is to create a deep understanding of this environmental complexity facing the extended supply chain, and the main research objective is to develop a construct, consisting of factors and measures, that can aid in describing its state in the context of logistics.

Overall, the dissertation assumes an international business (IB) standpoint in undertaking this task whereby it is argued that countries and borders matter, and that differences between country environments lead to environmental complexity in the geographically dispersed supply chain. Country-oriented constraints may then exist at macro-economic level, or the micro-/meso- e.g. firm, network and industry levels of the business environment. In this dissertation, *supply chain (logistics) environmental complexity* is developed and operationalised in terms of the range and heterogeneity of country-oriented macro- logistics factors that need to be considered in extended, cross-border, or global supply chain (logistics) operations. The remainder of this dissertation is thereafter dedicated to finding these factors, and their respective information measures, by the application of a decision-making approach. A decision factor is one that influences the decision on selection with regards to environmental complexity, and an information measure is a unit of measurement that aids decision-making by providing some information on the factor.

The findings of this dissertation are based upon multiple literature reviews, content analyses and expert opinions, and suggest the importance of 17 such decision factors and 187 different types of information measures, which describe the state of environmental complexity in extended, cross-border, or global supply chain operations. The study is particularly relevant from the perspective of strategy and design issues in global supply chain management, international operations management and international business, and more specifically for environmental scanning and decision-making applications such as site location and transport mode selection. By applying the results of this dissertation decision-makers may, for example, get a preliminary idea of the environmental complexity surrounding their extended supply chains.

Dansk resumé

Der har i den senere tid været fornyet fokus på organisation og ledelse af globale forsyningskæder. Den globale forsyningskæde skaber imidlertid også miljømæssig kompleksitet og usikkerhed for organisationer, især for den udvidede forsyningskæde med geografisk spredte operationer og aktiviteter. Termen miljø referer her til organisationsmiljø, og kompleksiteten til risiko og omkostninger i form af barrierer, begrænsninger og endda muligheder, som organisationer står overfor i den globale kontekst.

Hovedformålet med denne afhandling er at skabe en grundlæggende forståelse af den udvidede forsyningskædes miljømæssige kompleksitet, og forskningens hovedmål er at udvikle en hierarkisk konstruktion bestående af faktorer og måleenheder, der kan beskrive den udvidede forsyningskædes logistiske forfatning. Overordnet antager denne afhandling et International Business (IB) standpunkt, hvor det argumenteres at lande og grænser har betydning, og at forskelle mellem involverede landes miljøer fører til miljømæssig kompleksitet i den geografisk spredte forsyningskæde. Landeorienterede begrænsninger kan eksistere på såvel et makro- som et mikroøkonomisk niveau.

I denne afhandling er forsyningskædens (logistiske) miljømæssige kompleksitet udviklet og operationaliseret i form af antallet og heterogeniteten af landeorienterede makrologistiske faktorer, som må tages til overvejelse i udvidede, grænseoverskridende eller globale forsynings (logistiske) operationer. Resten af denne afhandling er herefter dedikeret til at finde disse faktorer, og måleenheder gennem anvendelsen af en beslutningstagende fremgangsmåde.

En beslutningsfaktor er én, der influerer beslutningsprocessen hvad angår valg, der indeholder miljømæssig kompleksitet, og en informationsmåleenhed er en måleenhed, der afhjælper beslutningsprocessen ved at frembringe information om en faktor. For eksempel er *Told* en central beslutningsfaktor, der er relateret til miljømæssig kompleksitet. Den influerer forsyningskædestrømme, idet en velfungerende, konkurrencedygtig eller effektiv toldinstitution er essentiel for at udføre fysiske varestrømme på tværs af landegrænser. En beslutningstager kan have information om denne beslutningsfaktor via referencer til informationsmåleenheder som *told forsinkelser i antal dage*, hvilket er en måleenhed baseret på objektiv data og/eller *gennemsigtighed i toldgodkendelsesprocessen*, som er en måleenhed baseret på perceptuel data.

Resultatet af denne afhandling er en fremlægning af 17 sådanne vigtige beslutningsfaktorer og 187 forskellige typer informationsmåleenheder, som frembringer information om faktorerne og beskriver typen af miljømæssig kompleksitet i udvidede, grænseoverskridende eller globale forsyningskæder. Opgaven har særlig interesse for de, der er involverede i problemstillinger inden for strategi og design, såsom placering af produktions- og logistikfaciliteter og valg af transportformer i global forsyningskædeledelse, international operationsledelse og international forretning. Ved at anvende denne afhandlings resultater får beslutningstagere således en umiddelbar ide om den miljømæssige kompleksitet, der omgiver netop deres udvidede forsyningskæder.

Afhandlingen er opdelt i fire hoveddele. Del 1 sætter dagsordenen ved at dokumentere problemformuleringen, problemets relevans, forskningsspørgsmål, forskningsdesign og implicitte bidrag, og fortsætter derefter til en detaljeret behandling af det videnskabelige paradigme (systemtilgang) og den teori (organisationsteori), der er brugt i opgaven. Del 1 skal derfor ses som en guide til det arbejde, der præsenteres i resten af afhandlingen.

Del 2 omhandler konstruktionsudvikling. Det argumenteres først og fremmest, at forsyningskæder har en høj grad af strukturel organisatorisk kompleksitet, da der er minimum tre forskellige aktører. Da hver enkel organisationsaktor kan være placeret i hvert sit land, indeholder forsyningskæden således også miljømæssig kompleksitet, og forskelle mellem de involverede lande, i relation til deres antal og heterogenitet, bliver herefter relevant, idet de kan forårsage/beskrive tilstanden af miljømæssig kompleksitet. Ydermere er det konstateret, at forsyningskæden er tilbøjelig til et højere niveau af miljømæssig kompleksitet, fordi omfanget at disse lande, og forskellene imellem hver enkelt, er mere markeret end i for eksempel en multinational organisation. Endeligt er det demonstreret, gennem anvendelse af en detaljeret samling litteraturanmeldelser og indholdsanalyser, hvordan et sæt beslutningsfaktorer gav anledning til miljømæssig kompleksitet i forsyningskædeoperationer. Ydermere er det vist, at måleenheder baseret på forskellige datakilder og typer (perceptuel og hård data) er i stand til at frembringe information om beslutningsfaktorer, og derigennem beskrive tilstanden af miljømæssig kompleksitet i forsyningskæden.

Del 3 omhandler konstruktionsvalidering og fremlægger hovedstadierne i et valideringsstudie, som var nødvendigt for at nå til en valideret konstruktion. Opgaven blev fuldført ved brug af ekspertmeninger, og her blev det fundet, at konstruktionen af forsyningskæde (logistisk) miljømæssig kompleksitet er baseret på og kan operationaliseres via en liste af 17 beslutningsfaktorer og deres 187 informationsmåleenheder, som beskriver deres kompleksitet.

Del 4 konkluderer på afhandlingen gennem besvarelse af forskningsspørgsmålene. Denne del præsenterer også arbejdets hovedbidrag, og præsenterer en dybdegående diskussion af begrænsninger og uløste områder i denne opgave, samt debatterer (enhver) manglende mulighed der kunne have gjort denne afhandling mere interessant. Endeligt foreslås en liste over fremtidige forskningsretninger, såsom supportsystemer til beslutningstagning med henblik på at løse globale placeringsproblemer.

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Copenhagen, May 2009

Chapter 1

Introduction

1.1. Background

1.1.1. Globalisation, new organisational forms, new organisational environments

"Globalization of the marketplace results in supply chains facing more and more global issues that are critical for their success" (Lee and Ng, 1997, p. 192). Organizations must therefore attempt to optimize their logistics and supply chain networks because logistics and supply chain management hold global relevance and affect all types of organizations (Stock 2007). Since it is not uncommon for a company to develop a new product in the United States, source and manufacture it in Asia, and distribute and market it in the US, Asia and Europe, the issue of how each of the countries involved support the effective operation of supply chain/s, is as crucial as how companies re-organise themselves to deliver value under various extended formats e.g. as supply chains (Anand and Ward, 2004).

Friedman (2005) discusses how and why our present day world is flat and points out the existence of supply chains between countries, whereby nations themselves are to be reckoned with as important actors (in any modern supply chain view). For example, *"In the US, executives often look at many government functions as a hindrance to the smooth operation of the economy"* (Sheffi, 2001, p. 6). Meyer and Peng (2005) therefore point out the importance of adopting an institutional view to managing operations, especially in the context of those (Central and Eastern European) countries where the institutional and infrastructural context of business activity is in a state of constant flux. Sheffi (2001) emphasizes these trends in the current business environment as he points out:

> *"The globalization of manufacturing, the explosion of new products, and shortened product life cycles have burdened logistics managers with long supply lines and significant demand uncertainty",* (p. 4).

Notice the changing landscapes at play here – globalisation and its effects are increasingly linked to changing business environments, changing organisational forms, and changing organisational environments.

1.1.2. Do countries, borders matter?

One may then either adopt Friedman's (2005) prophecy of a flat world where borders do not matter because the same information is freely available at all locations in analysing the extended scope of organisations and its effects on managerial decision-making. In this case, organisational and country borders do not matter in our borderless world with borderless organisations, typified by free flows of goods and resources. Or one may adopt Ghemawat's

(2001) thesis on the continued importance of borders, distance and country differences in operations with extended scope (global). Borders matter in this instance. For example, as Romania and Bulgaria have recently been welcomed into the EU (on January 1, 2007), a debate also surrounds whether these countries are in fact ready with their macro and micro institutional structure and practices (Spiegel Online, 2006). Corruption affects institutions that support business activity, and corrupt institutions in these countries may impede the flow of goods and services in or through these countries. Thus, if Customs, which is an essential institution directly affecting the logistics and transportation of goods is corrupt in these countries (Global corruption barometer 2005 report, Corruption perception index 2006), it will affect the time (responsiveness) and costs (efficiency) needed for carrying out the essential supply chain flows that passage through these environments.

All these trends in the business environment point to some interesting aspects concerning organisations and their environments namely, the reconfiguration of organisations, the reconfiguration of organisational environments, and the reconfiguration of methods to analyze the new organisational environments. Whether it is a multinational enterprise (having an intra-firm manufacturing network outlook) or a global supply chain (based on an inter-firm ideology), the importance of organisational operations or activities (re-) adjusting to their broader environmental context, is thus reemphasized (Kinra and Kotzab, 2008a). An operation is one that (e.g.) involves all the activities necessary for the fulfilment of customer requests (Slack et al., 2007). For instance, both logistics and production are integral operations, while recognising that they provide differentiated yet complementary utility to operations (Chikan, 2001) in order to meet a customer request.

Given these trends, interesting questions that relate to the definitions and scope of organisational- units, environments, problems, and problem owners and their methods of (environmental) analysis therefore re-emerge. Subsequently, factors constituting the environment and environmental uncertainty should be re-analysed for each new organisational type (e.g. a supply chain), and for each new organisational environment (e.g. a supply chain environment) in order to determine how the broader super-system or context supports or impedes business operations.

1.2. Disciplinary domain of the problem – supply chains and supply chain management

> *"First introduced in 1982, the term supply chain management (SCM) could have easily disappeared into the history of business jargon. Instead, SCM rapidly passed into the public domain — a sure indication the concept holds meaning for executives wrestling with the endless challenges…"*[1].

The problem of this dissertation therefore originates in the context of a relatively new organisational form (Anand and Ward, op. cit.), the supply chain (as defined by Mentzer et al., 2001)[2], supply chain operations and supply chain environments. Supply chain management (SCM) is a practitioner-generated "discipline", which has gained much popularity in the last two decades. Although there exist fundamental differences in how we understand and use the term, Oliver & Webber (1982) may generally be regarded as the first to coin it. While at the same time, there are certain fundamental principles that are shared among researchers and practitioners of supply chain management that predate the early 1980's literature to Forrester's (1958) exploration of industrial (systems) dynamics and even to 'Charles Babbage's [1832] book on the economy of machinery and manufacturing' (Monczka et al. 2002, Burt et al. 2003). Given the different definitions of the terms, it is easy to attract a wide audience of researchers, practitioners and the common man into the examination of different types of problems and solutions under the scope of supply chains and supply chain management. "Turf wars" and turf setting discussions, as Mentzer et al. (2008) phrase it, on the origins and definition of SCM are thus not without merit, and have become an intricate part of research endeavours in the area. As Mentzer et al. (2008) note:

> *"In academia, the determination of a definition and bounds for "SCM" has very real implications for faculty. Awarding faculty lines, merit raises, budgets, curriculum design, and tenure and promotion…, if SCM is "owned" by operations research/management scientists, research will involve mathematical modelling and teaching will focus on decision analysis tools…., if SCM is "owned" by marketing, for example, then SCM tends to resemble marketing channels; if owned by purchasing it resembles strategic procurement; if owned by logistics it resembles integrated logistics, and so on",* (p. 31).

There are different starting points, ways of perceiving supply chain management and charting the discipline's origins, and even though distinguishing these is not the purpose here, Hesse and Rodrigue (2004) provide one such useful frame of reference, where they show how the discipline has evolved to its present form over the last forty years. Similarly, Slack et al.

[1] http://jobfunctions.bnet.com/abstract.aspx?docid=72889 19/06/08 17:36.

[2] This is not to say that the results of this dissertation are not applicable to other types of supply chains, than those defined by Mentzer et al. (2001).

(2007) offer one such useful frame of reference, which portrays the broad disciplinary scope of supply chain management as encompassing the procurement, production, physical distribution and logistics functions. As can be evident, supply chain management is a large disciplinary area, relates to a large body of knowledge and multiple outlets that appeal not only to the separate functional aspects of business operations, but also to their inter-organisational aspects.

Without taking away valuable space here in quoting alternative definitions and understandings of supply chains and SCM within the sub domains of business operations, it is more appropriate to state the definition of supply chain that this study plans to adopt. This study adopts the logistics management tradition of SCM and makes its point of departure in Mentzer et al.'s (2001) definitions. They define a supply chain as:

> *"..... a set of* ***three or more*** *entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer",* (p. 4).

This study then deals with a collection of consequences that follow the adoption of such a definition of the supply chain, namely those related to the (extended) scope of organisational operations and exposure to environmental uncertainty.

1.3. The (country) environment of the (global) supply chain?

The background discussion implies that in order for an adjustment to its broader environmental context, it has first to be determined what constitutes the super context, which embeds each organisational type. For example, Guisinger (2001), who emphasizes the importance of MNE[3] (Multi National Enterprise) activity, has MNE environments as his super context. Whereas, Kinra and Kotzab (2006) emphasize the importance of supply chain activity, supply chain operations strategy and therefore supply chain environments as their super context. In the instance of the present dissertation, the supply chain organisation becomes the unit of analysis, whereas its environment becomes the level at which the analysis takes place. Likewise, the background discussion also implies that there must be other factors (such as 'customs') in the environments (Romania and Bulgaria) that impede essential supply chain flows; and the possibility of a construct within the scope of which, differences between these variables may be analysed. Thought provoking questions that then arise in relation to the (SCM) disciplinary domain are: what constitutes the environment of

[3] Note that this abbreviation will be interchangeably used with MNC throughout this dissertation.

the supply chain, and what factors operationalise this environment. Furthermore, if borders and countries do matter, as Ghemawat (2001) posits from a globalisation and international business viewpoint, or as Mentzer et al. (2001) and Closs and Mollenkopf (2004) pose from a global SCM viewpoint, then how are these (countries) related to uncertainty in the supply chain environment? The emerging theme of "supply chain management in a global economy"[4] is then an important one, one that has repeatedly featured in the discipline's top journals in the last few years, and one that holds managerial relevance. This is well echoed in the recent conference themes and the main practitioner associations covering the domain of supply chain management, as researchers (e.g. Stock, 2007; Flynn, 2008) and practitioners[5] jostle to find out how (country) environments are to be dealt with extended operations of the supply chain organization.

1.4. Problem statement

The need to update the concept of organisational environments therefore makes sense. If in uncertain environments, decision makers need to increase the amount of information during task execution in order to achieve a given level of performance (Galbraith, 1974); if changing organisational environments pose opportunities and threats in terms of information processing requirements and methods of supply chain managers (e.g. Aguilar, 1967; Keegan, 1974); if supply chain managers need to design and structure their organisations in order to evade environmental uncertainty (e.g. Lawrence and Lorsch, 1969); and if they need to create a strategy to fit each type of environment they navigate through (e.g. Bourgeois, 1980), they need to analyse (e.g. scan) supply chain environments. The problem is, how can these managerial needs of environmental scanning and organisational requirements of environmental adaptation/accommodation (e.g. Ghemawat, 2001; Guisinger, 2001) be met if there exists no construct that deals with supply chain environments, and uncertainty caused by these?

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[4] See call for papers: 2008 Supply Chain Management Educators' Conference (SCMEC)

[5] See for example theme for the forthcoming CSCMP Europe (Council of Supply Chain Management Professionals) conference 2009: *"Turning Supply Chain Barriers Into Successes"*

1.5. The problem domain

1.5.1. Identifying the specific problem domain: global supply chain management – strategy, engineering and design problems

As the background discussion hints, the primary stakeholder in terms of an academic problem domain is one that focuses on the extended scope of supply chain operations and the management of global supply chains. From this point of view, this dissertation may then be related to the different research outlets in the supply chain management domain that demand resolution of the causes of uncertainty to supply chain operations in an extended (global) environment, and the definition of extended (global) supply chains, and management of these.

However, global supply chain management as a sub-domain is also rather extensive and disintegrated, as global may imply different things, and different (functional) starting points. As the domain review demonstrates, Global issues may imply differences between domestic supply chains across different country environments. For example, do traditional SCM models hold across different countries (e.g. Mentzer et al., 2001; Kaufmann and Carter, 2002; Bhatnagar, Jayaram and Phua, 2003; Closs and Mollenkopf, 2004)? Or global may imply one of the many expansion strategies (Kogut, 1985; Doz and Prahlad, 1991) that are available to organizations, for example, a global sourcing strategy (e.g. Trent and Monczka, 2003; Kotabe and Murray, 2004), a global production strategy (e.g. Shi and Gregory, 1998; Dicken, 2003), or a global distribution strategy (e.g. Zinn and Grosse, 1990). As Capacino and Britt (1990) point out, a global strategy is that, which considers the entire world as one, features a coordinated strategy for worldwide operations and globally optimized decision-making.

Global may also imply differences between the same supply chain that extends globally, thus emphasizing the field, space, or scope (e.g. Guisinger, 2001; Kotha and Orne, 1989; Stock et al., 1999) within which essential (global) supply chain flows take place. From this point of view, global SCM presents major challenges and opportunities to firms, and even industries (Lee and Ng, 1997). Stated in a different way, what are the constraints facing a globally dispersed supply chain in terms of environmental complexity, and why do these pose a decision-making problem for managers (e.g. Kinra and Kotzab, 2008b), with typical examples including but not limited to supply chain strategy (Christopher and Towill, 2002), engineering (Bhatnagar and Viswanathan, 2000) and design problems (Meixell and Gargeya, 2005) such as “site location”, “supplier selection”, “production/shipment quantities”, "transport mode selection", "resource allocation" etc. Although contributing to most of the global supply chain management avenues presented here, this last point of departure forms the specific problem domain where the dissertation will contribute the most. The following discussion seeks to bring out deficiencies in the problem domain that aided in formulating and stating the research problem.

1.5.2. A review of the (problem) domain

1.5.2.1. Extended supply chain operations and environmental uncertainty

The supply chain according to Mentzer et al. (2001) consists of many actors whose processes are interlinked in a global environment. Just as with other authors (e.g. Cooper et al 1997; Croxton, Garcia-Dastugue and Lambert 2001; Lambert, Garcia-Dastugue and Croxton 2005), Mentzer et al. (2001) also concentrate on the development of inter-organisational business processes, which disembogue in a series of supply chain flows. Their model of supply chain management, which they suggest viewing as a *pipeline*, shows the direction and the content of the main supply chain flows i.e. those of product, services, information, financial resources, and informational flows of demand and forecasts. Customer value is generally accepted to be of critical importance, and the main output of the system. Their model stresses inter-functional coordination, which includes the examination of the role of trust, commitment, risk, and dependence (that are generally regarded as input factors) on functional coordination. Similarly, their model stresses inter-organisational sharing and coordination, in tandem to the first, in order to provide customer value. Lastly, and of relevance to this study, they stress on the importance of these flows, structures and processes in a global environment and state:

> *"How all these phenomena vary in different global settings is relevant and, thus, represented….",* (p. 18).

This said, the external environment dimension of the supply chain is neither operationalised, nor further discussed. They provide outlook and set the future research agenda by concluding that the area of global supply chains provides a wealth of research opportunities, and will help in understanding the phenomenon of supply chains, supply chain orientation and supply chain management. In this sense, the supply chain refers to a global environment. For example, do antecedents such as trust, commitment etc. remain the same, or do they change under and across different cultures? Is there a common understanding of supply chain management and processes across different environments, in other words, does this model of supply chain management hold across different environments?

An alternative framework proposed by Closs and Mollenkopf (2004), builds on Bowersox et al.'s (1999) notions, and differs between three types of processes and four flows, which connect a resource base with end customers. Closs & Mollenkopf's (2004) global supply chain model however does not consider an external global environment at all, and does not (clearly) modify Bowersox et al.'s (1999) 21st century supply chain framework. However, it does provide some interesting results towards Mentzer et al.'s (2001) future research agenda, by concluding that supply chain competencies appear to be employed differently for different performance benefits across US and ANZ[6] firms. Global here, as in Mentzer et al. (2001), implicitly implies differences between domestic supply chains across different country environments. But the field, space, or scope within which the essential supply chain flows take place, is neither considered nor specified from the sheer complexity that a supply chain perspective imposes. They recognise a part of this problem in stating that:

> *"….additional measures will need to incorporate notions of organizational complexity and even a firm's supply chain complexity……these organizational issues may vary substantially across business environments, and act as moderators in the competencies/performance relationships",* (p. 44).

Differences in (business) environments represent key challenges to supply chain operations, but how to conceptualise these differences in a way that is meaningful and appropriate to the supply chain perspective, is open and may be phrased as '*up for grabs*'. Referring to different traditions on the impact of external environment (uncertainty) on organisation structure and transaction costs, Klein, Frazier and Roth (1990) argue:

> *"What each perspective ignores is the possibility that external uncertainty has multiple dimensions, each with a differential impact on organization structure and channel choice. External uncertainty appears to be too broad a concept to be treated unidimensionally; different facets of external uncertainty may lead to either a motivation to reduce transaction costs (the economic tradition) or a desire for flexibility (the organization theory tradition)",* (p. 199).

Thus, in fact, it becomes important to understand and analyze the environment in managing logistics operations because of the renewed scope of logistics activities, which is now global. For example, this range of additional factors has been associated to country specific macro-institutional and infrastructural factors affecting global operations (Guisinger, 2001). However, this area is scarcely dealt within conceptual supply chain management literature in

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[6] Australia and New Zealand

terms of why and how the environment specifically affects logistics operations in the global supply chain (e.g. Bowersox, Closs and Cooper, 2006; Grant et al., 2006; Handfield and Nichols, 1999). Whereas there are application studies done in this direction (e.g. Bowersox, Calantone and Rodrigues, 2003; Hausman, Lee and Subramaniam, 2005; Rodrigues, Bowersox and Calantone, 2005), a unifying theoretical framework to understand the raison d'être behind these studies is generally missing, thus posing questions as: why is it important to understand logistics costs at a national level, or why is it important to look at the (global) environment from a (supply chain) manager's point of view? From this point of view, we need a reliable construct in the domain that can address the issues mentioned here.

1.5.2.2. Key supply chain environmental complexity factors

The next issue relates to the previous one and concerns the understanding of the "environment" when referring to supply chain operations. In other words, what constitutes the environment of the supply chain, not to mention the specific factors that operationalise this environment and environmental complexity? For example Grant et al. (2006), following the tradition of Stock and Lambert (2001), come closest to an understanding of the (global logistics) environment for operations by distinguishing between controllable elements referring to the key activities of a function (logistics), and uncontrollable elements surrounding the (logistics) manager within this function:

> *"An uncontrollable environment is characterised by uncertainty, and frequently by volatility…. (an) executive must make decisions within such an environment – for example, cost trade-offs, customer service levels and pricing",* (p. 360).

Stock and Lambert (2001), (also) borrowing from the international marketing discipline, even elaborate on how to deal with the environment while describing the global (logistics) management process.

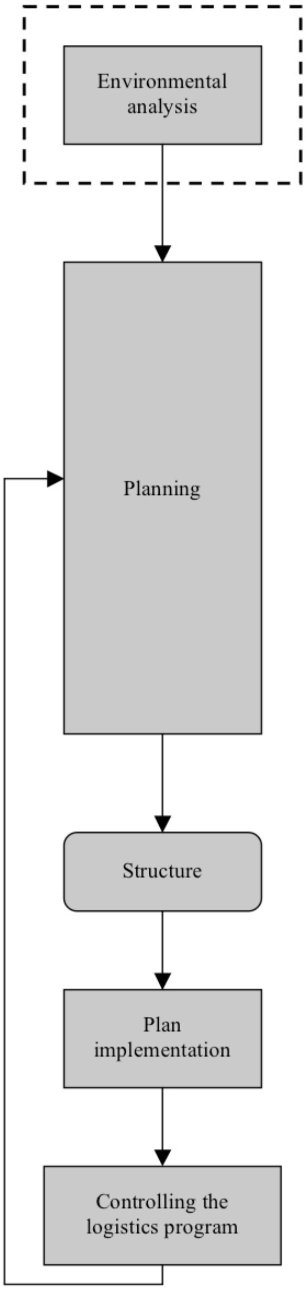
> *"Management of a global supply chain is much more complex than that of a purely domestic network. Managers must properly analyse the international environment, plan the foreign logistics system, and develop the correct control procedures to monitor its success or failure",* (p. 551).

They assume the first stage of any (logistics) strategy process as that of conducting an environmental analysis, and classify the key questions for the manager into 5 main categories (Fig. 4), namely (1) environmental analysis, (2) planning, (3) structure, (4) implementation, and (5) control. Though, just as Grant et al. (2006), they fall short in specifying the content of such an environmental analysis. They also fail to assume a supply chain perspective of inter-

Figure 1

"The Global Logistics Management Process"

(Adapted from Stock and Lambert, 2001)



Key Questions for Analysis, Planning, and Control

Environmental analysis

1. What are the unique characteristics of each national market? What characteristics does each market have in common with other national markets?

2. Should the firm cluster national markets for logistics operating and/or planning purposes?

Planning

3. Who should make logistics decisions?

4. What are our major assumptions about target markets? Are they valid?

5. What are the customer service needs of the target markets?

6. What are the characteristics of the logistics systems available to our firm in each target market?

7. What are our firm's major strengths and weaknesses relative to existing and potential competition in each target market?

8. What are our objectives, given the logistics alternatives open to us and our assessment of opportunity, risk, and company capability?

9. What is the balance of payments and currency situation in target markets? What will be their impact(s) on our firm's physical distribution system?

Structure

10. How do we structure our logistics organization to optimally achieve our objectives, given our skills and resources? What is the responsibility of each organizational level?

Plan implementation

11. Given our objectives, structure, and our assessments of the market environment, how do we develop effective operational logistics plans? Specially, what transportation, inventory, packaging, warehousing, and customer service strategies do we have for each target market?

Controlling the logistics program

12. How do we measure and monitor plan performance? What steps should be taken to bring actual and desired results together?

Source: Adapted from Warren J. Keegan, *Global Marketing Management*, 5th ed., p. 37. Copyright 1996. Reprinted by permission of Prentice Hall, Inc., Upper Saddle River, NJ.

functional and inter-organisational coordination, in order to understand its implications on a supply chain organisation.

Furthermore, just as Stock & Lambert (op. cit.), the domain literature does not touch upon the different attributes/dimensions of environmental uncertainty (pointed out by Klein et al., op. cit.) in relation to the different aspects and stages of supply chain management; this in essence makes it harder to distinguish between the different levels of the environment, whereby some (macro- level) are more relevant from the point of view of environmental complexity rather than other attributes (Kinra and Kotzab, 2008a). Finally, how the environment may systematically be analyzed in terms of a structural (e.g. operations site or logistics mode selection decision-making) problem (Kinra and Kotzab 2006) is generally not even an (explicit) concern of the entire domain. From this point of view, we need an operationalisation of supply chain environments in the problem domain. Furthermore, we need to specify how supply chain environments hinder supply chain operations by posing uncertainty, and barriers or constraints.

1.5.2.3. Measurements of supply chain environments and environmental uncertainty

The final aspect of the problem domain concerns itself with analysis and measurement. A debate surrounds and clearly seeks to divide researchers and practitioners alike on what represents the environment, and how it is to be measured. For example, do there exist objective referents of the environment or, is the environment a perceptual construct? This debate on organisational environments, and constructs related to this (e.g. environmental uncertainty) is fairly well developed in sociology and psychology traditions (organisational science), is emergent within the field of economics, but is quite new to the supply chain management domain with recent emerging contributions in the form of varying environmental scanning indexes, methods and tools, both prescriptive (e.g. *The Logistics Performance Index*, 2007[7]) and descriptive (e.g. Bagchi, 2001). However, since environmental scanning is as much a managerial decision-making concern as a policy-making one, it doesn't make sense for individual managers to scan single countries to decide on business environmental issues that span more than single environments (countries).

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[7] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTTLF/0,,contentMDK:21514122~menuPK:3875957~pagePK:210058~piPK:210062~theSitePK:515434,00.html

Furthermore, it doesn't make sense for the manager to give equal priorities to all factors of the supply chain environment, when specific business contexts play a role in decision-making. Lastly, the decision-making process becomes extremely ambiguous while using the (scarce) existing measurement schemes viz. these do not offer the possibility of clarifying how the decision (e.g. to outsource or locate) is reached, thus falling short on the understanding of the managerial decision-making process (Kinra and Kotzab, 2008a; 2008b). Populist environmental scanning indexes like the World Competitiveness Index and Logistics Performance Index (op. cit.) thus fall short in resolving managerial decision-making problems. To an academic stakeholder, the discussion provided here is then also related to the (researcher's) methodological preferences in the operationalisation of supply chain environments, as the preferred starting points in the domain literature.

From this point of view, we not only lack an operationalisation of supply chain environments in the problem domain, a healthy discussion in the domain on different types of measurement items, but also specific measures that empirically reflect on decisions with respect to particular situations, e.g. global supply chain design problems. Furthermore, we need to promote the use of decision-making methodologies for generating measures that provide information on supply chain environments.

The domain review then points towards the following gaps in the area of logistics/supply chain management i.e. the need to update the concept of organisational environments by 1) operationalising supply chain environments; and 2) creating a reliable construct within which such a (macro-) environmental analysis may take place.

1.6. Research rationale and relevance (to stakeholders)

The problem domain may then be summarised as an academic (sub-) domain covering the area of logistics and supply chain management, where there is a dire need to discuss macro-level constraints (issues) to supply chain operations, because of e.g. *extended (global) operations*; but one that is ignorant about an underlying construct that binds these issues together. Furthermore, as a result of the missing construct, the domain is not able to structure problems at the macro-, meso-, micro- levels, thus exposing drawbacks with respect to what specific type of environmental uncertainty is appropriate for analysing different (supply chain) problems. In other words, an emergent academic sub-domain (global supply chain management) that seeks explanatory power through theoretical constructs. The problem domain also holds managerial relevance because it includes a managerial area, namely that of *scanning methods and tools* of managers, which experiences the need for measures and frameworks arising out of (extended) supply chain operations, e.g. CSCMP *Global Perspectives*. In other words, a domain that seeks to alleviate their managerial decision-making tasks with respect to these global supply chain management problems by utilising environmental scanning methods and tools.

This brings out the relevance of the present research for two types of stakeholders in the area of supply chain management, namely managers involved in supply chain management with respect to global supply chain strategy, engineering and design issues; and academics who research and teach within the field of (global) supply chain management. One may accordingly state that while the managerial stakeholders have environmental scanning needs with respect to the supply chain problems mentioned above, the academic stakeholders are involved in the service of theses needs by developing constructs that aid in understanding global supply chain management, and methods and tools that aid in scanning the global environment. However, since this PhD dissertation is an academic exercise, and because the dissertation will not directly contribute to the managerial needs of environmental scanning by developing a full-fledged (validated) decision-making model, it is important to specify that the broad academic audience within the area of global supply chain management, and those that focus on global supply chain strategy, engineering, and design problems within that, shall remain as the primary stakeholders of this dissertation.

1.7. Research purpose, objectives and questions

Accordingly, within the main purpose of contributing to the gaps in literature identified here with respect to supply chain environments, and uncertainty in these supply chain environments from the dispersed (global) scope of supply chain operations, by further developing concepts that aid in understanding (Kinra and Kotzab, 2008a), and measures that aid in measuring (Kinra and Kotzab, 2008a; 2008b) the extended environments that global supply chains encompass, the purpose of this dissertation was to bring the construct of environmental complexity to the supply chain management domain.

The dissertation sought to achieve this purpose by outlining the following set of research objectives:

- To **understand** the relevance of environmental complexity in supply chain operations by applying the theoretical lens of *organisation-environment relations* to the supply chain organisation.

- To **develop** the construct of supply chain (logistics) environmental complexity by operationalising supply chain logistics environments and by developing and structuring a (construct) hierarchy of decision factors and (information) measures that are related to complexity in the environment.

Corresponding research questions that could guide the attainment of each objective and the purpose of the dissertation were then formulated in the following way:

1. RQ1 corresponds to the research objective of "understanding the relevance of environmental complexity in supply chain operations" and is phrased as:
   ***What** is the relevance of environmental complexity for the supply chain?*

2. RQ2 corresponds to the objective of "developing supply chain environmental complexity" and is phrased as:
   ***Wha**t are the key (decision) factors and their (information) measures that operationalise the construct of environmental complexity in supply chain logistics environments?*

1.8. Research approach

This thesis proposes and argues that environmental uncertainty, and herein environmental complexity, as the main attribute explaining constraints to dispersed (global) supply chain operations. Environmental complexity as a construct in itself is borrowed from organisational studies, where e.g. Child (1972, p. 3) defines it as *"the heterogeneity and range of an organization's activities"*; and the environment is studied by applying a *modernist* perspective and theories on *organisation-environment relations* (Hatch, 1997). Countries, and borders then matter because in a supply chain context, environmental complexity may be understood as the range of additional factors that supply chain logistics operations have to contend within a global environment, especially for domain seeking decisions, e.g. market/country entry (Kinra and Kotzab 2008a). And it is from this point of view that the construct of *supply chain (logistics) environmental complexity* is then framed in terms of the range and heterogeneity (see Cannon and St. John 2007), of the most important factors that are to be considered in globally dispersed supply chain operations.

Furthermore, this study applies a decision-making oriented approach (see Zack, 2007) for construct development and theory building (see Lewis et al., 2005) by constructing a decision hierarchy (see Saaty, 1980) of the factors and measures that seek to operationalise the construct, with particular emphasis on country (macro-) logistics systems and country oriented site location problems. In a multi-criteria decision-making environment, a decision factor is one that influences the decision (Min 1994a) on selection (Meixell and Gargeya, 2005). It is also interchangeably referred to as a decision attribute (Min, 1994b), a decision criterion (Liberatore and Miller, 1998), or even a decision parameter (Meixell and Gargeya, 2005), much dependent on the level it falls in a decision hierarchy, and the particular way a problem is framed (see Saaty, 1980). Whereas a measure is a unit of measurement that aids decision-making by providing some information on the factor (Liberatore and Miller, 1995; Teng and Jaramillo, 2005), thus contributing to the overall quality of managerial judgements about a decision issue, especially one that is based on a mix of qualitative (subjective) and quantitative (objective) factors.

Because of the environmental complexity theoretical approach, the study then sought to form its eventual point of departure only in those studies that are focused on cross-country comparisons of macro logistics systems, on a set of (decision) factors (based on constraints or barriers) that impede extended (global) supply chain (logistics) management.

1.9. Research scope

The following set of delimitations was designed to limit the scope of the present study. These delimitations concern different aspects of the research project, and therefore refer to the main stages of the research project i.e. problem formulation, theoretical and methodological approach, and the execution of the research process. Limitations with respect to the findings of the (validity) study and the entire research course are, however, covered in their appropriate sections towards the end of this dissertation.

1.9.1. Delimitation with respect to the problem formulation process

First, whatever the reasons for its continued popularity, the direct purpose of this PhD dissertation is to neither create a niche for supply chain management as a promising field, a distinct discipline, nor is it to examine or test its manifest foundations. Whether supply chains really exist (Mentzer et al., 2001), are contractually created entities (Halldorsson et al, 2007), or whether SCM is a discipline (Harland et al, 2006), are all honourable and valid questions, but not within the scope of this dissertation. The scope of this dissertation, instead, is delimited by the consequences of a (widely accepted) definition of “supply chain”, on business operations. It thereby presupposes the existence of a supply chain organisation in order to problematise consequences for management. In other words, assuming a “supply chain" perspective on an organisation has consequences for managerial strategy, decision-making and choice.

Second, and related to the first, the dissertation presumes the supply chain to be an organisational form. Indeed, only such an assumption can allow for a deeper investigation into supply chain environments. Interesting questions like - is the supply chain an organizational form; can it be treated as one? - could require more in-depth treatment of aspects like a) the focus of supply chain decision-making e.g. joint decision-making between supply chain members; b) possession of (joint) supply chain assets; 3) common supply chain cultures etc. However, these shall remain beyond the scope of the present dissertation as these relate to those research endeavours that primarily aim for establishment of the supply chain as an organisational format, based on characteristics other than (only) governance structures that are employed in the present dissertation.

Third, the terms supply chains, extended supply chains and global supply chains tend to be interchangeably used in this study. Because the study adopted a generic definition of the supply chain, one of the objectives itself related to the illustration and demonstration of the consequences of environmental uncertainty/complexity, that are embedded within this definition, as the author's who provide this generic definition (Mentzer et al., 2001) themselves remain unclear about these differences. Similarly, as the original authors of the definition state that all supply chains operate in a global environment, the same goes for supply chain environments i.e. does environmental complexity then arise in supply chain environments or does it happen in global supply chain environments? The author acknowledges that the reader may have to bear this ambiguity until Chapter 4, where it becomes clear that global and extended are purely environmental and structural scope related issues that supply chains have to contend when adopting this generic definition. In this way, this is an issue that was supposed to get clarified through the study, or at its conclusion.

Fourth, in referring to the term 'environment', this dissertation refers to how (modernist) organisational theorists and economists have used the term in order to understand the (external) business environment surrounding organisational functioning and operations (see Hatch, 1997). In this sense, the term should not be confused with the 'green' environment issues that currently preoccupy the domain, as this dissertation has very little direct relevance to such issues. Similarly, each time the terms *supply chain environmental complexity* and *supply chain (logistics) environmental complexity* are used in this dissertation, the former refers to the state of uncertainty, whereas the latter refers to the construct. From this point of view, it is important to note environmental complexity is a state, and the first research question (RQ1) seeks to conclude on this state, and the relevance of this state for supply chain management/operations. Whereas RQ2 seeks to conclude on a (decisional) construct. Because of the (AHP) methodological orientation, the many links (in the model) of the construct are not conceived as being cause-effect driven, the decision factors and their measures will always only seek to provide a description (and *not the causes*) of the state of the complexity. Any confusion caused by jumping between these two aspects, and by interchangeability in the use of terms (e.g. *cause/describe*) therefore needs to be seen in light of the discussion provided here.

Fifth, in referring to the term operations, this study does not seek to study operations areas (e.g. vehicle routing, replenishment quantities, order expedition etc.). Logistics is understood as one type of supply chain organisational operation (Slack et al., 2007; Mentzer et al., 2008) that provides time and place utility (Chikan, 2001). The key decision-making areas that affect this operation may then be characterised at the strategic, tactical and operational levels. Since inventory strategy, transport strategy and location strategy, also known as "logistical drivers", are long-range strategic supply chain management areas that affect the logistics operation (Chopra and Meindl, 2007), the term supply chain (logistics) operations refers to a (secondary) stakeholder of this research study, not the object of analysis per se. From this viewpoint, key supply chain strategic decision-making areas, that affect operations, include problem areas like facility location, transport mode selection. It is these types of strategy and design issues (problem domain) that formed a point of departure (primary stakeholder) in this dissertation. Supply chain management (disciplinary domain) then, amongst other things, involves the design, management and implementation of supply chain strategy and operations.

Sixth and related to the above, the term "Logistics", as understood with reference to the domain of business logistics, quite often invokes interrelationship and connotation to SCM. Frankel et al. (2008) acknowledge this interchangeability and note that:

> *"A review of the supply chain management literature's development during the late 1980s and the early 1990s reveals a lack of definitional consensus illustrated by the interchangeable use of neologisms: logistics management (Lambert and Stock 1993), network sourcing (Wijnstra and van Stekelenborg 1996), supplier-base reduction (Balsmeier and Voisin 1996), and inter-organizational integration (Cooper, Lambert, and Pagh 1997)",* (p. 4).

Whereas Stock et al. (1999) present the connection between logistics and supply chain management in terms of inter-enterprise integration of logistics activities, which they term as integrated logistics. Following Rudberg & Olhager (2003), this interchangeability is mainly because the field of studying supply chains as a whole originates in the Logistics Management domain, a view that is widely shared in the community (see for e.g. Metz, 1998; Hesse & Rodrigue, 2004). Whether or not SCM is just a new name for logistics (Cooper et al., 1997), or for instance falls within the purview of logistics (Cooper et al., 1997; Larson et al., 2007), is a different matter as this relates to the scope of each. But from the point of view of its origin, *"that there is no connection between logistics and SCM, seems indefensible",* (Larson et al., 2007).

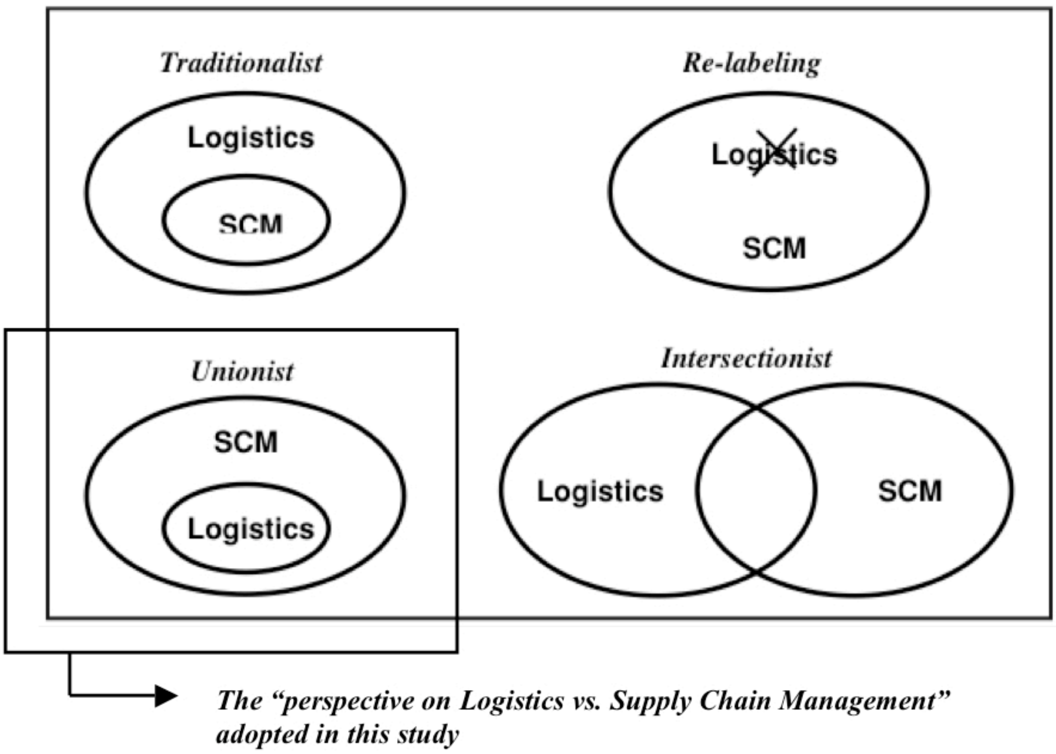
Since this (connection) may be confusing from the perspective of the present study, especially in terms of supply chain environments and the place of logistics therein, it therefore needs a little clarifying and delimiting here. Because logistics as an operation has transformational nature, and falls within the purview of supply chain management (Frankel et al., 2008), it may be said that the present study adopts a *unionist perspective* in relation to Larson et al.'s (2007) typology. In other words, as pointed out in the previous delimitation, logistics is seen as an operation within supply chain operations, which consists of the typical activities of warehousing and storage, inventory, transportation, packaging and materials handling (Bowersox et al., 2002; Stock and Lambert, 2001), and decision–making areas related to these at different levels (Chopra & Meindl, 2007). This way of viewing logistics is similar to Mentzer et al. (2001) and Mentzer et al. (2008), and is unlike the *traditionalist perspective* that Stock et al. (1999) cover in their literature reviews on enterprise logistics integration, to which e.g. Stock and Lambert (2001) subscribe. Given this approach, logistics environments signify the task of the broader supply chain environments, of which they are a part. Moreover, since environmental complexity is conceptualised as arising out of differences in general environments, or macro environments, macro logistics systems and differences across countries in these systems, are of particular interest to the present study.

Lastly, in order to problematise and argue for a supply chain environmental complexity construct, especially given the extended (global) scope of supply chain operations and activities, the dissertation assumes the standpoint of *'countries and borders do matter'* (e.g. Mentzer et al., op. cit.; Closs & Mollenkopf, op. cit.). This may be refuted by competing viewpoints, especially in developing theory and practice that supports the management of extended, global supply chain operations. For example, Kotzab (2000) notes how the German logistics literature views logistics and SCM in the same vein in order to connect resource and consumption bases. Similarly Stock (2007), although stressing globalization as an important consideration, states that organizations should focus on optimizing their logistics and supply chain processes irrespective of location. As they seek to underline that the primary task of logistics is *to connect*, these viewpoints open up an interesting discussion for the field. In this instance, locations should not matter from the point of view of *country peculiarities*. However, given the international business and operations starting point (e.g. Ghemawat, 2001; Guisinger, 2001) adopted here, which is in contrast to these traditional logistics starting points, *'countries and borders do matter'* and the author acknowledges this ideological bias in problem formulation.

Figure 2

Perspectives on Logistics vs. Supply Chain Management

(adapted from Larson et al., 2007)



1.9.2. Delimitation with respect to the methodological approach and scientific claims

In positioning this research project in its scientific paradigm, the author acknowledges the convenience and familiarity that the Arbnor & Bjerke (1997) paradigm classification structure offers, as it has been applied by other (Nordic) researchers in the field. From this point of view, the dissertation does not seek to create new knowledge, as the main purpose of the study and competences of the author lay beyond any ambition to distinguish accepted paradigm classifications. Similarly, the author acknowledges that there are problems related to Arbnor and Bjerke (1997) only including the constructivist perspective within their actors approach (e.g. Johannessen, 2006). However, since it remains representative enough of the interpretive perspective, and as this approach is not applied in this dissertation, it remains incorporated in its original form. A more detailed discussion on this topic then remains outside the scope of this dissertation. Also in relation to the scientific approach, the author acknowledges that the two divides created in the systems approach may be done in other ways, depending on the specific characteristics and owners of a research problem.

Next, it is important to delimit the dissertation with respect to its scientific claims, especially those arising out of the methodological approach applied here. In this sense, it is important to delimit and clarify the research objectives of construct development and operationalisation. As can be evident from the research approach, to a decision scientist, construct development and operationalisation implies developing decision factors that need to be considered with respect to a particular decision issue, and measures that aid in making the decision by providing some information on the decision issue. To an empirical decision scientist, this may only be done by performing all three stages of the construct development and validation process (e.g. Forza, 2002). From this point of view, the present dissertation will clearly (only) meet content validity concerns of construct development, i.e. stage I and stage II mentioned in Lewis et al. (2005). A 'decision instrument' may then be envisaged as a likely consequence of the construct development process here. Stage III of the Lewis et al. (2005) methodology, which includes other (generalisability) tests amongst nomological validity, is then beyond the scope of this dissertation. However, this is not to diminish the research objective of construct operationalisation in this dissertation, because as a descriptive MCDM (multi-criteria decision modelling) problem, each problem-owner will any case tend to operationalise the construct differently, by assigning different priorities to each decision factor, and by using a different set of (information) measures for each decision task. In this sense, developing and structuring a (construct) hierarchy, different attributes/factors and (information) measures, as is done using the AHP, is understood as construct development and operationalisation in this dissertation.

1.9.3. Delimitation with respect to the theoretical approach

First, even though organisational theorists such as Emery and Trist (1965) and Child (1972) mention about *interconnectedness* between environmental segments, the present dissertation ventures out in understanding and measuring environmental complexity in isolation of other environmental uncertainty attributes, like environmental dynamism and munificence. This standpoint is largely based on early modernist thought on uncertainty (Hatch, 1997), and the way strategy contingency scholars (see Bourgeois, 1980) seek to operationalise environmental uncertainty with respect to each attribute, for example 'fit' studies in the context of operations strategy (see Kinra and Kotzab, 2008b). From this point of view, geographic dispersion of activities in terms of the macro- environmental factors is an environmental complexity issue.

Second, although most of Hatch's (1997) environmental categories (i.e. physical, economy, technology, political, and legal) have been explicitly included and are therefore visible throughout the analysis of supply chain environments and complexity thereof, 'culture' has been excluded because it represents a behavioural dimension. From the point of view of this study, such a behavioural dimension comes into play at the second stage of decision-making, and therefore represents micro-/meso- environmental aspects of environmental uncertainty.

Third, environmental complexity is assumed to be antecedent to risks, and costs, as complexity may lead to risks in a system, or impose costs on the system. This is the standpoint that is assumed in the present dissertation. Though such an interpretation of the link between complexity and risk/cost may be refutable, such a discussion will remain beyond the confines of this dissertation.

Fourth, based on the understanding presented in the following chapters, with regard to the (theoretical and methodological) approach employed in this study, the task of construct development and operationalisation was interpreted as the fulfilment of the following conditions: 1) developing actual measures (i.e. decision factors and their underlying measures) that could be used to observe the construct, for instance, such as the Sharfman & Dean (1991) measures mentioned in Fig. 19; 2) demonstrating environmental complexity by showing the complete range of these measures (i.e. component preponderance) and comparing how these measures vary (i.e. component heterogeneity) across different country environments (e.g. as proposed by Guisinger, 2001, Kostova and Zaheer, 1999); and 3) suggesting a method or tool to structure and to use these measures in a meaningful way, for example, such as the *Herfindahl Index* and *Grossacks Ratio* mentioned in Fig. 19; or sundry models for calculating environmental complexity as proposed in e.g. Duncan (1972), Galbraith (1977) and Kanwar et al. (1991). Given this, it was understood that it was acceptable for authors to attempt different things within this scheme, governed apparently by the scope of their respective research projects (Canon & St. John, 2007). From this point of view, the present study shall therefore only selectively seek to contribute to these three conditions.

Fifth, do supply chains come into existence because firms tend to evade environmental uncertainty and risks and costs associated to this (e.g. as a result of increased outsourcing, Anand & Ward, 2004), or do supply chains come into existence as a part of pre-defined plan of creating value (e.g. Stabell & Fjeldstad, 1998) and eliminating costs and risks in the system? This questionable link between (e.g. global) supply chain management and uncertainty resurfaces, but is taken into account by assuming the Mentzer et al. (2001) definition of the supply chain. In a similar vein, it may be argued that environmental complexity may have both negative and positive effects on supply chain logistics operations. However, since the purpose of this dissertation is not to study competitive behaviour, i.e. how firms and their supply chains evade environmental complexity or make use of it, by e.g. creating competitive advantages, this aspect will not be dealt within the scope of the study.

Finally, while the author admits that value is created at each node of the supply chain, value creation in this dissertation has only been employed as a means to identify design aspects that bind the supply chain together as an organisational format in terms of an organisational structure (e.g. Mentzer et al., op. cit.). Aside from this treatment, this interesting discussion will also remain outside the scope of the present dissertation.

1.9.4. Delimitation with respect to construct application and managerial implications

While stating the managerial implications of the present dissertation, it is presumed that managers face increased environmental scanning needs because of extended supply chain environments. This assumption is based on anecdotal evidence, and by inferring such a managerial demand from publications such as “CSCMP Global Perspectives”. While the author accepts that a slightly more rigorous empirical justification of these managerial environmental scanning needs e.g. through a preliminary/exploratory case study could have strengthened the problem formulation, this shall remain beyond its confines because of limited resources, and the primarily "academic" orientation of the present dissertation.

Secondly, although construct application is an important part of a 'holistic' construct development process, it remains beyond the scope of the present study because of some of the methodological delimitations mentioned earlier. Because each problem-owner was envisaged to operationalise the (resulting) construct differently, to provide any meaningful construct application would need resolution of a specific problem, by specific problem owners e.g. a 'site location' problem. As can be justified through Mitroff et al. (1974), building a multi-criteria decision-making model by way of such an application requires a different research loop, different skills and resources, a different research project, and thus lay beyond the dissertation's scope.

Finally, even though it is the duty of all research processes to be as conscientious, and rigorous as is possible (Mentzer, 2008), it must be reemphasised that the author views the present dissertation and its processes from a particular (pre-assumed) scientific lens. From this point of view, the present research will always appeal in its relevance to the problem-owning audience, than others in the supply chain management domain.

1.10. Research Design

According to Zikmund (2000) a research design should be developed after the problem has been formulated, and should be understood in the following way:

> *"A research design is a master plan specifying the methods and procedures for collecting and analyzing the needed information. It is a framework of the research plan of action. The objectives of the study determined during the early stages of the research are included in the design to ensure that the information collected is appropriate for solving the problem. The research investigator must also determine the sources of information, the design technique (survey or experiment, for example), the sampling methodology, and the schedule and cost of the research",* (p. 59).

It was therefore important to reflect on the overall research objectives, and the total research project in order for the study to commence. Here, all the considerations with regards to the research design are documented.

1.10.1 The main research processes of construct development

The two related yet varied objectives of this study were conceived of being carried out using different research approaches, methods and techniques at different stages of the research project. These objectives were varied in that while the first aimed at understanding the relevance of environmental complexity for extended supply chain operations, the second aimed to develop a construct for supply chain (logistics) environmental complexity. Both were related by the common purpose they sought to achieve, i.e. of bringing the construct of environmental complexity to the supply chain management domain. Based on this it was held that a construct development study would be appropriate in answering the research questions and in meeting its objectives. The study was therefore driven by a construct development and validation paradigm that is akin to Mitroff et al.'s (1974) loop of *conceptualisation – modelling – validation* model development process[8] within empirical descriptive research, with the most important objective being that of developing and operationalising the construct of supply chain logistics environmental complexity.

A construct development study was therefore designed around this purpose, which then sought to meet the research objectives, and to answer research questions under two broad processes: **a) the construct conceptualisation process** and, **b) the construct (internal) validation process**. The construct conceptualisation process was intended to perform an examination of the (application) domain (Sethi and King, 1991), as stage I of the construct development process (Lewis et al., 2005). Whereas, the construct validation process was intended to test the efficacy, and to meet content validity requirements of any emergent models on the construct, as stage II of the same construct development process.

These two processes would then seek to deal with a list of 5 essential issues/dilemmas/questions with the task of construct development. The first process of construct conceptualisation was envisaged to require theoretical work in the form of literature reviews, meta-analyses, and the formulation of interconnections between different domain literatures in order to create a conceptual framework on the construct of supply chain logistics environmental complexity. Essential questions (pertaining to the task of construct development) that this process of construct conceptualisation was envisaged to answer were:

1. How do we know which factors cause/describe environmental complexity?
2. How can these factors be grouped together?
3. What (information) measures provide information on these factors, and therefore can be used to measure these factors?

The second process of construct validation was then envisaged to answer essential questions, especially those that would remain unanswered even after the conceptual framework, and

[8] *"It is interesting to note that the main risk that Mitroff et al. notice is an overconcern with validation, i.e., the researcher wants to make a perfect fit between the model and reality",* (Bertrand and Fransoo, 2008, p. 12).

theoretical model would have been developed. These essential questions may be summarised as:

4. Construct validation concerns – is the construct well founded or good enough?

As per the two narrowly confined research objectives and the scope of this study, a third, and related process of construct application was then to be left untouched in this dissertation. However, it must be pointed out that certain aspects of this process were subsequently covered in other related publications that were made during the research study. Such a process could be envisaged to answer the following question with regards to the construct:

5. Are the results (from applying the construct) good enough?

A publication strategy that targeted top academic journals within the domain, and involved peer reviews, was then envisaged in order to install scientific rigour into these processes. Subsequent publication attempts, along with the respective issues that each dealt with, may be summarised under each publication type that consequently materialised:

Journal of Business Logistics[9]:

- *Concept of supply chain environmental complexity*
- *Relevance to the logistics domain i.e. logistics environment*
- *Choice of decision-making methodology, and application to a logistics problem*

International Journal of Production Economics[10]:

- *Construct of supply chain logistics environmental complexity*
- *State-of-the art in "Environmental Uncertainty" related research problems in operations*
- *Why is environmental scanning a decision-making problem*
- *Application to a logistics operation/problem.*

1.10.2. Design: an overview of key research stages, methods and approaches

The study was then designed by breaking the entire process of construct development into 5 stages. Each of these 5 stages corresponded to tackling the essential questions mentioned in the previous section. The overall set of approaches, methods and techniques that were relevant for construct development, and essential questions that each stage sought to answer in the process are the subject of description in this section. Fig. 3. is provided here from this point of view, in order to illustrate, and to give a good overview of the entire construct development and validation process. Given its research objectives, all 5 stages were

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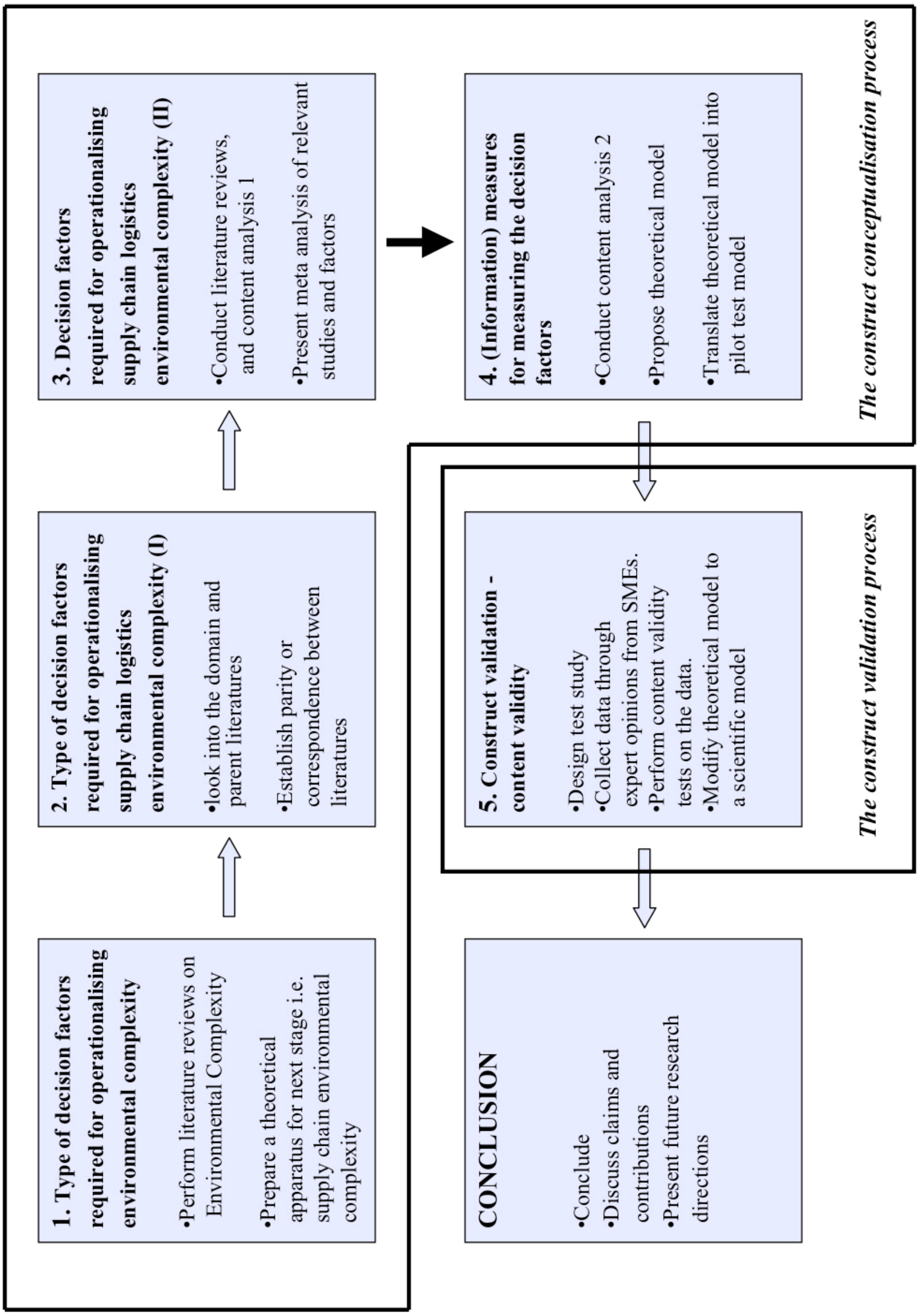
[9] See Appendix A.1. for a brief abstract of this publication.

[10] See Appendix A.2. for a brief abstract of this publication.

envisaged to be completed within the present dissertation. A stage-wise explanation, and brief descriptions are as follows. Since all of these stages shall be given a more in-depth treatment in each individual chapter that covers these, the reader is referred to their original locations in this dissertation for the bulk of the discussion regarding their execution.

Figure 3

An overview of key research stages, methods and approaches for construct development



1.10.2.1. Stage 1: type of decision factors required for operationalising environmental complexity

The opening stage corresponded to the question of "how do we know which factors" operationalise environmental complexity. More precisely, this stage sought to look into the broader subject area of *environmental complexity* research in order to find out the type or categories of factors that have been used in literature. Since an explicit operationalisation of the construct of environmental complexity was new to the dissertation domain literature of logistics and SCM, literature reviews at this stage were meant to look beyond into the broader organisational research literature, and methods used therein in order to see how the construct had been operationalised. This stage is given an exclusive treatment in Chapter 3, where the "Methods & issues in construct measurement" are discussed.

1.10.2.2. Stage 2: type of decision factors required for operationalising supply chain logistics environmental complexity (1)

This stage may be referred to as the first of the two sub-stages that sought to answer the question of "how do we know which SCM factors". For this, this stage sought to look more specifically into the domain literature of logistics and supply chain management in order to find relevant studies, and to build correspondences with those studies that most closely matched the description of environmental complexity research within the domain literatures. In other words, a starting point for embarking on a more detailed literature review process was sought at this stage. This stage is given exclusive treatment in Chapter 5, where "Specific categories and factors of supply chain logistics environments", are discussed. Once again, literature reviews were to represent the bulk of the approach employed here in order to identify and short-list studies, which were then meant to serve as a starting point for the next stage involving more in-depth reviews of the domain literature. For this purpose, since the construct was new to the domain literature of logistics and supply chain management, a broader mapping of the construct was envisaged not only within 'parent'[11] literature in operations management, but also within the context of the parent construct of environmental complexity, which is environmental uncertainty. The reader may refer to literature reviews and the meta-analysis presented in Chapter 3 in order to get a grasp of these issues. Furthermore, the reader is also referred to Chapter 5, where parity between various categories of decision factors is established.

[11] One may argue for a different term than 'parent' based on Mentzer et al. (2008) and Frankel et al. (2008), who delve into the relationship between the disciplines of logistics/SCM and OM.

1.10.2.3. Stage 3: decision factors required for operationalising supply chain logistics environmental complexity (2)

This stage was envisaged as the second of the two sub-stages that sought an answer to the question of "how do we know which SCM factors"; the first has just been described in the previous sub-section. Based on the input from the previous stage, a more detailed literature review in the form of a content analysis was to be performed here. Furthermore meta analyses were to be employed for guiding these literature reviews and for concentrating the results of the content analyses in a meaningful manner. The reader is referred to Chapter 6, where the initial and first rounds of content analyses are described, and where the specific techniques employed in order to short-list the decision factors that were deemed as being important for operationalising the construct, are described in more detail.

1.10.2.4. Stage 4: (information) measures for measuring the decision factors

Stage 4 was to mark the beginning of data collection activities in this study, as specific (information) measures, that provided information on supply chain environmental complexity through their respective decision factors, were to be sought within the objectives of this study. It was envisaged that undertaking an in-depth content analysis of relevant material within the problem domain, would bring out a range of measures that could be linked to each decision factor. The ensuing content analysis, and its findings are described in detail in Chapter 6. Furthermore, it was envisaged that a theoretical model on the construct, with a hierarchy of decision factors and (information) measures would emerge at the conclusion of this stage.

1.10.2.5. Stage 5: construct validation - content validity

Stage 5 was envisaged to deal with aspects of *content validity* and *construct validity*. More specifically it was to deal with aspects of internal validity of the theoretical model on the construct that would have emerged from the previous stage. This was envisaged in the form of the following objectives:

- Validating the theoretical model in terms of whether each decision factor was important for operationalising the construct.
- Short-listing only those measures from the previous stage, that provided important information for assessing or measuring each decision factor.

It was therefore envisaged that a small (e.g. pilot) test and screening empirical study in the spirit of Lewis et al. (2005), could check for internal validity of the model by garnering responses from subject matter experts. It was also envisaged that aiming for more than internal validity of the theoretical model, e.g. external validity, would remain beyond the confines of this dissertation because of the methodological delimitations outlined earlier. The reader is referred to Chapter 7 in order to gain more insight on this stage, where more detailed objectives and findings of this test study are documented.

1.10.3. Organisation of the dissertation

The thesis is organised under four main parts. Part 1 of the thesis sets the research agenda by documenting the problem formulation process, problem relevance, domain and implied contributions through Chapter 1. Chapter 1 should therefore be seen as the guiding map to the work presented in the remainder of the dissertation. Chapter 2 then moves on to a detailed explanation of the scientific paradigm and theoretical approach used in the study. A presentation of alternative research directions and designs that seeks to delimit the scope of the present dissertation from distinct research angles is also made here.

Part 2 concerns itself with presenting the main processes in construct conceptualisation. Chapter 3 shall present the different theoretical perspectives that were applied in order to get to a theoretical apparatus for analyzing the construct i.e. environmental complexity. It therefore presents an in-depth discussion and analysis on environmental complexity (as a research object). Chapter 4 then presents the process of applying this apparatus to the domain of supply chain management so that a conceptual framework on the construct of supply chain logistics environmental complexity could be identified. An answer to research question 1 became apparent after this stage, for which reason a sub-conclusion is presented at the end of Chapter 4. The concept, and the processes behind the formulation of supply chain environments are then documented in chapter 5. A part response to research question 2 was rendered possible after this stage; therefore a sub-conclusion is also presented at the end of the chapter. Chapter 6 marks the end to the construct conceptualisation phase, and to part (2), by presenting all the work done in order to prepare a (theoretical) model on the construct of supply chain logistics environmental complexity. Chapter 6 seeks to document the entire range of decision factors and their information measures that resulted in the theoretical model on the construct. The sub-conclusion presented at the end of the chapter therefore provides a more complete (but yet in-validated) response to RQ 2.

Part 3 of this thesis concerns itself with presenting the main processes in construct validation. Chapter 7, the only chapter in the part (3), starts by setting the scene for a short content validity study, which was required for (internal) validating the theoretical model that had emerged in the previous stage. It then briefly describes the translation of the theoretical model into its empirical frame of reference, and then presents a step-wise account of the data collection strategy, methods, sampling and instrument that were used to go to the field. The chapter concludes by presenting the main findings of the content validity study, and its consequences for the revision of the theoretical model. A clear response to research question 2 is thus only made possible at the conclusion of Part 3, the construct validation phase.

Part 4 concludes the dissertation, as it starts by wrapping up the responses to each of the research questions in Chapter 8. The chapter also presents the main contributions of this dissertation, and presents an in-depth discussion on the limitations and unresolved issues of the study, thus debating (any) missed opportunities that could have made this dissertation a more interesting one. Chapter 9 presents a list of future research directions that have originated in the work presented here.

Chapter 2

Scientific Approach

The nature of social explanation gives rise to the importance of scientific means as a way of explaining different social phenomena. The topic of scientific explanation covers an array of different questions, which may be summarised in the form of the following guiding questions:

> *What is the purpose of scientific explanation? What is the logical form of an explanation? What are the pragmatic requirements of an explanation? What are the criteria of adequacy of an explanation? And what role do general laws play in scientific explanations?* (Little, 1991, p. 3).

Therefore, the main objective of this chapter is to disseminate the process of refining the problem domain of this dissertation, which included matching it with its (relevant) scientific domain, and setting the disseration confines. The main objective of this chapter is therefore to disseminate the choices on scientific recourse, as were available to the present study. The chapter starts out by providing a general discussion on (alternative) research paradigms in social sciences, and the paradigm adopted in this thesis. These alternative research paradigms were subsequently applied to the problem domain (of environmental complexity) in order to visualise the problem under each, and in order to select the one paradigm that closest matched the problem owner's and the researcher's (author's) value system and mindset. Finally, the systems paradigm was selected, and the theoretical and methodological frames of reference were specified.

2.1. Scientific paradigms – ontological and epistemological considerations in social sciences and choosing the relevant paradigm classification structure

Taking Kuhn's (1962) ideas about paradigms and paradigm shifts into account, Little (1991) presents the following description of paradigm, which I adopt as the basic understanding of a paradigm in the present dissertation:

> *"A paradigm is a set of models of scientific explanation, exemplary explanation, exemplary experiments, background assumptions about the world, and the like in the context of which researchers formulate more specific research problems. Paradigms embody comprehensive worldviews, they define the categories in terms of which investigators organize the data available to them, and competing paradigms implicitly constitute systems of concepts and beliefs that cannot be intertranslated. Meanings of theoretical terms, interpretations of empirical data, theoretical assertions, and standards of inference are incommensurable across paradigms",* (Little, 1991, p. 206).

A paradigm is thus an *"accepted model or pattern"* (Kuhn, 1962, p. 23), which lends itself to a field of research through a set of methods that all exhibit the same pattern or element in common (Meredith et al., 1989). Since science, as a process of establishing 'warranted belief', may be understood as a formalisation of our cognitive processes (Sanchez, 2008), paradigms help organise the processes of science and this formalisation (Mackenzie and House, 1978).

Given the above citation from Little (1991), there exist alternative paradigms to view any given problem, each leading to a different set of assumptions about the problem and the problem owner. Furthermore, there exist multiple perspectives on the issue of taxonomically dealing with (different types of) paradigms (Meredith et al., 1989), of defining *paradigm spaces* as Hassard (1993) notes, thus making paradigm choice reliant on area/discipline-level studies. For example, Burrell and Morgan (1979) offer their definition of paradigms from an organisational analysis[12] perspective thereby attracting immense attention in the area of organisation studies (Hassard, 1991), and offering relevant takes to categorise paradigms based on underlying scientific assumptions on ontology, epistemology, human nature and methodology. Likewise, Little (1991) offers a more simplified perspective on different types of paradigms, applicable to a broad range of social sciences, by centralising these under three central models of social explanation: causal, rational-intentional, and interpretative. In contrast, Mitroff et al. (1974), who follow a Churchmanian perspective of deductive vs. inductive research paradigms in modelling, delineate *two schemas for the study of science* that are already based on an assumed paradigm of scientific existence (systems perspective), and attract attention in the area of Management Science and OR studies (Bertrand & Fransoo, 2008). Whereas Burrell and Morgan (1979) and Little (1991) offer a typology on paradigms, Mitroff et al. (1974) offer a concrete operationalisation of a single paradigm in terms of its diverse research stages. However, the basic understanding of the research process in terms of paradigm application, theory and concepts, models and validation tend to confirm to the standard purpose[13] of description, explanation, prediction (Meredith et al., 1989) and intervention, an importance purpose in the area of management studies (Sanchez, 2008).

In line with the research scope of this study, Arbnor and Bjerke (1997), who are highly regarded in the field of Logistics Management (Gammelgaard, 2004; Arlbjørn and Halldorsson, 2002), were therefore used to identify the main school of thought, intended to

[12] Burrell and Morgan (1979) note this as the initial objective of their book, even though they admit that the finished product stood to represent broader social science significance.
[13] For instance, this was also the standard theme of all four courses in philosophy of science and methodology undertaken during this PhD research project.

drive this research project. *philosophy of science* issues, though important in the author's opinion, require deeper introspection than simply characterising research projects according to their salient methodological apparatus. Given this, Arbnor and Bjerke's (1997) 3-point spectrum of paradigm varieties, which in essence is similar to Little's (1991) basic models of scientific explanation - causal, rational-intentional, and interpretative - provides broader leverage in specifying the approximate range of value systems within which the researcher operates (see e.g. Sørensen, 2007 for a demonstration). Finally, the application (of Arbnor and Bjerke, 1997; Little 1991) was the preferred choice because it explicitly lent itself into the eventual paradigm choice, in order to visualise the main problem in this dissertation i.e. a *systems* perspective or approach. Arbnor and Bjerke (1997) were thus used because of the relative freedom they provide in helping researchers to position themselves in identifying their respective value systems, and for some very reasons that they have been critiqued (e.g. Johannessen, 2006); though a detailed discussion on their critique is beyond the scope of this dissertation, their critique shall be evident further on in this chapter.

Whereas Meredith et al. (1989), who are also well regarded (Forza, 2002; Bertrand and Fransoo, 2002), were referred to with the pupose of elaborating the 3 basic schools of scientific thought mentioned in Arbnor and Bjerke (1997). Similarly, in identifying the different scientific processes and stages driving this research project – ***"model construction", "construct development" "model validation" and "model application"*** – Mitroff et al. (1974) were used in order to contribute to the study's research objectives, while keeping in mind any (future) research ambitions of DSS model building. This process of paradigm choice and application to different aspects of the research design is now discussed in more detail.

2.2. Alternative research paradigms – *"identifying the scientific domain"*

Gammelgaard (2004) provides a concise presentation (see Fig. 4) of the Arbnor and Bjerke (1997) framework in displaying its relevance to the logistics domain. Each of Arbnor and Bjerke's (1997) three basic (methodological) paradigms – analytical, systems, and actors - span different ontological and epistemological presumptions.

Figure 4

The Arbnor and Bjerke (1997) framework,

(Gammelgaard, 2004)

	Analytical approach	System approach	Actors approach
Theory type	Determining cause-effect relations. Explanations, predictions. Universal, time and value free laws	Models. Recommendations, normative aspects. Knowledge about concrete systems	Interpretations, understanding. Contextual knowledge
Preferred method	Quantitative (qualitative research only for validation)	Case studies (qualitative and quantitative)	Qualitative
Unit of analysis	Concepts and their relations	Systems: links, feedback mechanisms and boundaries	People – and their interaction
Data analysis	Description, hypothesis testing	Mapping, modelling	Interpretation
Position of the researcher	Outside	Preferably outside	Inside – as part of the process

Source: Based on Arbnor and Bjerke (1997)

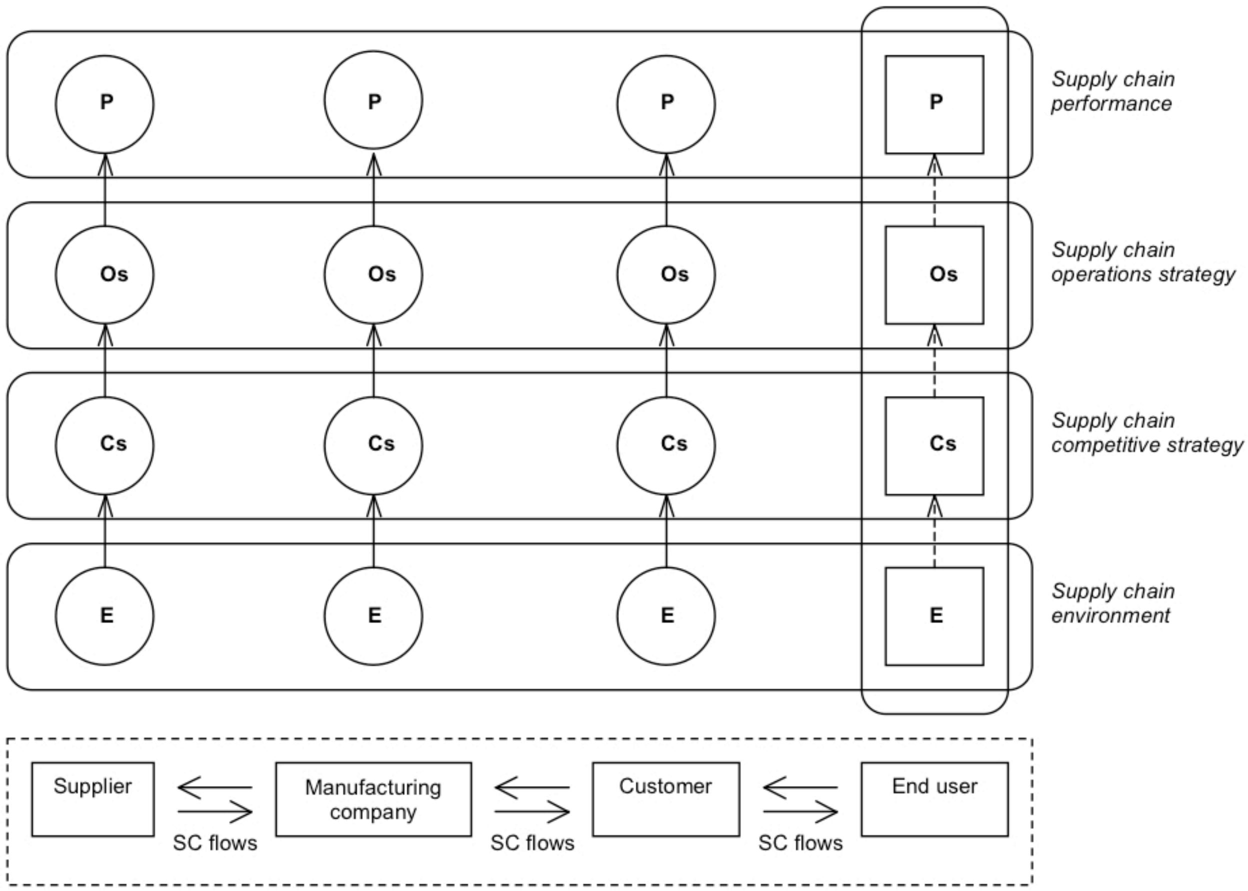
The brief exercise of identifying an appropriate paradigm was influenced and performed by applying this classification. Although the purpose here is to cover each alternative paradigm and the process of identification in a conscientious manner, the reason for delving more deeply into one over the other may be explained by the author's preferences and final choice. This said, such an exercise was constructive and aided this dissertation a) in choosing the appropriate course; b) in creating a niche amongst a range of studies that incorporate environmental analysis; and c) in establishing future research endeavours.

2.2.1. The Analytical approach: environmental complexity as a "cause-effect" problem

Given the ontological presumption of *"an objective reality that can be described as constitution of summative components"* (Arbnor & Bjerke, 1997, p.65), social explanations from this point of view take the form of causal explanations, and treat all types of sciences as equal by posing the generality and absoluteness of reality. Operationalising the construct from this point of view then essentially entails visualising supply chain logistics environmental complexity as a "cause-effect" problem. This implies that the construct has to be posited in a manner that intends to explain and operationalise it from the point of causal relations it shares with other dependent/moderating/mediating/independent variables in its *system of description* (Popper, 2004; Sanchez, 2008). From the perspective of studying environmental complexity, problem owners could then be interested in understanding how such a construct affects supply chain performance, and the role of strategy therein. A particularly representative consequence of this type of research for the supply chain management discipline would involve specifying a structural model of the following nature (Fig. 5), with a speculated research design that (typically) uses existing measures of each of the constructs (supply chain complexity, strategy and performance), and involving methods that seek to confirm/disconfirm the *environment-strategy-performance* relationship.

Figure 5

Supply chain logistics environmental complexity as a "cause-effect" problem



Examples of such research have also been cited further on (in Chapter 3), where a meta-analytical map of (environment) related research in operations is presented. However, it is interesting to note that this type of research, with notions similar to the analytical school, represents an emerging trend in the area of logistics/supply chain management with typical examples relating in varying degrees to the primary research objects of the present study, some referring to supply chain environments, others to logistics e.g. Defee and Stank (2005); Stank & Traichal (1998); Chow et al. (1995); Stank, Davis and Beth (2005); Rodrigues, Stank and Lynch (2004); Kohn et al. (1990); Kohn and McGinnis (1997); McGinnis and Kohn (1993) etc.

2.2.2. The Systems approach: environmental complexity as a "decision-making" problem

A presumption of *"an objective (or at least objectively accessible) reality, consisting of wholes, the outstanding characteristic of which is synergy"* (Arbnor & Bjerke, 1997, p.70), and one which treats human beings as *intentional* or *deterministic* creatures acting on the basis of reasons (Little, 1991), underlines the systems approach to problem solving. Operationalising the construct from this point of view then entails visualising supply chain logistics environmental complexity as a "decision-making" problem, decision-making as an activity underlined by models based on e.g. rational choice theory (Little, 1991), and a systems paradigm that treats reality (or the problem) as a system of interdependent elements. This implies that the construct has to be posited in a manner that intends to explain it from the point of the broad interrelationships it shares with other constructs and variables in its *system of description*, in order for it to make sense as a whole.

In the context of the present study, the problem owner would then be a priori presumptive about environmental complexity as affecting supply chain operations (e.g. in terms of logistics strategy, or performance), for in order to solve decision-making problems related to strategy and choice. In other words, researchers would seek decision-making models and solutions that incorporate the total range of factors in order for the problem to make sense. Examples of this type of research in the area of logistics/supply chain management include specifying supplier-selection models, site-location models and technology-selection models based on a range of variables that affect the choice. Here too, one may further distinguish between existing studies based on their end purposes (e.g. environmental scanning as the purpose; this aspect is also covered in Chapter 3). This is to say that even within this paradigm, methodological orientations may differ based on different intra-paradigmatic divides i.e. quantitative –qualitative, inductive – deductive, formal – non-formal, content – process, prescriptive – descriptive, empirical – axiomatic etc. (see e.g. Mitroff et al. 1974; Meredith et al. 1989; Bertrand & Fransoo, 2002) types of (decision-making) frameworks.

However, from the perspective of the present study, a divide within the systems paradigm in a manner that corresponds to the following classification was found to be most useful because it fit Arbnor & Bjerke's (1997) classification scheme. This divide was used to create a niche for this study, and is also documented further on in the dissertation (Chapter 3).

2.2.2.1. The construct as a general (context free) "decision-making" problem

From this point of view, supply chain logistics environmental complexity causes a decision-making problem, regardless of the exact problem context. This may be likened to the Meredith et al. (1989) *logical positivist/empiricist* approach for dealing with decision-making within the scope of the systems paradigm where, for example, a total reliance on "perceptions of object reality" is employed as the preferred methodological apparatus. Operationalising the construct from this point of view would entail prioritising all decision-making constraints related to environmental complexity equally, regardless of the specificity of the problem (e.g. managerial) context. The application of such a paradigm would then either focus on the broad criteria that are required to operationalise the construct in order to seek a more standard solution to a standard problem by offering e.g. an absolute index of environmental complexity related constraints, and performance rankings; the fundamental idea being that problems and/or solutions are generalisable to all/most (e.g. managerial) contexts. The better solution would try abstracting lesser and would seek to narrow the problem to a level that captures more of the context. *The Logistics Performance Index* (LPI) represents a good example of such a paradigm in the area of logistics/supply chain management. Other examples of studies employing such a paradigm include Carter et al. (1997) and Menon et al. (1998) and Bookbinder and Tan (2003). Applications corresponding to the use of such a paradigm, where a review of country economic/business indexes is presented, can also be found in Chapter 3.

2.2.2.2. The construct as a specific (context dependent) "decision-making" problem

When viewing the problem from this perspective, supply chain logistics environmental complexity causes a decision-making problem for the problem owner from the perspective of specific decisional departure points, such as a site-location problem, a supplier selection problem etc. The main difference between the previous approach and the present one is that managerial decision-making takes into account individual problem contexts (Zack, 2007) e.g. a site-location problem where decision-making constraints are prioritised differently as per the overriding managerial problem context (see Bhatnagar et al., 2003). Availability of information and information systems then drives the paradigm in order to reach a justified decision based on the varying levels of artificial reconstructions of the object reality. As Zack (2007) proposes, decision support technologies are more appropriate in supporting decision-making under conditions of uncertainty and complexity, whereas under conditions of ambiguity or equivocality, human-centric approaches may be more appropriate. This said, “information (or its absence) is central to decision making situations involving uncertainty and complexity”, (Zack 2007, p. 1664).

One may therefore argue that such an approach *“is frequently used to construct models that are embodied in software for expert and decision support systems and in mathematical models of operational systems”,* (Meredith et al., 1989, p. 314). They further state:

> *“These approaches recast the object reality, as originally determined from one of the above two categories (usually the researcher’s own belief concerning the object reality), into another form that is more appropriate for testing and experimentation, such as analytical models, computer simulations, or information constructs”,* (p. 308).

Additionally, based on Meredith et al. (1989), one could even further distinguish these systems based on the prescriptive/normative – descriptive divide, i.e. the level of rationality employed in the construction of these systems, whereby the more rationally presumptive would tend to be more prescriptive, as compared to those that are descriptive in terms of the decision-making process. For example, a common distinction between the Analytic Hierarchy Process (AHP) and its well-accepted counterpart – the Multi-Attribute Utility Theory (MAUT) –, both well-accepted methodologies underlying decision systems and falling under this type of systems paradigm, is that the AHP is descriptive, whereas the MAUT is more normative (e.g. see Saaty, 1994a; Saaty, 1997).

The reader may gain further knowledge of this type of paradigm in Chapter 3, where conditions surrounding the analysis of environmental complexity using decision support systems (DSS) are cited. With respect to the present study, applying such a paradigm would then aim at posing its research objectives and questions as a decisional problem, in order to operationalise the construct of supply chain logistics environmental complexity. Some examples of (issues related to environmental complexity) research in the area of logistics/supply chain management using this paradigm are: Kinra and Kotzab (2008a; 2008b), Bagchi (2001), Min (1994a; 1994b), Teng and Jaramillo (2006), and Min and Eom (1994).

2.2.3. The Actors approach: environmental complexity as an "interpretation" problem

An actors approach that corresponds to an interpretive perspective in social sciences (Little, 1991), presumes a *"socially constructed reality that consists of different levels of meaning structures"*, as actors and reality stand in mutual dialectic relation to each other (Arbnor and Bjerke, 1997, p. 79). Seen from this perspective, the construct of supply chain logistics environmental complexity causes an interpretation problem for each manager in an individual way. Operationalising the construct from this perspective then implies individual definitions in terms of its underlying variables. As Flint (2008)[14] suggests, such an approach would be interested in charting out the management and social aspects of environmental complexity by posing questions such as *"how do managers perceive and define environmental complexity"*, *"how does the concept of 'shared interpretation' manifest itself in terms of the construct"* etc.

In terms of environmental complexity-related research, and the main problem underlying this dissertation, the present research effort was unable to locate studies in the area of logistics/supply chain management that utilise this paradigm using an explicitly pre-specified research design. However, there exist studies that can be broadly related to the use of this paradigm. For example, Flint et al. (2005) refer to innovation as an effect of managerial interpretations of dynamism in the environment, using introspective reflections as a method/technique. Given this perspective, problem owners should theorize environmental uncertainty as a positive outcome rather than creating (e.g. decisional) models that aid in avoiding the same. De Koster and Shinohara (2006) also discuss cultural diversity between different environments based on methods that are likely to fit this paradigm, namely intensive interviewing for exploratory purposes. Author narratives on environmental complexity in CSCMP *Global Perspectives*, based on managerial interviews could also be profiled under this paradigm. Similarly, the Teng and Jaramillo (2006) study discussed under the previous paradigm may be placed somewhere between these two approaches as it involves mixed

[14] A meeting with Prof. Daniel Flint, UTK, Fri. 29/02/08 15:00hrs.

methods corresponding to both paradigms in order to construct reality. Finally, Lau and Zhang (2006) could also be peripherally related to this approach.

2.2.4. Identifying the scientific domain – why systems paradigm, why a decision-making problem?

Having treated each paradigm with respect to the problem characteristics of this dissertation and domain of interest, it was evident that the application of a systems paradigm was the preferred choice due to the decision-making characteristics and implications of the construct. Furthermore, it was decided to position this dissertation within the latter systems sub-paradigm of viewing the *construct as a specific (context dependent) "decision-making" problem*. This choice is now further explained hereunder.

Kinra and Kotzab (2008b) note that operationalising the construct of environmental complexity is best a multi-criteria decision problem. This is because given a set of varied, multiple generic constraints, these constraints typified by both objective and subjective measures of the environment, each individual manager perceives the importance of these constraints differently. This is one reason why Zack (2007) attributes this as a specific type of decision-making problem. Subsequently, environmental complexity arising from these constraints is perceived differently depending on the decision maker, the problem situation, and the focus of measurement shifts towards the process of decision-making under constraints. According to Zimmermann (2005), the basic characteristic of a multi-criteria decision problem is a goal conflict, as different decisions with different objectives have to be solved instantaneously e.g. reducing logistics costs and speeding up lead times. The goal of any algorithm for solving such problems is to calculate or to select the most advantageous solution that a decision maker prefers most with regard to all objectives (Zimmermann, 2005). Therefore, the objective of operationalising the construct is best resolved by viewing it as a multi-criteria decision-making problem. And since there exist multiple criteria, which also represent conditions of complexity and uncertainty beyond those that are present in the environment (e.g. complex models required to deal with environmental complexity), the underlying problem is best viewed as a decision-making problem (Zack, 2007).

Furthermore, a systems approach was appropriate here because, in posing construct development and operationalisation as a decision-making problem, (the author as) the researcher has recasted the problem based on his view of reality, which in this case is a mix of objective, and relativist/subjective referents on the environment. This position may well be interpreted based on Meredith et al.'s (1989) view of the systems perspective, which has also been presented in the previous section. For the author, as the systems researcher, 'reality' then is neither completely absolute, nor completely relative, but rather formative in nature (Arbnor & Bjerke, 1997). For a more detailed treatment of visualising environmental complexity as a decision-making problem using the systems approach, the reader is referred to Kinra and Kotzab (2008b).

2.2.5. Mapping the research project by way of paradigm type

In concluding this section, the present study and other studies in the problem domain, may be mapped according to the respective paradigms on the Arbnor and Bjerke (1997) paradigm scale, as is demonstrated through Fig. 6. Note that all these studies have been covered earlier in this section under their respective paradigms, where a discussion surrounding why they should be mapped in the following way has been provided. Because most of these studies do not explicitly deal with the construct of environmental complexity, but instead on the broader aspect of organisational environments and environmental uncertainty[15], I have mapped these studies under the heading of environment-related research.

2.3. Theoretical Approach – type of theories used in the research project

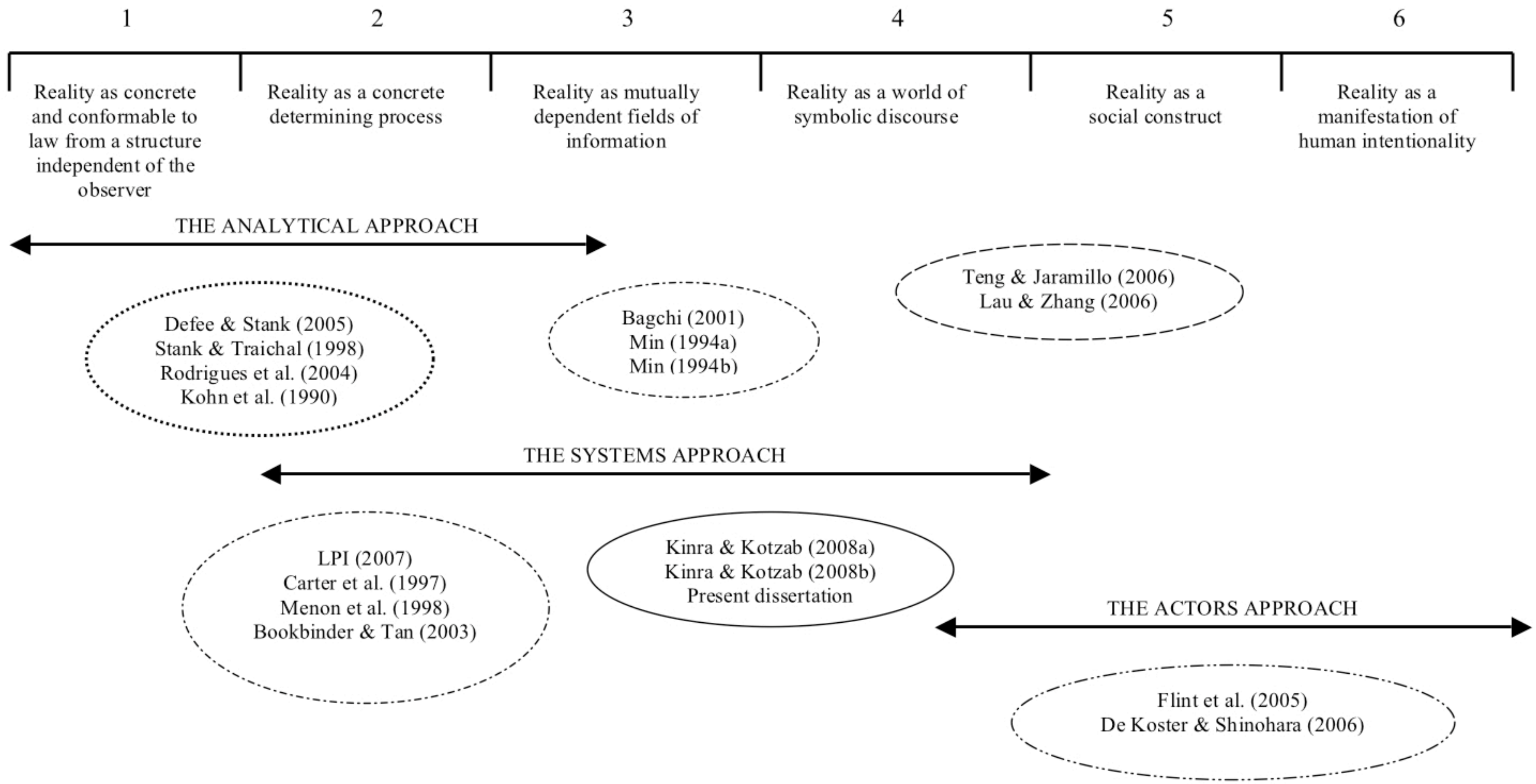
In general, the theoretical approach in this research project stems from the inherent systems approach that underlies theories explaining organisations e.g. contingency theory, institutional theory, and population ecology theory. From this point of view, the dissertation employed a (strategic) contingency model for the research objective of "**understanding** the relevance of environmental complexity in supply chain operations"; in other words, why should one operationalise the construct of supply chain logistics environmental complexity. On the other hand, it employed institutional and population ecology theories for the research objective of "**developing** the construct of supply chain (logistics) environmental complexity"; in other words which factors and measures operationalise the construct of supply chain logistics environmental complexity. Kinra and Kotzab (2008a) employ a similar approach in framing a (strategic) contingency model using an institutional perspective (North, 1990; 1992; 1994), in order to understand the environmental complexity

[15] For a more detailed treatment of environmental complexity within the broader construct of environmental uncertainty, the reader is referred to Chapter 3.

Figure 6

Classifying scientific paradigms in environment-related logistics/SCM research

(Scale adopted from Arbnor and Bjerke, 1997)



factors affecting supply chain logistics systems. This approach is made clearer in the following discussion.Following Stock's (1995; 1997) suggestion of borrowing theories from other disciplines in order to solve problems specific in the emerging discipline of Logistics/SCM, this study used a strategy that according to Grieger (2003) may be characterised as an "abductive theorising approach" (p.35). This implies that theory was borrowed, and lessons were learnt from how researchers in other disciplines have studied environments and environmental complexity. The concept of supply chain environments, and thereby environmental complexity was hence studied using the lens of *organizational environments* (e.g. Emery & Trist, 1965; Duncan, 1972), and using theories of organisation-environment relations (see Hatch, 1997).

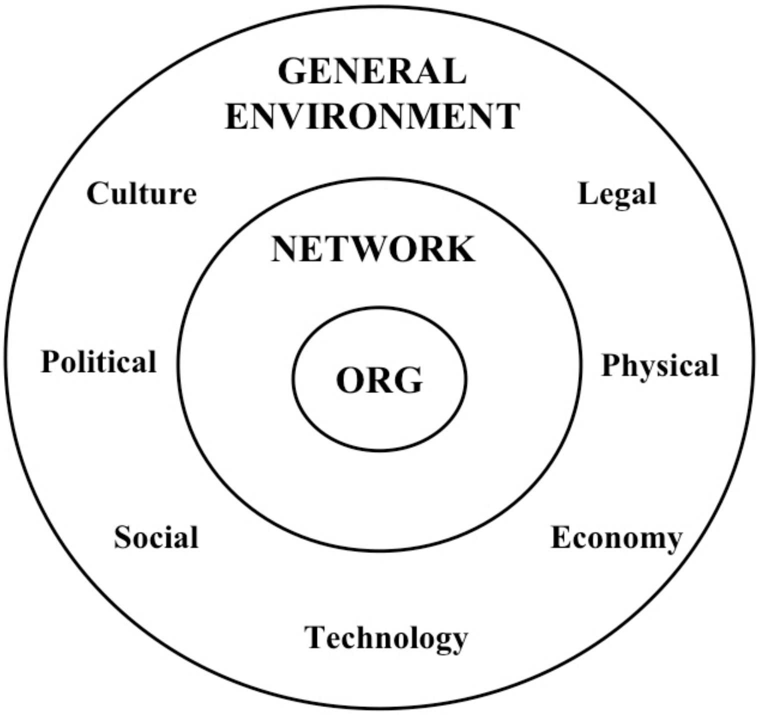
However, as follow-on to the preceding discussion on different paradigms in social sciences, there are many ways of looking at organisational environments. According to Hatch (1997), modernist organisation theorists generally tend to conceptualise the environment as being peripheral to the boundaries of the organisation, and as something that poses uncertainty and causes constraints to organisations, thus constantly requiring organisational adaptation to any given state. Whereas, symbolic-interpretivists view the environment as a social construction, which may have material consequences for the organisation, but primarily of a symbolic nature and that they derive their degree of importance based on the individual interpretation attached to each. And then there are postmodern organisation theorists, who view the organisation as "boundaryless", and therefore do not necessarily distinguish between organisations and their environments. In a similar manner to Chapter 3, where the notion of different types of environments i.e. "general" and "task" in the context of environmental complexity and how each appeals to a different organisational (e.g. decision-making) task is introduced, Hatch (1997) describes this as a modernist organisational theory perspective by dividing an organisational environment into its "Interorganizational Network", "General", and "International and Global" elements (see Fig. 7).

These divisions remain arbitrary in reality because of the deep embedment of all these environment types/elements and the organisation with each other. But these divisions are helpful for analysis and for conceptual purposes, lest *"we might forget to examine aspects of the environment that are critical to our understanding"* (p. 75), and in order that managers

Figure 7

"Sectors of the general environment"

(Hatch, 1997, p. 68)



may possess frames to decompose environments while dealing with uncertainty (an important assumption and ambition of the modernist perspective). And since a major objective of this dissertation is to operationalise environmental complexity, based on the (meta-theoretical) assumption that the construct is relevant to managerial decision-making under uncertainty, these type of divisions were adopted in the present dissertation. In the area of logistics/SCM, Stock and Lambert (2001) and Grant et al. (2006), come closest to this type of a theoretical approach, but only from the conceptual point of view.

Although it is difficult to wholly subscribe to any of Hatch's (1997) three broad strands within organisational theory, if anything, then the present thesis tends to assume a modernist organisational perspective in distinguishing between different layers of organisational environments, in order to elaborate the concept of supply chain environments. Moreover, if at all it does, then the present thesis tends to apply a group of theories underlying the study of organisations, namely contingency, institutional and population ecology theories. It applies contingency theory for understanding the importance of environmental complexity decision factors in managerial strategy and choice; such a theoretical approach is also referred to as a "configurational approach" and is common in the area of logistics/SCM (see Neher, 2005), with typical examples in relation to the current research project including, but not limited to Defee and Stank (2005); Stank & Traichal (1998); Chow et al. (1995), Rodrigues, Stank and Lynch (2004). Examples on some of these types of studies have been covered under section 2.2.1. At the same time, the present dissertation applies institutional and population ecology theories in order to operationalise the (general) environment surrounding supply chain operations; as explained earlier, such a theoretical approach may be referred to as a modernist organisational perspective in distinguishing between different layers of organisational environments. Stock and Lambert (2001) and Grant et al. (2006), and Stock et al. (1999) are good examples of conceptually developing such a perspective in the area of logistics/SCM; whereas Bagchi (2001) may be regarded as a good example of implicitly applying such a perspective. These applications are also made clearer in Chapter 3 where the environmental complexity construct is given a detailed treatment, and in Chapter 5, where supply chain environments are eventually operationalised. Lastly, the reader is also referred to Kinra and Kotzab (2008a) for more information on this type of a theoretical approach.

2.4. Methodological considerations in research design

We have already covered and introduced quite a few aspects on methodology, which normally form the entourage of the scientific paradigm employed in any research project (Solem, 2003); following any given paradigm "should" open a range of methodological choices. Here, the main methodological choices that were available to the author within the meta-theoretical scope of the systems paradigm, are documented and the methodological apparatus of the study is identified.

Gammelgaard (2004) also utilises Churchmanian ideals on systems in suggesting that case studies are the main methodological choices that are available to systems researchers, though however, both quantitative and qualitative methods may readily be used for different purposes in systems research. Such a view is commonly held in systems science as Solem (2003), citing perspectives in critical systems thinking and total systems intervention developed post-Jackson and Keys (1984), notes that:

> *"Complementarism, in its essence, a way of understanding complex phenomena using more than one perspective, is, in total systems intervention, translated down to the methodological level through the use of multiple metaphors to interrogate problem situations. The proponents of total systems intervention argue that systemic thought does not seek to describe a social world which is 'presumed to be ontological*

> *systemic, rather it ought to be systemic in its method of inquiry about the social world by employing a variety of perspectives and models.' In other words, systems exist in our minds, not necessarily in an objectively given world of social phenomena (Flood and Jackson, 1991)",* (p. 446).

Therefore, from the point-of-view of systems science, methodological alternatives are available in a broad array, and depend on how the total system is modelled e.g. which part of the problem is of mechanical systems nature, and which part is that of organic systems nature (see Solem, 2003). Such methodological pluralism also formed a part of this dissertation, as the main objective of developing the construct of supply chain logistics environmental complexity involved the design of system based on a methodology (the Analytic Hierarchy Process) that adopts different methods of data collection and generation for different purposes. This shall be clearer as we proceed further in this section.

2.4.1. Methodological choices in the problem domain

Since the stance on the adoption of a (systems) paradigm - i.e. scientific domain - has already been documented, this section only discusses the methodological choices that researchers in a similar problem and scientific domain have adopted, and therefore offered a knowledge base for this choice. For a more general treatment on methodologies and methods in the discipline of logistics and SCM, the reader should refer to Mentzer and Kahn (1995), Mentzer and Flint (1997), and Kotzab et al. (2005). Following the arguments presented in the previous section, the main methodological choices in the problem and scientific domain were subsequently looked from the perspective of 'modelling as a means to systems design', where the main task is that of modelling the construct of supply chain logistics environmental complexity. In fact, available models of managerial decision-making with respect to the construct, and their lack of e.g. explanatory power, were inspirational ingredients for this study.

The methodological choices in this dissertation were driven by the manifold inter-related aspects of the total modelling process, which a researcher ought to aim for (Bertrand and Fransoo, 2008) and as have been documented by Mitroff et al. (1974). From this perspective, researchers use different methods in order to meet research objectives and answer research questions that correspond to different stages of their research projects; these research stages have been documented in Mitroff et al.'s (1974) total research cycle/process.
From such a systems (modelling) perspective, Bertrand and Fransoo (2008) then offer a relevant typology of choices where they classify most quantitative modelling research into 4

types based on whether these are Axiomatic – Empirical, or Prescriptive – Descriptive in nature (see Fig. 8).

Figure 8

Classification of modelling research

(Bertrand and Fransoo, 2008)

	Descriptive	**Prescriptive**
Empirical	ED	EP
Axiomatic	AD	AP

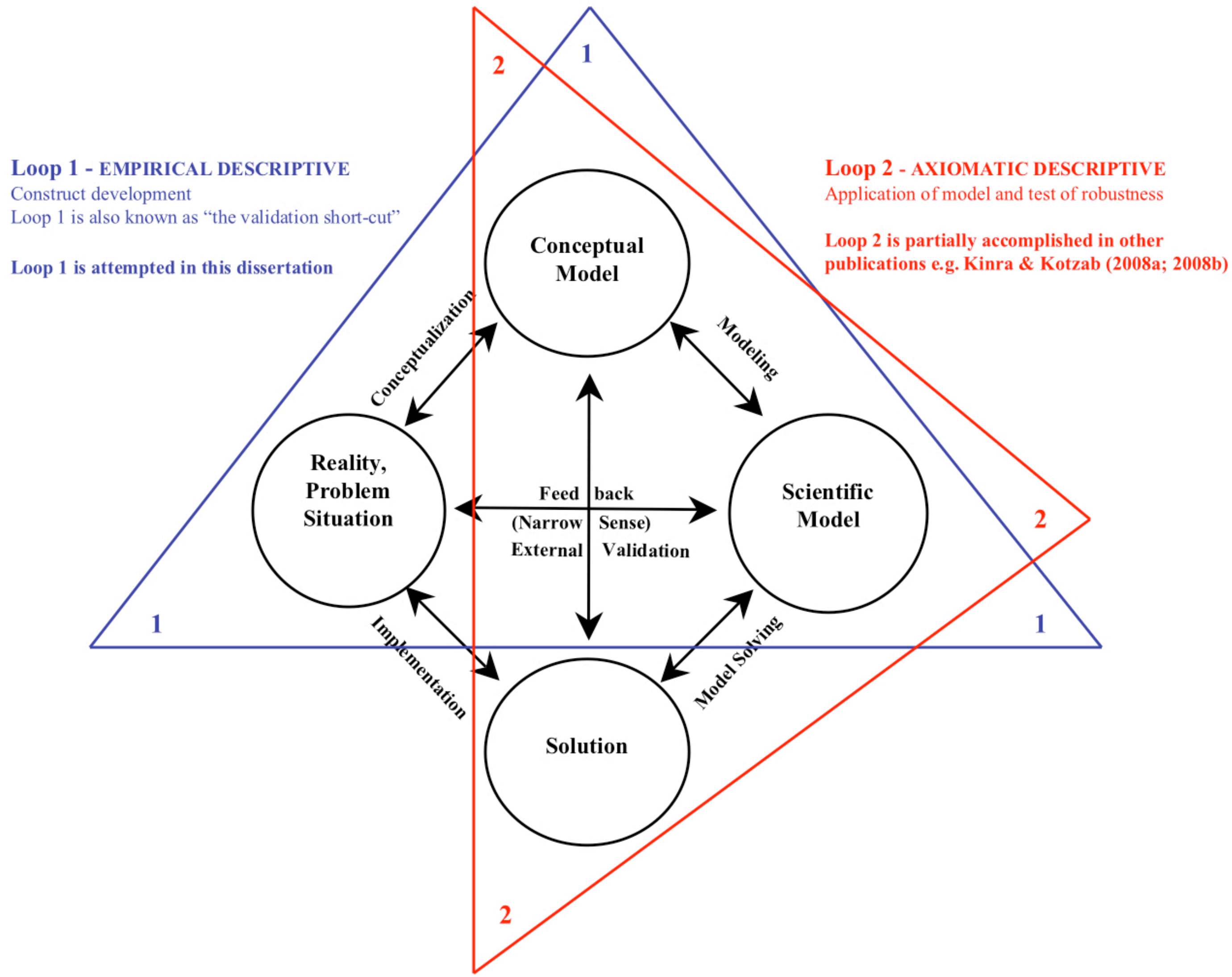
In order to identify/classify one's research and methodological apparatus with these viewpoints, it may then be worthwhile considering the author's total research scope and interests. These may be defined as the sum of the 1) research objectives of the present study, 2) research objectives of related academic publications made during the tenure of the present study (e.g. Kinra & Kotzab, 2008a; 2008b), and 3) future research areas with respect to construct application and external validation that arose at the conclusion of the present study. Given this total realm of research interests, for **achieving its main research objectives (1)** , e.g. developing the construct of supply chain logistics environmental complexity, the present dissertation falls under the **Empirical Descriptive (ED) category** of modelling research. Whereas, Kinra and Kotzab (2008a; 2008b) fall under the **Axiomatic Descriptive (AD) – Prescriptive (AP) category** for meeting the objectives of construct appication in an attempt to bring out its managerial DSS relevance. Lastly, if the (external validity) concerns of the the construct are successfully met with in the future, as is also mentioned in the future research section of this study, then the author may claim a conclusion of the *conceptualisation-modelling-validation* sub-cycle in the Mitroff et al. (1974) scheme. Fig. 9 maps the different stages and loops within the Mitroff et al. (1974) total modelling process that have been attempted in this study, in related studies that were done during the last three years, and those that correspond to future research areas.

This said, all present and future reseearch objectives are interrelated as they should be seen in light of the inter-connections between the problem formulation process, relevance to stakeholders, and managerial consequences. For this reason, the available methodological choices that could assist in all these objectives fell under multi-criteria decision-making methodologies.

Figure 9

The Mitroff et al. (1974) system's view of problem solving – modelling stages attempted in this thesis

(Based on Mitroff et al., 1974 and Bertrand & Fransoo, 2008)



2.4.2. Multi-criteria decision-making methodologies in the domain

The purpose behind this review was then to frame and structure the problem from the perspective of a suitable (multi-criteria decision-making) methodology in a way that sought to take all (present and future) research objectives into account. The main multi-criteria decision-making methodological choices that were available may be summed up in the form of Fig. 10, provided by Sarkis and Sundarraj (2000), who keep the logistics/SCM context in mind while listing the salient features of each methodology. Their table also helps in evaluating the most important factors – ease of use, rigour, complexity, data requirements, costs of implementation, parameter flexibility and sensitivity - in the selection of a multi-criteria decision-making methodology that best meets research objectives. This choice is now documented as follows.

In the discussion surrounding aspects of the (supply chain logistics environmental complexity) construct in the problem domain e.g. supply chain design problems such as site location/selection, four of theses factors are considered to be very important, namely: flexibility in parameter mixing (i.e. where both qualitative and quantitative data may used at the same time), mathematical complexity and management understanding (i.e. managerial ease of use). Therefore, the AHP (Analytic Hierarchy Process), Expert Systems, Scoring Models and MAUT (Multi Attribute Utility Theory) were short-listed as relevant methodological choices, or methods theory governing more detailed methodological choices. This choice is also in line with the opinions of Sarkis and Sundarraj (2000). Scoring Models were then left out of consideration because of their relative simplicity, e.g. employing interval scales to measure constructs, and (only) parameter mixing flexibility being their main advantage. Expert Systems were left out because of high mathematical complexity, high costs of heuristic implementation within organisations, and lack of managerial understanding of the entire decision-making process.

The final choice thus centred on the use of MAUT or AHP. Belton (1986) also notes that the AHP and a Simple Multi-Attributed Value Function are the approaches best suited to multiple criteria decision-making to aiding in the selection of a preferred option from a short-list of alternatives, in the light of a wealth of information about those alternatives. This choice was then dealt with the author's world-view on the problem, as the methodology with a descriptive potential to it in terms of the decision-making processes (the AHP),

Figure 10

The main multi-criteria decision-making methodological choices

(Sarkis and Sundarraj, 2000)

Evaluation technique	Cost of implementation	Data requirements	Ease of sensitivity	Economic rigor	Management understanding	Mathematical complexity	Parameter mixing (flexibility)	References[a]
AHP	M	M	L	L	M	L	H	a, b, c
DEA	M	M	L	M	L	H	M	d, e
Expert systems	H	H	L	H	M	H	H	f, g
Goal program	M	M	M	H	L	H	L	c, h, i
MAUT	H	H	M	M	M	M	H	j, k
Outranking	M	M	L	M	L	M	M	l
Simulation	H	H	H	H	H	H	M	m, n
Scoring models	L	L	L	L	H	L	H	o, p

Notes:
H = high; M = medium; L = low
[a] References: a = Albayrakoglu (1996); b = Kleindorfer and Partovi (1990); c = Suresh and Kaparthi (1992); d = Khouja (1995); e = Sarkis (1997); f = Borenstein (1998); g = Padmanabhan (1989); h = Stam and Kuula (1991); i = Suresh (1991); j = Chandler (1982); k = Pandey and Kengpol (1995); l = Parsaei *et al.* (1993); m = Suresh and Meredith (1985); n = Primrose (1991); o = Nelson (1986); p = Semich (1994)

was preferred in contrast to one that sought idealised and prescriptive solutions (the MAUT) based on simple scales (e.g. ordinal and interval scales) (see Saaty, 1994a; Saaty, 1997; Forman and Gass, 2001). The AHP was thus chosen as the preferred methodological choice[16].

2.4.3. The Analytic Hierarchy Process (AHP)

> *"The Analytic Hierarchy Process (AHP) (Forman et al., Harker 1986, Harker and Vargas 1987, Saaty 1986, 1988a, b, Saaty and Vargas 1987, Xu 1988, Golden et al. 1989, Saaty and Alexander 1989) is a theory of measurement"* , (Saaty, 1990, p. 259).

Countless examples abound in the literature on the AHP, either mentioning it as a technique (e.g. Zahedi, 1986), a tool (see Saaty, 1994b for such examples), a decision-making methodology (e.g. Millet and Wedley, 2002) or the like. The reader may also refer to Vaidya and Kumar (2006) for their (subtle) distinction in providing an overview of AHP applications. But most importantly, from the perspective of this dissertation, Saaty's (1980) AHP is a 'theory of measurement' (Ruf et al., 1998), which at its core is intended to be a descriptive, not a normative, theory (Saaty, 1997). According to Saaty (1997), the main theoretical rationale of the AHP may be summarised as:

> *"A good descriptive theory should be able to say what the current situation is now and how it will be in the future"* (p. 328).

The AHP is based on hierarchical decision models and it empowers the relationship of intangibles to tangibles, the subjective to the objective. It is a "participation-oriented methodology", which makes use of "pair-wise comparisons". It models the way a human mind structures and tries to solve a complex problem involving numerous factors and thus uses a process of decomposition and synthesis (Saaty, 1980). The AHP is based on the following three principles: decomposition, comparative judgements, and the synthesis of priorities. The method was originally developed between the early 1970's and 1980's, out of the purpose of advancing a theory and providing a methodology for modelling unstructured problems in the economic, social and management sciences. Ever since, it has found wide application in diverse fields. Finding its roots in mathematics and decision theory, it also greatly relies on systems theory in order to come forth with a methodology that can provide

[16] It is important to note that this choice is not as simple as it may seem. There is a vast body of literature that specialises in evaluating the appropriateness and validity of MAUT vs. AHP (e.g. see Belton and Gear, 1983; Dyer 1990a, 1990b; Saaty 1990; Harker and Vargas, 1990; Pérez, 1995 etc.). In fact respected academic journals will only accept contributions if one is used over the other (Prasad 2008). Furthermore, it is also important to note that the entire process of making choices here was governed by my paradigmatic lens that has been discussed earlier in the chapter.

analysis of any type of system, large or small, whether consisting of subsystems or subservient to others. Its point of departure is that a much richer description of any system can be given by considering its structure, functions, objectives of its design, and its environment, stressing on the inseparability of the structure of the system and its functions. As a result, "a hierarchy is an abstraction of the structure of a system to study the functional interactions of its components and their impacts on the entire system", (Saaty, 1980, p. 5).

The AHP starts by decomposing a complex, multi-criteria problem into a hierarchy where each level consists of a few manageable elements that are then decomposed into another set of elements (Wind & Saaty, 1980). The second step is to use a measurement methodology to establish priorities among the elements within each level of the hierarchy. The third step in using AHP is to synthesise the priorities of the elements to establish the overall priorities for the decision alternatives. Thus, during this process of decomposition and synthesis, hierarchies are developed whereby factors based on common perspectives are grouped and these groups are aggregated to higher-level factors.

From the perspective of this dissertation, the AHP was applied in the spirit of a *theory of measurement*, which was intended to aid in the operationalisation and measurement of the construct of supply chain logistics environmental complexity. Korpela et al. (1998) refer to this spirit as a measurement methodology. Regardless to say, its axiomatic foundations were readily accepted, and the problem in this dissertation was thus framed and driven by using the AHP. For a good description of the axiomatic foundations of the AHP, the reader is referred to Forman and Selly (2001). The reader is also referred to Kinra and Kotzab (2008a), who offer an approach to frame the construct in an AHP format. Furthermore, the reader is additionally referred to Kinra and Kotzab (2008a) for an informative state-of-the-art on the usefulness and applicability of the AHP in the area of logistics/supply chain management.

2.4.4. Research design, data collection and typical methods supported by the AHP

As a natural follow-on to the discussions in the last two sections, there are at least two aspects of data collection in a multi-criteria decision-making methodology like the AHP - one is to collect (decision) factors and measures that give some information on these factors; the other is to collect data on the (decision) factors by using these measures in order to reach a specific decision. As interpreted through Bertrand and Fransoo (2008), whereas the first aspect of data collection refers to the construct/model development process and data collection as a means to conform to (internal) validation of the construct/model; the second aspect refers to the construct/model application process and data collection as a means to conform to the (external) validation of the decisional model that rests on the construct. In general, the AHP methodology thrives on expert opinions and expert choice for data (Forman and Gass, 2001); but it happens in a way that *"the decision maker does not need to rely on an expert but rather becomes an expert through study and practice and the assistance of other decision makers",* (Saaty, 1994, p. 445). This implies that data collection is done for personal purposes, by the expert, and for the expert. Claims should be made accordingly; though given similar constructs and contexts, one would start noticing a pattern of similar decisions as the sample size increases (Bagchi, 2008)[17]. Expert opinions were therefore employed as the main data collection technique.

The main objectives of the present dissertation – construct development – were thus sufficed by undertaking the first aspect of data collection, which involved data collection using literature reviews, content analyses and expert opinions. The reader is referred to Part 3 of this dissertation for a detailed treatment of data collection phases and techniques. Here the main approach applied data collection and validity approaches within the **Empirical Descriptive (ED) category,** as according to Bertrand and Fransoo (2008):

> *"….model-based empirical research is concerned with either testing the (construct) validity of scientific models used in ….. theoretical research, or with testing the usability or performance of the problem solutions obtained from …..theoretical research, in real-life operational processes",* (p. 23).

Whereas, although this discussion is beyond the scope of the present study, for the any other future objectives or managerial consequences - e.g. development of decisional models for the managers – the author envisages the main data collection and validity approach to fall within the second aspect or the **Axiomatic category**, as Bertrand and Fransoo (2008) note that axiomatic research primarily focuses on rules and tools for managerial decision-making, and that:

> *"In the axiomatic domain, the discussion of methodology is largely absent…focus on mathematical correctness…and in some cases on a judgement of the referee on relevance of the problem",* (p. 10).

[17] An interview with Prof. Prabir Bagchi, 04/04/2008, 15:00.

2.4.5. Mapping the research project by way of methods type

In conclusion of this section, the author presents the following attempt to map the present dissertation on Meredith et al.'s (1989) typology of research methods. Meredith et al. (1989) present a framework of research methods (Fig. 11) based on ontological and epistemological considerations in research. This typology has already been introduced and referred to earlier in this chapter. According to Meredith et al. (1989) *"current research in operations has tended to lie in the rational-artificial quadrant and thereby has limited not only the phenomena that can be researched effectively but also the utility of the findings",* (p. 309).

On the one hand, mainstream logistics/SCM research could be associated with the logical positivist paradigm in Meredith et al.'s (1989) scheme. For example, Gammelgaard (2004) cites influential contributions (e.g. Mentzer & Kahn, 1995; Mentzer and Flint 1997) in reporting that the positivist paradigm and associated methods form the predominant approach in logistics research. On the other hand, it was hard to generalise SCM modelling literature, and hard to distinguish how accepted modelling research in logistics/SCM research is different from mainstream modelling OM and OR research. This is because (in a lot of cases) both use common outlets and references to reach their audience[18]. Whereas, with respect to the methods employed in the present research project, since the AHP assumes a descriptive stance on decision-making, with each decision in specific context to the decision maker, data collection methods in general correspond better towards the 'interpretive' spectrum, and more towards the 'artificial' side of the Meredith et al. (1989) scale. These and the present study were therefore mapped in Fig. 11 accordingly.

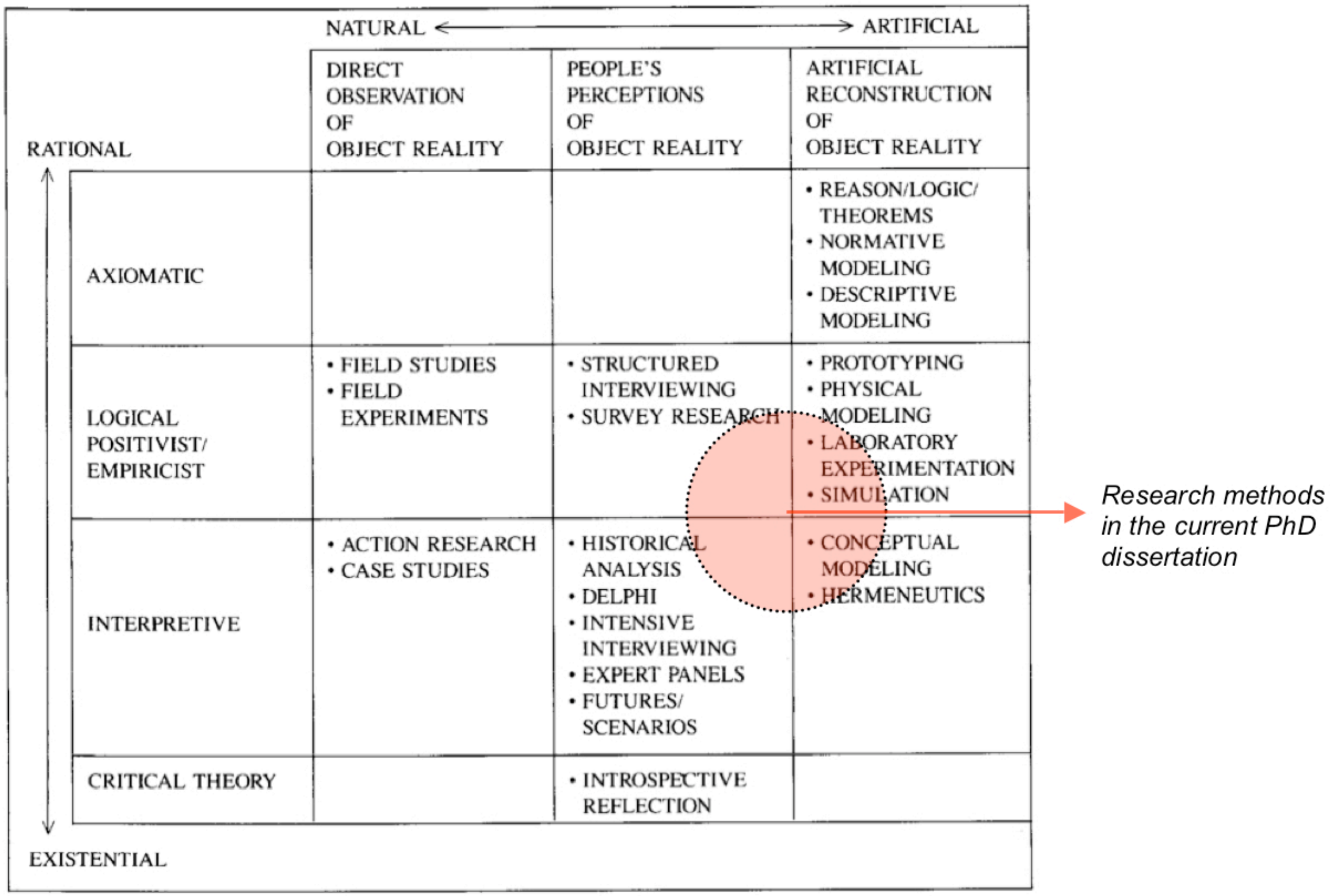
To conclude the chapter, this dissertation employed a systems perspective to look at the problem of construct development. This is why the problem of developing a construct that captures supply chain environmental complexity was resolved from the perspective of 'modelling as a means to systems design', where the main task is that of modelling the construct in terms of its decision factors and measures. The AHP methodology and its preferred data collection methods, which correspond to such a (systems) perspective, were thus employed in order to develop a hierarchy of the problem and construct.

[18] For example, see section/contributions on 'modelling supply chains' in Kotzab et al. (2005) to ascertain this.

Figure 11

The Meredith et al. (1989) framework for research methods – mapping the research methods employed in this thesis

(Based on Meredith et al., 1989)



Chapter 3

Environmental Complexity

The purpose of this chapter is to document the process of construct development. More specifically, the chapter seeks to contribute equally to all research questions by performing an in-depth examination of the environmental complexity construct. For example, here it is argued for/against why one needs to apply an "organisational theory" lens to look at this problem, and why environmental complexity is relevant for logistics/SCM. In doing this, the chapter attempts to document the *mental analogies for problem resolution* (Grieger, 2004), and the theoretical apparatus that were formed in order for the dissertation to meet its objectives. The theoretical apparatus created here, was then applied at different stages of the dissertation in order to answer each research question. This chapter may then be seen as a repository of theoretical resources that the remainder of this study made use of.

In revisiting typical theories underlying the construct, the chapter starts out by a discussion on the theoretical antecedents of the construct of environmental complexity. Next, a discussion on the relevance of the construct with respect to organisational operations in terms of managerial relevance (management activity) and timing (temporality) is performed, thus bringing out managerial implications of this study. In particular, the author delves into the need and appropriateness of bringing the environmental complexity construct to the supply chain domain. Next, a detailed treatment on how to study the construct, and how other researchers have typically dealt with the issues pertaining to construct measurement is performed. This was important because it created a framework within which the construct was operationalised in the present study. Finally the chapter concludes by providing some theoretical directions and relevance of construct application.

3.1. The Construct of Environmental Complexity and theoretical antecedents

Environments and their attributes have long been preferred starting points in social sciences and the domains of psychology, sociology, anthropology and economics.
Claude Bernard (1813–78), noted French physiologist, first stated within his thesis on 'homeostasis' that maintenance of a constant internal environment was necessary for the survival of an organism in a varying external environment (Martin & Hine, 2008).
Environments come from systems; systems may be open or closed; environments may be external or internal (Hatch and Cunliffe, 2006). In open systems, it's irrelevant to distinguish between external and internal environments (Hatch, 1997), whereas in closed systems,

demarcating external and internal environments is easier said than done, as it engages in no exchanges with its environment (Jackson, 2003).

Following this, environments may be perceived as being dependent on how different authors, or even disciplines, view different types of systems (e.g. Boulding, 1956). The following definitions bring out some important differences in disciplinary perspectives on the environment:

Figure 12

The different ways of understanding and defining "environment"

Definition	**Source**
"The complex of physical and biotic factors within which an organism exists"	A Dictionary of Genetics, King et al. (2007)
"The external surroundings within which an organism lives"	A Dictionary of Zoology, Allaby (1999)
"The conditions under which people, creatures, and plants have to live. The natural environment concerns matters such as the purity of air to breathe, water to drink and soil to cultivate, and several further aspects ranging from biodiversity to noise. The built environment concerns the effects on quality of life of human constructs such as buildings, roads, dams, or power lines"	A Dictionary of Economics, Black (2002)
"In other usages the environment is simply the (delimited) social context in which the individual (or any living organism) is located, and the emphasis is on issues of adaptation and adjustment to this environment…." *"The natural environment, for all its potential significance to sociology as the territory in which human action occurs and as itself modified by human agency has featured in sociological thinking mainly in references to the heredity versus environment debate"*	A Dictionary of Sociology, Scott & Marshall (2005)
The institutions and people outside a business organization that affect it; these include national and local government, trade unions, competitors, customers, suppliers, etc. The external environment is one of the contingency factors that has to be taken into account in designing an organization.	A Dictionary of Business and Management, Law (2006)

Accordingly the field of business management and its sub-fields tend to rely on how organisational theorists and economists view the environment and incorporate it into the functioning and operations of organisations (companies). For example, Bourgeois (1980) notes that:

> *"Although Chester Barnard [1938] was among the first to recognize the system properties of organizations, it was Dill's [1958] pioneering study that both defined the components of top management's task environment and suggested a causal relationship in which this task environment affected managerial autonomy",* (p. 32).

This section revisits how environments and environmental complexity have been viewed in the literatures of strategic management, organisations and international business. It is worth recalling that the problem domain contains each of these disciplinary aspects in the form of an organisation (supply chain), strategy and design issues (e.g. site location), with respect to extended operations (e.g. international or global operations). Therefore, the discussion on the environment performed here is based on Ketokivi & Schroeder (2004), who point out that the importance of the environment and its attributes can be looked at using three perspectives: from a structural contingency argument, from a strategic contingency argument or by using an institutional perspective. This structure of discussion aids in bringing out some preferred starting points that were useful for this study.

3.1.1. Environments and organisational structure

> *"Contingency organization theory suggests that the match between environmental complexity and the formal structure is an important determinant of organizational performance",* (Osborn, 1976, p. 179).

Since contingency theorists link organisational structures to their environment and performance, how organisational theory literature treats the environment and its attributes is relevant from the point of view of understanding what environmental complexity implies for the supply chain organisation. Consider Negandhi's (1980) leading text on (inter) organisational theory, which features invited papers from noted organisational theorists in this area (e.g. Lawrence & Lorsch, 1969; Lorsch, 1973). Any integration of task environmental agents, variables and factors into an organisation's functioning, contributes to the enhancement of organisational effectiveness, both behavioural and economic (Negandhi & Reimann, 1980). Task environmental agents are perceived not only to be the organisation's supplier, customers and stakeholders but also the government and community. Notwithstanding, whether managers perceive the environment to be important or whether the environment actually is important in the form of real stimuli, the relationship between the environment and the organisational structure is considered to be an important one.

The overall importance of the environment, both task and the general environment, and how the environment has to be viewed viz. as an external constraining phenomenon or as a collection of interacting organisations or as a social system (Van de Ven & Koenig jr., in Negandhi ed., ch. 2, pp. 19-38), is an issue that has been central to organisational literature. There is a prevalent starting point in this literature (i.e. Lawrence & Lorsch, 1969; Lorsch, 1973), which stresses the need for a fit between an organisation's (e.g. a supply chain) internal structure (organisational and activity structure) and the external environment. In particular, I would like to stress on the following sets of relationships, which sums the essence of how this stream views the environment, and is relevant for this dissertation:

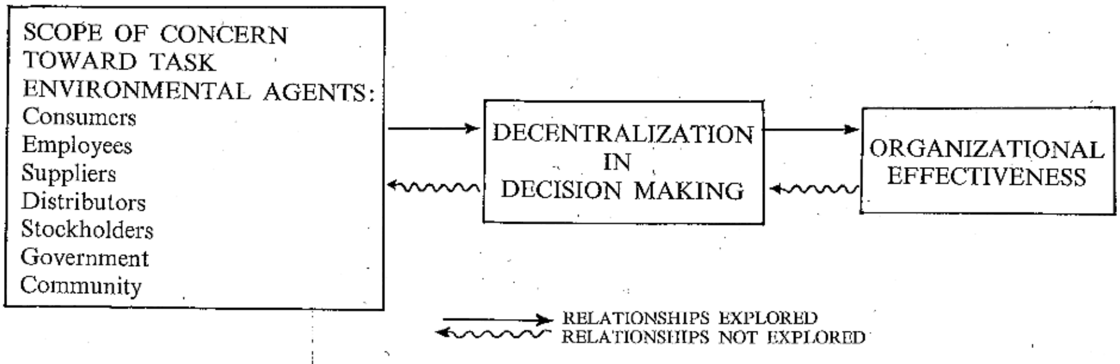
1. *The more the environment is dynamic, the more the organisation shall be loosely structured (decentralised/cooperative in terms of organising its activities) and the higher shall be the organisational effectiveness (Lawrence & Lorsch, 1969).*
2. *Or as in another case, the greater the perception of managers that the organisation is dependent on its environment, the higher shall be its organisational effectiveness, even though the organisational structure remains constant in some contexts such as stable market environments such as a developing country (Negandhi & Reimann, 1980, pp. 141-154).*
3. *A long-term view on the importance of the task environment (that makes mangers take it more seriously and tend to integrate components of the environment into their organisation)* ***vs.*** *A short-term view on the importance of the environment.*
4. *The difference between the task environment and the general environment. The greater importance of the task environment (which has to do with the individual organisation's goal setting, specific industry/firm context) compared to the lesser importance of general environment (which consists more of general conditions prevailing in the market like overall macro policy & structure).*
5. *The perception of the environment as an input to organisational structure, either as a competitive/non-competitive input (Negandhi & Reimann, 1980, pp. 90-99) or as a longitudinally-laterally interfering input (Negandhi & Reimann, 1980, pp. 141-154). These are environmental inputs to the organisational structure, which then determine the effect viz. organisational effectiveness.*

It is therefore interesting to note how literature on organisations specifies a relationship between the environment, organisational structure and organisational effectiveness (Negandhi, 1980). An important implication of these views in the supply chain context is that depending on the manager's perception, which if long-term (more environmentally focussed), the organisation's (supply chain's) task environment may very well include agents such as government and other macro actors and factors. This means that in such cases, these macro actors & factors have a high likelihood of being integrated in the organisations daily functioning. This also means that they are perceived to be principal contributors to organisational decision-making and performance.

Figure 13

Major environmental variables of interest and investigation

(Negandhi & Reimann, 1980)



3.1.2. Environments and organisational strategy

> *"Strategic decision making is at the heart of the organization-environment co-alignment process so heavily emphasized in both the business policy (BP) and organization theory (OT) literature",* (Bourgeois, 1980, p. 25).

Since contingency theorists link organisational strategies to their environment and performance, it is interesting to explore how this stream treats the environment in order to understand the relevance of the environmental complexity for supply chain strategy and choice. The typical characteristics of environment research within this field are related to scanning the environment for opportunities and threats, and for matching opportunities with organisational capabilities; how the strategy formulation "process" may be integrated with environmental scanning (e.g. Khandwalla, 1976); how changing organisational environments pose opportunities and threats in terms of information processing requirements and methods of managers (e.g. Aguilar, 1967; Keegan, 1974). In effect, business policy or strategy literature concerns itself more with the *"looking into"* the environment for the trends and forces relevant for strategy making. This is in contrast to how the organisation theory domain sees the environment as *"causing"* or *"determining"*:

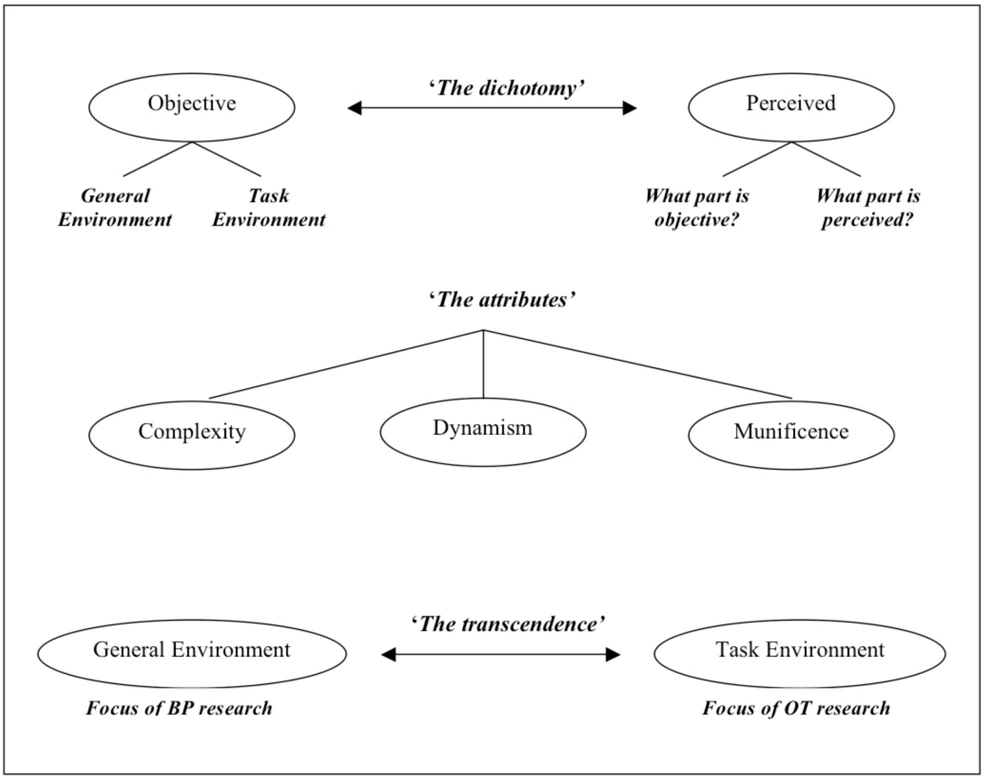
> *"OT (Organisation theory) has taken a more* ***reactive stance*** *(in comparison to strategy literature) by viewing the environment as a* ***deterministic force*** *to which organisations respond [Anderson & Paine 1975; Duncan, 1972b; Lawrence & Lorsch, 1967]"* whereas, *"BP's (business policy) approach has been to view management as a* ***proactive or opportunistic*** *agent and has centred much of its research on the* ***strategy variable*** *[Hatten, Schendel, & Cooper, 1978; Mintzberg, 1972]",* (Bourgeois, 1980, p. 25).

Besides offering useful distinctions on the focus of research between business policy and organisation theory literature, Bourgeois (1980) provides a useful description of the environment by dividing it into its types and attributes, and its relevance according to different strategy tasks. These are provided in Fig. 14, and ought to be treated as considerations that studies on the environment should make and pre-specify, in order to generate any constructive future attempts on (environment) domain integration. From this point of view, environmental uncertainty may arise because of either dynamism, or munificence or complexity in organisational environments. General environments may transcend into the task environment depending on the managerial activity. Whereas, by posing a distinction between objective and perceptual referents of the environment, the third consideration concerns itself with measurement aspects of environmental complexity.

Figure 14

"The dilemmas posed by the environment"

(Based on Bourgeois, 1980)



3.1.3. The concept of institutions and institutional environments

Guisinger (2001) follows North's (1990) distinction between institutions and organisations while trying to understand the (international business) environment and states that:

> *"The environment can be subdivided into organisations, called here `interactors', and institutions, called hereafter the `geovalent component'. Interactors comprise the organisations that interact directly with the firm - suppliers, customers and competitors. Interactors have other important properties: they can acquire other members (or be acquired), form alliances or simply cease to exist (liquidation/bankruptcy)…. The geovalent component comprises all other environmental forces that impact on the firm but are not themselves organizations",* (Guisinger, p. 266).

From this point of view, institutional theory, in terms of institutional economics, offers relevant takeaways to understanding the content of the environment e.g. what (institutions) are external and what are internal, differences between institutions and organisations, if any. Similarly, Klein et al. (1990) also invoke transaction costs, and thereby institutional arguments in order to understand the environment. With special regard to the supply chains and outsourcing, Williamson (2008), notes the concept of institutional environments as those 'formal rules of the game', which change slowly as compared to the actual 'play of the game' (Fig. 15). In this way, Williamson (2008) then implies different levels of institutions for different levels of the environment. For example, if polity, judiciary and bureaucracy form level 2 institutions, then these will create a level 2 environment, changes in which may cause uncertainty to managers. *'Getting the institutional environment right'* is then very important to managers from this point of view. Institutional theory is also relevant in attempting to operationalise the environment of (e.g.) organisational structures (Hatch, 1997), and is dealt with more depth within the next few sections while discussing the causes and measurement aspects of environmental complexity.

3.2. Causes and relevance of environmental complexity

> *"Environmental complexity refers to the heterogeneity and range of environmental activities which are relevant to an organizations operations. The greater the degree of complexity, the more a profusion of relevant environmental information is likely to be experienced by organizational decision-makers",* (Child, 1972, p. 3).

In this section, the task of specifying the relevance of environmental complexity to organisational operations is performed. This is done by relating different types of strategy and managerial decision-making tasks to different types of environment, and environmental attributes. However, in order to this, the section first seeks to elaborate on the causes of environmental complexity to organisational operations.

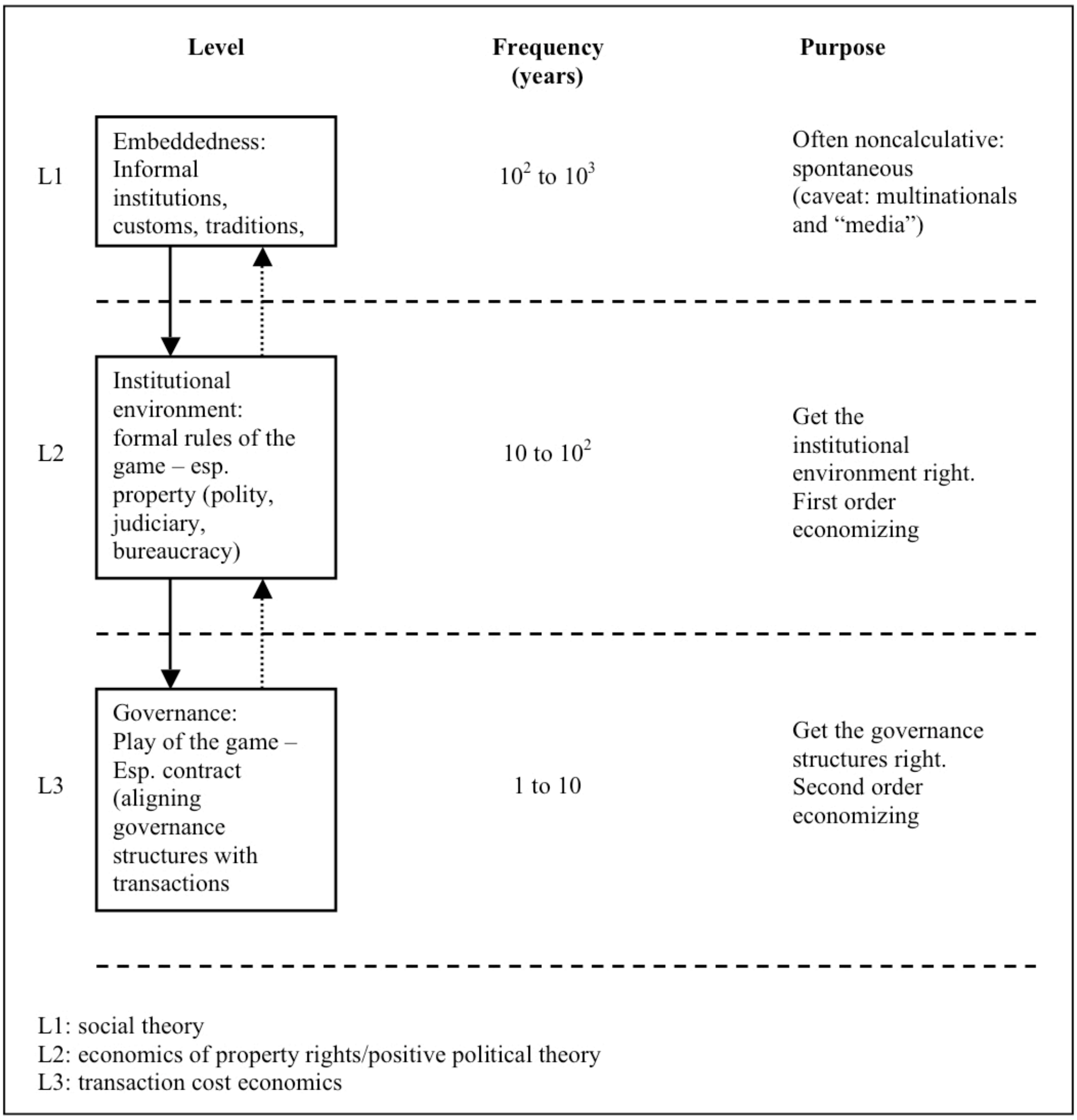
3.2.1 What causes environmental complexity

"The causal interconnectedness between environmental segments which Emery and Trist (1965) have identified, together with many economists before them, can be regarded as contributing towards complexity", (Child, 1972, p. 4).

Figure 15

"Economics of Institutions"

(Williamson, 2008)



Guisinger (2001) notes the importance of structural complexity as a core in organisation theory, since its inception, and distinguishes between organisational complexity and structural complexity by describing structural complexity as the degree of a firm's structural diversity, including varieties of products, divisions, and managerial functions. Structural complexity is then concerned itself with the complexity of the design and structure of organisations, its operations and activities, as Guisinger (2001) notes that it *"refers to the numbers of businesses, functions, and products that the firm's managers must control"* (p. 259). Whereas, organisational complexity (see Doz & Prahlad, 1991) is the result of adaptation of these structural forms to their corresponding environmental components. The inextricable relationship between environmental complexity and structural complexity is brought forward by such a view. As a result it may be posed that an increase in structural complexity causes a relative increase in environmental complexity, or vice-versa.

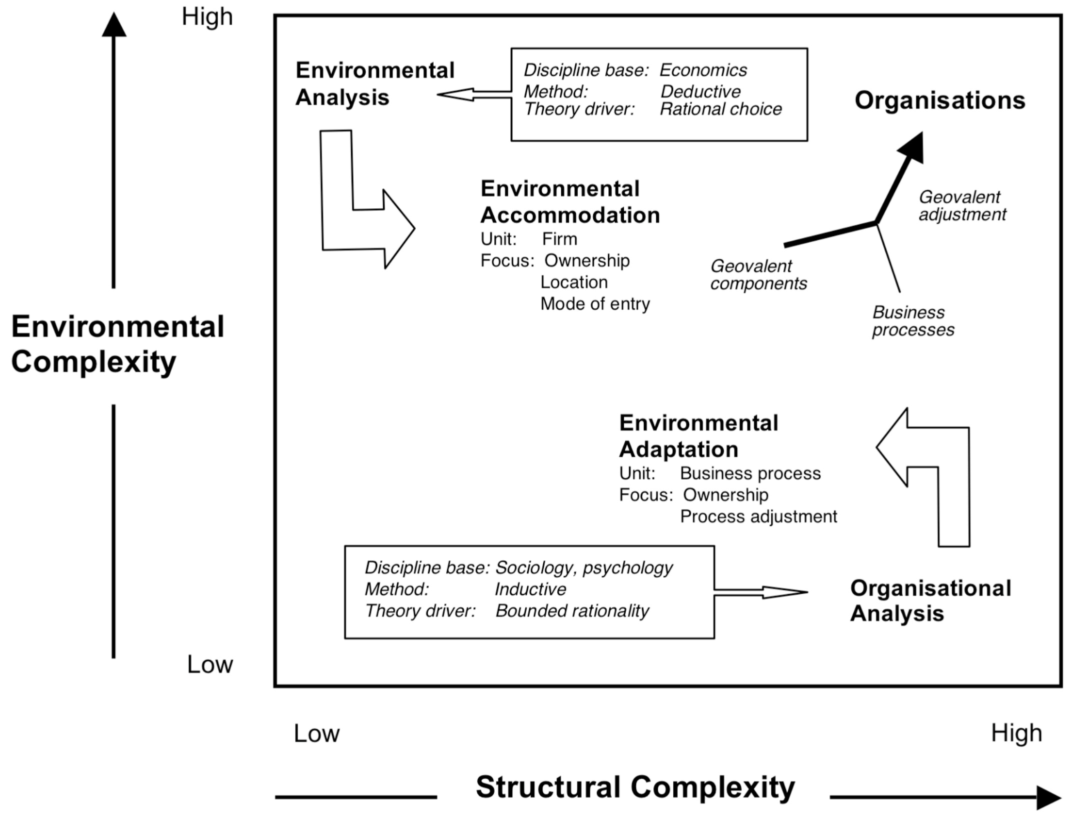
Whether structural complexity leads to environmental complexity, or vice-versa, the nature of these two constructs is as inseparable as that of organisations, and their environments. For example, Ghoshal and Nohria (1993) work on this idea of inseparability and demonstrate the continued relevance of this notion by showing that some combinations of environment and structure fit better than others. Fig. 16, which has been adapted from Guisinger (2001), illustrates the inextricable relationship between environmental and structural complexity and states that disciplinary bases covering 'environmental analysis' generally tend to work on the premise of environmental accommodation of firm units, whereas disciplinary bases covering 'organisational analysis' tend to work on the premise of environmental adaptation of business processes. Furthermore, it suggests that these two research streams, if integrated, offer the potential of providing a unified explanation of complex organisational forms.

This inextricable relationship between environmental complexity and structural complexity therefore underlines the main causes of environmental complexity, which in the context of the present study were seen by adopting an international business perspective, and may be visualised as falling under the category of disciplinary bases covering 'environmental analysis' in Fig. 16. From this point of view, international business and globalisation lead to environmental complexity, which leads to structural complexity in order to meet environmental accommodation and adaptation needs of organisations. Furthermore, since an international business perspective was applied, the causes and drivers of environmental complexity were envisaged as arising out of the various (country) environments in which organisational operations take place. This aspect shall be clearer further on while presenting the development of the supply chain (logistics) environmental complexity construct.

Figure 16

"Environmental Accommodation and Adaptation of Organisational Structures"

(Based on Guisinger, 2001)



3.2.2. Relevance of the environmental complexity construct

Environmental complexity is the complexity arising from *turbulent fields* (Emery & Trist, 1965). Following the discussion in the last section, environmental complexity is to be understood as a specific attribute of environmental uncertainty. It is to be understood as a part of, but is not be confused with other attributes of environmental uncertainty such as environmental dynamism, and environmental munificence. Environmental complexity is more to do with the 'range' of environmental factors; as compared to environmental dynamism, which is more to do with the 'rate of change' issues of these factors; as compared to environmental munificence, which is more to do with the presence or 'sufficiency of resources' in an environment. Environmental complexity may then be described as *"... some combination of uncertainty and reliance"* (Osborn, 1976, p. 180).

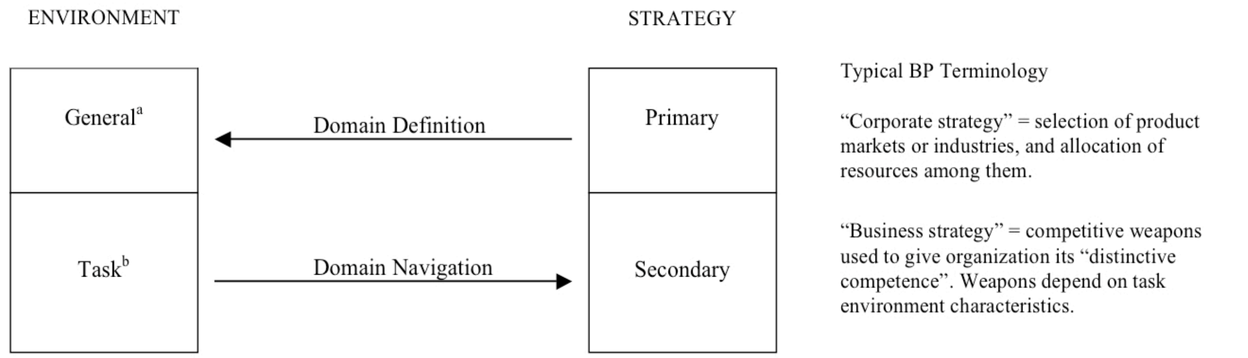
Bourgeois' (1980) exploration into *what type of strategy refers to what type of environment,* is important to bring out the overall relevance of the construct of environmental complexity, especially in terms of managerial implications of strategy making and choice. From this point of view (see Fig. 17), 'domain definition' or exploration concerns itself with finding out about organisational choices or change of domain in terms of e.g. niches and strategies related to this task. Bourgeois (1980) refers to Miles and Snow's "entrepreneurial problem" (1978), and Alfred Chandler's "strategic decisions" (1962) as this type. Once organisational domains have been identified, 'domain navigation' deals with strategy and decision-making problems associated with navigating vis-à-vis competitive decisions, and environmental constraints faced by task environments such as specific product markets and/or industries. Bourgeois (1980) refers to Hofer's "distinctive competencies" (1973), Uyterhoeven et al.'s "competitive weapons" (1973), Churchman's "missions" (1968), and Chandler's (1962) and Ansoff's (1965) managerial "decisions" as this type.

From this point of view, just as with Bourgeois (1980), if one assumes a hierarchical view of strategy at different levels, then the "general" environment should form a reference point for 'domain definition' (corporate) strategies as opposed to the "task" environment, which should be more relevant for 'domain navigation' or lower order strategies. However, in what may be referred to as important for studying environmental complexity in isolation to the other environmental attributes such as dynamism, Child (1972) remarks that *"…environmental complexity does not itself necessarily give rise to uncertainty if little environmental variability is present, and if sufficient organizational resources are devoted to monitoring all the facets of the complex environment",* (p. 4). This has amongst other things (limitation) implications for analysing the complexity construct independently of the other sub-constructs of uncertainty, and has also been mentioned under the delimitations to the present study.

Figure 17

"The hierarchical nature of strategy and environment"

(Bourgeois, 1980)



[a]Composed of multiple task environments. Source of general social, political, economic, demographic, and technological trends.
[b]Composed of competitors, suppliers, customers, and regulatory bodies with whom the organization interacts and whose actions directly affect organizational goal attainment.

3.3. Methods and issues in construct measurement

> *"Researchers attempting to measure environmental complexity remain challenged by the lack of a theoretically compelling and empirically sound scheme for operationalizing this important construct"*
> (Cannon & St. John, 2007, p. 296).

As it becomes important to understand environmental complexity in its own, as a distinct construct, separate from other environmental dimensions (e.g. dynamism and munificence), methods and issues in construct measurement become relevant. Issues pertaining to distinguishing complexity from non-complexity and other environmental traits become relevant. Issues pertaining to operationalising environmental complexity become important. This section therefore seeks to provide an understanding of these issues, one that was used to create a theoretical framework for working with the construct in this study.

Duncan (1972) is regarded as one of the first to differentiate the environment on the "simple-complex" dimension, and offers a method for measurement of environmental complexity. A simple environment is characterised by a high degree of homogeneity. In an organisational setting, a simple environment is one that is characterised by the relative scarceness and similarity of these environmental factors (to one another) that surround a decision unit. *"The complex phase indicates that the factors in the decision unit's environment are large in number"* (Duncan, 1972, p. 315). Environmental complexity, as a research object, is a latent multi-dimensional construct, which varies with component preponderance, component heterogeneity, and information processing requirements (Cannon & St. John, 2007). A discussion on these integral aspects of environmental complexity is next conducted.

3.3.1. Latency and multidimensionality of environmental complexity

Latency of environmental complexity is concerned with how or whether the construct may be observed, measured or analysed. Bacharach (1989) provides a scheme to describe the essential components of (good) theory, and provides a framework that can be used to distinguish between constructs, variables and theory. This is provided in Fig. 18 and a discussion is relevant to this section from the point of view of understanding the central construct in this dissertation i.e. environmental complexity.

A construct, by its very nature is impossible to observe directly, because it is constructed, because it is "a broad mental configuration" of a phenomenon. *Environmental complexity* is a construct, and is an "approximated unit", just as other constructs that are impossible observe directly such as *satisfaction, culture*, *centralisation* or even *competitiveness etc*. All these constructs are latent, and are underlying a set of sub-constructs and variables that seek to operationalise these constructs. Bacharach (1989) notes:

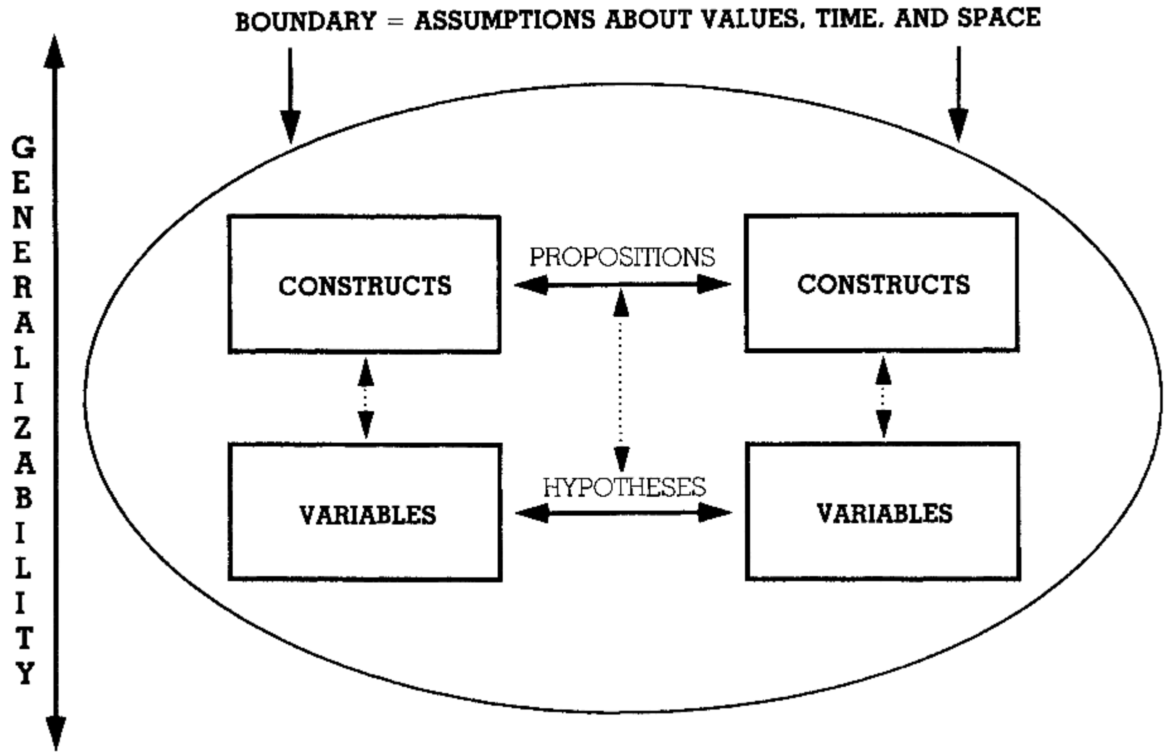
> *"Constructs may be defined as "terms which, though not observational either directly or indirectly, may be applied or even defined on the basis of the observables" (Kaplan, 1964, p. 55)",* (p. 500).

The multidimensionality aspect of environmental complexity is closely related to this argument, as variables are those observed units that seek to empirically operationalise constructs, by way of measurement. Variables may be viewed as an "operational configuration" derived from constructs. The number/type of, and interrelationships between variables operationalising constructs would then provide information on the dimensionality aspects of the underlying construct. Since environmental complexity arises from many sources, is operationalised using a variety of measures (see Fig. 19), and there lacks an agreement in the (environmental complexity) research community on its measurement, it is reasonable to conclude that it is multidimensional in nature, and that researchers should consider this while attempting to capture the construct (Cannon & St. John, 2007).

Figure 18

"Components of a theory"

(Bacharach, 1989)



3.3.2. Component preponderance and environmental complexity

The more the number of markets covered by an organisation, the more the environmental complexity it faces. The more the number of countries and country-based peculiarities (factors) an organisation interacts with, the more the environmental complexity it faces. Such arguments have their underlying notion as *the range, number or quantity of environmental components that an organisation is exposed to*. In this sense, environmental complexity has to do with the number of environmental components that the firm interacts with. Starting with the early works on the construct (e.g. Child, 1972), this aspect of environmental complexity has remained a preferred point of exploration, and is well engrained in most of the domain. For example, Miller and Chen (1996) simply took the total number of markets served by an organisation, and the total number of competitors faced as surrogates for environmental complexity surrounding organisations. Similarly, as brought out in Fig. 19, and in direct relevance for the present study, the total number of institutional domains that are a part of the organisation's environment, and the total number of institutional environments that an organisation interacts with (Kostova & Zaheer, 1999), are also relevant points of exploration that have been employed using component preponderance as the main logic for environmental complexity.

3.3.3. Component heterogeneity and environmental complexity

Similarly component heterogeneity, which may be defined as the diversity between the range of environmental factors mentioned in the previous sub section, has remained central to the domain of environmental complexity. This may be well evident from the early conceptualisations of Duncan (1972), as well as the more recent literature reviews presented by Canon & St. John (2007). In fact as Fig. 19 shows, the *homogeneity-heterogeneity* argument is more preferred than the *preponderance* and *information processing* arguments of/for operationalising environmental complexity. The basic fundament underlying this argument is that heterogeneous environments pose more constraints on organisations than homogeneous ones (Thompson, 1967).

Apropos to the present dissertation, Kostova & Zaheer (1999) operationalise environmental complexity as the heterogeneity in the character of 'a' range of institutions and environments, with which the firm interacts. For example, they remark the following with respect to multiplicity of institutional environments as an important factor causing environmental complexity:

> *"The institutional distance between two countries, defined as the difference/similarity between the regulatory, cognitive, and normative institutions of the two countries (Kostova, 1996), will affect both the difficulty of understanding and correctly interpreting local institutional requirements, as well as the extent of adjustment required. …Thus, it will be easier for an (organization) to understand and adjust to the legitimacy requirements of a country that is institutionally similar to its home country than of one that is institutionally distant from the home country",* (p. 71).

Figure 19

"Complexity measures used since Dess and Beard (1984)"

(Canon & St. John, 2007)

Study	Complexity Measure or Measures	Primary Subdimension Tapped		
		Component Preponderance	Component Heterogeneity	Required Knowledge
Keats and Hitts (1988)	Grossack's ratio		X	
Boyd (1990)	Herfindahl index		X	
Sharfman and Dean (1991a)	Diversity of product categories		X	
	Workforce's % scientists/ engineers			X
	Workforce's geographical concentration		X	
	Competitors' geographical concentration		X	
Wiersema and Bantel (1993)	Specialization ratio		X	
Kotha and Nair (1995)	Modified Herfindahl index		X	
Dean and Snell (1996)	Schmalensee index		X	
Miller and Chen (1996)	No. of geographic markets	X		
	No. of competitors faced	X		
Jarley, Fiorito, and Delaney (1997)	Avg. employees per firm	X		
Kostova and Zaheer (1999)	No. of regulatory domains[a]	X		
	No. of cognitive domains[a]	X		
	No. of countries in which multinational enterprise (MNE) operates[a]	X		
	Variety of countries in which MNE operates[a]		X	

3.3.4. Information processing requirements and environmental complexity

The basic contention here is that environmental complexity can be measured by judging the information processing requirements of an organisation. Dealing with environmental complexity as a result of higher information processing needs of the organisation is a management issue, and may either be accomplished by embedding more complex structures, or by simplifying existing structures (e.g. Schonberger, 1986, 1987, 1996). But the important thing to recognise is that higher information processing needs are related to high levels of environmental complexity (Flynn & Flynn, 1999), whether or not one is antecedent to the other. In other words, managers in highly complex environments have to account for more while making decisions. As Cannon and St. John (2007), quoting on Sharfman and Dean's work (1991), phrase:

> *"Decision making amid complexity requires a greater understanding of the environment; managers in complex environments must know and consider more than those in relatively straightforward ones (Sharfman & Dean, 1991a, 1991b). Increases in information requirements can result either from the breadth of organizational activities or linkages that must be considered (Pfeffer & Salancik, 1978) or from the level of intellectual and/or technical sophistication required for comprehension (B. Gibbs, 1994)",* (p. 298).

With particular reference to the causes and relevance of environmental complexity, the relationship between environmental complexity and structural complexity because of the information processing argument may then be depicted as in the following figure. Fig. 20 is essentially built upon the arguments presented in Flynn & Flynn (1999), which itself is based on the Galbraith (1973, 1977) arguments on managerial information processing needs and environmental complexity. Galbraith (1973, 1997) deals with alternatives to counter complexity e.g. creation of slack resources and self-contained tasks in order to reduce the amount of information to be processed, and investment in information systems in order to increase information processing capacity (Flynn and Flynn, 1999). From the perspective of the current dissertation, the following aspect of relating environmental complexity to information processing requirements is therefore most interesting:

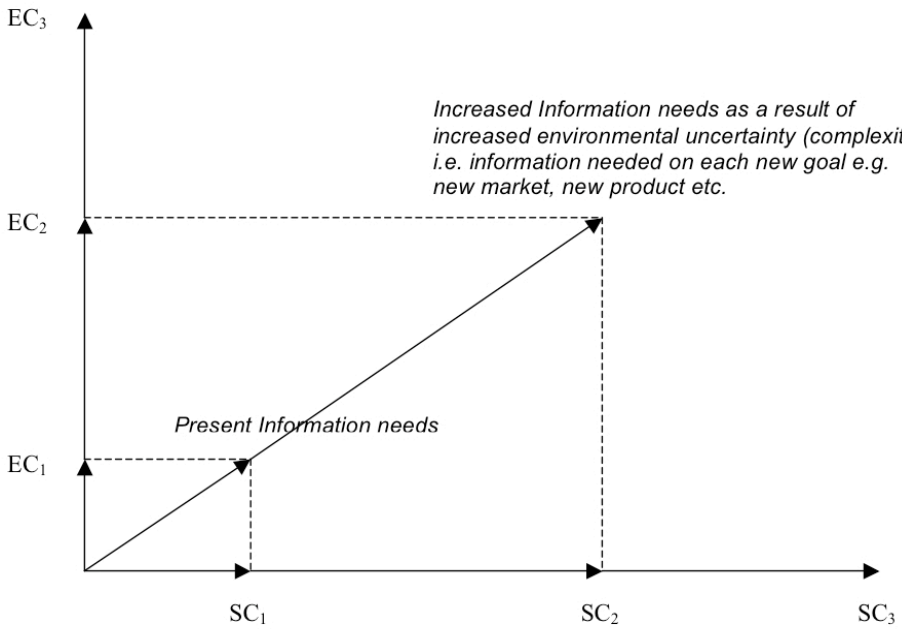
> *"The complexity of an organization is directly related to the organization's information processing needs (Galbraith, 1973, 1977), which result from the uncertainty of its internal and external environments (Bantel, 1993)",* (Flynn and Flynn, 1999, p. 1023).

The circular argument surrounding this notion may then be phrased as – a rise in environmental complexity exerts pressure on the information needs of the organisation in order to deal with this increased complexity. This in turn exerts upward or downward pressure on the organisation to adapt and adjust, either by becoming e.g. more structurally complex, or by simplifying existing structures.

However, in the illustration here, the basic principle of 'Ashby's Law of Requisite Variety' - that states that an organisation's internal complexity has to match the external one (Steger et al., 2007) – holds, even though Steger et al. (2007) themselves (like many others) do not believe such an *isomorphic* perspective (Hatch, 1997) to be requisite for managing complexity. Here, in order to demonstrate this dissertation's standpoint i.e. an increase in complexity because of increasingly environmentally and structurally dispersed operations, the author thus chose to go with the requisite variety principle. This implies that with each new foray such as an entry into an additional or new market, product etc., the organisation experiences increased environmental complexity (EC_2) as a result of its increased information processing requirements, and has to accordingly adjust to this new environment with a new organisational structure and related structural complexity (SC_2). As can be evident through Fig. 19, a variation in environmental complexity because of added information processing requirements has been the least utilised mode of operationalising the construct.

Figure 20

Information processing needs and environmental complexity



EC = *Environmental Complexity*
SC = *Structural Complexity*

To summarise, an important implication of the discussion performed here on the central research interests of this dissertation was that environmental complexity was hereafter supposed to vary with component preponderance and component heterogeneity because of added geographic scope (Guisinger, 2001; Kotha and Orne, 1989), added institutional scope (Kostova and Zaheer, 1999; Guisinger, 2001) and added information processing requirements (Flynn & Flynn, 1999). Therefore, it was envisaged that a study and measurement of the environmental complexity construct would be demonstrated by following these measurement conventions and by demonstrating a variation in the construct in terms of “component preponderance” (range of additional factors to be considered) and “component heterogeneity” (diversity between these factors).

3.4. Environments and environmental complexity in operations

This section provides a set of literature reviews on environment, environmental uncertainty and complexity-related research in operations management that were carried out with the primary purpose of problem identification. The main reasons for these literature reviews were as following – 1) it was important to establish preferred (paradigmatic and referential) starting points in the domain literature for the operationalisation of the construct of environmental complexity. The purpose was also that such an exercise would aid the present study in establishing construct equivalence, and problem equivalence. This is to say that it was to establish whether the nature of the (underlying) problem in the present dissertation indeed fell under the realm of the (environmental complexity) construct and vice-versa; and if not, what other constructs were being used to describe it. 2) Because the research area in the immediate domain literature of logistics/SCM is in its infancy, and initial attempts to short-list (directly) relevant literature failed[19], it was more than appropriate to not only broaden the scope of the domain literature (i.e. from logistics/SCM to OM), but also to broaden the scope of the construct (i.e. from environmental complexity to environmental uncertainty). 3) Since the study defines logistics as an operation, as the point of departure in analysing environmental complexity in Chapter 5, it made sense to refer to literature in OM journals too. These literature reviews then not only met the above-mentioned purposes, but also fed themselves further into the identification of studies that were relevant from the point of view of the immediate problem domain. For example, the meta-analysis on paradigmatic approaches in 'environment-related research' in the logistics/SCM area, which has been presented in Chapter 2, would not have been possible if this exercise was not undertaken. Similarly, a more detailed round of content analyses presented in the following chapters would not have been possible, if the following literature review had not have short-listed studies that demonstrated construct and problem equivalence.

The literature reviews are structured along identifying the problem characteristics and environmental scanning implications mentioned in Chapter 1, that justified the design of an environmental complexity led research approach to the present study. The results of this literature review led to a meta-analytical map of key studies in the domain from the point of view of the research problem.

[19] This may also be adjudged by the paucity of logistics/SCM studies in the meta-analysis that directly follows this literature review (see Table 1).

3.4.1 The environment of operations and its relevance – a literature review

Skinner (1969) advocates the importance of a 'fit' between strategy (S), the environment (E) and performance (P) through his emphasis on the 'focussed factory', which may be regarded as a starting point for much of the conceptual basis of the importance of the environment and the E-S-P paradigm in the field of manufacturing and operations, in the last three decades. Following this, and as pointed out by the operations strategy literature reviews carried out by Anderson et al. (1989) and Leong et al. (1990), there is broad support for the conceptual existence of the E-S-P paradigm within the operations domain (Ward and Duray, 2000). Skinner (1969), for example, is significant in prescribing poor performance as a consequence for firms with a poor fit in this relationship in his seminal contribution, though only from a conceptual viewpoint. The essence of the environment, strategy, and performance relationship can be gauged from the following quote:

> *"The purpose of manufacturing is to serve the company-to meet its need for survival, profit, and growth. Manufacturing is a part of the strategic concept that relates a company's strengths and resources to opportunities in the market. Each strategy creates a unique manufacturing task. Manufacturing management's ability to meet the task is the key measure of its success" (p. 140).*

This implies that there should not only be a fit between firm strategy, firm environment and its performance but also (may be interpreted) as the environment triggers firm strategy, which in turn adapts and adjusts to achieve performance. However, as Ward and Duray (2000) point out, even though this relationship has continued to exist and dominate operations strategy in terms of its conceptual underpinnings, it is only fairly recently that the relationship has been empirically put to test. Therefore, issues of antecedence, causality, directionality, form and nature of this relationship have come to occupy a large part of operations domain. A documentation of this part of literature, or sub-domain in operations, is called for here as it has explicitly sought to operationalise the environment, and its attributes. Therefore, this line of thinking is of interest to the present dissertation.

A well-acknowledged contribution in this direction is that of Swamidass and Newell (1987), where they put to test their contingency theory based model of manufacturing strategy using a path analytic approach. Their basic premise is the sequential relationship amongst the external environment, strategy and business performance variables. Manufacturing strategy (as a subset of corporate and business strategy), its content and process, and its considerations in the broader context of its environment and business performance, is essentially the focus of this work. Although there are self-admitted concerns about generalisability of their findings in light of industry effects affecting the sample, Swamidass and Newell (1987) demonstrate that environmental uncertainty influences manufacturing strategy content and process, which in turn makes a measurable impact on the performance of a business. They cite Van Dierdonck and Miller (1980) as the lone empirical study, which considers the relationship between the environment and operations strategy, preceding their study.

Ward et al. (1995) employ structural equation modelling to shed light on the links between operations strategy, environment and performance from a sample of Singapore manufacturers (NIC context) and to describe the nature of the relationship. Their models show that high and low performers emphasise differently on their competitive priorities, even though they are faced with similar environmental concerns. Though the essence of their contribution is the same, their work differs subtly from that of Swamidass and Newell (1987), described by them as:

> *"In addition to a more complete rendering of environmental concerns...(1) the sample is broader in industry coverage and larger in size; (2) the model is restricted to operations strategy content rather than content and process, but covers content somewhat more completely; (3) the geographic locale is different; and (4) covariance structure modelling is used to estimate the path model",* (p. 100).

The causality of the (E-S-P) relationship is upheld by demonstrating that factors in the environment sparks the choice of an operations strategy, which in turn translates into performance. Ward et al. (1995) leave out of complexity while choosing to focus on the dimensions of dynamism and munificence in the environment:

> *"...future efforts should include measures which capture environmental complexity, a dimension not explored in this present research",* (p. 112).

Williams et al. (1995) investigated a sample of 85 firms in a mature industry context (the fabric industry), and found a significant relationship between a firm's business level strategy, its manufacturing strategy and performance. In a similar vein, the essence of Badri et al. (2000) lies in exploring and testing the idea of strategic response to (perceived) environmental dynamism in a developing industry context. Strategic response is explored in terms of the chosen operations strategy attributes of cost, quality, delivery and flexibility. This is then related to business performance in a developing country context i.e. the United Arab Emirates. Their findings, though upholding the existence and nature of the environment-strategy-performance relationship, has implications in terms of the different nature of environmental concerns in mature and emerging countries or manufacturing contexts. Moreover, environmental concerns such as 'government laws and regulations' and 'political considerations' are also important variables to be considered in a developing country context. Again, as Badri et al. (2000) explicitly state the exclusion of environmental complexity as opposed to munificence and dynamism in their study, there is some confusion regarding this exclusion because 'government laws and regulations' and 'political considerations' may generally be linked to the environmental complexity dimension. On the importance of the environment to operations, they suggest:

> *".... researchers should build into virtually all research design explicit consideration to environmental factors. Environment should be included for substantive and methodological justifications",* (p. 170).

Ward and Duray (2000) provide an important extension to the E-S-P paradigm, which is the topic of the present review. Although, it should be pointed out that the contingency theory perspective and the path analytic method used in their investigation remains the same as in previous studies. They explicitly make a differentiation between manufacturing strategy, which is a functional level strategy, and competitive strategy, which is more representative of corporate strategy. Then they test the relationships as shown in Fig. 21 and find that relationships 1a, 1b and 1c between the firm's environment, its competitive strategy, manufacturing strategy and performance hold. This "obvious" finding upholds the conceptual literature within operations management and strategy. By thus doing, they not only empirically test the relationship but also manage to define the broader strategic context of manufacturing strategy in terms of a firm's competitive strategy. Their findings also dismiss relationships 2 and 3 i.e. direct independent effects of the environment on manufacturing strategy, and that of competitive strategy on performance respectively:

> *"From the perspective of operations management, the paths between each of the competitive strategies and the manufacturing strategy dimensions are of great interest…competitive strategy of differentiation is linked with each of the manufacturing strategy variables",* (p. 134).

Ward and Duray's (2000) study reveals the mediating effect of competitive strategy and confirms that environmental dynamism has an important effect on manufacturing strategy "but that influence is articulated through and modified by competitive strategy" (p. 135). Some important research implications of their study are that any model of manufacturing strategy must simultaneously include competitive strategy variables in order to capture the context of functional (manufacturing) strategies correctly. And following this, a case may be made that any model on (manufacturing or operations) performance or competitiveness must include all in the same i.e. variables of the environment, competitive strategy and manufacturing/operations strategy to capture the context of performance. Most notably since their study provides empirical evidence that in high performance firms a) there is a fit between the environment, strategy and performance, and b) competitive strategies of the firms are "inextricably" linked to their manufacturing strategy, a case can be made that the understanding of these links, the processes behind their design and management, is a neglected research area. As they point out this important lacuna in research:

> *"The importance of the close coupling between competitive and manufacturing strategies among high performance manufacturers raises interesting questions about how such coupling can be accomplished. Hill (1994) provides one methodology for achieving such a coupling and also points out many potential pitfalls in the process. Adam and Swamidass (1989) and others point out that manufacturing strategy process research has been neglected relative to content research. The content research findings reported here underline the importance of process research for developing an understanding how firms establish close linkages between competitive and operations strategy without adopting bureaucratic strictures that impede responsiveness",* (Ward and Duray, 2000, p.134)

Anand and Ward (2004) work on the same relationship, though following a different approach, which suggests the moderating role of the environment in the relationship between flexibility (strategy) and performance. They argue that flexibility is still a viable option even though the environment is less dynamic or differently dynamic. It follows that each type of environment demands a different type of flexibility strategy i.e. mobility flexibility in unpredictable environment, whereas, range flexibility for volatile environments. The theoretical implication for operations is that a fit between environmental conditions and flexibility strategy matters with respect to business performance.

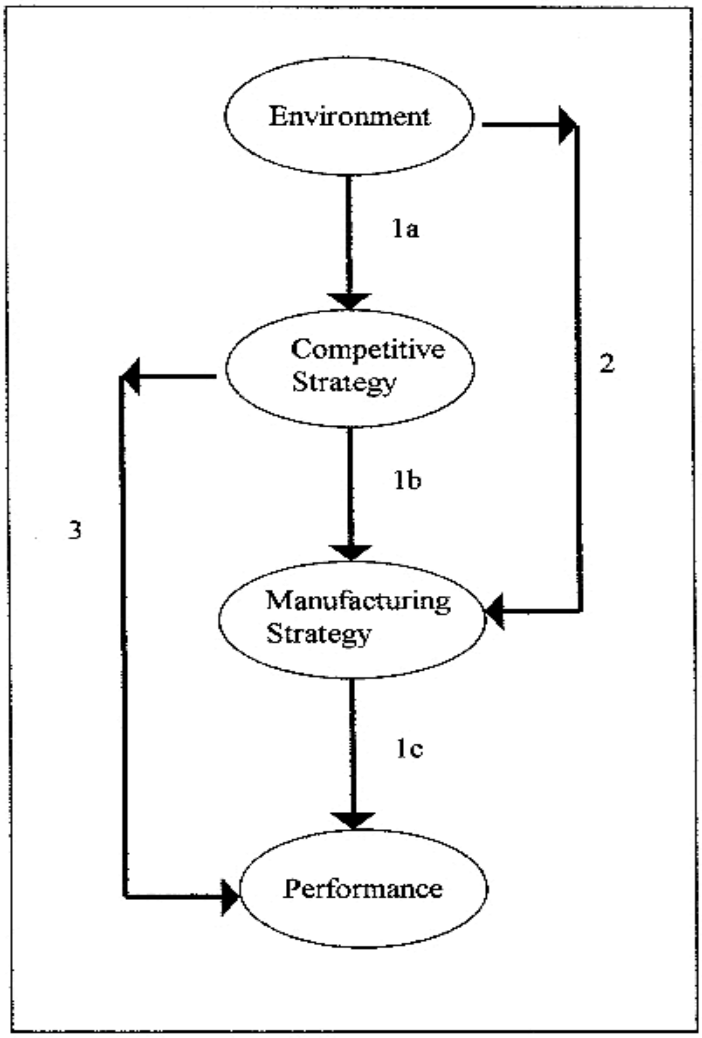
An important managerial implication is that managers should recognise the specific environmental challenges faced by their business and choose the appropriate flexibility approach. Yet again, the focus on environment in their paper deals with environmental dynamism and they concede that a broader theoretical map of environmental conditions and specific types of operations strategy is required.

To summarise, the focus here has been to conceptualise the *environment-strategy-performance* (E-S-P) relationship and empirically test whether there exists a significant relationship between (perceived or objective) environmental dimensions, (corporate, business or operations) strategy and business environment. The E-S-P paradigm assumes a hierarchical view on strategy and advocates a causal fit between firm strategy, its environment and performance. A similar trend in conceptually incorporating the E-S-P paradigm into supply chain operations was found to be emergent in logistics literature, where Defee and Stank (2005) put forth propositions using E-S-P paradigm in the supply chain context. It was then inferred that the research stream cited here, in fact focuses on why the environment, environmental uncertainty and its referents are important for organisational operations, and that in each case, the inbuilt contingency argument helped framing theoretical models that sought to confirm this.

Figure 21

"*Conceptual model of manufacturing strategy in its context*"

(Ward and Duray, 2000)



3.4.2. The environment of operations and its application – a literature review

Before providing a brief overview of the typical applications that, consciously or unconsciously, were found to apply the construct of environmental uncertainty or complexity, it is appropriate to start out by discussing the fundamental notion that underlies this literature review.

The fundamental notion that underlies this literature review is **the field of environmental scanning and different types of environmental measures.** The central theme in all applications related to environmental (complexity) analyses concerns on how researchers view the construct, i.e. is environmental complexity objective or perceptual in nature?

> *"Measurements of environmental complexity are generally of two types: (a) perceptual and (b) objective or archival"* (Canon and St. John, 2007, p. 299).

Objective measures refer to archival data and seek to capture environmental complexity by comparing data within or across units of analysis e.g. industries (as in Dess and Beard, 1984 and Lawless & Finch, 1989).

> *"Objective measures (e.g. Dess & Beard, 1984) are typically based on industry-level data, and are useful for quantifying structural differences between industries. Data for these measures are available from archival sources, which in turn facilitate replication and comparative studies"* (Boyd and Fulk, 1996, p. 3).

Duncan (1972), on the other hand, worked on environmental complexity under "perceived environmental uncertainty" (PEU), and thereby suggested perceptual measures on the external and internal components of the environment, responses to which were received by way of "pooling" organisational or "key informant" (Boyd & Fulk, 1996) responses. In his case, the unit of analysis was the organisational decision unit. For instance, most of the operations management and strategy domain presented in the literature reviews in this chapter relies extensively on perceptual measures while operationalising PEU. Although not necessarily true, one may (thus) notice a trend or even infer the following by way of the disciplinary origins e.g. organisation scientists prefer to work on perceptual measures, economists prefer to work on hard or archival measures, whereas decision scientists or behavioural theorists may use a mix of the two or whatever is available to the decision maker in order to study environmental complexity.

While these subjective or objective measures of environmental complexity relate to its content, the process of incorporating these into any environmental analyses may be referred to as environmental scanning. The broad area of 'environmental scanning' has provided a range of opportunities for academics and practitioners alike.

> *"….called **environmental scanning**, this information-gathering process detects environmental turbulence or change likely to affect the homeostasis of the organizational system [Dozier, 1992]"* (Lauzen and Dozier, 1994).

In general, environmental scanning as an area implies the design, implementation and management of scanning methods/models that can calculate risks, opportunities, and threats related to different types of environments at different levels, i.e. country or regional levels, industry level, firm and/or network levels, or even function-specific environments. For example, Guisinger (2001) provides a range of studies that deal with environmental scanning with respect to international operations (Fig. 22). The basic notions behind environmental scanning are the same as discussed earlier in this chapter e.g. scanning the organisation's environments in order to seek opportunities that can be matched to its capabilities (Fig. 23). Environmental scanning may be performed with varying degrees of formality, and it results in some assessment of risk and uncertainty (Bourgeois, 1980).

Figure 22

"Environmental scanning studies relevant for international operations"

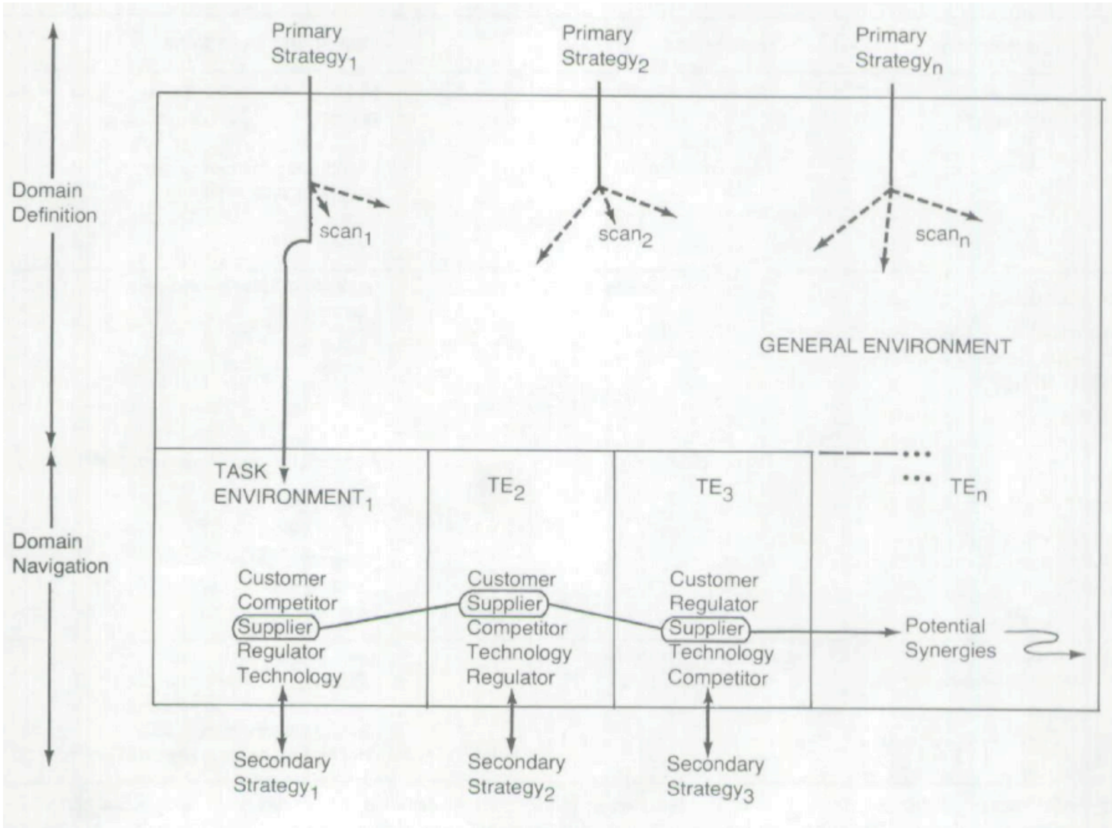
(Guisinger, 2001)

Climate	Sachs & Warner, 1997
proximity to major markets	Peterson & Malhotra, 1997
Physical size	Porter, 1999
Infrastructure	Sachs, 1999
Values	Hofstede, 1983
Attitudes	Kogut & Singh, 1988
Beliefs	
Common	La Porta *et al.*, 1998
Civil	Posner, 1998
Religious law	
GNP per capita	Golub, 1995
Growth of GNP	Sachs, 1999
Income inequality	
Government instability	La Porta *et al.*, 1998
Corruption	Transparency
Bureaucratic instability	International, 1999
Quality of government	Porter, 1999
	Howell & Chaddick, 1994
Effective tax rate for multinational firms	Loree & Guisinger, 1995
Exchange rate variability	Miller & Reuer, 1998
Exchange rate overvaluation/undervaluation	
Tariffs	Laird & Yeats, 1988
Quotas	UNCTAD, 1995
Investment controls	Porter, 1999

Figure 23

"Different types of environments and environmental scanning"

(Bourgeois, 1980)



The essential point, however, is to consider which environment to scan, what in the environment to scan, and lastly how to go about such a scanning. Just as Boyd and Fulk (1996) found out that scanning declined as managers perceived the environment to be more complex, or as Ebrahimi (2000) found the opposite, the accentuated point is what part of the environment is relevant for the manager, what tools should the manager employ in order go about this process, and how routine or non-routine should this process be (Chakravarthy, 1982)? So, the content and process of environmental scanning offers opportunities in terms of tools and methods to be deployed by managers for this purpose. For example, modelling the content of environmental scanning is relatively popular in operations research and decision sciences, as can be evident by examining a large percentage of publications in reputed journals such as *Management Science*, *EJOR*, *IJPE* etc. Given this background knowledge, it is now appropriate to present the review of some well-know environmental complexity applications.

3.4.2.1. Country 'competitiveness' indexes

Leading country indexes such as the *Global Competitiveness Report* (published by WEF since 1979) and *The World Competitiveness Yearbook* (published by International Institute for Management Development [IMD]) in fact perform environmental analyses under the heading or construct of 'competitiveness'. Seen from the managers POV, these indexes fall in the realm of environmental scanning because managers may use these to make decisions such as where to invest, or where to locate. Both reports are founded on a (questionable) methodology that encompasses a number of criteria measured either by opinion polls or hard data placed under (eight) major Competitiveness factors. For example, Kinra and Tansug (2003) report:

> *"Although the Global Competitiveness Report finds positive correlation between the executive opinion surveys and hard data when there is overlap between survey questions (GCR, 2000, p. 97), it should be taken into account that these indices are subjective indices that rely extensively on survey questions. Both indices have substantially increased the number of countries they include in their rankings.....",* (p. 36).

This said, these decisions fall into Bourgeois' (1980) 'primary strategy' or 'domain identification' type of decisions that seek to scan the general environment for opportunities and threats. This is because these indexes do not provide information to the manager about specific criteria related to managerial problems; these managerial problems could be function related or related to other managerial task environments e.g. specific product groups and categories. Where such data is available in these studies, the issue is that of inherent context independence i.e. the application is left entirely to the user's own imagination. Managers' imagination, however, can be costly forays into organisational resources. This and the absence of an undisclosed and confidential methodology (as in the case of the WCY), has prompted researchers (e.g. Oral and Chabchoub, 1996; Zanakis and Becerra-Fernandez, 2005) to call for developing other techniques and modelling methods that can help in structuring such analyses. The important point here is not whether these indexes are worthy, but rather what purpose these indexes perform in conducting environmental scanning. And this purpose, at least in their original spirit, may be termed as that of scanning the "general environment". Studies of this type were also found to be emergent in logistics literature; as mentioned earlier on, the LPI (*Logistics Performance Index 2007*) may be regarded as a good example in terms of its representativeness to the problem area of this dissertation.

3.4.2.2. Decision Support Systems and models for environmental uncertainty

Decision support systems (DSS), just as expert systems and other quantitative techniques for environmental uncertainty, put organisational users and managers at the origin of the strategy and decision-making process, and work on the premise that each problem is distinct from the others. The whole idea underlying this is that *"decision making involves processing or applying information and knowledge, and the appropriate information/knowledge mix depends on the characteristics of the decision-making context" (Zack, 2007, p. 1664).*

However, this does not imply that problem commonalties cannot be aggregated into some general guidelines on developing or standardising the DSS to a common extent. In essence, environmental scanning from this point of view involves its linkage to a particular decision problem, which is a priori well-defined. The chief aim of a DSS may be summarised as that of aiding the manager in information processing and decision-making (Banker and Kaufman, 2004; Blackhurst et al., 2005). For example, Yurimoto and Masui (1995) design a decision support system to give appropriate information, on environmental constraints amongst other factors, to manufacturers interested in setting up plants in Europe. Similarly Badri (1999) incorporates environmental constraints and factors in suggesting an AHP and Goal Programming-based DSS.

DSS and modelling applications may involve improving the methodology (e.g. algorithms) behind those models and techniques that aid in decision making. For example, Borgonovo and Pecatti (2005) discuss the use of Global Sensitivity Analysis techniques for better investment decisions. Though their model addresses and takes into account environmental uncertainty, their primary focus lies in the address of model complexity and uncertainty. On the other hand, DSS applications may also involve a conceptual improvement of problem characteristics in order that the problem is better defined. For example(s), Lau and Zhang (2006) focus only on the Chinese environment, environmental constraints and drivers related to the outsourcing decision; Amoako-Gyampah (2003) examines manufacturing strategy choices in an emerging economy (business environment) context; MacCarthy and Atthirawong (2003) study international business environment factors related to site location. Minfie and West (1998) develop an international market selection model that takes into account environmental constraints. Finally, a similar trend of studies suggesting environmental scanning of supply chain operations, from the DSS perspective, was also found to be emergent in logistics literature; Bagchi (2001) may be regarded as relevant in terms of its representativeness to the problem area of this dissertation.

Therefore, it was inferred that environmental constraints impeding particular decision areas such as site-selection, supplier selection, transport-mode selection, resource allocation etc. have been incorporated in modelling studies, and that DSS applications were a result of these. Finally, some essential points that were to be noted were as follows: 1) such modelling studies and DSS studies present “real life” applications of environmental uncertainty and/or complexity; and 2) the main distinguishing feature of this (DSS) type of application to the country competitiveness indexes, is how components of the “general environment” in fact transcend into the manager’s “task environment” or specific problem area.

3.5. A meta-analytical map of research problems in operations

The findings of the literature reviews, presented in the last section, on environment-related (OM) research may be summarised by these salient features:

1. On the one hand a dedicated stream of empiricists, within operations strategy, were found to focus on the *environment-strategy-performance* (E-S-P) relationship. On the other hand, a dedicated (systems-perspective oriented) stream of modelers, were found to focus on environmental scanning applications.
2. A stronger focus could be ascertained on the content of strategy and decision-making, rather than its process.
3. Operationalisation of the environment and strategy components was found to take place from the perspective of the single organisation, applicable in an intra-firm scenario, and functionally specific to the operations and manufacturing task.
4. An extensive focus on environmental dynamism could also be ascertained. There were only a few instances where environmental complexity factors were considered, however these too within the dynamism construct (e.g. Badri et al., 2000).
5. Kotha and Orne (1989), and Flynn and Flynn (1999) could be regarded as good examples in the explicit use of environmental complexity in the operations and production management domain[20].

[20] Note that both these studies didn’t show up in the initial literature reviews and don’t show up in Table 1 as 1) Kotha and Orne (1989) was published in SMJ, whereas Flynn and Flynn (1999) in Decision Sciences; both journals were left out of the OM domain in the present thesis. and also 2) because neither operationalise the construct using macro- level constraints. In other words, these only stress the importance of environmental complexity.

6. A similar trend to conceptually incorporate the E-S-P paradigm, and the environmental scanning application into supply chain operations was emergent in logistics literature.

Table 1[21], which has also been presented in Kinra and Kotzab (2008b) and was made for the purpose of showing the general orientation of literature, summarises an overview of the key studies within operations that work with the construct of external environmental uncertainty while sharing important common attributes with the underlying problem of this dissertation. These common attributes include the importance and effects of environmental uncertainty on operations strategy, decision and choice.

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[21] It is important to note that it was not possible to modify this table as it was in a review process. Therefore, any studies post Oct. 2006 (e.g. LPI 2007) were left out because of this aspect.

Table 1

"Some key studies using macro-institutions within the construct of external environmental uncertainty", (Kinra and Kotzab, 2008b)

Key authors	Research problem	Level/ Unit of analysis	Prime focus	Domain	Macro-institutional perspective – context of application
Theoretical – confirmatory studies					
Swamidass & Newell (1987) Ward et al. (1995) Williams et al. (1995) Badri et al. (2000) Ward & Duray (2000) Anand & Ward (2004)	Testing the importance of a 'fit' between firm strategy, its environment and performance (E-S-P relationship)	Firm	Theory testing – does the environment affect organizational strategy and performance; does the fit exist?	Operations management and strategy	Certain macro-institutional factors operationalised within the context of 'Environmental Uncertainty' (hereunder *dynamism* and *munificence* dimensions; complexity deemed as unimportant to operations strategy)
Theoretical – conceptual studies					
Guisinger (2001)	Proposing the concept of increased 'environmental complexity' as being parallel to increased 'structural complexity' and scope of operations	Multi-national firm	Theory building – proposes conceptual frameworks to incorporate environmental complexity into international/global operations	International operations	Macro-institutional factors incorporated within the context of '*environmental complexity'*
Defee and Stank (2005)	Proposing the validity of the E-S-P relationship in a supply chain context	Supply chain	Research proposiitions leading to an explanatory E-S-P framework	Logistics and supply chain management	Certain macro-institutional factors incorporated within the context of 'external environment'. However, do not distinguish between what part of the external environment poses complexity and what part poses dynamism and munificence
Methodological – application studies					
Badri (1999)	Global facility location and allocation problem	Multi-national/ Trans-national firm	Demonstrative validity and application of decision-making methodologies for site selection, location and resource allocation	Operations management and strategy	Macro-institutional factors utilized within the context of volatility and *dynamism* of 'external environment'; compare the efficiency of individual national environments
Bagchi (2001)	Measuring supply chain competency of countries	Supply chain	Application of decision-making methodology to rank countries	Logistics and supply chain management	Macro-institutional factors structured according to essential supply chain flows and within the context of competency of nations ('external environment')

3.6. Sub-conclusions

In terms of a grand design, this chapter has now met its main objective in presenting the repository of (theoretical) resources, which was used throughout the study. This was necessary in order to achieve the study's main objectives, and from now onwards, it will be fairly easy to refer the reader to this chapter, and theoretical arguments presented herein, from the point of view of being able to answer both research questions.

As a quick recap, the chapter started out by bringing attention to the theoretical antecedents of the environmental complexity construct, with the problem characteristics finding home in different theoretical orientations in explaining organisations (organisational behaviour, strategy and choice), namely: *contingency and institutional theories, and strategic choice, industrial organisation and international business literatures*. This was done in order to pinpoint relevant theoretical reference points in order to research the construct. Next, it discussed the causes and relevance of the environmental complexity construct, where it was brought forward that the construct forms a part of another (latent) construct environmental uncertainty, and that it was not to be confused with environmental dynamism and environmental munificence. Managerial relevance was brought forward by relating it to higher-order strategy (domain seeking) decisions (e.g. market/country entry), as opposed to actual operations strategy, and the construct found itself inextricably linked to organisational structure and structural complexity. In a way, all this was necessary in order to justify the study's theoretical assumptions and research approach.

Next, the chapter moved into the area of construct operationalisation, as it not only discussed methods and problems related to construct analysis and measurement, but also the preferred starting points for such ventures in literature. The chapter then concluded in a set of literature reviews that demonstrated these preferred starting points, and finally a meta-analytical map showing studies that could be used to assess how this study could proceed forward with the construct, in a way that was compliant with the research questions posed in this dissertation. All this groundwork in order, the next chapter then represents the first step in bringing the construct of environmental complexity to the domain of supply chains and supply chain management.

Chapter 4

Supply Chains:

The organisational context of Environmental Complexity

> *"In conducting an environmental analysis from a modern perspective, you must first define the organization whose environment you are interested in analyzing…In some ways the trickiest part of the entire analysis is the first step-defining the organization. This is because the definition implies that you know where the organizational boundary lies",* (Hatch, 1997, p. 96).

As the study progressed with its main objective, that of operationalising the construct of supply chain logistics environmental complexity, this chapter documents the first step in construct development where the study sought to bring the construct of environmental complexity to the supply chain domain. For this purpose, it warranted that the supply chain not only be defined as an organisational form, but also given the diffuse and emergent nature of the SCM discipline (as brought forward in Chapter 1), it first be argued for as an organisational form. This was necessary for proceeding to the next stage of determining (organisational) environments. Though as pointed out by Hatch (1997), such a task was easier said than done.

This chapter is therefore structured in a way that in its first division involved the study getting to the appropriate definition of a supply chain, and in its second division then involved checking its resilience against the main theoretical axioms of the construct of environmental complexity, which are presented in the previous chapter (3). Such an exercise then directly resulted in ascertaining/justifying whether the environmental complexity construct is (especially) applicable in the supply chain context, as the author proposes, or not. Once this was achieved, the dissertation was in a good position to answer the first research question:

***What** is the relevance of environmental complexity for the supply chain?*

4.1. The supply chain as an organisational form - *an introduction*

Issues that underline the organizational context of environmental complexity are related to quintessential supply chain definition/s, underlying elements, activities & tasks, and different types of supply chains based on different structural scopes. A quick look through the dictionary definition of a supply chain, which the Oxford English dictionary defines as *"the sequence of processes involved in the production and distribution of a commodity"*, opens up an interesting debate on the definition and etymology of the term. Just like different perspectives underlying the domain of SCM differ in their disciplinary origins, a supply chain may be understood in many ways and based on different dimensions. For example, Grieger's (2004) account of different supply chain (management) research objects (decision-making, productivity, control etc.) depending on different underlying scientific and theoretical orientations (e.g. sociological, political science, economic theories), is just one way of looking at different SC conceptualizations. Since purchasing, procurement, production, marketing and logistics form the underlying functional disciplines of SCM (Chen & Paulraj, 2004), one may also have a normative[22] starting point by understanding how managers (and academics) within these view and define the supply chain (Mentzer et al., 2008). Notwithstanding its pros and cons, such an approach to defining supply chains is also referred to as the "managerial solution" to defining networks from an organizational theory perspective (Hatch, 1997).

Accordingly, as also mentioned in the very first chapter, this study took its inspiration from Mentzer et al.'s (2001) definition of a supply chain. Their set of definitions not only influences managerial decision-making in the (9000 member-strong) Council of Supply Chain Management Professionals, but also impacts a broad academic community[23]. Therefore, building on this perspective and others, the present study formed its understanding of the supply chain as an organizational form based on the following important features:

- *a value chain* (Stabell & Fjeldstadt, 1998)
- *an extension of the firm* (Vokurka et al., 2002)
- *a hybrid network organisational structure* (Stock et el., 1999)
- *essentially an inter-organisational arrangement* (Rudberg & Olhager, 2003).
- *an arrangement of independent organizations* (Rudberg & Olhager, 2003)
- *a complex structural form consisting of three or more firms* (Mentzer et al., 2001).
- *an environmentally complex structural form* (Kinra & Kotzab, 2008a)

The in-depth treatment of each of these individual features, which helped in establishing the supply chain as an organisational form, and in distinguishing it from other organisational forms, is documented next.

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[22] Normative here implies excessive interest in managerial implications. For example, "A great deal of organization theory has been criticized for its normative (in this case pro-managerial) bias" - http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t88.e1631&category=&authstatuscode=202, accessed 18/08/2008, 18:45.
[23] As of 15/08/08 15:00, Mentzer et al. (2001) has been cited 76 times in EBSCO databases.

4.2. The supply chain as a value chain

Mouritsen (2007) invokes Stabell & Fjeldstadt (1998) in suggesting that maybe "it (a supply chain) is called 'a chain' for a specific reason"[24]. Kotzab and Otto (2004) do the same using Thompson's (1967) "technologies" that underlie such a perspective. For example, Stabell & Fjeldstadt (1998) provide an interesting distinction between chains, shops and networks based on their respective value creation logics. From this perspective, in order to be called a chain, an organizational form should be based on a value chain model (Porter, 1985), whereby the value creation logic involves long-linked technologies for the transformation of inputs into products, and is based on a sequential links between the main activity categories of inbound logistics, production, distribution and after sales services (Stabell & Fjeldstadt, 1998).

Though this type of analogy goes a long way in explaining the underlying assumptions of a large part of supply chain literature (e.g. Mentzer et al., 2001), applying the appropriate "network" perspective (see Fig. 24) for understanding the existence of supply chain networks in the same literature, doesn't necessarily yield the same results. For example, a supply chain network in the (logistics management tradition) supply chain domain is not necessarily based on reciprocal value creation logic, or employ mediating technologies for value creation. For examples, one may refer to the understanding of the term "network" in Frankel et al. (2008), and Stock et al. (1999), who tend to connote it with a (value) chain concept. Nor does applying a "chain" perspective (see Fig. 24) go far in explaining industries that are atypical to the scholarship of SCM. For example, Kotzab and Otto (2004) find support for the "chain" perspective only in those industries, which form a typical point of departure in SC/M studies i.e. fast moving consumer goods, packaged goods or the fashion industry.

4.3. The supply chain as an inter-organisational arrangement

Larson et al. (2007) suggest four different ways to view the "discipline" of SCM. In essence, what they bring out is an interesting distinction between different types of supply chains and different perspectives on SCM depending on whether one assumes an intra- or inter-organisational stance. Similarly Chopra & Meindl (2007), who adopt a supply chain operations lens, distinguish between different types of supply chains based on four distinct (organizational and functional) strategic scopes (see Fig. 25) i.e.:

[24] A discussion with Jan Mouritsen within the PhD course on Leadership Technologies, 24/01/2006.

a). Intracompany intraoperation scope – where *“….the strategic fit is considered is one operation within a functional area of a company”,* (p. 39).
b). Intracompany intrafunctional scope – where *“….the strategic fit is expanded to include all operations within a function”,* (p. 40).
c). Intracompany interfunctional scope – where *“….the goal is to maximize company profit. To achieve this goal, all functional strategies are developed to support both each other and the competitive strategy”,* (p. 40).
d). Intercompany interfunctional scope – *“…in which all stages of the supply chain coordinate strategy across all functions, ensuring that together they best meet the customer's needs and maximize supply chain surplus”,* (p. 41).

Figure 24

“Overview of alternative configurations”

(Stabell and Fjeldstadt, 1998)

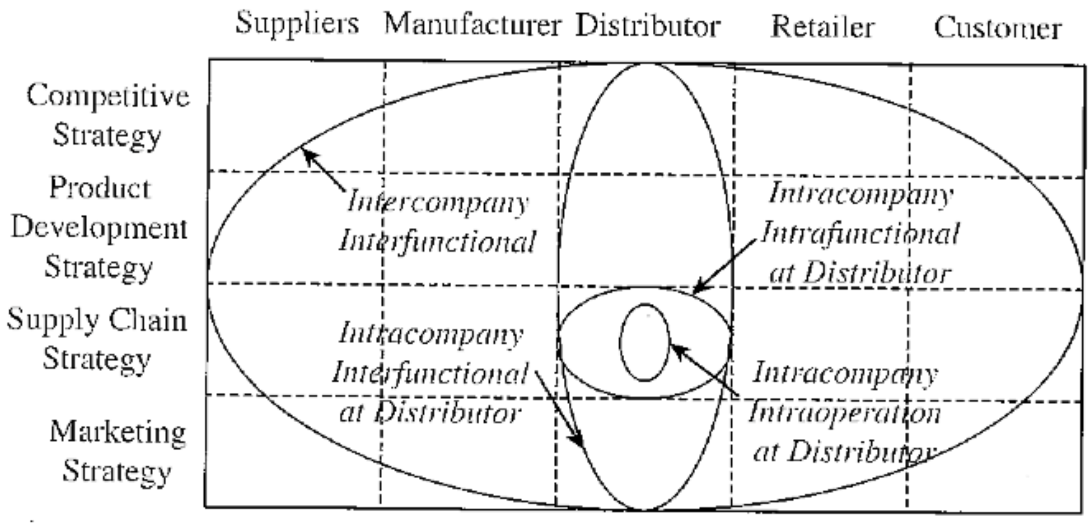
	Chain	Shop	Network
Value creation logic	Transformation of inputs into products	(Re)solving customer problems	Linking customers
Primary technology	Long-linked	Intensive	Mediating
Primary activity categories	• Inbound logistics • Operations • Outbound logistics • Marketing • Service	• Problem-finding and acquisition • Problem-solving • Choice • Execution • Control/evaluation	• Network promotion and contract management • Service provisioning • Infrastructure operation
Main interactivity relationship logic	Sequential	Cyclical, spiralling	Simultaneous, parallel
Primary activity interdependence	• Pooled • Sequential	• Pooled • Sequential • Reciprocal	• Pooled • Reciprocal
Key cost drivers	• Scale • Capacity utilization		• Scale • Capacity utilization
Key value drivers		• Reputation	• Scale • Capacity utilization
Business value system structure	• Interlinked chains	• Referred shops	• Layered and interconnected networks

Even though there are important commonalities that underlie the most influential definitions of SCM and its scope, it can be evident through Gibson et al. (2005), and the literature reviews carried out by Bechtel and Jayaram (1997) and Cooper et al. (1997) that this constant tension concerning functional, and organizational scope of supply chain management is visible throughout the SCM domain. For example, Mentzer et al. (2008), while trying to stress that supply chain management has grown out of its functional orientation and has best a cross disciplinary orientation at the present moment, point out to the following common grounds in describing SCM and consequently supply chains: 1) coordination/collaboration with suppliers and customers; 2) demand and supply side matching; and 3) a flow perspective.

Figure 25

Different types of supply chains based on different strategic scopes

(Chopra and Meindl, 2007, p. 39)



The Council of Supply Chain Management (CSCMP) defines SCM as:

> *"…the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies".*[25]

As regards its scope, the council notes that SCM is primarily an integrating function with responsibility for linking functions and processes within and across companies. Similarly, Rudberg and Olhager (2003) also stress that external 'links' connecting different organizations and not the organizations' internal links per say, are the distinguishing feature

[25] http://cscmp.org/aboutcscmp/definitions/definitions.asp, accessed 19/08/08, 12:12 PM.

of supply chains from other organizational forms such as production networks. They distinguish between networks and supply chains based on two key operations strategy areas (Hayes and Wheelwright, 1984; Hayes et al, 1988) i.e. facilities and vertical integration, and bring out important distinctions (see Fig. 26). They take an operations strategy perspective in pointing out why it is important to assume the broader value network proposition underlying the "manufacturing network" concept (which mostly arises out of the operations management stream) and the "Supply Chain" concept (which has its roots in the logistics management stream), and stress the need to integrate the two especially in light of globalization of markets and operations. Integration is made possible through the complementary nature of these two concepts. Whereas "manufacturing network" theory has an intra-firm orientation with focus on the number of nodes or sites within the same organization, "supply chain" theory has an inter-firm orientation with its focus on the number of links or organizations within the same network.

This discussion therefore led to the conclusion that while intra-organisational issues are important, they have to possess and preferably be preceded by inter-organisational relevance in order for an organisation to be termed as a supply chain.

Figure 26

Key differences between manufacturing networks and supply chains

(Rudberg and Olhager, 2003)

	Manufacturing network theory (intra-firm focus)	Supply chain theory (inter-firm focus)
Facilities		
Size	No. of sites (No. of nodes)	No. of organizations (No. of links)
Location	Corporate decision within the network	Decision based on which collaborative partners to include in the supply chain
Specialization/Focus	Vertical and/or horizontal	Mainly vertical
Vertical integration		
Direction	Both forward and backward, but mainly intra-firm perspective	Both forward and backward including inter-firm manufacturing
Extent	Narrow—only intra-firm manufacturing	Wide-focus on coordinating inter-firm relationships
Balance	External interfaces with 1st tier supplier and 1st downstream customer	Collaborative interfaces between sets of suppliers and customers

4.4. The supply chain as an arrangement of independent organizations

Independence, here, primarily relates to the degree of organizational integration in terms of sovereignty in ownership and control. From this point of view, a supply chain is an organization made up of independent organizations; if these independent organizations had no sovereignty, the arrangement may well be termed as an e.g. *(integrated) firm*.

Since a focus on 'links', and not 'nodes' is what essentially distinguishes supply chains from production networks (Fig. 26), it becomes clearer as to why supply chains are treated differently in SCM literature originating in Logistics, Production, or Procurement. For instance - following Slack et al. (2007) - *supply management* is not the same as *supply chain management*, and requires a different functional orientation i.e. a preoccupation with purchasing and procurement related issues. From this perspective, supply management (only) concerns upstream actors of the total supply chain organization that Mentzer et al. (2001) and the Michigan State University **supply chain 2000 framework** (developed by Donald Bowersox and colleagues) refers to.

It is also interesting to note that literature (e.g. Camm et al., 1997; Arntzen et al., 1995) generally does not distinguish between single or multiple organizations, internal or external networks while using the term "supply chain" (Rudberg & Olhager, 2003). According to this perspective, intra-firm networks are what is traditionally studied under the "manufacturing network" literature stream, whereas, inter-organisational networks are the domain of the "supply chain". Fig. 27, which is based on the notions presented in Rudberg & Olhager (2003), illustrates this distinction between different structural types of supply chain (networks) based on a) the number of actors (organizations), and number of actor facilities that have to be taken into consideration, and b) based on the ownership, control and types of co-ordination mechanisms required for the supply chain.

Such a perspective then shed light on what the term supply chain means for different disciplinary domains e.g.: supply chain research in production networks (e.g. Cohen and Mallik, 1997; Camm et al., 1997; Arntzen et al., 1995) within the domain of operations management would fit in box 2 of the matrix; supply chain research in "cross-border production networks" (e.g. Zysman et al, 1997; Borrus and Zysman, 1997) and in the "multi national corporation" (e.g. Buckley and Casson, 1976; Rugman 1976) within the International Business discipline, which also has an inherent "manufacturing network" orientation would also fit in box 2 of the matrix. Whereas the present dissertation, like Mentzer et al. (2001), Cooper et al. (1997) and other peers would fit in box 3 and find themelves with a specific starting point while understanding supply chains. As per Rudberg and Olhager (2003), these belong to the "logistics management tradition" within the broader supply chain literature:

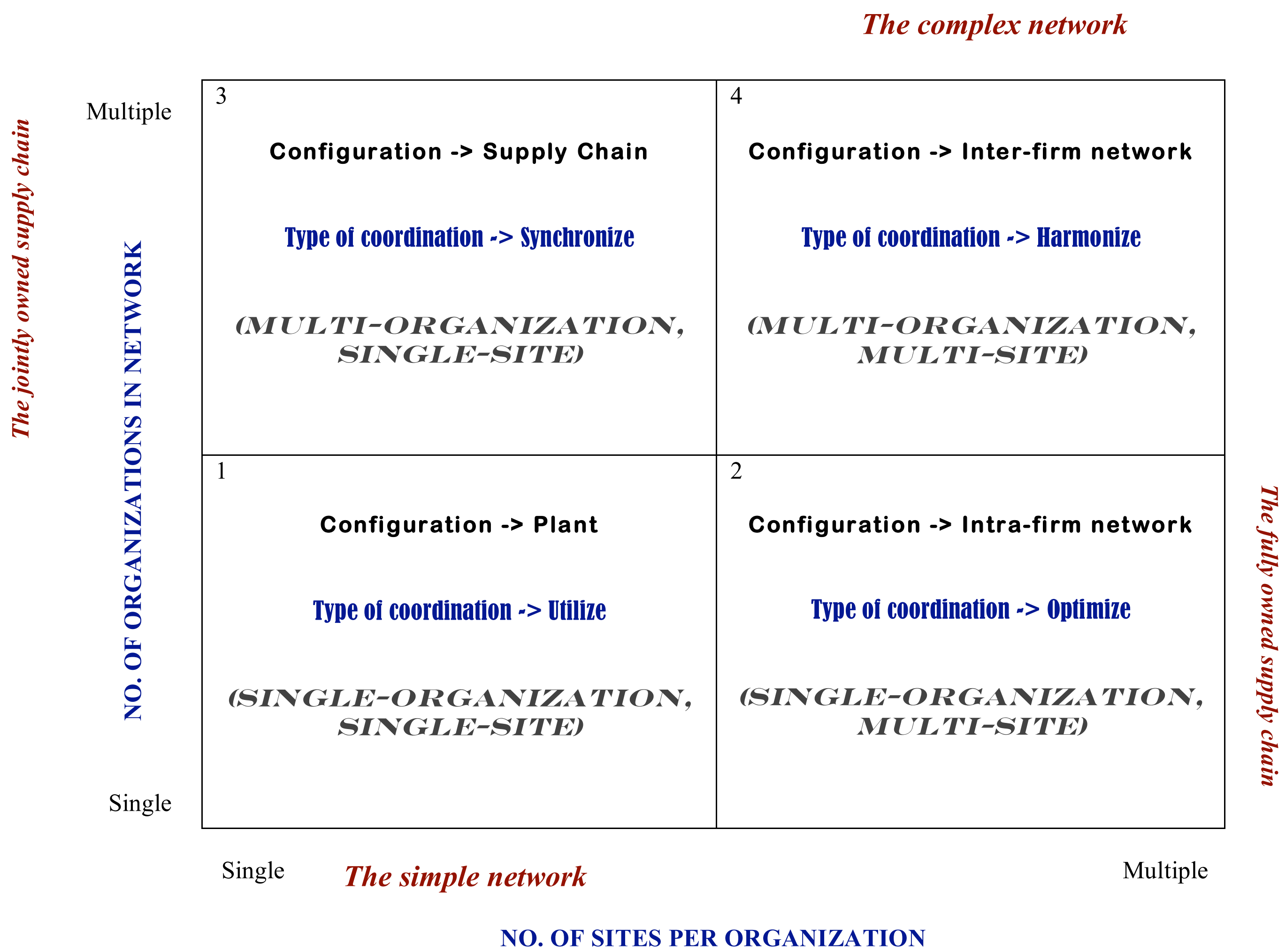
"The research on supply chains has its origin in logistics management", (p. 30).

Although it is difficult to map entire supply chain management research in this thesis, and it is problematic to portray entire research traditions through this matrix, Fig. 27 essentially aided the study in establishing the structural dimensions of a (logistics management tradition)

Figure 27

Different types of supply chains in terms of 'inter vs. intra' and 'ownership' focus

(Based on Rudberg and Olhager, 2003)



supply chain based on the following characteristics: a multi-organisation single-site type network, which by virtue of a structure consisting of independent firms focuses on synchronising the activities of its different members, and is therefore distinct from other (e.g. OM tradition) supply chains like cross-border production networks. For the sake of further exploration and ease in identification, four different types of supply chains were then (tentatively) characterised based on the above discussion:

- 1 – *The simple "plant" type supply chain*
- 2 – *The "intra-firm" production network type supply chain*
- 3 – *The "inter-firm" value chain type supply chain*
- 4 – *The complex "inter-firm" network type supply chain*

4.5. The supply chain as a hybrid network organisational structure

Similarly notions presented in Stock et al. (1999; 2000) could also be integrated into the framework presented above (Fig. 27) as they brought about two more related dimensions that help distinguishing different supply chain types. While Rudberg and Olhager (2003) focus on the importance and number of links vs. nodes in order to typify supply chains, Stock et al. (1999) may be regarded as a supplement, in that they stress upon the 'type or strength of links' that distinguish different type of organisational structures. In their own words, their typology on organizations differs from the Ghoshal et al.'s (1994) 'centralisation-decentralisation', or the 'organic-mechanistic' types (Burns & Stalker, 1961) because they primarily concern themselves with:

> *".....how structure is related to manufacturing. .... (and) structure as it relates to an entire supply chain, although…may focus on a single firm within that supply chain",* (p. 43).

Furthermore, clearly finding their inspiration in transaction cost economics (see Table 2), Stock et al. (1999) also focus on the importance of the 'degree of vertical integration' in determining different (supply chain) organisational structures. Following this, the author argued that the (logistics management tradition) supply chains are a particular type and may be distinguished from other types (e.g. stand alone production networks) based on the strong inter-firm links that bind independent organisations within the supply chain. Also, it was argued that Rudberg and Olhager's (2003) intra-firm (production network) type supply chain is a hierarchy - though a more loosely coupled one than the "plant", because of extended operations from the high number of nodes that need to be taken into account – because of the control that a single actor retains on the chain, and the (high) degree of vertical integration it employs in order to maintain control of dispersed operations. This is the opposite of how Rudberg and Olhager (2003) view their (inter-firm) value chain type supply chain where the number of actors that retain control over the supply chain are high and the degree of vertical integration amongst these actors is lower. Fig. 28 was therefore the outcome of integrating the views presented thus far with the Stock et al. (1999) notions, and in essence modified the tentative typology introduced in the previous section in the following manner:

- 1 - Type A – *The "hierarchical" "plant" type supply chain*
- 2 - Type A – *The "hierarchical" "intra-firm" production network type supply chain*
- 3 - Type B – *The "network-form" "inter-firm" value chain type supply chain.*
- 4 - Type C – *The "market-form" "inter-firm" network type supply chain.*

Table 2

"Expected differences in organizational structure"

(Stock et al., 1999)

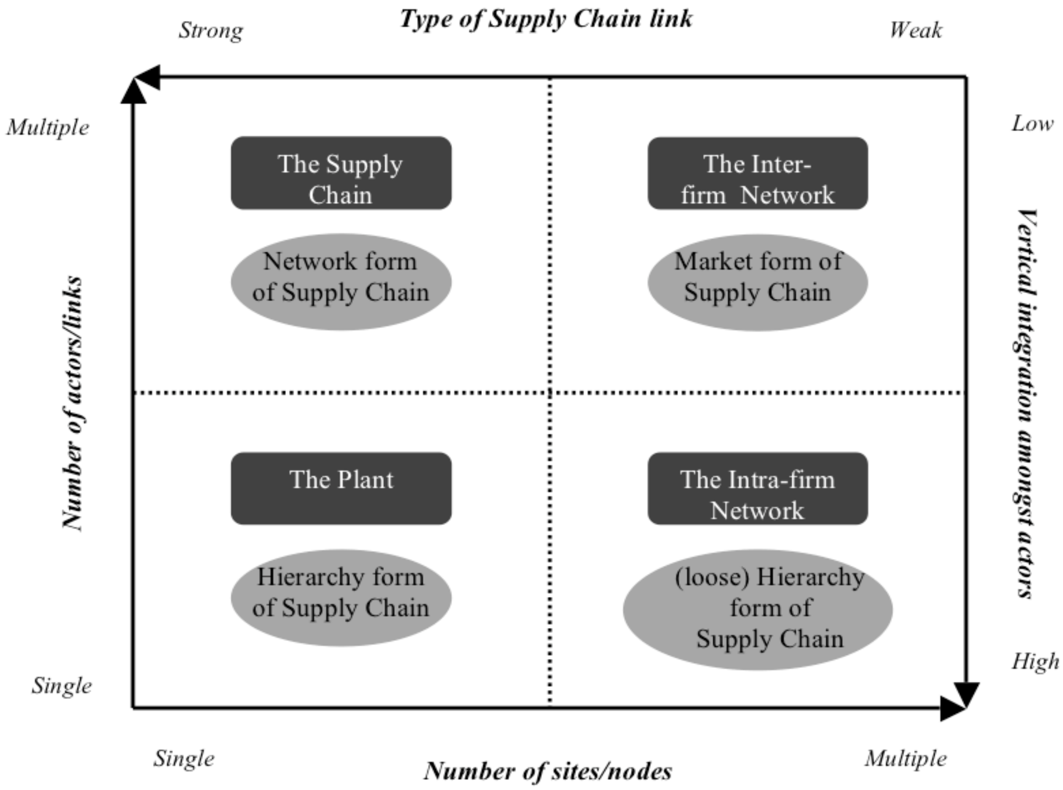
	Hierarchy	Market	Network
Vertical integration	High	Low	Low
Flexibility	Low	High	Medium
Relationships			
Control	High	Low	Medium to low
Information exchange	Low	Low	High
Interdependence	Low	Low	High
Time horizon	Long	Short	Medium
Goal consistency	Low	Low	High
Formality	High	High	Low

4.6. The supply chain as a structurally complex organisational form consisting of three or more firms

As mentioned earlier, structural complexity is the complexity posed by structure and design of organisational operations. (Supply chain) structural complexity then became evident by revisiting the adopted supply chain definition in this thesis (p. 14), where Mentzer et al. (2001) define it as at least and any three separate firms engaged in performing physical, financial and information flows between a point of resource origin and end consumption.

Figure 28

Different types of supply chains



Though the exact interpretation of their definition is debatable[26], what they essentially do is to distinguish between different types of supply chains based on at least three basic degrees of (structural) complexity that supply chains may possess (see Fig. 29), namely:

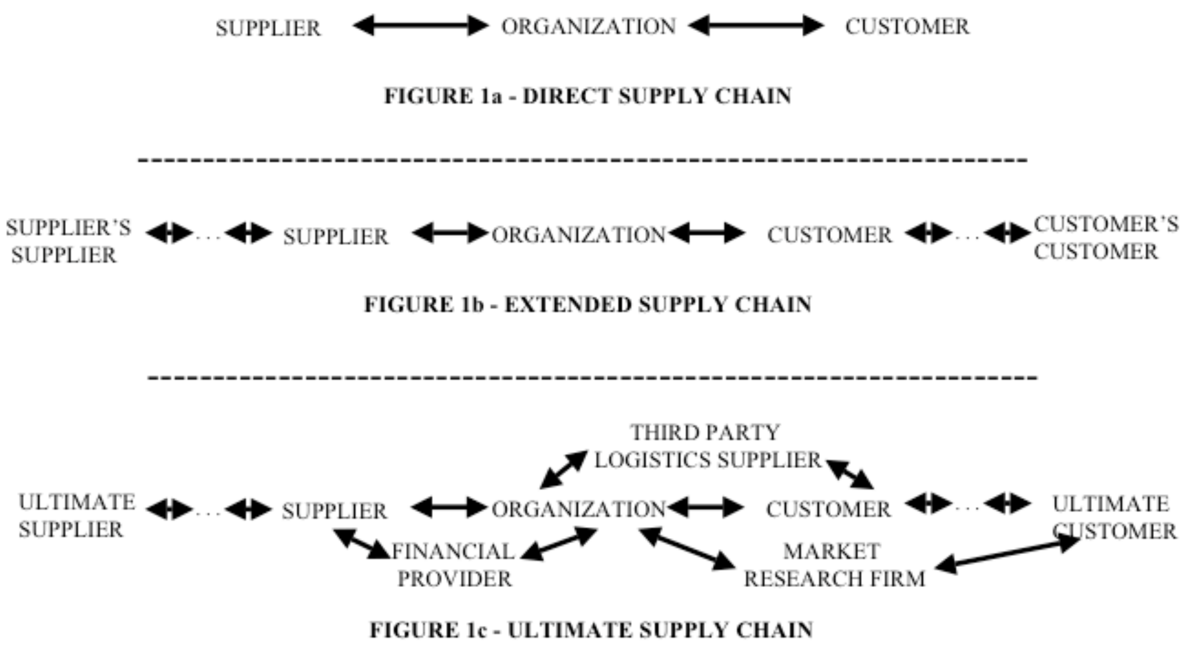
1. *"The direct supply chain"* – A direct supply chain consists of a company, a supplier, and a customer involved in the upstream and/or downstream flows of products, services, finances, and/or information.
2. *"The extended supply chain"* – An extended supply chain includes suppliers of the immediate supplier and customers of the immediate customer, all involved in the upstream and/or downstream flows of products, services, finances, and/or information.
3. *"The ultimate supply chain"* – An ultimate supply chain includes all the organizations involved in all the upstream and downstream flows of products, services, finances, and information from the ultimate supplier to the ultimate customer.

[26] For example, the Mentzer et al. (2001) definition is supposed to apply to both individuals, and firms.

Figure 29

Different degrees of supply chain complexity

(Mentzer et al., 2001)



From this it followed that a supply chain is inherently structurally complex because it consists of a minimum of three independent organizations, which require inter-organizational co-ordination mechanisms in order for the supply chain to create value. Following the thinking presented in Croom et al. (2000), if the arrangement were to consist of two firms, it would connote a dyad e.g. a buyer-supplier dyad (e.g. Harland et al., 1999), or a marketing channel dyad (e.g. Achrol et al., 1983), or even a partnership (e.g. Lamming, 1993; Macbeth and Ferguson, 1995), which would be (relatively) less structurally complex, merely based on the fact that there are fewer actors and inter-organizational issues that need to be considered.

Furthermore, it also made the following argument possible. A *"network-form" "inter-firm" value chain type* supply chain is inherently predisposed to higher structural complexity than other organizational forms like individual firms (that fit the description of the *"plant" type*), and even large corporations with extended operations like MNC's (that more appropriately fit the description of the *"intra-firm" production network type*). For example, Fig. 28 implied the following propositions that make the supply chain (*"network-form" "inter-firm" value chain type supply chain*) [e.g. Mentzer et al., 2001; Cooper et al., 1997] more structurally complex than the manufacturing network (*"hierarchical" "intra-firm" production network type supply chain*) [e.g. Cohen and Mallik, 1997], and less complex than the industrial network (*"market-form" "inter-firm" network type supply chain*) [e.g. Håkansson, 1982; Ford, 1997; Gadde et al., 2003]:

- *P_1 - structural complexity based on (channel) governance*
  Given that supply chain/channel governance in any supply chain type is a function of the type of supply chain links and the extent of vertical integration between supply chain partners, where channel governance is lowest, structural complexity shall be the highest. i.e.:
  Type 3 supply chains are more structurally complex than Type 2 and Type 1, and less complex than Type 4 supply chains.

- *P_2 - structural complexity based on actor attributes or actor configuration*
  Given that actor attributes and configuration like number of organisations in a supply chain and the number of sites they own/control affects structural complexity, where actor configuration is homogeneous, structural complexity shall be lowest. i.e.:
  Type 3 supply chains are more structurally complex than Type 2 and Type 1, and less complex than Type 4 supply chains.

In conclusion, it could now be stated that it is easier to implement overall governance & control in supply chain Types 1 and 2 and that they are more homogenous (under the same ownership) as compared to Types 3 and 4.

4.7. The supply chain as an environmentally complex organisational form

The final (and most relevant) aspect about supply chain organisational forms to this study concerned the degree to which it is predisposed to environmental complexity. Guisinger's (2001) framework on organisational-environmental relations, discussed in Chapter 3, proposes that environmental complexity accompanies structural complexity, and implies that the more structurally complex an organisational form is, the more predisposed it becomes to environmental complexity. Although developed in the context of a multinational enterprise (MNE/MNC), it was then argued that Guisinger's (2001) framework is fit for analyzing the different types of supply chain organizations discussed here in terms of their structural and corresponding levels of environmental complexity. Having modified Guisinger's (2001) framework, Fig. 30 illustrates this relevance by including the supply chain as a highly complex organisation in terms of its structure and environment.

This also opened up multiple research avenues, as one avenue envisaged out of this application (Fig. 30) was that of understanding the range and constituents of supply chain environments. It was envisaged that such a research avenue would aid in operationalising the concept of supply chain environments and would focus on e.g. what environmental accommodation of supply chain processes implies and what "geovalent" means in this respect; this is done in the next chapter (5). This was in line with the research objectives. However, a different research avenue could have involved testing the propositions laid down here - for example, to show that the supply chain (Type 3 - *"network-form" "inter-firm" value chain type*) is prone to more environmental complexity than the MNC (Type 2 -*"intra-firm" production network type*). This avenue was then only pursued to the extent that it led to propositions relating structural and environmental complexity, and thereby a further refinement of the provisional supply chain typology developed thus far; the refined typology is presented further on in the chapter. However, testing these propositions or confirming the proposed typology was ascertained as a different research project to the present study, and therefore remained beyond its scope.

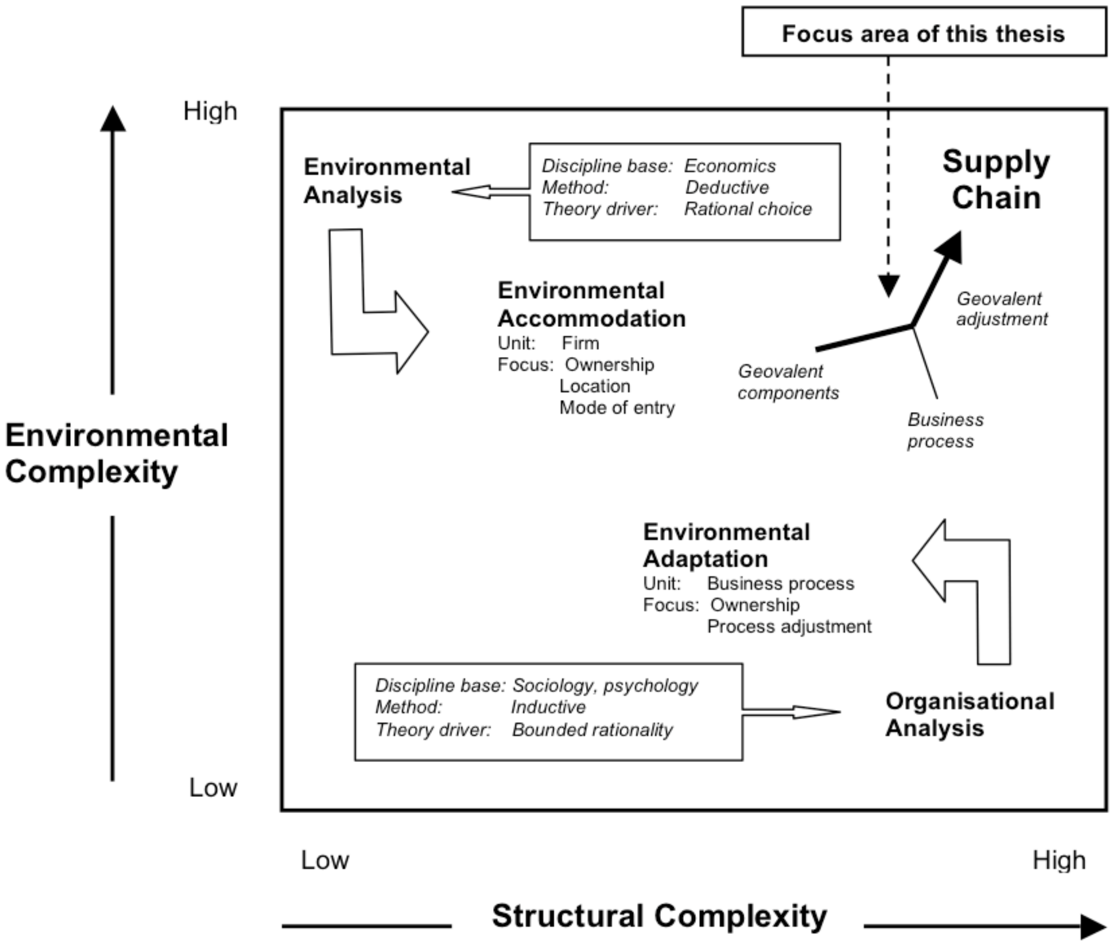
Since environmental complexity arises from the range and heterogeneity in an organization's environmental activities, the number and type of environments that the organization faces is key to determining the corresponding level of environmental complexity it is exposed to. To put different organisational forms into an *environmental complexity* perspective, one therefore needs to determine their range and heterogeneity. This was then accomplished by looking at their generic definitions, especially those, which provided an idea of their organisational scope; and then by mapping different (supply chain) organisation types against each other on these dimensions. Scope may imply many things. For example, within the area of supply chain operations, organisational scope may be considered in terms of geographic scope (e.g. Guisinger, 2001; Kotha & Orne, 1989; Stock et al., 1999); institutional scope (e.g. Kostova & Zaheer, 1999; Guisinger, 2001); competitive (market) scope (e.g. Stock et al., 1999; 2000); scope of organisational operations like manufacturing and logistics (e.g. Stock et al., 1999; Kotha & Orne, 1989) and other supply chain activities (e.g. Guisinger, 2001); scope of information requirements (e.g. Flynn & Flynn, 1999) or as Canon & St. John (2007) note, a mix of all these or a particular mix in order to solve a specific domain-related problems:

> *"In more recent years, researchers have focused on assessing the effect of complexity in particular settings and have adapted or proposed measures to suit particular purposes",* (Cannon & St. John, 2007, p. 302).

Figure 30

Geovalent adjustment and environmental accommodation of supply chain processes

(Based on Guisinger, 2001)



Since the problem formulation in the present thesis concerned itself with environmental complexity issues surrounding (globally) dispersed supply chain operations, with particular hints to macro environments as the object of analysis, it was decided to proceed with a geographic scope based definition of scope, and further on, with an institutional-, infrastructural- and technology- related aspects of this geographic scope. This is in accordance with the recommendations on *environmental complexity* research made by Cannon & St. John (2007).

Next, a discussion on each (supply chain) organisational type is performed in relation to its structural and environmental complexity. The process eventually resulted in a (final) modified typology of supply chains based on scope of their organisational operations (Fig. 31).

4.7.1. Environmental complexity surrounding the "hierarchical" "plant" type supply chain – the type $A_{(1\ and\ 2)}$ supply chains

The *"hierarchical" "plant" type* supply chain is essentially an intra-organisational type, and best connotes with literature on the single or individual firm, or the functionally specialised firm. For such a firm, the term supply chain implies the (focussed) operation it owns, and refers to its internal operations (intra-firm focus). Furthermore, a fully domestic focus with meagre support operations also comes to mind while conceptualising this type. Though there are a lot of empirical referents of this type in the broader (e.g. general) management discipline, the purpose here was to relate to examples of this type within the field of supply chain operations. And here, Skinner's (1974) *"focussed factory"* and Rudberg & Olhager's (2003) *"single-organisation, single-site"* and other connotations like *'the all domestic firm'* come to mind as examples. For the purposes of constructing a typology this type was then termed as Type A_1 and illustrated in Fig. 31.

It was also conceptualised that such a firm may in fact grow out of its current operation and expand its scope. For example, this could be conceived in terms of a firm moving to new consumer markets by changing its (primarily) domestic focus to include international exports. Typical examples from the supply chain area are Skjøtt-Larsen et al.'s (2007) *"globally concentrated production"* type supply chain, or connotations such as *'the all domestic firm with an export focus'* type supply chain. It was conceived that in such cases the supply chain would considerably expand its exposure to environmental complexity with only a marginal increase in the structural complexity required to support such an expansion. Such a supply chain type was then termed as Type A_2 and illustrated in Fig. 31 by adding outward arrows to Type A_1, illustrating this increased scope. The single coloured circle in both these types represents homogeneity of the supply chain environments, whereby both these supply chains were thought of being primarily domestic, operating in the same country.

4.7.2. Environmental complexity surrounding the "hierarchical" "intra-firm" production network type supply chain – the type $A_{(3 \text{ and } 4)}$ supply chains

Structurally still falling within the category A, and keeping in mind its geographical scope, the (loose) *"hierarchical" "intra-firm" production network* best fits the description of supply chains in the literature on international/global manufacturing networks and Multi National Corporations. This is to say that structurally it still maintains its intra-firm focus as in the other type A supply chains, but because the geographic scope expands to include more countries, the additional number of the (country) environments, and diversity between these environments imposes additional environmental complexity on operations. Here too, for the purpose of illustration, one could make a distinction between the multinational supply chain and the global manufacturing or production network. The multinational supply chain by its generic definition operates in at least two countries[27], thus generating a minimum environmental complexity by that factor; this type was then illustrated as Type A_3 in Fig. 31. Since the Multinational supply chain refers itself to literature on MNCs and thereby the International Business (IB) discipline, it was envisaged that this organisational type is the result of a well-conceived design process, whereby the design refers itself to the important factors of why firms should go international, when they should do so, and where they should go (e.g. the OLI framework – Dunning, 1977; 2000). Therefore this type of supply chain was conceived as *'made by choice or design'*, as being based on design-based coordination mechanisms, which restrict the complexity that additional scope brings. In supply chain literature, examples of such a type include *"the MNC production network"* (Rudberg & Olhager, 2003), and the supply chain subscribing to a *"Transnational vertical integration"* strategy (Skjøtt-Larsen et al., 2007).

Whereas, the global manufacturing network is both structurally and environmentally more complex, as it involves structural coordination of two or (generally) many sites that are intertwined in a complex, value creation logic and are dispersed globally. The aspect of poor integration amongst disparate nodes, spread out over a larger number of locations makes the "optimisation" task more difficult (Rudberg and Olhager, 2003). Though it could be argued that such a supply chain type could be natural evolution to the Multinational supply chain, it is also important to note that it seems more prone to being *'made by chance'* as opposed to *'made by choice or design'*. This supply chain type was termed and illustrated as Type A_4 in

[27] This definition was accessed through the http://globaledge.msu.edu/resourceDesk/glossary.asp?word=MNC resource on the Academy of International Business (AIB) website, 11/10/2008, 19:00.

Fig. 31, its graphical representation both showing a greater range and heterogeneity of its environments by depicting a greater range of countries (each different type of circle implies a supply chain node in a different country), and also a higher structural complexity by showing complex interconnections between the different nodes. Note that the bold line boundarying the supply chain denotes that it is yet an intra-organisational type, and that the same supply chain actor owns all these nodes and interconnecting operations. Examples of this type in supply chain operations literature include Stock et al.'s (1999; 2000) *"manufacturing enterprise"*, or familiar connotations such as *'the MNC with a global strategy'* and *'the global firm'*, and the supply chain following a *"Transnational vertical integration"* strategy (Skjøtt-Larsen et al., 2007).

4.7.3. Environmental complexity surrounding the "network-form" "inter-firm" value chain type supply chain – the type B supply chains

Even though one purpose of this chapter is to distinguish between different types of supply chains, there has been a tendency by the author to presume or allocate a certain understanding to the "supply chain" term until this point in the dissertation. As shall be clearer to the reader now, this presumption is based on the following type (B) supply chain, because it takes the Mentzer et al. (2001) definition as a starting point. A "supply chain" i.e. a *"network-form" "inter-firm" value chain type supply chain* has an inherent global scope in its operations in that its operations may be geographically spread out around the world (Stock et al. 1999; Guisinger, 2001); its three independent organisations may be conceived as being dispersed in three different locations (countries), which can pose both range and heterogeneity in the organisational environments. As in the categorisation of the other supply chain organisational types (A), here range arises from the 3 locations, and heterogeneity arises from the differences in the environments of these locations. Therefore, the Mentzer et al. (2001) definition of a supply chain implies this generically high level of structural and environmental complexity.

However, although this type of supply chain can generically imply global operations based on the above arguments, it may also imply minimal (geographic) scope in terms of a purely domestic type where all actors are based in the same country (Type B_1 in Fig. 31), a slightly higher scope where at least one out of the three is based in different countries (Type B_2 in Fig. 31), or the highest or extended scope where all three actors are based in different countries (Type B_3 in Fig. 31). Such supply chain types (B) were therefore argued to possess higher levels of structural complexity and environmental complexity as compared to types A. The dotted line boundarying the supply chain denotes that it is an inter-organisational type, and that different supply chain actors own all these links that interconnect operations between each other. Examples of this type in supply chain literature are Mentzer et al.'s (2001) *"direct supply chain"*, Rudberg and Olhager's (2003) *"multi-organisation, single-site" network,* Stock et al.'s (1999; 2000) *"manufacturing enterprise"* and *"network configuration"* type organisation and the supply chain following a *"Transnational vertical integration"* strategy (Skjøtt-Larsen et al., 2007).

4.7.4. Environmental complexity surrounding the "market-form" "inter-firm" network type supply chain – the type C supply chains

The final type of supply chain essentially originates in what Rudberg and Olhager (2003) term as *"the unfocussed network"*, and was conceived to derive its high structural complexity from its sheer size in terms of number of actors (independent organisations) involved in this network, and the complex array of nodes or sites belonging to each organisation that participate in this type of network. As Rudberg and Olhager (2003) phrase it:

> *"The focus of the complex network is most likely a combination of vertical and horizontal focus, resulting in an "unfocused" network. Concerning vertical integration issues, the extent is both narrow and wide; narrow for the part of the system that is under direct control, and wide on a collaborative basis",* (p. 36).

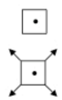
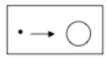
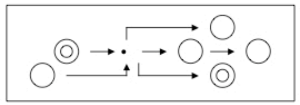
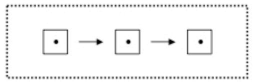
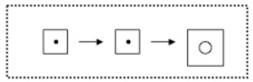
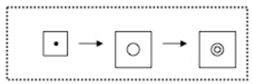
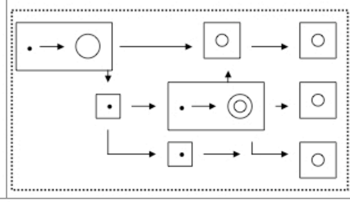
Just as with the previous types, the dimension of (geographic) scope was conceptualised in this type by introducing range and heterogeneity in the environments that the operations of such a complex network span; it was then termed as the Type C supply chain. Such a supply chain may be visualised as some combination of Types A and B in that it possesses important characteristics of both e.g. an intra-firm type (A) issues and inter-firm type (B) issues (see Table 2), for example:

> *"Both the number of organizations and the total number of sites within the system determine the size of the network. The location of the sites within each respective organization can be decided by the organization's corporate headquarters, but the location of collaborative partners' sites have to be taken into consideration",* (Rudberg and Olhager, 2003, p. 36).

The inherent (geographic) scope and corresponding environmental complexity that such a complex supply chain type (C) implies is immense, and relatively larger than any other types discussed here. This is primarily because each organisational actor in such a supply chain may be located in a different environment, and furthermore each organisational actor may have nodes/sites (e.g. units, divisions etc.) that are located in different environments. The sheer complexity in managing such a supply chain requires that coordination mechanisms that help manage such a disparate network be based on a “harmonisation” strategy, where “the coordination problems are ‘beyond’ optimization (of the intra-firm type A), and even synchronization” of the inter-firm supply chain type B (Rudberg and Olhager, 2003). Hatch (1997) describes such a complex supply chain as an *“interorganizational network”*, which is essentially a more balanced way of looking at organizational environments, where the concept of “focal company” or “channel captains” (e.g. in mainstream logistics management supply chain literature) gets blurred; such complex *interorganizational networks* represent a “complex web of relationships in which a group of organizations are embedded” (Hatch, 1997, p. 65). Accordingly, Type C supply chains were visually represented in Fig. 31 by showing different types of actors and nodes based in diverse locations. Note that a different dotted line boundarying the entire supply chain denotes (Type C) as a mix between an inter- and intra-organisational type (from an ownership and control perspective), where each of the nodes and links that interconnect operations are owned by the different supply chain actors. Examples of this type in supply chain operations literature could relate to Rudberg and Olhager’s (2003) *“unfocussed network”* and *“multi-organisation, multi-site”* type network, Skjøtt-Larsen et al.’s (2007) *“the global supply chain”* and the supply chain following a *“Host market production”* strategy (Skjøtt-Larsen et al., 2007); Stock et al.’s (1999; 2000) *“manufacturing enterprise”*; and because it tries describing the complexity in the entire supply chain from a resource base to the point of end consumption, Mentzer et al.’s (2001) *“the ultimate supply chain”*.

Figure 31

A geographic (scope) based typology of supply chains

Type	Organisation	Structural Attributes (1) *Channel Governance Type* (Stock et al., 1999; 2000)	Structural Attributes (2) *Production Network Type* (Rudberg & Olhager, 2003)	Structural Complexity (STRCOMP) Scale (1-4) (Guisinger, 2001; Kinra & Kotzab, 2008)	Scope of organisational operations (Kotha & Orne, 1989; Guisinger, 2001; Kostova & Zaheer 1999; Kinra & Kotzab, 2008; Stock et al., 1999; 2000)	Environmental Complexity (ENVCOMP) Scale (1-4) (Kostova & Zaheer 1999; Guisinger, 2001; Kinra & Kotzab, 2008; Canon & St. John, 2007)	Visual Representation	Description and Characteristics
A	Intra Organisational Supply Chain	The "hierarchical" type supply chain	"The Plant"	STRCOMP 1	Domestic A_1 SC_1, EC_1 International A_2 SC_1, EC_{1-n}	ENVCOMP 1		*"single-organisation, single-site"* (Rudberg & Olhager, 2003) *"the all domestic firm"* *"the focussed factory" (Skinner, 1974)* *"single-organisation, single-site"* (Rudberg & Olhager, 2003) *"the all domestic firm with an export focus"* *"globally concentrated production"* (Skjøtt-Larsen et al., 2007)
		"loose hierarchy"	"The Intra-firm Network"	STRCOMP 2	Multinational A_3 SC_2, EC_2 Global A_4 SC_{2-3}, EC_{2-n}	ENVCOMP 2	 	*"the MNC production network"* (Rudberg & Olhager, 2003) *"Transnational vertical integration"* (Skjøtt-Larsen et al., 2007) *"the MNC with a global strategy"* *"the global firm"* *"Host market production"* (Skjøtt-Larsen et al., 2007) *"the manufacturing enterprise"* (Stock et al., 1999; 2000)
B	Inter Organisational Supply Chain	The "network" type supply chain	"The Supply Chain"	STRCOMP 3	Domestic B_1 SC_3, EC_0 International B_2 SC_3, EC_1 Global B_3 SC_{3-n}, EC_{3-n}	ENVCOMP 3	  	*"the direct supply chain with a domestic focus"* (an interpretation of Mentzer et al., 2001) *"multi-organisation, single-site"* (Rudberg & Olhager, 2003) *"the direct supply chain with an international focus"* (an interpretation of Mentzer et al., 2001) *"the globally dispersed direct supply chain"* (an interpretation of Mentzer et al., 2001) *"Transnational vertical integration"* (Skjøtt-Larsen et al., 2007) *"the manufacturing enterprise"* (Stock et al., 1999; 2000)
C	Inter Organisational Supply Chain Network (Rudberg & Olhager, 2003) A_4 x B_3	The "market" type supply chain	"The Inter-firm Network"	STRCOMP 4	Global C_1 SC_n, EC_n	ENVCOMP 4		*"the unfocussed network"* (Rudberg & Olhager, 2003) *"multi-organisation, multi-site"* (Rudberg & Olhager, 2003) *"Host market production"* (Skjøtt-Larsen et al., 2007) *"the global supply chain"* (Skjøtt-Larsen et al., 2007) *"the ultimate supply chain"* (an interpretation of Mentzer et al., 2001) *"the manufacturing enterprise"* (Stock et al., 1999; 2000)

4.8. Distinguishing supply chains: a proposed typology of different supply chains based on their organisational scope

Fig. 31 presents a typology of different types of supply chains, on different structural and environmental dimensions, that resulted based on the considerations made so far. Stock et al.'s (1999; 2000) attributes of channel governance and ownership types (i.e. Market, Hierarchy or Network) have thus been used for structural dimensions, following which different supply chains have been categorised under *Structural Attributes (1)* in the typology. Rudberg and Olhager's (2003) structural attributes of operations/production network types (i.e. Plant, Intra-firm, Supply Chain or Inter-firm Network) have also been used in the typology to categorise different types of supply chains under *Structural Attributes (2)*. Following these groups of structural attributes, each type was then assigned with a degree of structural complexity. Whereas environmental attributes were operationalised using the notion of geographical scope (Guisinger, 2001; Kotha and Orne, 1989; Stock et al., 1999), and institutional-, infrastructural-, and technology-related scope as a result of this geographic scope. Following these groups of environmental attributes in mind, each type was then assigned with a corresponding degree of environmental complexity.

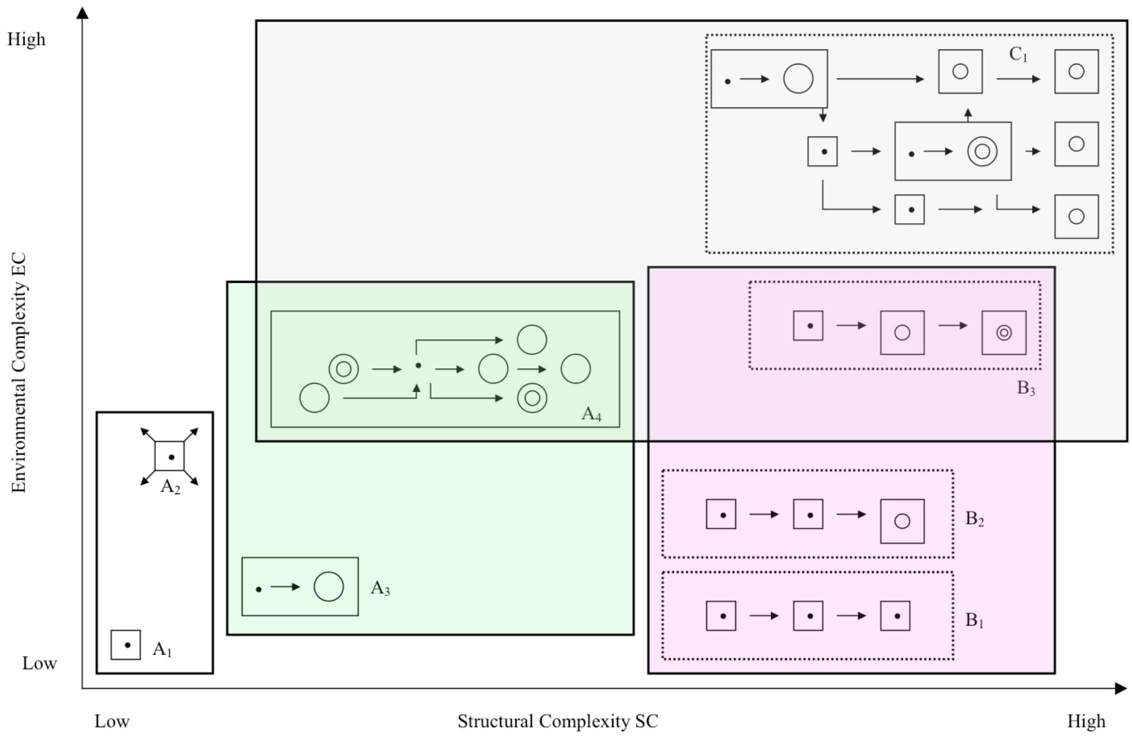
4.9. Distinguishing supply chains: mapping supply chains according to their structural and environmental complexities

Following the typology presented here, the three different types of supply chains (A, B and C) were then mapped in terms of their respective structural and environmental complexity. This is presented in Fig. 32, which also presents/proposes the envisaged range of expansion or contraction for each supply chain type by showing overlaps between each other. For example, a multinational supply chain (Type A_3) could be envisaged to grow and in this process may grow out into Type B (e.g. B_2 or B_3) supply chain where it establishes strong interorganisational links with its supply chain partners, or it could grow out more drastically and resemble a Type C supply chain where it is a part of a larger network of other multinational supply chains, connected to each other with weak interorganisational links.

Figure 32

Mapping different types of supply chains

with respect to structural and environmental complexity



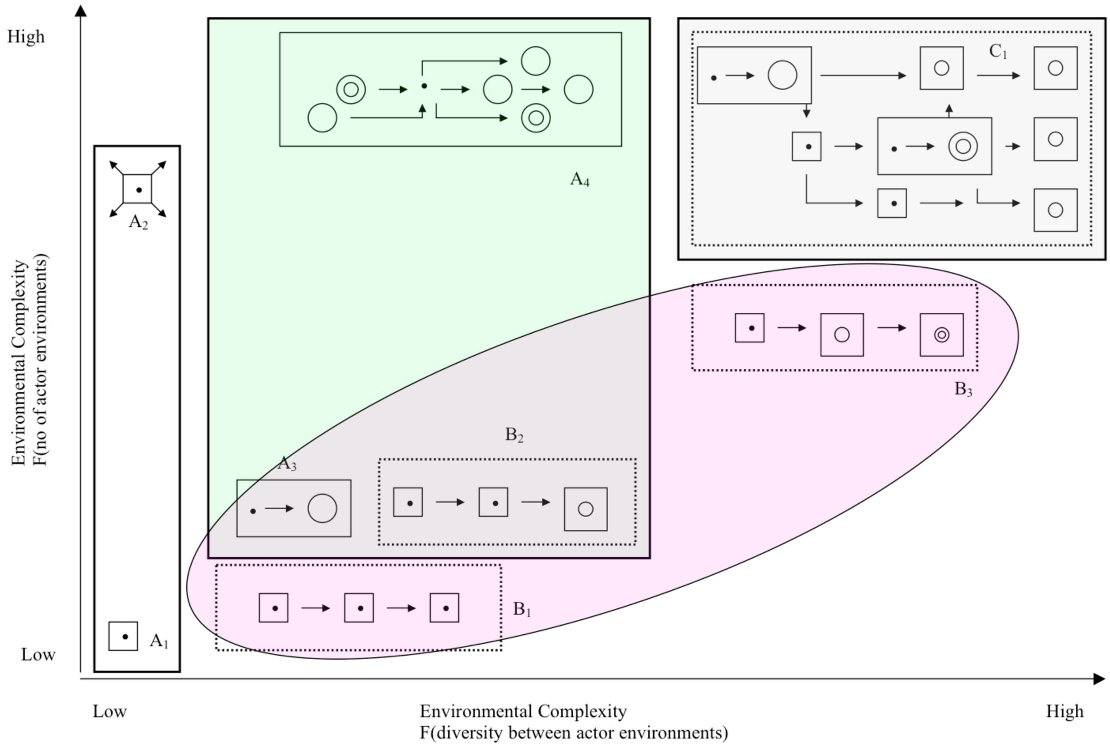
Similarly, the environmental complexity dimensions were then considered in isolation i.e. geographic scope of each supply chain type based on the two dimensions a) range, and b) heterogeneity, in order to map the different supply chain types in Fig. 33. Range implies the total number of environments (countries) the operations of each supply chain type may span, whereas heterogeneity, which is the opposite of homogeneity, implies the diversity between each of the environments (countries). In conclusion, propositions extending out of this process sought to distinguish between different types of supply chains based on dimensions of structural and environmental complexity.

4.10. Sub-conclusions with respect to RQ1

To recap, this chapter has defined the supply chain as an organisational form. This was necessary from two related perspectives, firstly in order to take the argument of organizational environments further, to develop/operationalise the construct; and secondly, in order to ascertain whether the construct of environmental complexity was in fact applicable to the supply chain as an organisational form. This chapter has then presented (theoretically)

Figure 33

Mapping different types of supply chains on environmental complexity dimensions



valid arguments for bringing the construct to supply chain domain and has demonstrated that supply chains are complex organisational forms, and as such face a higher degree of environmental complexity as compared to other organisational forms such as MNCs. Because of the inherent structural complexity of the supply chain as compared to other organisational forms, the need for understanding and measurement of its correspondingly high level of environmental complexity arises. More specifically, as demonstrated in this chapter, the definition of a supply chain involves extended organizational operations, or operations with respect to extended scope. This extended scope was demonstrated by showing relative differences in geographic scope e.g. between the supply chain, and the network as an organisational form.

Taking this aspect in combination with the managerial (environmental scanning) implications presented in Chapter 3, it became easier to understand the purpose and objectives of this study that intend to bring the construct to the supply chain domain. Furthermore the following sub-conclusions with respect to RQ 1, on the relevance of environmental complexity in extended supply chain operations, were rendered possible:

1. *The generic definition of a supply chain lends into the relevance of environmental complexity as each organisational actor may be situated in a different country; differences between these countries, in terms of their range and heterogeneity then become relevant as they can cause/describe the state of environmental complexity.*
2. *The supply chain is prone to higher levels of environmental complexity because the range of these countries and differences between each is more marked than in e.g. a multinational organisation.*

Finally, though unintended, this chapter resulted into a (geographic) scope-based typology of different types of organisational forms, which proposes and highlights the (organisational) differences, which cause/describe environmental complexity.

Chapter 5

Operationalising Supply Chain Environments

> *"Every organization exists in a specific physical, technological, cultural, and social environment to which it must adapt. No organization is self-sufficient; all depend for survival on the types of relations they establish with the larger systems of which they are a part. Environments are all those significant elements outside the organization that influence its ability to survive and achieve its ends",* (Scott and Davis, 2007, p. 18).

Having argued for the supply chain (Type B) as a distinct organisational form, the next step in this study constituted in determining its environment. The concept of supply chain environments could then be studied from the perspective of *organizational environments* (e.g. Emery & Trist, 1965; Duncan, 1972), which has been discussed in the earlier chapters. Operationalising supply chain environments was an important step (in construct development) in order to frame arguments regarding environmental complexity originating from supply chain operations i.e. one first needed to determine the constituents of these environments.

The chapter is structured in a way that first describes the understanding, constitution, specific dimensions and elements of supply chain environments as was adopted in this study. Following earlier discussions, there are at least two dimensions of the concept of organisational environments viz. the *general environment* and *task environment*. Here, each of these dimensions was pursued and applied in the supply chain context. This process then led to an identification of specific categories and decision factors that underlie supply chain environments, and consequently built up a position to answer the second research question, which is:

> ***Wha**t are the key (decision) factors and their (information) measures that operationalise the construct of environmental complexity in supply chain logistics environments?*

5.1. Supply chain (general) environments –*the macro dimension*

As brought forward in Chapter 2, the general environment surrounding organisations best relates to the *macro*-dimensions of the environment (Farmer & Richman, 1964; Osborn, 1976). For instance, with reference to Fig. 7, if the organisation in the centre of an environmental analysis represents the *micro*-dimension, its inter-organisational network represents the *meso*-dimesion, then the general environment surrounding these two represents the *macro*-dimension. While conceptualising organisational (general) environments, it becomes obvious that the level of analysis tends to be at the level of environments (e.g. see literature reviews carried out by Guisinger, 2001). According to Fig. 7, the general environment constitutes of various sectors i.e. culture, legal, physical, social, political, technology etc. Whereas population ecology theory seeks to explain environmental influences generated by the technical, physical and economic sectors, institutional theory seeks to explain influences by the social, culture, legal, political and social sectors. And since both theories seek to explain environmental influences at the level of the environment, in a way that resembles the environment's viewpoint of organisation-environment relations (Hatch, 1997), it is safe to relate these to the *macro*-dimensions of the environment. Therefore geographical, demographic, ecological and institutional demarcations in terms of continents, countries, regions, etc. come to mind while conceptualising general environments. And therefore, research domains such as international business, (international) operations management, and (global) supply chain management come to mind in terms of how each have accounted for general environment variables.

From this point of view, and because the supply chain is an organisation, supply chain (general) environments were conceptualised as being constituent of social, cultural, legal, political, social, technical, physical and economic sectors. The scope of the environment and of its constituent sectors was then envisaged as being dependent on the scope of the supply chain (Type B) activities, which in this case could vary between Type B_1, which is wholly domestic, to B_3 that is a global supply chain. The important point here is that the supply chain (Type B) environment was conceptualised as one that <u>typically</u> spans a host of different (country) environments, as different supply chain activities tend to be dispersed in different nations.

> *"...supply chains operate in a global arena. It is not uncommon for a company to develop a new product in the United States, source and manufacture it in Asia, and distribute and market it in the US, Asia and Europe"*[28]

The word *typically* is used to signify the state of inherent predisposition, as it was irrelevant to ascertain whether all supply chains meet this criterion, more so since the aim was to arrive at a generic understanding of supply chain environmental complexity.

28 Community of European Management Schools (CEMS) call for papers, "Supply Chain Management – Recent Trends and Future Perspectives", (2007).

Figure 34

The concept of supply chain environments

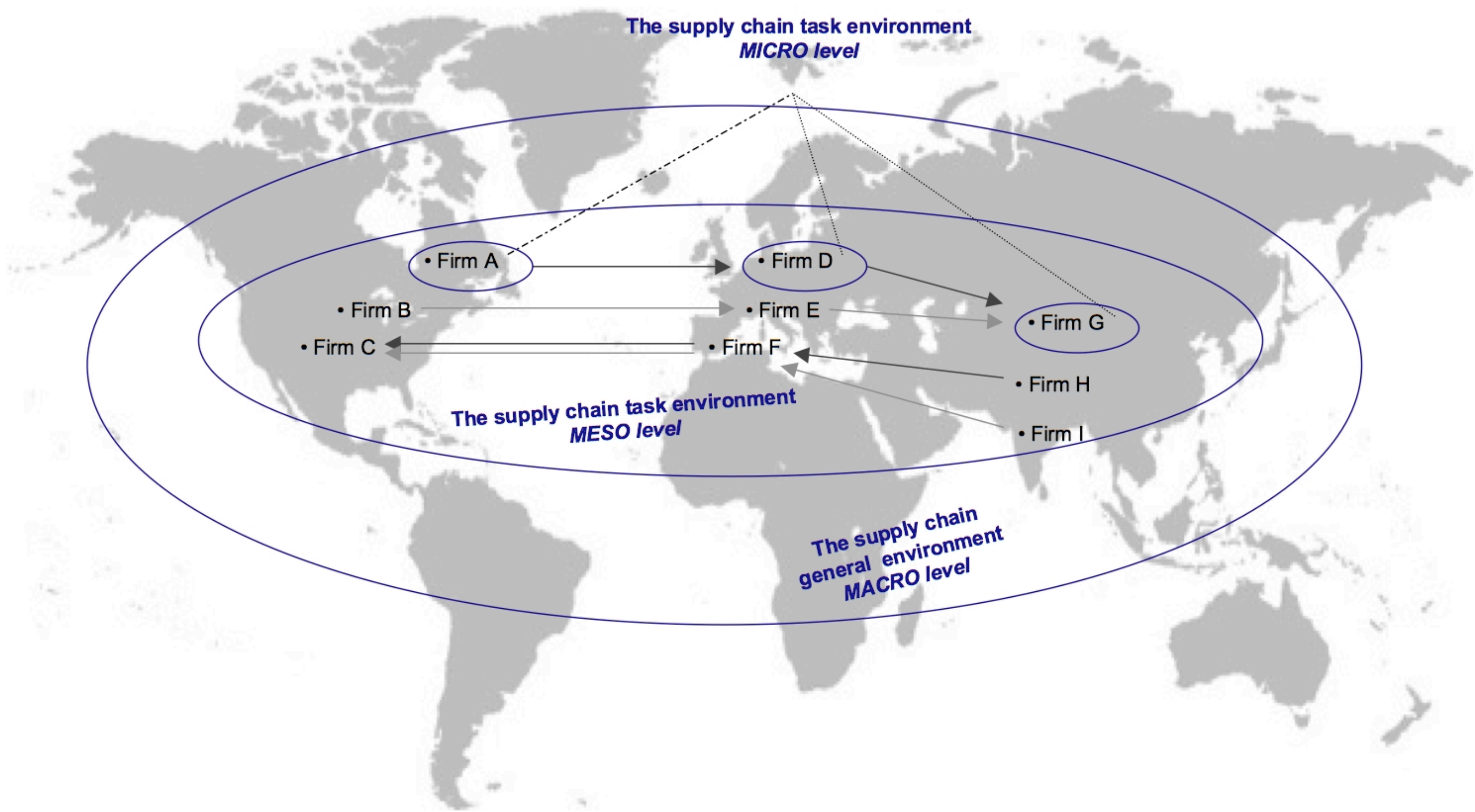


Fig. 34 illustrates this notion of supply chain environments by showing the expanded scope of supply chain operations in terms of its environmental levels (general = macro; task = meso/micro) and conceptually relevant sectors (e.g. social, cultural, economic etc. for the general or macro environment) that influence supply chain operations. Take for instance the (global) supply chain consisting firm's A, D and G, where each supply chain actor is placed in a different country environment. This supply chain then refers to an expanded (general) environment and environmental sectors consisting of some mix of the three different country environments.

5.2. Logistics: "The Task Context of Supply Chain Environmental Complexity" – *the micro and meso dimensions*

> *"Drawing a boundary around an organization is a difficult exercise and the implications of various definitions for decision-making situations must be taken into account when you make an analysis…It is not that one view is correct and the others are wrong; rather boundary definition is determined by your reasons for conducting an analysis",* (Hatch, 1997, pp. 96-97).

To interpret the above excerpt, a conceptualisation of supply chain (general) environments, or a segregation of the environment into its different layers is a futile exercise in isolation of the (study's) problem characteristics, or aloof of its (managerial) consequences of environmental scanning. This also meant that supply chain task environments are inextricably related to their general environments. Both these aspects are now brought out in the following discussion.

It is worth recalling that in a modernist organisational theory perspective, environmental segregations are made because they are helpful for analysis purposes, lest critical aspects of the environment aren't forgotten. Since task environments relate to immediate organisational environments (Osborn, 1976), and include all those organisations such as customers, partners, regulatory bodies, suppliers etc. (Bourgeois, 1980; Hatch, 1997), they represent all those elements or sectors that relate to immediate organisational tasks e.g. formulating a 'domain navigation' strategy (Bourgeois, 1980). For instance, this task could well refer to an operations issue that involves devising a logistics strategy. The immediacy and nature of the task itself defines different types of task environments and how the organisation interacts with these.

In this way, a task environment best related to the *micro- and meso-* dimensions of the organisational environment. For example, Hatch (1997) refers to the task environment as the *"interorganizational network"*. As does Osborn (1976) who also states that this network may not be necessarily confined to one, single, homogeneous general environment as in the case of a single country, thus lending support to the conceptualisation in Fig. 34. Whereas, if one had to further distinguish between the *micro-* and *meso-*dimensions of task environments, such a distinction could be made using resource dependence theory, one that views the environment more from the organisation's viewpoint (Hatch, 1997). From the author's perspective, resource dependence theory is more about how organisations (at the *micro-*level) control, negotiate, and deal with environmental uncertainty at the task level (e.g. a group of suppliers), by forming new organisations at the *meso*-level e.g based on strategic alliances, developing relationships, merger, acquisitions etc. (Pfeffer and Salancik, 1978). In other words, understanding power/dependence relationships helps managers in (re) defining organisational structure choices. Such a distinction between *macro-*, *meso-*, and *micro-* in SCM literature shall be clearer in the next sub-section, where the main findings from a related/parallel publication (Kinra and Kotzab, 2008b) are presented.

These considerations then brought out the following important aspects: first, managers define their task, and narrow down their environments according to the nature and characteristics of the problem at hand. Second, managers scan their task and general environments at different stages, with different frequencies, and for specific needs in order to determine uncertainty in their environments (Bourgeois, 1980). This gives rise to (the concept of) transcendence between general and task environments, whereby only those sectors in the general environment transcend into managerial decision-making at the task level, which are relevant to the manager's immediate problem domain. Since logistics formed the point of departure in this study's objective of developing supply chain environmental complexity, the logistics industry or sector, and logistics operations and activities, became the task environment. The following paragraphs then provide explanation on the constituents of logistics (task) environments.

The concept of logistics environments, in this study, thus originated in the concept of organisational task environments (e.g. Osborne, 1976), and built on the understanding of logistics that has been delimited in Chapter 1. It is a relatively new idea in the field, and Stock and Lambert (2001), Grant et al. (2006) and work by John Kasarda, Noel Greis and

Gregory Stock deserve special mention in this regard. For example, in creating a distinct niche for the concept of logistics environments, Gregory Stock et al. (1999) put forth:

> *"Logistics has, in the past, been considered a narrowly-defined functional activity concerned with tasks such as transportation, warehousing, inventory, and materials management. A new concept, that of the "logistics environment" must also be considered",* (p. 38).

Similarly, as briefly brought up in the earlier chapters, Grant et al. (2006) follow the tradition of Stock & Lambert (2001) in conceptualising a niche for the logistics environment, whereby they put forth that each logistics activity such as transportation, warehousing, packaging etc. form the task of the logistics executive and thereby relate to a (controllable) task environment, which lies in the logistics executive's capacity to influence. On the other hand, what is uncontrollable by the logistics executive are sectors of the general environment. It is interesting to note that such a perspective also represents a modernist organisational theory perspective of conceptualising organisational environments.

Stock et al. (1999) also represent an important contribution in the direction of logistics environments, as they point out the importance of logistics in managing discrete, dispersed, loosely structured supply chain operations by making use of competences existent in an 'industry's logistics environment'. According to this perspective, (e.g. manufacturing) firms operate within an (particular) industry logistics environment that sets the boundary for the choices available to firms within that industry in terms of logistics activities. Stock et al. (1999) therefore lent support to the conceptualisation of supply chain task environments in Fig. 34 by providing for the (logistics) industry as a task environment at the meso level.

Grant et al. (2006), through their framework, therefore offered conceptual repercussions for operationalising supply chain environments in this study, in terms of how each general environment sector, such as political conditions in a country, influence warehousing and storage options for logistics executives operating in that country. Whereas Stock et al. (1999) bridged the gap between the general environment (macro level) and the logistics activity (micro level) by setting up a meso-level "logistics" task environment, to which the logistics executive refers while performing his/her task. To exemplify this from an information processing perspective, if 'air freight' is the competitive norm in an industry, then it could preoccupy the executive in the following ways: 1) whether this option is available in the logistics task environment (e.g. are there suppliers in the industry) and; 2) depending on the strategic scope of the executive's job description, whether there are general environmental factors at the macro level, that facilitate or impose constraints in the attainment of this competitive norm. In the 'air freight' example used here, these (factors) could then be government regulations on transportation, or geographic characteristics affecting quality and quantity of airports in a country or region, and thereby the 'air freight' option. This is in fact what transcendence between general and task environments implies, as only those sectors of general environment that were relevant to the manager's immediate problem domain, transcended into managerial decision-making at the task level. From an environmental complexity perspective involving differences between country environments, the operationalisation of supply chain environments then connotes with the macro-constraints, and thereby the macro (logistics) systems that impede the attainment of the immediate logistics task.

5.3. Demonstrating the *macro-*, *meso-*, and *micro-* dimensions of supply chain environments

The *macro-*, *meso-*, and *micro-* dimensions of supply chain environments discussed here were subsequently also ascertained through a literature review in a sub-domain of supply chain management (i.e. production economics), where Kinra and Kotzab (2008b) demonstrate how supply chain literature tends to preoccupy itself with the (dominant) *micro-*, and (increasing) *meso-* levels of analysis when conceptualising various supply chain problems. In line with the discussion presented in the previous section, they too posit that supply chain logistics problems may arise because of constraints faced at different levels – firm, supply chain, country of operation. Firm level logistics problems refer to systems at the micro-level, and those at the level of a supply chain refer to meta/meso-systems dealing with (logistics) partnerships between firms. Whereas macro-logistics, at the country level, is the primary system that provides the necessary institutions and infrastructure for all logistics systems. According to Kinra and Kotzab (2008a), although this way of distinguishing supply chain (logistics) environments is well engrained and accepted in the German logistics literature, it is yet to materialise in the broader supply chain literature (e.g. in the American and International journals). The latter primarily deals with *micro-* and/or *meta/meso-* systems, which means that the research objects are either flows between supply chain actors or problems that are solved on a company level (see e.g. Pfohl, 2004 or Ihde, 2001).

It was therefore interesting to note how existing literature on SCM treats supply chain environments. For example, the supply chain is increasingly seen as a micro institution as a part of a broader supply chain macro institution, which means that the focus is on individual organisations or the interplay of individual organisations in a given setting. Since their literature review found all supply chain problems to almost entirely fit within the task context of supply chain environments, at the *micro/meso*- levels, Kinra and Kotzab (2008b) rationalise that the general environment within or with which systems at the *micro/meso*-levels are co-embedded, is perceived as given and fixed. In other words, the *macro*-level of analysis is lacking. These findings then also reinforced the rationale for the present dissertation, for focussing on macro- logistics systems, supply chain general environments and the environmental complexity concept. The next section documents the development of all those broad categories of factors through which supply chain (*macro*-) environments were operationalised.

5.4. Specific categories of supply chain logistics environments: the macro-infrastructure, institution, and technology-diffusion categories

The study then applied the modernist perspective of environment-organisation relations, in order to take the process of operationalising supply chain environments a step further, in terms of its specific categories. This was done by developing the broad categories of general environment sectors that surround the supply chain at the *macro*- level. This section presents the process of developing these environmental categories through 1) an explicit consideration of the physical, economy, technology, political, and legal environmental sectors, documented in Fig. 7. and; 2) by applying theoretical notions on organisational environments and their operational referents, especially those referring to the various measures of environmental complexity that have been presented in the theoretical framework for this study. Measures related to institutional and technology domains of the general environment could therefore be visible in the ensuing operationalisation.

Yet again, there were two considerations in operationalising supply chain environments, namely that of building broad categories corresponding to environmental sectors such as political, legal, economic etc. relevant to the supply chain (Type B), and that of applying these categories to the logistics task environment. Therefore the study needed a starting point in terms of studies that fit the description of these two dimensions of operationalising supply chain environments before embarking on more detailed analyses. In terms of its problem characteristics, this study then needed a starting point with respect to global supply chain (logistics) operations corresponding to the (Type B) supply chain. Moreover, it was required that parity be established within and between these two dimensions in order to ascertain that the same phenomenon - that of supply chain environments – was under observation. Guisinger (2001) was therefore identified as an important starting point in terms of the first dimension, i.e. building broad categories of supply chain general environments. This was because the study offered (8) categories that a) are exhaustive, mutually exclusive, partly quantifiable, and globally reproducible (Guisinger 2001); b). are explicitly relevant for managing individual supply chain operations; and c) refer to the international business environment, which is an important feature of and very relevant to the (Type B) supply chain. Guisinger (2001) refers to these categories as *'geovalent components'*. The term geovalent as in 'geovalent component' of the environment (also see Fig. 30) implies all types of environmental forces that impact firms, supply chains and other organisational types, but are not themselves organisations:

> *"The geovalent component comprises all other environmental forces that impact on the firm but are not themselves organisations: institutional rules, regulations, cultures and exchange rates, for example. The geovalent elements, unlike organisations, are not mobile, but are fixed in geographic space, usually but not always, following national boundaries….they have the potential for directly and significantly affecting the performance of firms…they are to some extent quantifiable, permitting measures of how they vary over time and space",* (p. 266).

Even though *'Geovalent'* as a word may be relatively hard to come across in an English language dictionary, and Guisinger (2001) prefers to discuss environmental 'geovalence' in terms of institutions and thereby uses an institutional theory perspective, from the author's point of view it (geovalent) clearly refers to all sectors of the general environment that are covered in a typical organisational theory book (e.g. Hatch, 1997). Moreover, it is clear that he refers to the supply chain general environment component in Fig. 34, or the general or *macro-* level environment surrounding a (Type B) supply chain. Therefore, Guisinger's (2001) geovalent components were adopted from the dimension of building broad environmental categories. Incidentally, as can be evident by the work of Myers et al. (2006), these (similar) categories are now also gaining popularity in the SCM problem domain of global supply chain management.

Next, although Guisinger (2001) provided a good foundation, in understanding the general environment surrounding global supply chain operations, it lacked in the second dimension, that of (direct) relevance to the logistics task. It was hard to arrive at definitive factors of supply chain logistics environments by following Guisinger's proposed taxonomy. For instance, how do we know that these categories, and illustrative factors (elements as he refers them to) of each category are relevant for the logistics task? For this reason, Bagchi (2001) was identified as a relevant study. Bagchi (2001) is one of the few studies that exclusively focus on the logistics task while working on the *macro-* dimension of supply chain environments by taking the *macro-* environment (country) as the level of analysis. It does this by suggesting logistics related factors that impede the essential flows of supply chain management (i.e. physical, information, payment and ownership flows) at the country level and categorises them under *physical infrastructure*, *institutional*, and *technology* factor types (see Fig. 35).

However, the highest level of theoretical rationale that Bagchi (2001) could offer, was similar to the 'logistics costs' (e.g. Bowersox, Calantone and Rodrigues 2003; Rodrigues, Bowersox and Calantone 2005) and the 'country level constraints' (e.g. Hausman, Lee and Subramaniam 2005) one. For example, Bagchi (2001) offers neither any higher-order theoretical rationale, nor any specific task-oriented (i.e. emanating from logistics/SCM theory) rationale in grouping *macro-* level logistics factors as he does in Fig. 35. Kinra and Kotzab (2008a; 2008b) therefore had to come to terms with how Bagchi's (2001) construct – competitiveness/competency – actually refers to environmental complexity, and that his grouping makes sense and actually finds its roots within the broader SCM and logistics conceptual literature. They did this by relating Bagchi's (2001) categories to (fundamental) logistics/SCM notions presented in Handfield and Nichols (1999), Bowersox and Closs (1996) and Closs and Mollenkopf (2004).

Nevertheless, Bagchi (2001) represented a good starting point for this dissertation because it took into account a broader (supply chain) perspective by considering other supply chain competitive priorities (e.g. responsiveness) as well. It is one of the very few studies that provide an approach to categorise *macro-* level logistics factors. Moreover, Bagchi (2001), in addressing the problem, also employed a similar scientific approach to the present study. Therefore, this study found it relevant to build upon Bagchi's (2001) categories and *physical infrastructure*, *institutional*, and *technology* factors for operationalising supply chain environments.

Figure 35

A category of supply chain logistics macro- environment factors

(Bagchi, 2001)

Factor	Means	Type of flow it affects	Major Operations Efficiency Metrics
Physical Infrastructure	Transport Modes : ◆ Road ◆ Rail ◆ Water ◆ Air ◆ Intermodal Micro-infrastructure ◆ Waterhousing ◆ Ports	◆ Material ◆ Information	◆ Average Transit time and variance ◆ On-Time delivery ◆ Loss and damage ◆ Accidents ◆ Value added per employee ◆ Operating ratio ◆ Load factor ◆ Vehicle to road ratio ◆ Road space % ◆ Length of network per unit population ◆ Pipeline inventory ◆ Type of road surface/track ◆ Customatization of routes ◆ Use of hub and spoke system ◆ Average port dwell time ◆ Net asset turns ◆ Cash-to-cash cycle
Institutional	◆ Regulations and administration ◆ Banking and Insurance ◆ Materials Management Methods ◆ Judicial system ◆ Education and training ◆ Professional associations	◆ Material ◆ Payments ◆ Ownership	◆ Claims handling ◆ Average payment delay ◆ Customs delay ◆ Educational institutions with logistics major ◆ Use of EDI in banks ◆ Currency convertibility Administration of judicial systems transparency and backlogs
Technology-Use and Rate of Diffusion and Adaptation	Information Technology And Communications ◆ Logistics information systems ◆ Electronic data Interchange (EDI) ◆ E-commerce ◆ RF/Bar codes/Smart cards	◆ Information flow order processing ◆ Payments flow	◆ Call completion rate ◆ Telephone penetration ◆ Internet penetration ◆ IT expenditure, % ◆ E-commerce business volume ◆ Bandwidth, transfer rate, bps

Finally, to conclude this phase of research, the study sought to establish parity between the Guisinger (2001) and Bagchi (2001) categories. . This parity was subsequently established and (peer-) reviewed through Kinra and Kotzab (2008b). Fig. 36 demonstrates how each of Guisinger's (2001) categories and factors that were developed in lieu of the general environment of operations with an extended scope, correspond to the Bagchi (2001) categories and factors.

5.5. Sub-conclusions with respect to RQ2

At the conclusion of this stage, this study had achieved its purpose in construct development to the extent of operationalising (the concept of) supply chain environments. This was achieved by providing in-depth treatment of its constituents in terms of the general, and task environment contexts. In particular, **logistics was formally considered for the first time**, as it was defined and chosen as a point of departure, as the task environment. This led itself into an identification of those studies that (specifically) offered categories and factors of supply chain logistics environments. After a thorough scrutiny that involved evaluating its advantages/disadvantages, Bagchi (2001) was established as an important study, but only in terms of a starting point in that the varied constituents of supply chain environments mentioned in Bagchi (2001) needed further verification. Therefore, these specific categories and factors represented a starting point for further construct development. Fig. 35, which is adopted from Bagchi (2001), lists these preliminary factors in a systematic manner. For example, *road*, *rail* and *air* in a given (country) environment are some of the factors that operationalise supply chain logistics environments within the physical infrastructure category. Whereas, *banking and insurance* and *judicial systems* are factors that fall within the institutional category. Having done this, the study was in a better position to explain the constituents of supply chain environments, in terms of (decision) factors that operationalise the construct of environmental complexity in supply chain operations (RQ 2). The next phase then involved framing a theoretical model on the construct of supply chain logistics environmental complexity, achieved through a preliminary validation and refinement of the factors presented here.

Figure 36

Establishing parity between the Guisinger (2001) and Bagchi (2001) categories (Kinra and Kotzab, 2008b)

Guisinger (2001)		Bagchi (2001)	
Illustrative Geovalent elements posing environmental complexity	**Examples of attributes defining each element**	**Corresponding categories of supply chain logistics factors**	**Macro-institutional factors used for operationalising and corresponding to "geovalent elements" in this paper**
Econography	*Climate, proximity to major markets, Physical size, Infrastructure*	*Physical infrastructure factors" & "Technology use, rate of diffusion and adaptation factors*	*Roadways, Railways, Airways, Shipping, Warehousing space, Ports; Information systems infrastructure as typified by e.g. rates of telephone penetration, internet penetration*
Culture	*Values, Attitudes, Beliefs*	*Institutional factors*	*Rules and regulations governing ownership flows; Judicial systems*
Legal systems	*Common, Civil, Religious law,*	*Institutional factors" affecting supply chain logistics flows*	*Rules and regulations governing ownership flows; Judicial systems*
Income profile	*GNP per capita, Growth of GNP, Income inequality*	*Since Bagchi's (2001) study is in a developing country context, he links "Technology use, rate of diffusion and adaptation factors" and "Physical infrastructure factors" to income profiles*	*Roadways, Railways, Airways, Shipping, Warehousing space, Ports; Information systems infrastructure as typified by e.g. rates of telephone penetration, internet penetration*
Political risk	*Government instability, Corruption, Bureaucratic instability, Quality of government*	*Institutional factors*	*Political stability; Rules and regulations governing ownership flows; Judicial systems*
Tax systems	*Effective tax rate for multinational firms*	*Institutional factors*	*Economic policy and structure conduciveness*
Exchange rates	*Exchange rate variability, Exchange rate overvaluation/undervaluation*	*Institutional factors*	*Economic policy conduciveness; Economic structure conduciveness*
Government restrictions	*Tariffs, Quotas, Investment controls*	*Institutional factors*	*Rules and regulations governing ownership flows; Judicial systems*

Chapter 6

Operationalising Complexity in Supply Chain Environments

The next stage of construct development represented the task of conceptualising supply chain logistics environmental complexity. Having given an in-depth treatment to the topic of supply chain environments in Chapter 5, the study then concentrated on developing the construct in a more meaningful way. For this purpose, this chapter is structured in a way that documents the following tasks that were undertaken at this stage: 1) the task of further developing and verifying the decision factors underlying supply chain environments, that were presented in Chapter 5; 2) the task of framing these factors in an *environmental complexity* argument in order that it was clear how these were related to environmental complexity; 3) the task of developing (information) measures on these factors; and 4) based on the previous three, the task of proposing a theoretical model on the construct. It was envisaged that performing these tasks would place the study in a better position to verify the *key (decision) factors that operationalise the construct of environmental complexity* (RQ 2); and would also offer a position to understand and answer the second aspect of RQ 2 i.e. *(information) measures of these decision factors*. These tasks were then achieved by applying notions presented in the previous chapters, especially those relating to methods and issues on (environmental complexity) construct measurement from Chapter 3, and those relating to the elaborate treatment of supply chain environments in chapter 5. The chapter now begins by documenting the task of framing the construct.

6.1. Framing a construct and model on supply chain (logistics) environmental complexity

Keeping in mind all the theoretical considerations made so far, and the logical buildup to a supply chain construct demonstrated in the previous few chapters, the author framed supply chain (logistics) environmental complexity as follows:

> *Supply chain logistics environmental complexity is an environmental complexity originating in supply chain environments. This environmental complexity arises because of extended supply chain organizational operations. In this study the subject of interest is the Type B supply chain as this matches closest with the target disciplinary domain, namely logistics and (global) supply chain management. Environmental complexity arises because of the geographic dispersion of the (Type B) supply chain. Because of the international business perspective applied to understand this dispersion, it arises because operational activities take place in various countries. The Type B supply chain is more structurally complex and is predisposed to more environmental complexity than the Type A, and less complex than Type C supply chains. The extended scope of this organization concerns the logistics task, and therefore extended supply chain logistics operations. Whereas the extended scope of this organization, and environmental complexity, is formulated in terms of geographic scope, and institutional-, infrastructural- and technology-related scope as a result of this geographic scope. Supply chain environmental*

complexity then arises as a result of differences within the extended organizational (i.e. supply chain) environment, and may be operationalised using geographic scope driven, institutional-, infrastructural- and technology- related factors that underlie the environments. In other words, differences in these factors across supply chain environments cause/describe environmental complexity. To analyse (measure) these differences is to analyse (measure) supply chain environmental complexity.

This propositional description of supply chain environmental complexity framed the construct in a manner that is self-explanatory and in a manner that directly applies the notions presented in the last three chapters. However, one aspect warranted clarification i.e. the differences between (the yet ambiguous) supply chain environments causing environmental complexity to supply chain logistics operations. Accordingly, the study built on operational referents of supply chain logistics environments, more specifically on Bagchi's (2001) categories of supply chain environments (section 5.4.), in order to frame the construct of supply chain logistics environmental complexity. It was therefore put forth that differences between these - *physical infrastructure*, *institutional*, and *technology* – factor types across each geographic (i.e. country) environment that the (Type B) supply chain logistics operation spans, causes/describes environmental complexity. Since a decision-making approach to framing the construct was being applied, these factors are interchangeably referred to as decision factors in this study. Specifying the full range of these - *physical infrastructure*, *institutional*, and *technology* – decision factors was thus envisaged to contribute towards satisfying the first theoretical convention of construct operationalisation that is mentioned elsewhere in the dissertation (see e.g. theoretical delimitations). Whereas specifying a theoretical model, by presenting a structured hierarchy of the construct that allows for comparing and measuring differences between these decision factors across different environments (countries), was envisaged in order to contribute towards the second theoretical convention on environmental complexity.

6.2. The range of decision factors that operationalise supply chain logistics environmental complexity

Parallel, related publications made during this study, namely Kinra and Kotzab (2008a; 2008b), then provided foundation to Bagchi's (2001) categories by arguing that his construct (competitiveness/competency) and range of qualitative and quantitative factors in fact seek to capture supply chain environmental complexity, thereby highlighting the latency and multi-dimensionality aspects of the construct discussed in Chapter 3. With the main purpose to further refine these categories and decision factors in future research, these publications put forth a tentative structure to categorise the range of factors that constrain the design of the main supply chain flows, thereby causing supply chain environmental complexity. The following subsections document the chronological process of further refinement of these environmental categories and decision factors *post*-Kinra and Kotzab (2008a).

6.2.1. Initial round of content analysis to determine the range

As the study progressed *post*-Kinra and Kotzab (2008a), their range was first modified to include decision factors, some of which were either totally left out (e.g. *pipeline transportation*) of the analysis by both Bagchi (2001) and Kinra and Kotzab (2008a), or were mentioned but not treated in the analysis (e.g. *intermodal infrastructure*). An **initial content analysis** in the domain gave an indication that these decision factors could be important. Fig. 37 presents this (1st version) modified range of decision factors in a tabular format. The ticks (√) and crosses (x) therefore indicate the decision factors that were/not given treatment by Bagchi (2001). The other data in Fig. 37, such as author information, research problem and methodology, level of analysis and type of publication provides the all other relevant information, which was also used to embark on a more detailed analysis in the domain of logistics and supply chain management. This round was then meant to be a starting phase of a more detailed content analysis and state-of-the-art review of the topic in the domain.

6.2.2. First round of content analyses to short-list the full range

Next, the **first round of content analyses** was performed in order to short-list and finalise the complete range of factors that need to be incorporated into a theoretical model. Once all the necessary decision factors were established through this first round, a theoretical model could then be put forth and could be the subject of validity in the forthcoming stages/chapters. A more detailed demonstration of these decision factors and their interrelationships with the construct are, however, saved for the next section, where this is documented in the context of building a theoretical model on supply chain logistics environmental complexity.

The first round of content analysis then began with the *17 decision factors* listed in Fig. 37, whereby the initial list was modified both terminologically as well as in terms of the total range (quantity), to a new total of *21 decision factors*, as about 8 new factors were first introduced and then the list was finally contracted to its final size (of *21*).

Figure 37

Range of supply chain logistics environmental complexity decision factors (v1)

(Based on Kinra and Kotzab, 2008a)

	Authors:	Bagchi (2001)
	Publication:	*SC Forum*
	Type:	Logistics /SCM academic journal
	Problem Methodology & Notes:	Supply chain competence DS problem for policy makers: AHP application study with Illustrative environmental analysis.
	Unit:	*India Brazil China USA*
Type of supply chain flows	Decision factors	
Physical flows	Roadways	√
	Railways	√
	Airlines	√
	Ports & shipping	√
	Pipeline	X
	Intermodal infrastructure	√
	Warehousing	√
Information flows	Text communication	√
	Telephone penetration	√
	Internet penetration/ IT infrastructure/EDI	√
	Postal services	X
Payment flows	Economic policy	√
	Economic structure	√
	Liquidity	√
Ownership flows	Rules & regulations	√
	Judicial system	√
	Political stability	√

This was done using a state-of-the-art analysis, which involved a review of the domain, and the specifics of which may be highlighted as:

- *An identification of 22 studies with emphasis on environment analysis, and similar characteristics to the underlying problem of this PhD dissertation were identified in the domain (see Fig. 38).*

- *An identification of 25 broad (decision) categories of factors affecting global logistics decisions.*
- *All studies had a (extended/global) logistics & SCM orientation.*
- *95% dealt exclusively with logistics & SCM issues.*
- *20% practitioner publications, 50% academic journals, 30% discipline textbooks.*
- *Very few empirical, most of them conceptual and application studies.*
- *Most of the empirical & application studies were modelling oriented.*

From the list of 22 studies that were identified, only 9 studies (the ones highlighted in colour in Fig. 38) were short-listed as being relevant based on the criteria that they best matched the research profile of this dissertation, both in terms of their problem characteristics, and in terms of their paradigmatic approach applied to deal with the problem. Therefore all (7) discipline textbooks were dropped from the list because these only discussed the subject from a conceptual view-point; and the other (6) studies were dropped either because these focussed too much on the problem characteristics (e.g. Goh & Ang, 2000; Hesse & Rodrigue, 2004), or the methodological characteristics of solving the problem (e.g. Min & Eom, 1994); or because these were peripheral to the problem domain (e.g. Kovacs & Spens, 2006; Hesse & Rodrigue, 2004). Next, as the content analysis proceeded from its initial starting point of 17 factors, this list grew to a total of 25 factors at the height of the analysis, where all studies and all decision factors were comprehensively representable in the table. In the end, and as mentioned above, this first round of content analyses resulted in a short-list of 21 decision factors, depending on their prominence in the identified studies. These 21 decision factors therefore signify the total range of decision factors that are important to operationalise the construct of supply chain logistics environmental complexity.

Figure 38

An identification of relevant studies

Authors:	**CSCMP**	**IMD**	**World Bank**	**World Bank (2007)**	**Bagchi (2001)**	**Min (1994b)**	**Kinra & Kotzab (2008)**	**Carter et al. (1997)**	**Bookbinder & Tan (2003)**	**Teng & Jaramillo (2006)**	**Min (1994a)**	**Min & Eom (1994)**	**Goh & Ang (2000)**	**Wood et al. (1995)**	**Hesse & Rodrigue (2004)**	**Kovacs & Spens (2006)**	**Stock & Lambert (2001)**	**Bowersox et al. (2007)**	**Simchi-Levi et al. (2003)**	**Chopra & Meindl (2007)**	**Skjøtt-Larsen et al. (2007)**	**Rodrigue et al. (2006)**
Publication:	***Global Perspectives***	***WCY***	***Global Logistics Indicators***	***Logistics Performance Index***	***SC Forum***	***JBL***	***JBL***	***JBL***	***IJPDLM***	***IJPDLM***	***IJPDLM***	***IJPDLM***	***IJPDLM***	***International Logistics***	***JTG***	***JTG***	***Strategic Logistics Mgmt.***	***Supply Chain Logistics Mgmt.***	***Designing the Supply Chain***	***Supply Chain Mgmt.***	***Managing ...Global Supply Chain***	***The Geography of Transport Systems***
Type:	Logistics /SCM practitioner publication			World Bank Publication on "trade logistics"	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM Text-book	Transportation /logistics academic journal	Transportation /logistics academic journal	Logistics /SCM Text-book	Logistics /SCM Text-book	Operations /SCM Text-book	Operations /SCM Text-book	Logistics /SCM Text-book	Transportation /logistics economics Text-book
Problem, Methodology & Notes:	**Complexity of Global SC operations** for managerial decision-making: Description of state-of-the-art and trends			**Logistics competitiveness of countries for "policy reforms" in logistics:** Perception index using surveys of managers/ LSP's, statistical regression, PCA.	**Supply chain competence DS problem for policy makers:** AHP application study with Illustrative environmental analysis.	**Managerial ICTL problem, AHP application study** Illustrative environmental analysis.	**Managerial DS analysis of environmental complexity** :AHP application study with Illustrative analysis	**Int.Logistics Mgmt. problem.** Assessing **logistics barriers/complexity** using managerial surveys: statistical regression	**Logistics Excellence of Countries for "policy reforms" in logistics:** Tier building using Statistical Cluster Analysis of WCY rankings	**Managerial DS problem for Int. logistics supplier selection:** using an illustrative case study & AHP	**Managerial DS problem for Int. logistics supplier selection:** using MAUT											
Unit/Level:	*Mexico China Japan Italy Brazil*			*150 Countries*	*India Brazil China USA*	*Holland France Switzerland Austria Germany*	*Denmark Finland Norway Sweden USA*	*China + offers implications for Pacific Rim countries, GDP level countries*	*33 countries (European & Asian, & few American)*	*A. Mexico B. (South American) C. China*	*A. Mexico B. Taiwan C. Korea D. Japan E. Canada*											

The outcome of this content analysis is summarised in Fig. 39, which may be seen as an amalgamation of the results of the content validation processes described in this section. This is to say that the process of short-listing factors using ticks (√) and crosses (x), depending on their respective inclusion or non-inclusion (demonstrated in Fig. 37), was performed on the short-listed authors/relevant studies (highlighted in Fig. 38) in order to arrive at the total range of decision factors presented in Fig. 39. The next section presents the process of incorporating this total range of factors, and its information measures in the theoretical model on supply chain (logistics) environmental complexity.

6.3. Theoretical model on Supply Chain Logistics Environmental Complexity

Although Bagchi (2001) suggests that his range of decision factors correspond to the *physical infrastructure*, *institutional*, and *technology* – grouping, he falls short of actually grouping these in their respective categories in any meaningful way that puts all categories into a single unified perspective, either in terms of his own construct (competitiveness/competency), or in terms of the latent construct that is inadvertently being observed i.e. environmental complexity. The latter i.e. a lacking relationship to environmental complexity is though acceptable as Bagchi (2001) does not recognise environmental complexity as the underlying construct. However, this leaves open holes in terms of how each category of decision factors relates to the corresponding set of supply chain flows it affects, how it relates to the specific/chosen decision factors themselves, and how it relates to (any) measures needed to operationalise the decision factors. In fact this last aspect remains completely untouched in Bagchi (2001). Therefore, the study aimed to bridge these gaps through a theoretical model on supply chain logistics environmental complexity, which sought to highlight the above-mentioned relationships. This was done by constructing a decision hierarchy of the construct using the AHP and by applying other methodological notions in Chapter 2. This model is graphically illustrated in Fig. 40 and is explained here onwards. Yet again, it should be noted that the hierarchy that is specified in the theoretical model, however, should not be confused with specific cause-effect relationships between the construct and its operational referents. It just seeks to signify the broad operational relationships that are required when specifying theoretical models in a decision-making research paradigm.

Figure 39

Total range of supply chain environmental complexity decision factors (v2)

Type of supply chain flows	Type of environmental complexity	**Authors:**	CSCMP	World Bank (2007)	Bagchi (2001)	Min (1994b)	Kinra & Kotzab (2008)	Carter et al. (1997)	Bookbinder & Tan (2003)	Teng & Jaramillo (2006)	Min (1994a)
		Publication:	*Global Perspectives*	*Logistics Performance Index*	*SC Forum*	*JBL*	*JBL*	*JBL*	*IJPDLM*	*IJPDLM*	*IJPDLM*
		Type:	Logistics /SCM practitioner publication	World Bank Publication on "trade logistics"	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal	Logistics /SCM academic journal
		Problem Methodology & Notes:	Complexity of Global SC operations for managerial decision-making: Description of state-of-the-art and trends	Logistics competitiveness of countries for "policy reforms" in logistics: Perception index using surveys of managers/ LSP's,statistical regression, PCA.	Supply chain competence DS problem for policy makers: AHP application study with Illustrative environmental analysis.	Managerial ICTL problem, AHP application study Illustrative environmental analysis.	Managerial DS analysis of environm ental complexity:AHP application study with Illustrative analysis	Int.Logistics Mgmt. problem. Assessing logistics barriers/complexity using managerial surveys: statistical regression	Logistics Excellence of Countries for "policy reforms" in logistics: Tier building using Statistical Cluster Analysis of WCY rankings	Managerial DS problem for Int. logistics supplier selection: using an illustrative case study & AHP	Managerial DS problem for Int. logistics supplier selection: using MAUT
		Unit:	*Mexico China Japan Italy Brazil*	*150 Countries*	*India Brazil China USA*	*Holland France Switzerland Austria Germany*	*Denmark Finland Norway Sweden USA*	*China + offers implications for Pacific Rim countries, GDP level countries*	*33 countries (European & Asian, & few American)*	*A. Mexico B. (South American) C. China*	*A. Mexico B. Taiwan C. Korea D. Japan E. Canada*
Type of supply chain flows	**Type of environmental complexity**	**Decision factors**									
Physical flows	Complexity of transportation systems & transport geography	Geographical location	√	√	X	√	X	X	?	√	√
		Roadways	√	√	√	√	√	√	√	X	X
		Railways	√	√	√	√	√	√	√	X	X
		Airways	√	√	√	√	√	√	√	X	X
		Waterways	√	√	√	√	√	√	√	X	X
		Intermodal	√	√	√	√	X	√	√	X	X
		Public warehousing	√	√	√	√	√	√	√	X	X
		Hub & Spoke Systems	?	?	?	?	?	?	?	?	?
		Customs	√	√	√	√	√	√	√	√	√
		Logistics/SCM HR	√	√	√	√	√	√	√	√	√
Information flows	Complexity of communication systems	Telecom	?	√	√	√	√	√	√	X	X
		Post	√	√	X	X	X	X		X	X
		Telephone usage & penetration	√	√	√	√	√	√	√	X	X
		EDI usage in business & society	√	√	√	√	√	√	√	X	X
		Computer usage & penetration	√	√	√	√	√	√	√	X	X
Payment flows	Complexity of economic systems	Financial institutions & services	?	?	?	?	?	?	?	?	?
		Economic policy	√	√	√	√	√	√	√	√	√
		Economic structure	√	√	√	√	√	√	√	√	√
		Electronic banking & commerce	?	?	?	?	?	?	?	?	?
Ownership flows	Complexity of government systems	Business legislation	√	√	√	√	√	X	?	X	X
		Political climate	√	√	√	√	√	X	√	√	√

6.3.1. Different phases of model building

The task of building a theoretical model on supply chain logistics environmental complexity may be summarised under the following main phases:

- *Phase 1* – involved specifying all the decision factors that operationalise the construct.
- *Phase 2* – involved specifying why groups of decision factors cause/describe complexity in a common way, and grouping the decision factor to its relevant category - *physical infrastructure*, *institutional*, and *technology.*
- *Phase 3* – involved specifying how each decision factor causes/describes complexity i.e. a brief explanation on the significance of each decision factor.
- *Phase 4* – involved collecting (information) measures on each decision factor.

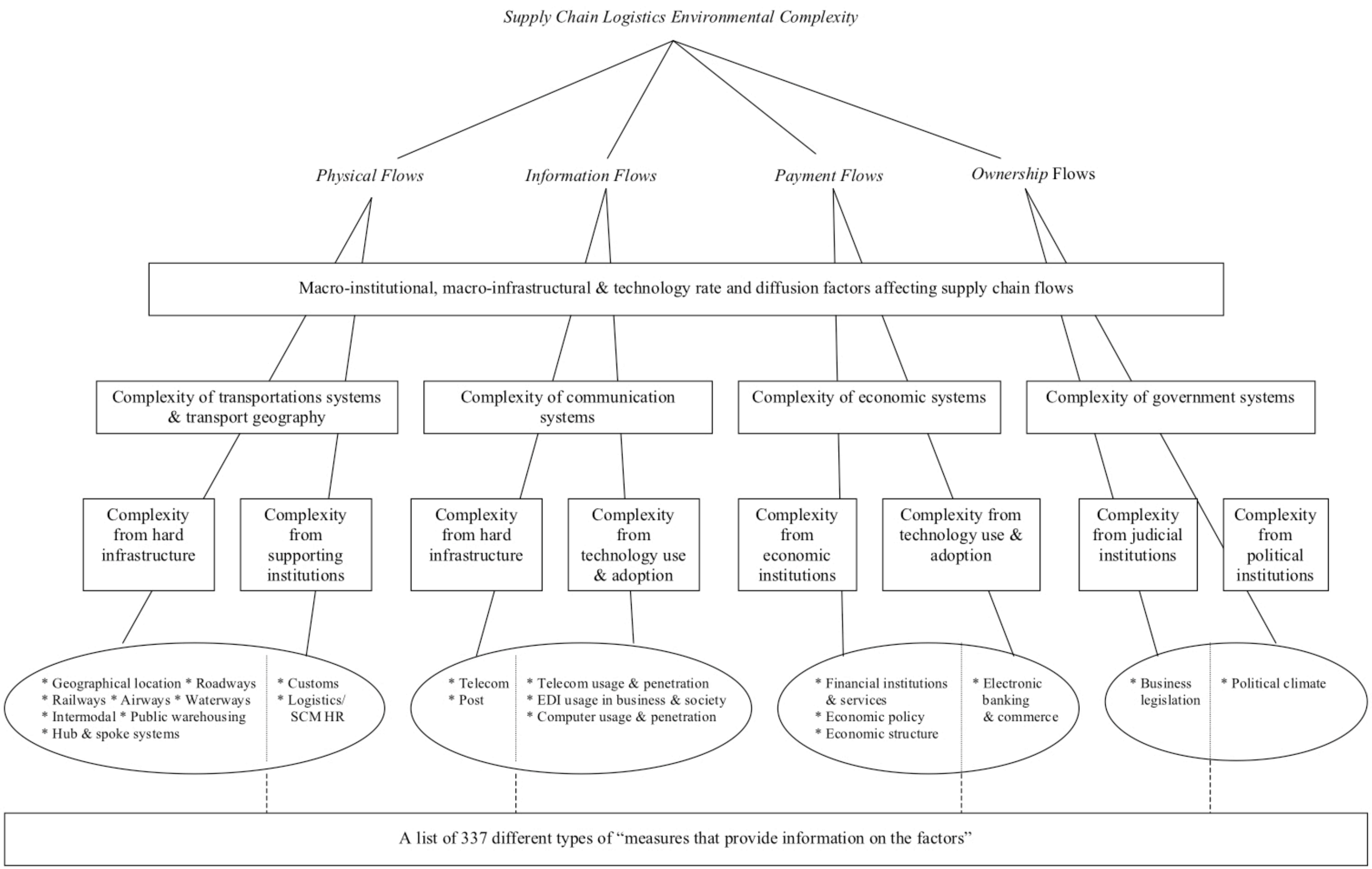
Phase 1 had already been dealt with through the first rounds of content analyses, which had resulted in a reasonable range of (21) factors that cause/describe environmental complexity. Whereas *Phases 2, 3 and 4* are now described in the following sub-sections.

6.3.2. Grouping decision factors into their relevant categories – phase 2

Since it had been defined earlier on, that the main objective of supply chain management is to carry out the four main flows of product/service (physical), information, payment and ownership (e.g. Handfield and Nichols, 1999; Bowersox and Closs 1996), any group of decision factors in supply chain (logistics) environments that impede or facilitate this objective, were deemed to cause/describe environmental complexity (Kinra and Kotzab, 2008a; 2008b). It could be argued that this complexity may have both negative and positive effects on supply chain activities and operations, but the formulation presented here described a state of *complexity* as long as it met the theoretical conventions on the construct, especially the component heterogeneity or environmental diversity one. Therefore it was taken that diversity or heterogeneity (complexity) in supply chain environments is based on diversity or heterogeneity of those (21) decision factors that impede or facilitate essential supply chain flows. Given this, it was then possible to categorise the (21) decision factors in terms of the respective supply chain flows they affect. Therefore, these four supply chain flows - *physical, information, payment, and ownership* – were incorporated at the 1st (hierarchical) level in the theoretical model (Fig. 40). Next, since each of the (21) decision factors corresponded to a particular supply chain flow, and furthermore a particular environmental category i.e. infrastructural, institutional, technology-related (Bagchi, 2001), it was possible to group these

Figure 40

Theoretical model on Supply Chain Logistics Environmental Complexity



factors in accordance with both, namely the categories of factors and the flows that they affect. Therefore each individual decision factor causing environmental complexity was linked to its corresponding flow using a relevant environmental category - *physical infrastructure*, *institutional*, and *technology.* For this purpose, and in order that Bagchi's (2001) categories could be accommodated, these had to be re-categorised, both in terms of the complexity they pose, and the breadth they cover. The three customised categories that emerged as a result were:

- Complexity from hard or physical infrastructure factors
- Complexity from different types of institutional factors – supporting institutions such as customs, judicial institutions such as courts and legislation etc.
- Complexity from technology-use/adoption factors

The main proposition underlying such a grouping was that certain groups of decision factors cause/describe environmental complexity in a common way. For instance, what both *Customs* and *SCM/Logistics HR* have in common is that they represent supporting institutions to essential logistical flows activities; they represent the institutional aspects of environmental complexity, and could be categorised as institutional decision factors. Furthermore, together with *Geographical location*, *Roadways* and other modes, *Warehousing* and *Hub & spoke systems*, these belong to a higher category that was thought of as posing complexity in terms of transportation systems and transport geography, at the level of the environment (e.g. a country).

Similarly, take *Financial institutions and services*, which together with *Economic structure* and *Economic policy* represent important institutional decision factors. These factors, together with *Electronic banking and commerce* (that is a technology-use/adoption factor) represents a group of decision factors that was thought of posing complexity in terms of economic systems, at the level of the environment. All this is made apparent in Fig. 40, in a self-explanatory manner.

6.3.3. Significance of decision factors to the construct – phase 3

Next, a more detailed explanation on the (21) decision factors, and how they relate to the construct is required. As a starting point, it is important to state that Bagchi's (2001) scheme was used here to link each decision factor to its respective flow. For example, self-explanatory as it may be, a decision factor such as *Economic policy* affects *Payment flows* following Bagchi's (2001) proposed model. However, in this direction, Bagchi (2001) does not provide the rationalisation for such a link. Given this, and the fact that most of the domain literature does not directly refer or make connections to the construct of environmental complexity while treating these decision factors, some of these are exemplified here in order that the reader is able to get a grasp of the inter-connections. Since most of these are self-explanatory, have been included in the domain in a similar way in terms of face validity, and are well described in the domain, only a select few are here.

Take, for instance, *Geographical location* as a decision factor. It's a decision factor because it poses a decision-making problem, e.g. given a set of locations, where should warehousing capacities be installed, what modes of transportation should be employed etc. Since different environments (countries) differ in the way they are geographically located, this decision factor becomes significant in terms of environmental complexity. This is because activities and operations may have been designed keeping in mind a certain country with a certain geographical location that is conducive to sea transport; or in other words, keeping in mind the shipping and sea freight option. But since the scope of the operation now extends to other countries, additional geographic locations need to be considered, which causes/describes environmental complexity in terms of "component preponderance". Furthermore, since the additional locations are different to the original one, the organisation faces environmental complexity in terms of "component heterogeneity"[29]. For example, the new locations might be land-locked countries, thus requiring a shift in how operations are planned, and goods are moved. *Geographical location*, as a decision factor, thus affects physical flows that are central to supply chain management.

Take *Political climate* as a decision factor, which poses a decision-making problem as well. This may yet again be posed in terms of the original site-location problem: given a set of political climates, where and how should the organisation extend, or locate its operations and activities? *Political climate* affects supply chain flows because a conducive climate is essential to carrying out ownership flows. Ownership flows refer to the downstream supply chain flows of ownership in the form of e.g. deeds and contracts between different supply chain actors. Governments and governance institutions control these essential flows. In an uncertain political climate where governments and other governance institutions become dysfunctional, ownership flows are thus impeded. Whereas, *Political climate* causes/describes environmental complexity because of the same reasons that are common to all decision factors, "component preponderance" and "component heterogeneity". With

[29] see sections 6.1. and 3.3 for more explanation of component preponderance and heterogeneity

respect to preponderance, environmental complexity arises because an additional climate of an additional environment (country) needs to be taken into account in light of extended operations; and heterogeneity, because the additional location is different to the original one. In this way, *Political climate* is a central decision factor for ownership flows.

Finally, as a concluding example, one may also consider *Customs*.*"If Customs, which is an essential institution directly affecting the logistics and transportation of goods is corrupt ...., it shall affect the time (responsiveness) and costs (efficiency) needed for carrying out the essential supply chain flows"*(ch. 1). *Customs* affects supply chain flows because a well-functioning, competitive, or efficient customs institution is essential to carrying out physical flows of goods across different environments (countries). Whereas, *Customs* causes/describes environmental complexity because of "component preponderance" as a result of taking into account an additional customs authority in the (additional) country, and "component heterogeneity" as a result of differences between customs authorities/procedures between the new and original environments. Therefore, *Customs* is a central decision factor for physical flows.

6.3.4. Collecting (information) measures on each decision factor – phase 4

Having had framed the construct into a hierarchy, which structured and demonstrated each decision factor relative to the construct, the study also moved a step forward in understanding the second aspect of RQ 2 i.e. *(information) measures of these decision factors*. For instance, it became easier to visualise the type of measures that provided information on each decision factor, and the place (level) that these would eventually occupy in the theoretical model. The process of discovering these (information) measures is described in a detailed manner by documenting each relevant aspect of data collection such as observation methods, sampling, phases and instrument in the following sections.

6.3.4.1. Research method and sampling of the content

The empirical measures were identified using a comprehensive content analysis, representing the second round of in-depth content analysis in this dissertation, and one that the study referred to as the *"CSCMP metrics analysis"*. This is because it was performed on a leading practitioner publication within the field, namely the *CSCMP Global Perspectives*. According to Zikmund (2000), a content analysis is a research technique used for the purpose of preparing a structured, systematic and (quantitative) description of the manifest content of communication, and deals with the study of the message. A content analysis could then be employed within the exploratory stages of this study, and within the methodological confines of data collection using secondary (or historical) data.

CSCMP Global Perspectives is an alternating trade publication by the Council of Supply Chain Management Professionals (CSCMP) that takes an "an in-depth look at a particular country or region"[30] in order to examine complexities facing global supply chain management. For example, the publication examines environmental complexity by exploring macro-institutional and infrastructural factors that are essential to contend with while operating in different environments viz. countries like China (Wang 2006), Italy (Borghesi and Signori 2006), Japan (Kitamura 2006) and Mexico (Torres 2007). There were compelling reasons for this obvious choice. Firstly, it may be evident through the meta-analysis presented in Fig. 39 that the publication was an essential part of scarce domain literature that dealt with the subject area of this dissertation. Secondly, considering that this dissertation would lack empirical data in terms of managerial responses, this publication was very relevant from the point of view of installing a method and source *triangulation* by including managerial perspectives or impulses on what is important in measuring the construct. Thirdly, CSCMP is a well-respected and representative association of the domain literature.

This analysis may be referred to as an "absolute" content analysis, because the entire population of the publication to date[31] was examined in the analysis. In other words, no sampling was performed to sample a representative number of issues. The main reasons for this were that the publication is fairly young, and that no combination of samples was envisaged to be uniform enough, as each issue focussed on a different (country) environment, and was authored by different types of stakeholders, each representing a different (business) context. Even though many authors (e.g. Bookbinder and Tan, 2003, *Logistics Performance Index*, 2007) seek to emphasise patterns of environmental differences by country development status, the focus of each issue on a separate and distinct country environment was not the biggest concern. This is because environmental complexity, the object, had been conceptualised in this dissertation as arising precisely because of these differences. Besides, considering that each issue focussed on geographically disparate locations, this was envisaged to provide a much richer picture in order for the construct to have global relevance.

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[30] http://cscmp.org/MemberOnly/Perspectives.asp

[31] Until the year 2007

Since a lot of emphasis in this dissertation has been placed on decision-making, and decision-making aspects related to the specific (managerial) contexts, it was therefore conceived that performing an absolute content analysis was not only necessary because of the above-mentioned reasons, but would also provide a more complete picture of the total range of decision factors and measures for operationalising the construct.

6.3.4.2. Data collection

The content analysis involved three progressive phases and the entire process lasted about six months, a majority of which was conducted during the author's stay at the George Washington University in the United States. From here onwards, the reader is referred to Table CSCMP Total Measures (v.7) in Appendix B in order to relate to the following description. The table presents the concentrated (data collection) work of these 3 progressive phases in the form of a sub-instrument that was used to identify measures of supply chain logistics environmental complexity, and was consequentially developed into a more full-fledged instrument for primary data collection. The first phase of the content analysis identified empirical referents of the construct in each of the publication issues; and then used one-to-one mapping for linking each of the (21) decision factors to those empirical referents. The purpose was to observe how each decision factor had been treated in every issue, and to observe patterns of measures that related to each factor in the different country environments. For example, this aspect is represented in the Table by: a) linking a measure such as *"Km seashore or coastline"* to its corresponding decision factor *Geographical Location*; and b) developing country codes such as MX (Mexico), CN (China), IT (Italy), JP (Japan) and BR (Brazil) for the countries that each publication issue described. In this way, the coverage of each measure was observed in every issue.

6.3.4.3. Data processing and analysis

The second phase involved developing a classification scheme that classified each measure according to its data type (source) e.g. objective data (also referred to as hard data) and perceptual data. In the Table [CSCMP Total Measures (v.7)] this aspect is represented by the classification of data sources depending on how measures were communicated in the publication. The following data codes were thus developed:

- INST1 = hard data:
- INST2 = perceptions - survey based (P)
- INST3 = perceptions - author's personal perceptions (P)
- INST4 = perceptions – data-based perceptions –DESCRIPTION (D)

Whereas the third phase firstly involved listing each measure together with its data type and compiling it together with its respective environmental complexity category. It secondly involved prioritising the measures in accordance to how consistently and frequently they had been considered, and then disposing of any spurious measures. Finally it also involved questioning the inclusion of those decision factors in the theoretical model in Fig. 40., that were found to have no measures relating to it in the content analysis e.g. *Hub & spoke systems*. Furthermore, it involved mainly identifying and promoting only those measures on which data availability was not a major issue. This was achieved by checking for data availability on each individual measure from three sources i.e.: two major electronic databases i.e. *World Development Indicators* (WDI database) and IMD's *World Competitiveness Yearbook* (WCY database)[32] and the World Bank's most recent publication in this field, the *Logistics Performance Index* (2007). The Table in Appendix B demonstrates all this in a self-explanatory manner.

6.3.4.4. Findings of content analysis 2 ("CSCMP metrics analysis")

As a result, a total of **337 different types of "measures"** that may be used to operationalise the construct of supply chain logistics environmental complexity, were identified. Though these measures were disproportionately aggregated, they were well-representative of their respective decision factors and environmental complexity categories. These measures now required meeting important validity concerns in order to be useful for any future environmental complexity analyses. These validity concerns are dealt with in the next chapter.

6.4. Sub-conclusions with respect to RQ 2 and next steps

This chapter marked the end of an important stage in this study, that of construct conceptualisation. By proposing a theoretical model on the construct of supply chain logistics environmental complexity, it was demonstrated how a set of (21) decision factors caused/described environmental complexity to supply chain operations. Furthermore, it was shown that 337 different types measures were capable of providing information on the decision factors, and thereby the state of supply chain environmental complexity. Having done this, this research stage directly contributed to answering the second research question (RQ 2) by deriving the decision factors, and their (information) measures that could operationalise the construct. Therefore the main contribution of this stage lay in proposing

[32] WORLD COMPETITIVENESS ONLINE, https://www.worldcompetitiveness.com.esc-web.lib.cbs.dk:8443/OnLine/App/Index.htm

the theoretical model on supply chain logistics environmental complexity (Fig. 40). However, it was also borne in mind that the theoretical model presented here was yet propositional, as it had been derived from literature using a series of content analyses. Other, important construct validity concerns yet remained un-catered. The next stage therefore involved working on the validity of the theoretical model presented here so that a definitive answer to RQ 2 could be provided. From this point of view, an important outcome of the research presented here was also the conception of an empirical model on the construct, which allowed for future validation of the construct, its underlying decision factors, and measures. This empirical model may be visualised as a modification to the theoretical model in Fig. 40. in terms of e.g. reducing the total number of decision factors from 21 to 20 (whereby *Hub & spoke systems* was dropped), and one that was done in order to carry out primary data collection for validating the original model. This was, however, the subject of the next stage.

Chapter 7

Validating
Supply Chain (logistics) Environmental Complexity

"The content validity of a construct measure can be defined as 'the degree to which the measure spans the domain of the construct's theoretical definition' (Rungtusanatham, 1998). It is the extent to which the measure captures the different facets of a construct. Evaluating face validity of a measure (i.e. the measure 'on its face' seems like a good translation of the theoretical concept) can indirectly assess its content validity. Face validity is a matter of judgement and must be assessed before data collection (Rungtusanatham, 1998)" (Forza, 2002, p. 160)

The next stage of construct development process represented the task of validating the construct of supply chain logistics environmental complexity. As the construct had now been conceptualised, this stage involved further working on the validity of the theoretical model on the construct, which had been put forth in the previous stage. This was required because it was still not known whether the groupings, categories and links through which the decision factors and their measures related to the construct were valid, or not. Neither was it certainly known whether data is available on the empirical referents (measures) in order to conduct any further environmental complexity analyses. These were some of the validity issues that this part then sought to tackle. A revised and more refined model on the construct of *supply chain logistics environmental complexity*, was thus envisaged as the consequence of this stage. In the following sections, this chapter presents the research process and methods employed in order to tackle these issues.

7.1. Aims and scope of the validity study

If construct development requires multiple stages, and the task of construct validation is treated as a process (O'Leary-Kelly & Vokurka, 1998), then the scope of validation in the present study fit Stage II of the construct development methodology that is described in Lewis et al. (2005), as it sought to deal with aspects of *content validity* and *construct validity* (both marked blue in Fig. 41) through the design of a short (empirical) study. Whereas a confirmation of the propositions that led to the development of the construct, and a test of how different decision factors related to each other and the construct, *nomological validity* (marked red in the figure) in this sense was never an aspiration. It is therefore important to recognise that Fig. 41 only intends to illustrate what was aimed for, as a part of the research design.

More specific objectives of the study with respect to the construct development of supply chain logistics environmental complexity could be summarised as:

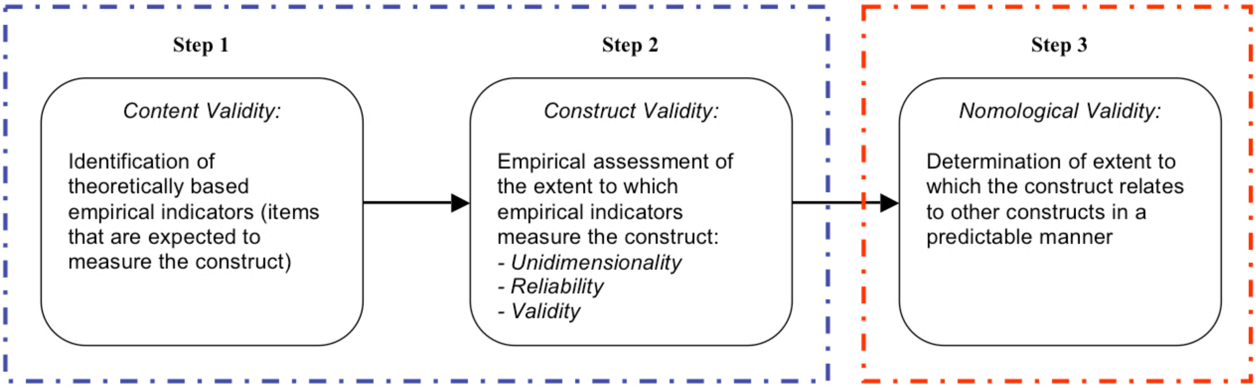
- **To validate the theoretical model** in terms of whether all (21) decision factors were important for operationalising the construct.

- **To short-list a handful of measures** from a list of 337 measures collected in the previous stage, which could provide information on each decision factor that was found to be important.

Figure 41

"The construct validation process"

(O'Leary-Kelly & Vokurka, 1998)



Therefore, because of the decision-making approach applied in viewing the construct, a prioritisation of the measures, which aimed to take decision-making and judgement tasks and stakeholders[33] into account, was sought. A short validity study, with the following characteristics, was then designed in order to achieve the above-mentioned objectives.

7.2. Data collection method: Expert Opinions

> *"In addition to self-validating the measure - through an agreement on the content adequacy among the researchers who developed the measure - additional support should be sought from experts and/or the literature. While literature is important, it may not cover all aspects of the construct",* (Forza, 2002, p. 160).

An expert opinion, from a methodological standpoint, is a "limited generalisation" (quasi-law) of reality, and a method of data collection that is based on soliciting judgements and opinions of subject-matter experts in order to capture the construct (Helmer & Rescher, 1959). From this it follows that expert opinions is the underlying methodology that is employed in data collection techniques such as the Expert Choice®software or the Delphi

[33] For example, the AHP methodology requires *n X (n-1)/2* managerial judgements, where *n* is the number of factors, in order to analyse any environmental complexity based decision-making goal. Given that there are 21 decision factors and 337 measures, it is improbable that stakeholders have the time and other resources to carry out these judgements; in other words, such a model would not be realistic. This aspect was discussed at a preliminary discussion forum consisting of the author and experts within the AHP i.e. Dr. Prasad and Dr. Kanungo, 04/04/2008, 12:00.

technique (Dalkey & Helmer, 1963) in order to record judgements. Expert opinions were chosen as the chief method for data collection because of the following coincidental reasons:

1. **The use of SME's in structuring decision-making problems** - because the study was paradigmatically driven by the Analytic Hierarchy Process (AHP), the extensive use and support of expert opinions as a method for data collection within this decision-making methodology (see e.g. Vaidya & Kumar, 2006), influenced this choice as it seemed to be in accordance to the AHP-based domain literature. Here, relevant reference points to work with expert opinions constituted studies related to multi-criteria decision-making. But because of the dearth of studies that were found describing how to (practically) work with expert opinions as a tool, other types of studies that used expert opinions as their main data collection tool were also used as reference points. These reference points may be preferentially listed as:
   - 1st pref. - expert opinions in DSS studies (e.g. Liberatore & Stylianou, 1995)
   - 2nd pref. - expert opinions in Delphi studies (e.g. Klassen & Whybark, 1994; MacCarthy & Atthirawong, 2003, Khakee et al., 2000)
2. **The use of SMEs for content validity purposes** – Following Lewis et al. (2005), Forza (2002) and Lawshe (1975), while working on content validity of the construct of supply chain logistics environmental complexity, SME's could be employed to quantify face validity of the measures that had been identified in the previous stage of the project.

7.3. Sampling and respondents

Expert opinions are based on subject-matter experts (SMEs), which according to Helmer & Rescher (1959) may be phrased as:

> *"…"expert" in some subject-matter is a person who is rational in the sense discussed, who has a large background knowledge…. in that field, and whose prediction…..in that field show a record of comparative successes in the long run",* (p. 36).

Given this, confounding questions pertaining to 'who are SMEs', 'how to identify SMEs' and 'how many SMEs' were to be dealt with while working with expert opinions. All this was evident after a literature review on select DSS and Delphi studies that sought to detail the expert selection process. Findings from this literature review were then fed into answering these confounding questions. From this literature review it followed that SMEs could be composed of academics, practitioners, policy makers, consumers. Therefore, experts corresponding to academics, representatives from government bodies and consultants have been used in previous studies (see for example MacCarthy & Atthirawong, 2003). Experts in particular (disciplinary) fields were another possible source for sampling. For example, just as industrial marketing managers are experts (Mentzer and Gandhi, 1993), supply chain managers and logistics managers could also be considered as experts in the field of logistics/SCM, drawing on a variety of resources to diagnose and solve supply chain problems. Furthermore, experts in particular (problem) fields represented another important source for sampling purposes.

The study then found inspiration in Okoli & Pawlowski (2003), who offer a structured approach to identify relevant SMEs. For instance, notions from their detailed procedures to avoid identification of spurious experts – such as the knowledge resource nomination worksheet (KRNW), and step-wise procedure - were applied. Whereas with respect to sample sizes, a consensus on an exact size was found hard to reach as different authors, driven by different research problems and designs, seemed to (whimsically) deal with this issue. For example, without pre-specifying their intention regarding sample size, Berittella et al. (1997) consult 9 experts; Ülengin & Ülengin (1994) consult 5 experts (3 academicians and 2 industry practioners); Gaudenzi & Borghesi (2006) involve 4 key managers; Karnes et al. (1995) use a mix of experts and a *convenience sample* of 30 consumers; whereas Das et al. (2001) consult 3 leading experts. Therefore it seemed that sample size didn't matter in studies driven by expert-oriented research designs. This finding was consistent with Okoli & Pawlowski (2003) who state that when working with expert opinions "size does not depend on statistical power, but rather on group dynamics for arriving at consensus among experts" (p. 19).

However, since this dissertation was also driven by a construct validity (content validity) paradigm, it then sought guidance in the very paradigm (e.g. Forza, 2002; O'Leary-Kelly & Vokurka, 1998) in order to tackle the issue of sample size. From this it followed that any number of experts ranging from **5 to 40 are ok, as long as they can satisfy Lawshes' ratio** criterion for those number of experts – (Lawshe, 1975). For example, Forza (2002) suggests using subject matter experts in this spirit, with regards to establishing content validity using the face validity of measures.

Therefore, the actual sampling of experts took place by putting all the above-mentioned issues into perspective; details with respect to the actual sampling are as follows. Since the theoretical model on supply chain logistics environmental complexity appealed to the generic constraints of supply chain logistics operations (Kinra and Kotzab, 2008b), and one that was applicable to most sectors, managers and consultants from particular (e.g. industry) contexts were left out as experts in this round of analysis. Instead academics, which represented a broader body of knowledge on the issue, were the first to be identified. The sampling procedure employed may be summarised as:

1. Sampling procedure – first addressed the issues of the relevance of sampling and domain literature for this study. Then applied non-probabilistic methods - e.g. a judgment sample (Zikmund, 2000).
2. Sampled respondents in three categories: MODCON[34] (MES), MODCON (TSK ENV), & DSSVAD[35]. Only MODCON (MES) respondents were used for this study.
3. Under MODCON (MES), sampled respondents geographically (NA, EU, AP)[36] with proportionate representation.
    - About 60 experts in supply chain operations were identified.
    - Experts were identified based on their research interest, contribution and publication in the area. Experts represented knowledge on:
        - The logistics environment
        - Research methods in environmental complexity
        - Environmental scanning systems
    - Most experts represented knowledge on environmental uncertainty/complexity, and constraints to extended supply chain operations.
    - A total of 34 experts were contacted (15 NA, 12 EU, 7 AP). These were categorised as the Expert Experts e.g. based on:
        - 1st author status, and cited publications in the top domain journals.
        - them figuring centrally, and repeatedly in the influential publications, global logistics & SCM programs, and research agendas.
        - them being nominated by other experts.

7.4. Data collection instrument and pretest – the 'expert opinion sheet'

Data collection was designed in a way that corresponded to the survey method (Zikmund, 2000). In other words, data were collected by viewing 'the gathering of expert opinions' as a survey issue. Therefore, an expert opinion (EO) sheet that intended to capture hand-written opinions of experts using postal dispatch, was designed to meet the purposes of collecting data through the survey method. This EO sheet, also referred to as the *pretest* version (see Appendix C), was a natural progression of the *"CSCMP metrics analysis"* conducted in the

[34] MODCON = *model construction*
[35] DSSVAD = *decision support system validation*
[36] NA = North America; EU = European Union; AP = Asia Pacific

previous stage, and therefore heavily relied on the same structure of decision factors and measures that is listed in the Table under Appendix B, and in a way that was coherent with the logical flow of the theoretical model. This version (1) of the EO sheet was then subjected to pretesting, and was thereby modified for data collection. For example, the modified instrument was redesigned for web-based dispatch and response. The reader may also access the modified EO sheet that was used for data collection under Appendix C. Details of developing the data collection instrument, and pretesting the instrument are summarised as under:

1. **Original data collection instrument:** ***expert opinion sheet (v1)***
    - questionnaire style, open ended
    - no scales
    - 337 measures grouped under 20 different categories (decision factors)
    - 9-page long MS word format
    - originally designed for postal dispatch, and hand-written response

2. **Test run:**
    - was conducted on colleagues at GWU, CBS, and peer group in UTK.
    - was conducted in close cooperation (1-day seminar) with a business researcher holding experience in "quant/qual" modelling, and in similar techniques of data gathering.

3. **Modified data collection instrument:** ***expert opinion sheet (v2)***
    - added scales
    - introduced random rotation and shuffling into the instrument
    - 10-page long, more interactive PDF form, increased aesthetics
    - redesigned for web-based dispatch and response

7.5. Data collection

The data collection strategy and process is summarised here. The entire process lasted 3 months, including pretesting, a part of which was carried out during the author's stay at GWU. The details of the data collection strategy and different phases are listed as under:

- In some cases a research presentation preceded the dispatch of the instrument.
- In about 50% of the cases (telephone and e-mail based) communication to clarify the study succeeded the dispatch.
- In all cases an intro letter or "face-to-face" communication explaining the study was used to requesting respondent participation, preceding the dispatch (see D.1, Appendix D).

- In all cases the respondents were related to the study, and were notified why they were identified as SME's (see D.1, Appendix D). An open dialogue ensured that counter arguments were encouraged.
- In all cases, respondents were encouraged to leave the study, if during the communiqué they felt uncomfortable about their (non)/expertise.
- Experts were encouraged to "nominate" other experts
- In all cases the dispatch dossier included these 3 files:
    1. A detailed covering letter explaining the study and purpose of the instrument (see D.2, Appendix D)
    2. Instructions for filling out the instrument (see D.3, Appendix D)
    3. The instrument (refer to Appendix C)

Out of the 34 experts that were initially contacted for this purpose, 18 experts agreed to participate and were then dispatched the dossier containing the instrument. Out of these, 14 experts responded; these experts were proportionately scattered around the 3 regions. Out of these, 2 experts opted to pull out the study for the fear of data contamination consequences of their perceived non-expertise on the subject matter. All but one of the experts followed the exact pattern and line of questioning, as was designed in the instrument. Expert opinions from a total of 11 experts were thus available for recording in the ensuing analysis.

7.6. Data processing and logical considerations

An analysis of the responses began after the (self-imposed)[37] deadline within which all respondents were supposed to answer. The analyses first included extracting data from the expert opinion sheets, and then running Lawshe's (1975) content validity tests (Forza, 2002) on the responses. A snapshot of the extracted data is presented in Appendix E (E.1).

Analysing responses using Lawshe's ratio means computing content validity ratio for each measure (CVR_i), and is based on the following assumptions on expert opinion (Lawshe, 1975):

1. Any item, performance on which is perceived to be "essential" by more than half of the panellists, has some degree of content validity.
2. The more panellists (beyond 50%) who perceive the item as "essential," the greater the extent or degree of its content validity.

[37] Because this was an SME-based study, it was important that the experts were given enough leverage to respond. The deadline was then primary driven by the following criteria: 1) to stop waiting for responses as soon as a reasonable number of experts corresponding to Lawshe's (1975) scale had responded; and 2) the deadline to conclude the PhD dissertation.

Accordingly, Lawshe's (1975) ratio for all measures was mathematically calculated using the following formula (Forza 2002):

$$CVR_i = (n_e - N/2) / (N/2)$$

Where n_e is the number of SMEs indicating the measure i as "essential", and N is the total number of SMEs in the panel.

Furthermore, based on the assumptions regarding expert opinions presented above, Lawshe (1975) establishes minimum ratios for different sizes of expert panels. Fig. 42 presents these minimum CVR_i values depending on the number of experts involved in the tests. Following the figure, a panel size of 11 experts corresponds to a minimum CVR_i value of .59; this is the value that was then to be aimed for because there were a total of 11 experts who participated in the study.

An analysis was then to be performed by applying the following logical considerations, and the findings were accordingly interpreted. A set of 'item screening' tests based on the Lawshe (1975) ratio were thus designed. In particular, the following step-wise logical considerations were to be undertaken in short-listing the factors and measures:

1. **Test 1**: perform a stringent first CVR test to identify only all the positive indicators.
2. **Test 2**: experiment by readjusting both *"important"* and *"maybe important"* as "essential" measures and thereby perform a less stringent second test to identify measures that lie above the minimum CVR requirement. Given construct development aims, such a step might be required (Lewis et al., 2005).
3. **Short-list**: include all measures based on the last step. However, also refine (rank) these measures.
4. Deem all other measures that don't meet the above criteria as unessential and drop these from the final list.
5. Evaluate the overall quality of the resultant model by incorporating (any) expert comments into the analysis and by identifying and eliminating (any) un-validated decision factors.

A snapshot of the process of conducting content validity tests, and of selecting the relevant measures of supply chain logistics environmental complexity is presented in Appendix E (E.2).

Figure 42

"Minimum values of CVR"

(Lawshe, 1975)

No. of Panelists	Min. Value*
5	.99
6	.99
7	.99
8	.75
9	.78
10	.62
11	.59
12	.56
13	.54
14	.51
15	.49
20	.42
25	.37
30	.33
35	.31
40	.29

7.7. Analysis and findings: decision factors and measures of supply chain logistics environmental complexity

It was interesting to find that only less than 2% of the total number of (337) measures qualified as being important in the first test. In effect there were only 6 measures that qualified and those that strictly confirmed to Lawshe's (1975) definition of *essential* measures. However, after readjusting *"important"* and *"maybe important"* as "essential" measures, it was interesting to see about 50% of the total number of (337) measures qualify to the final list. These measures were then classified based on the following scheme:

- Gold measures = *Essential Measures* = $CVR_i \geq 0.59$
  i.e. those that strictly followed Lawshe's (1975) definition of *essential* measures.
- Yellow measures 1 = *Maybe Essential Measures* = $CVR_i \geq 0.59$, and, = (1.00).
  i.e. those that gave a value of 1.00 after including experts who rated the measure as *maybe essential*.
- Yellow measures 2 = *Maybe Essential Measures* = $CVR_i \geq 0.59$ and, = (0.82).
  i.e. those that gave a value of 0.82 after including experts who rated the measure as *maybe essential*.
- Yellow measures 3 = *Maybe Essential Measures* = $CVR_i \geq 0.59$ and, = (0.64).
  i.e. those that gave a value of 0.64 after including experts who rated the measure as *maybe essential*.

As measures corresponding to certain decision factors didn't meet the criteria mentioned above, it should be noted that these factors did not get validated during the analysis and tests. As a result, the total number of decision factors was also short-listed. An analysis to determine the reasons for this absence of certain decision factors was then performed with the following considerations:

- Rechecked whether these factors were in fact important.
- Rechecked if the experts indeed had the expertise on the subject and the factors.
- Made a final judgement on non/inclusion.

This entire procedure then resulted in a short-list of 187 measures, and 17 decision factors. These measures were remapped according to their categories of decision factors. Table 3 presents the findings of this analysis where 1) each measure has been grouped according to its corresponding decision factor; 2) each measure has been presented in a way that prioritises it according to the scheme (logical considerations) mentioned above i.e. according to its respective Lawshe ratio value (CVR_i). The reader may also access a more complete list that complements Table 3 in Appendix E (E.3), where a list that not only prioritises all the measures according to their respective decision factors, but also presents data sources on these measures (especially with respect to how experts thought each measure to be important depending on type of data that each measure represented) is presented.

Table 3

Measures and decision factors of supply chain logistics environmental complexity

FACTORS	MEASURES	CVR_i
Complexity from Hard Infrastructure by **Geographical Location**	Geographical location, position & attributes	1.00
	Country area in km^2	0.82
	Km seashore or coastline	0.64
Complexity from Hard Infrastructure in **Roadways**	General road infrastructure	0.64/1.00
	General road infrastructure	0.64/1.00
	General road infrastructure	0.82
	Km 4-lane highways & 2 way roads	0.82
	% highways paved	0.82
	A description of transportation laws & regulations	0.82
	Km roads total	0.64
	Billion ton-km – freight volume	0.64
	% Tonnage/mile - freight volume	0.64
	"Growth in quality of transport infrastructure"	0.64
Complexity from Hard Infrastructure in **Railways**	General rail infrastructure	1.00
	General rail infrastructure	1.00
	Km total railways	0.82
	Million ton per year freight volume - haulage	0.82
	% of total volume, billion per year volume growth *Historical growth measure*	0.82
	A description of transportation laws & regulations	0.82
	General rail infrastructure	0.64
	Km/km^2 net transportation density	0.64
	Billion ton per km freight turnover	0.64
	% Of total import/export flows by rail - haulage	0.64
	% Of total weight/quantity by rail - haulage	0.64
	% Of total value of international transport flows by rail - haulage	0.64
	Km of new railways opened/planned per year *Future growth measure*	0.64
	"Rail flow logistics as a constraints at policy level"	0.64
Complexity from Hard Infrastructure in **Airways**	General air infrastructure	1.00
	General air infrastructure	1.00
	# Of airports	0.82
	# Of scheduled international flights – *flight network*	0.82
	# Of scheduled national flights – *flight network*	0.82
	Connection to # of cities – *flight network*	0.82
	# of international airports – *flight network*	0.82
	Million tons, billion tons per km, thousand tons per year, % volume, % company utilization	0.82
	"Air flow logistics as a constraints to international trade"	0.82
	"Air flow logistics as a constraints at policy level"	0.82
	# Of total, paved & unpaved runways	0.64

Table 3 - *continued*

	% Of total value of international transport flows by air	0.64
	% Of total import/export flows by air	0.64
	% Growth in total international freight *Historical growth measure*	0.64
	% Growth in total national freight *Historical growth measure*	0.64
	Spending on new infrastructure - millions investment *Future growth measure*	0.64
	A description of transportation laws & regulations	0.64
Complexity from Hard Infrastructure in **Waterways**	Km total waterways	0.64/1.00
	Containers per hour	0.64/1.00
	No. of major ports	0.64/0.82
	Handling capacity of containers in million	0.64/0.82
	General water infrastructure	1.00
	General water infrastructure	1.00
	Dock shipping length in mt	1.00
	Warehousing area in m^2 - *ports*	1.00
	Distance in days	0.82
	Km/km^2net transportation density	0.82
	# Of cities with a port	0.82
	Total # of berths – port size & capacity	0.82
	# of processed twenty-foot TEU's in millions	0.82
	Million tons general cargo - freight	0.82
	Million tons per port per year	0.82
	# Of containers per port per year - freight	0.82
	Growth in % per year water freight *Historical growth measure*	0.82
	Growth in quality of transport infrastructure	0.82
	"Water transportation logistics as a constraints to international trade"	0.82
	A description of transportation laws & regulations	0.82
	General water infrastructure	0.64
	Description of level of development of intermodal facilities	0.64
	# Of industrial parks located in ports	0.64
	% Of total import/export flows by waterways	0.64
	% Of total weight/quantity by waterways	0.64
	% of total value of international transport flows by waterways	0.64
	A description of investments in water transportation	0.64
	Investment in transportation with private participation in USD *Future growth measure*	0.64
	"Water transportation logistics constraints at policy level"	0.64
Complexity from Hard Infrastructure in **Intermodal**	General intermodal infrastructure	1.00
	General intermodal infrastructure	1.00
	Total # *Intermodal facilities*	1.00
	# of locations *Intermodal facilities*	1.00

Table 3 - *continued*

	Development of/investment in intermodal corridors *Future growth measure*	1.00
	# of total terminals *Intermodal facilities*	0.82
	# of port to port *Intermodal facilities*	0.82
	A description of transportation laws & regulations	0.82
	General intermodal infrastructure	0.64
	A description of developed intermodal facilities	0.64
	A description of government regulations on intermodal infrastructure	0.64
Complexity from Hard Infrastructure by Public **Warehousing**	Warehousing and storage area in million m^2	1.00
	# Of total Industrial parks & Warehousin	1.00
	General Warehousing infrastructure	0.82
	General Warehousing infrastructure	0.82
	Ports Warehousing and storage area in m^2	0.82
	A description of investment in Warehousing	0.82
	General Warehousing infrastructure	0.64
	# of total units for agricultural storage	0.64
	# of total tons for agricultural storage	0.64
	# of total companies using in-house Warehousing	0.64
	% of total companies using in-house Warehousing	0.64
	A description of new constructions and restructuring	0.64
Complexity from Supporting Institutions like **Customs**	Customs delays in # of days	0.64/0.82
	Customs clearance in # of days	0.82
	Customs clearance process	0.64
	A description of customs clearance process	0.64
	No. of border agencies for imports/exports	0.64
	"Competence of customs agencies"	0.64
	"Competence of other border related government agencies"	0.64
	"Transparency of customs clearance process"	0.64
Complexity from Supporting Institutions by **Logistics/SCM HR**	Economic size by labour force in million	1.00
	Skilled & semiskilled labour	1.00
	Skilled labour availability as a market obstacle on a scale from 1-7	0.82
	"Economy literacy amongst the population"	0.82
	Total # of Majors with a logistics/SCM education	0.82
	# of colleges & universities offering logistics major	0.82
	"Universities meets the need of a competitive economy"	0.82
	Skilled labour availability as a market obstacle on a scale from 1-7	0.82
	Literacy rate as a % of total population	0.64
	"Labour skills as a major business constraint"	0.64
Complexity from Hard Infrastructure	General IT infrastructure	0.82

Table 3 - *continued*

Complexity from Hard Infrastructure	General IT infrastructure	0.82
	General IT infrastructure	0.82
	Growth in IT infrastructure *Historical growth measure*	0.64
	Investments in telecommunications *Future growth measure*	0.64
	Secure internet servers	0.64
	"Cyber security"	0.64
	"Telecommunication logistics as a constraints to business"	0.64
Complexity from Technology **Use & Adoption in EDI**	Companies in % using ERP systems	0.82
	Companies in % using Descision Support Systems	0.82
	"Can customs declarations be submitted and processed electronically"	0.82
	EDI in customs	0.64
Complexity from **Financial Institutions & Services**	General financial infrastructure by "Country financial sector rating"	0.82
	Liquidity situation	0.82
	General financial infrastructure by "Quality of budgetary & financial management"	0.64
	"Loans access as a market obstacle"	0.64
	Financial institutions & services as a constraint to business activity	0.64
Complexity from Economic Institutions in **Economic policy**	Political effectiveness & stability with regards to economic policy	1.00
	General economic policy by "Policy direction of the government is consistent"	0.82
	Economic strategies of government by "Debt policy rating"	0.82
	Corporate tax	0.82
	Tax on assets – rate %	0.82
	Interest rates in %	0.82
	"Foreign commerce operation requirements as an obstacle to business development"	0.82
	Corruption world rank in #	0.82
	"Lack of transparency in policies and regulations as an obstacle to business development"	0.82
	General economic policy by "High adaptability of government policy to economic changes"	0.64
	A description of laws and regulations in relation to economic policy	0.64
	Value-added tax	0.64
	VAT on imports	0.64
	Inflation rates	0.64
	"Bribery - Informal economy as an obstacle to business development"	0.64
	"Trade unions as an obstacle to business development"	0.64
Complexity from Economic Institutions in **Economic Structure**	Export trade volume in billion	1.00
	Economic size by import trade in billion	1.00
	Economic development by logistics value-added as a % of GDP	1.00
	Economic capacity and output by growth rate in %	0.82
	Total investment in billion USD	0.82
	Economic growth rates in % *Historical growth measure*	0.82
	"Private companies' monopolies as a market obstacle"	0.82

Table 3 - *continued*

	Economic capacity and output by world rank in #	0.64
	Economic capacity and output by per capita	0.64
	Economic size by domestic consumption & demand by # of consumers	0.64
	Economic size by domestic consumption & demand by value	0.64
	Economic size by labour force in million	0.64
	Economic system - # of manufacturing & service firms, private non-profit and public institutions	0.64
	Price & price stability – index #	0.64
	Unemployment rate in %	0.64
	Export trade volume in billion	0.64
	Export trade volume in %	0.64
	Export trade in % of GDP	0.64
	Import trade volume in billion	0.64
	Import trade volume in %	0.64
	Trade deficit or surplus in billion	0.64
	Privatisation of economy by % of state-owned vs. collectively owned enterprises	0.64
	"Government monopolies as a market obstacle"	0.64
	"Market restrictions to entry & establishment - as a market obstacle"	0.64
	A description of logistics market entry rules	0.64
	Logistics market entry rules by country business legislation raking	0.64
Complexity from **Technology Use & Adoption in Electronic Banking & Commerce**	"Growth in quality of overall business environment"	0.64
Complexity from Judicial Institutions in **Business Legislation**	"Lack of transparency in law design, policies, and regulations as a government related obstacle"	1.00
	"Inadequacy of laws, policies, and regulations to companies necessities as a government related obstacle"	0.82
	Laws and regulations in relation to economic policy by Ease of doing business index	0.82
	Environmental laws & regulations by country business legislation ranking	0.82
	"Growth in quality of overall business environment"	0.64
	Law enforcement by country business legislation ranking	0.64
	Law enforcement by Ease of doing business index	0.64
	"Licenses and permits acquirement as a government related obstacle"	0.64
	Laws and rules for foreign investment by country business legislation ranking and by Ease of doing business index	0.64
	Taxation rules and regulations by country business legislation ranking and by Ease of doing business index	0.64
Complexity from Political Institutions by **Political Climate**	A description of general political situation	0.82
	Political stability	0.82
	Bureaucracy	0.82
	Political issues as logistics barriers	0.64

7.8. Limitations and discussion with respect to the findings and the validity study

As a starting point, because it was envisaged in the design phase that the validity study would result in a small quantity (handful) of measures, it was surprising to see so many (187) that could actually provide information on the varied decision factors, and thereby on supply chain logistics environmental complexity. This may then be interpreted in different ways because if seen as a limitation it could either pertain to a limitation of the methodology (Lawshe's ratio) and a limitation of the expert panel size, or it could pertain to a limitation of the design itself. As one expert pointed out:

> *"The scale (not important, maybe important, very important) might be too narrow to capture variance. My sense is that most responses will either be "maybe important" or "very important". This might be statistically a challenge for most methodologies"*

On the other hand it could also be seen as strength of the study as we now have 187 different (data types) of measures, which gives the possibility of preference and choice in different decision-making contexts. A rationalisation on these accounts is therefore appropriate here. Barring a few minor comments from the experts, since the decision factors and the structure of the theoretical model did not suffer from any unexpected findings, the following paragraphs shall refrain from discussing these.

First, Lawshe (1975) only mentions broad guidelines on how to deal with experts by looking for measures that are "essential", and though he mentions the disadvantages of installing weighting and rating, he also suggests applying *logical considerations* and *empirical evidence* to justify the inclusion of relativity in an instrument. Therefore, the original expert opinion instrument had been designed in a way that did not contain relativity. However, Lewis et al. (2005) justify their use of relativity while incorporating the "Essential", "Important but not essential" and "Unessential" scales because of the (peculiar) task of construct development, which is also this dissertation's main task, by reasoning that *"however, a less stringent criterion…could also be justified since responses of both 'Important (But Not Essential)' and 'Essential' are positive indicators of an item's relevance to the construct",* (p. 392). Given this, and the fact that that the previous stage had resulted in a comprehensive list of 337 measures, it was decided to install relativity with the hope of considerably lowering down and refining the list. However, this exercise also gave an impression of "developing scales" on the measures.

From this point of view it could be rationalised that because this study was never envisaged to directly result into a "(decision) instrument" for data collection purposes mentioned in the Lewis et al. (2005) methodology, the impression of scale development was faulty. Instead the purpose was that of construct development with the (yet) primary aim of construct conceptualisation. In retrospection, speculating on a goal of the study, as the attainment of a handful of measures was then incorrect, as developing scales on these measures is supposedly a next stage concern. This limitation on claims became evident during the execution of the study. Given this, the objectives of the validity study then required a modification.

Second, even though the aim was that of construct conceptualisation, using a data source such as CSCMP *Global Perspectives* as a starting point of the content analysis for the measures may also be questioned because it led to a proliferation of measures, and subsequently an overlap in the instrument and the results of the findings. Since the purpose was also to observe expert preferences on measures and how certain measures performed relative to others, based on each measure's data type (e.g. a perceptual measure or an objective measure) and source, this was thought to be a necessary evil. However, since no specific pattern on measure preferences could be observed in the results[38], it could be argued whether it was necessary to approach the experts with a list of 337 measures, many of which were already in a state of overlap.

On the other hand, this argument also has to be weighed against one that poses that different decision-making contexts would dictate the choice of measures from the plethora of (187) validated measures. Similarly, given the availability of data, one way of dealing with overlapping measures could also be to incorporate only those with the higher CVR value in a (next stage) decision instrument. Whereas in cases with similar CVR values, another approach could be to inform eventual respondents (of the next stage) of multiple, competing sources of information availability. Finally, as is common practice in an AHP decision instrument such as an expert choice tool, another option could be to present a description based on the top performing (information) measures on each factor, regardless of the overlap.

[38] Barring one expert, who clearly stated that "complexity is a perceptual construct", and that any attempt to quantify objective measures such as *paved roads* etc. would not give any information on it's state.; and another who suggested using *"Rating of overall business environment"* instead of *"Growth in quality of overall business environment"*

Third, it is important to recall that the size of an expert panel should (typically) not be an issue in decision-making studies; it is the nature and credentials of the experts that matter. Yet, validity was sought to the theoretical model, as it was important to generate some level of confidence by employing the Lawshe tests (see e.g. Huang et al., 2005, who follow a similar line of reasoning). However, findings should then also be evaluated by keeping in mind that the test is driven by a "logical positivist" paradigm, e.g. one that uses statistical significance as a means to attain content validity (Templeton et al., 2002; Lewis et al., 2005). This may be termed as the empricist's approach in decision-making studies. From this point of view, an inherent paradox in the approach to the present study was realised, as the AHP structures a hierarchy using experts in a different spirit, as compared to the approach applied here. This paradox then relates to the present study looking beyond its immediate (methodological) domain and approach in decision-making to an empricist's domain for sufficing an over concern with validity issues (Bertrand and Fransoo, op. cit.). On the other hand, however, this could be explained by the lack of faith in extant literature (e.g. Bagchi, 2001) in explaining the new construct.

Also, in relation to their performance, experts were found to be stronger in certain areas as compared to others. Expert responses seemed a little unassuming and unselective, especially when it came to short-listing measures on decision factors that were concerned with macro economic policies, structure and polity, as very few measures were found to be unimportant, also contributing to the proliferation and overlap of measures. From this point of view, the choice of experts could then be questioned.

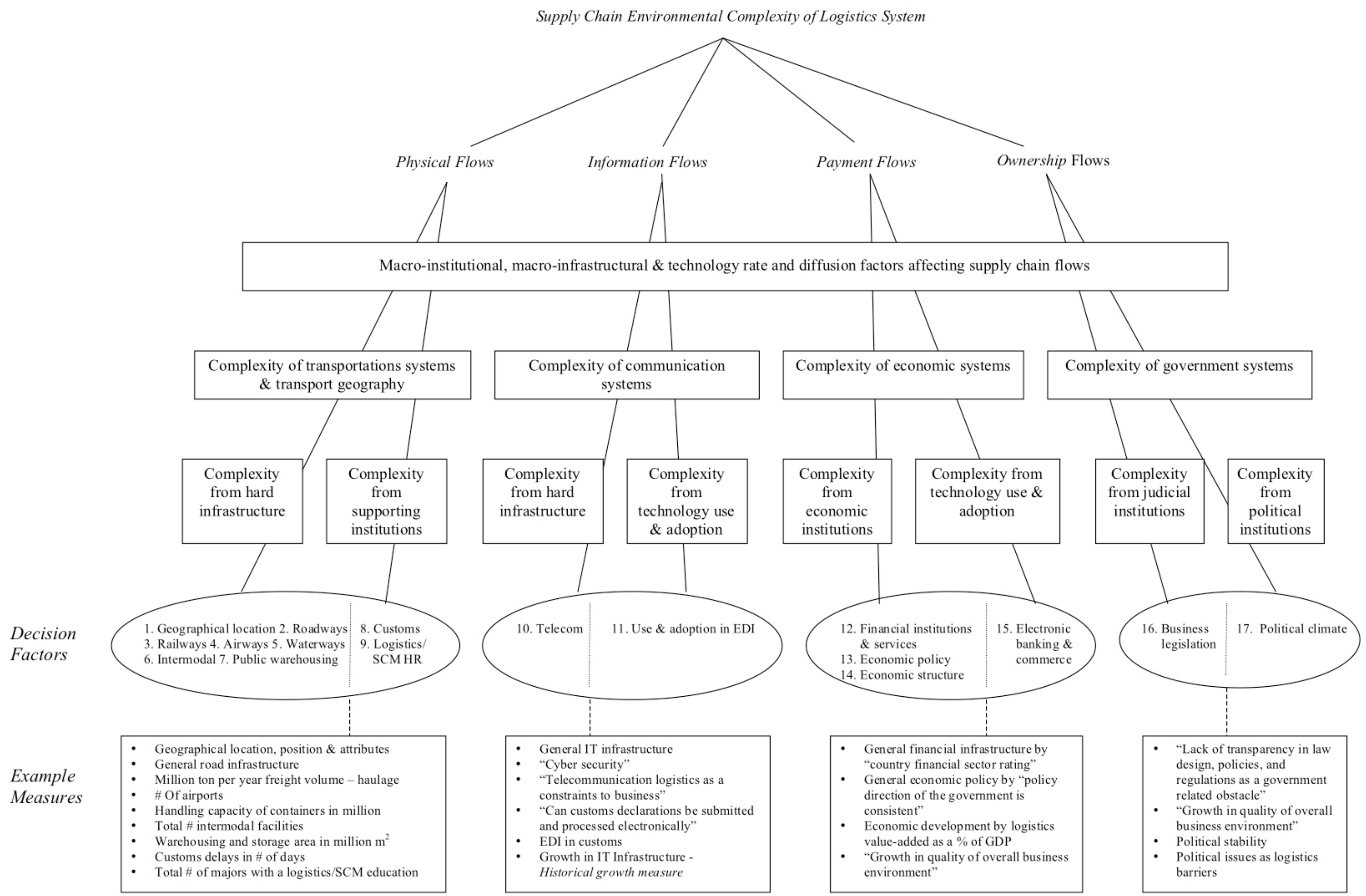
The final point relates to what steps and stages within the construct validation process mentioned earlier in this chapter have been accomplished by the validation study detailed here. From this point of view, it may be discussed that Stage II of Lewis et al. (2005) three-stage construct development methodology has almost been achieved here, as the findings presented here can be used to create a 'decision instrument', which when employed for data collection in a global supply chain oriented "site-location" decision-making scenario, is capable of prioritizing and generating individual managerial preferences on the decision issue (see Kinra and Kotzab, 2008a; 2008b for illustration of such an application).

7.9. Consequences of the validity study and some final thoughts

The main consequence of the validity study was in the form of a refined model of supply chain logistics environmental complexity. Fig. 43 summarizes the main findings of the study by listing the 17 decision factors and some examples of measures that were found to be important for reaching decisions on the factors. All the basic reasoning and workings of this model remain the same as outlined in the original theoretical model (Fig. 40), except that it has now been modified with findings of the validity study, i.e. the 21 factors in the original model have now been modified to 17 decision factors. Similarly, the list of 337 measures in the original model has been refined to 187 measures, which aid in measuring the construct. Furthermore, as a result of the work presented here, the study is in a definitive position to offer concrete answers to the second research question (RQ2), which pertains to the validated decision factors and their information measures presented here. The findings and model presented here may now be used for a list of sundry applications and future research purposes that are presented in Chapter 9. Finally, having answered all research questions and having met its research objectives, the dissertation is now in a position to conclude. Therefore, the following part on conclusions forms the final, and in many ways the most important part of this dissertation.

Figure 43

"a model of supply chain logistics environmental complexity"



Chapter 8

Conclusion: Environmental Complexity in Supply Chain Logistics Operations

This chapter marks the end, and represents the first of the two chapters that form the concluding part of this dissertation. It therefore concludes on the research problem and questions, and seeks to offer a discussion based on the research process encountered in the last three years. The chapter is structured according to the main research questions, as it seeks to conclude with respect to each and bring out salient contributions that have been made in this dissertation by sufficing each research objective.

8.1. A justification (need and relevance) for the construct

This study's main purpose of bringing the construct of environmental complexity to the supply chain domain was based on a set of assumptions, e.g. the supply chain as an organisational form, and environmental complexity as a distinct, identifiable construct. Though proving/disproving (testing) these assumptions was not an objective in itself, providing the (theoretical) rationale for each of these in the supply chain context was imperative, in order to quench the need for a distinctive uncertainty-related construct in a problem domain that sought to deal with strategy and design issues related to extended supply chain operations. The first research question (RQ1) was thus conceived as a consequence of resolving the above-mentioned issues, as it sought to ask the following:

> ***What*** *is the relevance of environmental complexity for the supply chain?*

It is therefore worthwhile recapping the design/process of responding to this research question, as it was first imperative to understand the concept of environmental complexity in terms of why and how it arises, and its theoretical antecedents for understanding preferred starting points in literature. Especially, with respect to its relevance, the inextricable relationship between environmental complexity and organisation structures and structural complexity was then brought forward. Whereas, the relationship between environmental complexity, organisational strategy and performance (E-S-P), a contingency argument formed the main departure point in exploring the relevance for such a construct. All this was made possible in Chapter 3.

Next, it was imperative to understand and position supply chains as organisational forms. Chapter 4 gave an in-depth treatment to the supply chain organisation in defining it as an organisational form. The original notions of environmental complexity were then applied not only in understanding its relevance for the supply chain organisation, but also in determining the degree of this relevance as compared to other types of organisations. The extended nature of supply chain operations, which is inherent in the supply chain definition, first helped establishing this relative degree and predisposition to environmental complexity as compared to other organisational forms (e.g. MNC's), and finally helped in arguing for the need and relevance of understanding environmental complexity in supply chain operations.

An answer to RQ1 was therefore rendered possible at the conclusion of Chapter 4 as it was found that supply chains are complex organisational forms, and as such face a higher degree of environmental complexity as compared to other organisational forms. Because of the inherent structural complexity of the supply chain as compared to other organisational forms, the relevance for understanding and measurement of its correspondingly high level of environmental complexity arises. This relevance of environmental complexity in supply chain operations may be attributed to the typical definition of a supply chain (with reference to Mentzer et al., 2001), which involves extended organisational operations, or operations with extended scope. The extended scope of the supply chain in this study was demonstrated using the instance of geographical dispersion of supply chain operations and activities, particularly with respect two variables i.e. the total number of supply chain actor environments, and the diversity between these environments. From this point of view, since countries and borders matter, since supply chains operate in a global environment, and since supply chains span multiple (country) environments, environmental complexity becomes relevant because of the differences between these countries, and how these differences support or impede supply chain operations.

Finally, it was also hoped that a sound theoretical response to the first research question would provide *"the raison d'être"* behind different global supply chain management (problem domain) issues, and thereby also provide the rationale for bringing the construct into the disciplinary domain of supply chain management. This was done as it now becomes easier to understand the role of an environmental complexity construct in explaining the relative importance of different global supply chain management issues and literature streams that pertain to international/global supply chain logistics management; logistics practices in different countries; constraints or barriers in global logistics operations; logistics costs of different countries; and risk in global supply chain operations.

8.2. Decision factors and (information) measures of supply chain logistics environmental complexity

Construct development, by way of developing supply chain logistics environmental complexity, was then framed as an important objective that would aid in the purpose of further developing a deeper understanding of environmental complexity in supply chain environments. The second research question sought to tackle this in the following form:

> ***Wha****t are the key (decision) factors and their (information) measures that operationalise the construct of environmental complexity in supply chain logistics environments?*

As it was then important to understand environmental constituents, Chapter 5 undertook the task of establishing and operationalising supply chain environments by applying theoretical notions that had been presented in the earlier chapters of the dissertation. At its culmination, a preliminary response to the RQ2 was rendered possible by an identification of the broad categories of decision factors that cause/describe (i.e. factors that are linked to and describe) environmental complexity. The process of refining this response in the subsequent chapters may thus be seen more as a validation and model building exercise. However, it was an important process because it was only possible to completely conclude on RQ2 at the culmination of Chapter 7.

Operationalising environmental complexity in supply chain environments involves deciphering the concept of supply chain environments and therefore the constituents of these environments. There are supply chain general environments, and there are supply chain task environments. Whereas general environments relate to the macro-environmental segments, task environments related to micro/meso-environmental segments These environments, however, do not exist independently of each other. There is transcendence between the two, whereby only those sectors in the general environment transcend into (e.g. managerial decision-making) at the task level, which are relevant to the problem owner's immediate problem domain. In this dissertation, logistics was formally defined and chosen as a point of departure for the task environment; in another case, this task could well have been purchasing, or even production.

It was then possible to categorise all decision factors that operationalise supply chain environments under three broad categories. These are:

1. *The hard or physical infrastructure factor category*
2. *The institutional factor category*
3. *The technology-use/adoption factor category*

Most importantly, because these impede or facilitate essential supply chain flows, a list of 17 decision factors corresponding to these three categories were found to operationalise supply chain logistics environmental complexity. These were categorised as:

1. *Environmental complexity from: hard Infrastructure factors – (#1) Geographical Location, (#2) Roadways, (#3) Railways, (#4) Airways, (#5) Waterways, (#6) Intermodal, (#7) Public Warehousing, (#10) Telecom.*

2. *Environmental complexity from: institutional factors - supporting institutions to physical flows like (#8) Customs, (#9) Logistics/SCM HR, and economic Institutions like (#14) Economic Structure, (#12) Financial Institutions & Services, (#13) Economic policy, judicial Institutions in (#16) Business Legislation, Political Institutions by (#17) Political Climate.*

3. *Environmental complexity from: technology Use & Adoption factors such as (#11) EDI, (#15) Electronic Banking & Commerce.*

The second aspect of RQ2 sought to operationalise the construct in a way that specific information measures could be attributed to the construct. This required framing the construct in terms of its factors and measures in Chapter 6. It was found that supply chain environmental complexity could be measured using a list of 187 information measures that corresponded to each of the 17 decision factors. Although these measures are disproportionately aggregated, and there were overlaps between some of these, the measures were found to be representative of their respective decision factors and environmental complexity categories. Each measure has been classified as "essential", and "important but not essential" depending on its relative importance to the construct. Furthermore, each "important but not essential" measure is ranked in importance depending on how well it performed in its content validity ratio (CVR_i). As an illustration from Table 3, some of the measures that performed well were:

- *"Geographical location, position & attributes"*
- *"Warehousing area in m^2 - ports"*
- *"Km total waterways"*
- *"No. of major ports"*
- *"Handling capacity of containers in million"*
- *"Containers per hour"*

It can now be concluded that these information measures provide a description on the state of complexity, and the decision factors aid in assuming decisions related to that complexity. Therefore, it is now also easier to understand the utility of the global supply chain management issues and literature streams that pertain to 'Globalization considerations' in supply chain design; country or regional logistics infrastructures and systems; macro effects of/on logistics systems; global supply chain management factors**;** and international logistics and supply chain systems from the perspective of macro-economic development, and country geography.

8.3. Contributions and implications

Although this study has accomplished its main research purpose of identifying decision factors and measures for managing global supply chain operations, and has extended the findings of existing studies in this direction (e.g. Bagchi 2001), the main contribution of the study may not be in these findings per se, as the results of large scale empirical studies such as the *Logistics Performance Index* (2007) may be more generalizable to this end. Instead the main contribution could be summarized as that of offering a new theoretical lens (environmental complexity) in the study of supply chain management, and construct development from this point of view.

Next, by explicitly conceptualizing and defining global supply chains and global supply chain issues, the main problem of this dissertation is resolved as the domain literature now finds itself richer with a construct that addresses strategy, engineering and design issues with respect to extended, and dispersed supply chain management operations. For example, now that we have a "*construct that deals with supply chain environments, and uncertainty caused by these"* (ch. 1), applying the environmental complexity lens provides more leeway in understanding barriers, costs and risks associated with global supply chain operations and the management aspects related to these. From this point of view, by assuming an explicit stance on global supply chains, the present study has aided in laying down, distinguishing and positioning itself within different avenues, thus making an important contribution in extending the theory and practice of global supply chain management.

The study has, however, also contributed to a list of other, peripheral problem domains and literature streams. For example, it has contributed towards organization fit and configuration literature by proposing differences (in the form a typology) between organizational types such as (global) supply chains based on relationships and (multi national) corporations based on contracts. These differences may now be put to further verification within the scope of a different research project. Similarly, this thesis is also of importance for the international business domain, as it is important for IB scientists to understand the constellation of, and barriers to global value chain (task) operations in the study of e.g. complex multi national networks. Similarly, given the nature of the strategic contingency arguments framed in this thesis, the dissertation has not only contributed towards the strategy domain by bringing out the importance of designing a supply chain strategy, but also to its essence in relation to other strategies such as operations (logistics), corporate and competitive strategies. From this point of view, given a complex environment, the design of a supply chain strategy should reflect this complexity by focusing on the appropriate trade-off between costs, risks and responsiveness in the system (e.g. Chopra and Meindl, 2007).

Most importantly, the study offers a different methodological paradigm by employing a decisional approach to identifying relevant factors and measures. From this viewpoint, although previous studies that employ such a paradigm in the logistics domain (e.g. Min 1994b; Bagchi 2001) advocate the use of experts for soliciting responses for developing their constructs, none effectively deals with instrument development and content validity concerns that the present study addresses. An implied consequence then contrasts applying such a perspective to that of widely-accepted environmental scanning indexes (e.g. IMD's *World Competitiveness Index* or the *Logistics Performance Index*), in that problem owners should then prioritise environmental complexity factors with respect to their particular decision-making situations. From this point of view, problem owners not only have a construct now, but also a methodological tool, which when applied in their individual contexts, can guide decision-making with respect to supply chain design problems such as "site location", "supplier selection" etc.

This study has therefore contributed to the discussion surrounding environmental scanning needs of supply chain managers, and the development of effective tools to deal with such needs (e.g. Aguilar 1967; Keegan 1974; Khandwalla 1976) in at least two related ways. First, by applying a decision making paradigm, a decision support system may be aimed as the end contribution (Zach, 2007); and the model presented here (Fig. 43) may well be termed as an instrument (Lewis et al., 2005), a 'decision instrument', which when employed for data collection in a global supply chain oriented decision-making scenario, is capable of prioritizing and generating individual managerial preferences on the decision issue (see Kinra and Kotzab, 2008a; 2008b for illustration of such an application). Second, an important implication of this study is also that managers should solve their environmental scanning needs by creating context-specific decision systems. It may not be enough to simply refer to existing country indexes and the (perceptual) importance of factors stated therein, because the priorities of these factors may change according to e.g. the industry, and specific decisional problem facing the manager. Through this set of implied consequences, the thesis has not only contributed to the content of strategy and decision-making (through a list of decision factors and information measures), but has also peripherally contributed to the process of decision-making.

Lastly, it may then also not be questionable that the present dissertation represents a modernist organisational perspective in order to understand environments. Applying any other perspective in the present world order could have been faulty as the current world map is overwhelmingly demarcated by boundaries. Countries and borders do matter, and the perspective of a flat world with free logistical flows remains utopia, until proven otherwise (Ghemawat, 2001) e.g. by the fall of these boundaries. Whereas the implication of this thesis on such a (macro) argument is that until that point is reached, countries, and policymakers will attempt to tackle the environmental complexity inherent in cross border-border supply chain operations by the design and implementation of (e.g. trade) agreements.

8.4. Discussion

The limitations of this dissertation have to be largely seen in light of the study's main purpose of bringing the construct of environmental complexity to the domain of supply chain management. These may then be broken down and discussed more specifically in terms of the study's research objectives and design, its contributions and implications, and some integral delimitation, without which this study may not have been possible.

8.4.1. Limitations

First, it must be admitted that the results of this study may only be seen in the context of particular global supply chain management decision-making problems, especially those related to "site-location" and future descriptive solutions to such problems. From this point of view, since location decisions are of long-term, 1st order strategy related (Chopra and Meindl, 2007), the author was driven by a site-location underlying problem situation whereby the decision to locate in a particular country/region takes place. Therefore the study sought its point of departure only in those studies that are focused on cross-country comparisons of macro logistics systems based on such a situation. In this case, even though it might have been implied otherwise in this study, a number of the measures and decision factors presented here may not (necessarily) be directly relevant for e.g. supplier selection problems.

Second, and related to the previous point, even though it was delimited with respect to the exclusion of culture from the analysis, social and cultural environmental segments are also important segments of the general environment (Hatch, 1997). From this viewpoint, questions may be asked with respect to why cultural factors did not figure in the meta analysis performed in the present study. But then again, since the present study is concerned with design issues, it can be argued that culture forms a second stage consideration, and is probably an important consideration in tactical decisions such as supplier selection (Chopra and Meindl, 2007). As Guisinger (2001) also phrases an important contribution in this regard:

> *"Geert Hofstede (1983), for example, has explored the nature of national cultures and the ways in which cultures affect individual decisions. Hofstede's principal interest has been focused less on the influence of cultures on the structure and operations of multinational firms and more on the ways in which individual managers should incorporate knowledge of cultures into their decision making"* (p. 264).

Cultural differences then also form an important part of environmental uncertainty and need to be taken into account while managing global supply chains (Whybark 1997; De Koster and Shinohara 2006), not designing these. This said, culture could be foreseen in the present research endeavor, within the scope of decision-making processes, in the application of the supply chain logistics environmental complexity construct.

Next, just as environmental complexity and environmental uncertainty researchers (e.g. Duncan, 1972; Galbraith,1977; Kanwar et al., 1991) devise formulae for calculating (perceived) environmental complexity, developing such types of formulations for supply chain environmental complexity has remained outside the confines of this dissertation. Firstly, this may then be seen as a limitation because it (yet) remains unclear in this study as to how environmental complexity will manifest itself in terms of a concrete formulation. Discussing decision factors and their measures is then only trying to describe the constituents of the state of complexity, but not demonstrating the degree or measure of it. Secondly, it remains a challenge, and thus a limitation for the present study to conceptualise this measure while taking the peculiarities of the (dispersed) supply chain organisation into consideration.

8.4.2. Reflections on aims and scope

Next, a substantial part of this discussion should relate to the aims and scope of the study. From this point of view, it may be argued whether it was indeed necessary to go through the grind that this Phd process represents, in order to bring the construct of environmental complexity to the SCM domain; whether it was necessary to conduct a validity study in order to short list the decision factors and measures etc.? A reflection on these has to take into account the (negative or positive) aspects of scientific enquiry, and the (academic) researcher as the primary problem owner. In that case, it was important to undergo the research stages and processes documented here from the point of view of discovering and developing constructs. Research conventions and protocols thus needed adherence. The generalisability of large-scale studies such as the Logistics Performance Index (2007), had in this sense, very little to do with the present study, as it was concurrently published, and employed a different approach.

As regards the aims and scope of the validity study, most of its limitations have already been discussed in its relevant section. However, from the point of view of the overall dissertation, the validity study was also required because of the competing constructs (such as *competitiveness*) that sought to describe the same phenomena under observation. In this sense, it was also important to unify the problem domain.

8.4.3. Reflections on scientific achievement

In a similar vein, it is also important to delimit the dissertation in terms of its overall scientific contribution. Since Mitroff et al. (1974) have been consciously applied throughout this dissertation, it is only appropriate that the present discussion form its departure in their research process, loops and stages. From this point of view, whether or not the refined, and validated model (Fig. 43) should still be termed as a theoretical model for future research, or is an end in itself remains a contentious issue and depends on the individual opinion. For example, some (e.g. Bertrand & Fransoo, 2008) would either agree that both internal and (to an extent) external validation concerns have been met in order to arrive at this model; or that external validation of the construct, using and AHP methodology, may not be seen in the same spirit as in the empirical approach. Whereas, others (e.g. Mentzer and Flint, 1997) would argue for more stringent tests in order to arrive at this research stage or to claim this as a model.

Regardless of this discussion, the author is comfortable enough in acknowledging that the result of this dissertation is what Mitroff et al. (1974) refer to as a *scientific model*. Since an important loop of construct *conceptualisation – modelling – validation* was attempted, and construct development took into account detailed internal, content validity issues, it is safe to conclude that external validation of this model (e.g. by undergoing Lewis et al.'s Stage III methodology), will only lead to more complete construct development. However, we are also faced with a paradox, as it yet needs to be ascertained what external validation implies under an Analytic Hierarchy Process (AHP) paradigm. Because, the many links in this scientific model are not necessarily cause-effect driven, they may never be framed, for example, like a structural model. To a large AHP audience, construct development and operationalisation may then have been achieved here, and external validation refers to construct application, and the evaluation of this application with respect to the internal and external quality of the model solutions. Discussing these aspects, as future research ventures shall then be an important subject of the next and final chapter of this dissertation.

Lastly, it may be worthwhile reflecting on the comprehensiveness of this study. Bertrand and Fransoo (2008) note that achieving the entire Mitroff et al. (1974) modelling cycle within the scope of any single research project is not only difficult, but is uncommon and that:

> *"…in large-scale research projects several of these research types could be combined. In addition, research methodology varies across the different types of quantitative model-based research",* (p. 10).

Given the considerations presented here, and having met important theoretical and methodological conventions on (environmental complexity) construct development, the present dissertation can then claim itself to be a complete piece of work within an ongoing process of scientific discovery.

8.4.4. Issues of broader resolution

Finally, there are some general issues pertaining to scope-based supply chain operations, and thereby the overall field of global supply chain management that require redressal. From this point of view, what if the dissertation had adopted an antithesis, and locations did not matter in extended or global supply chain flows? Would environmental complexity then not be relevant, or would it manifest itself in a different form? And even if location did matter, an interesting perspective is that of whether we need a separate intellectual stream for studying scope-based international operations (Whybark, 1997), and consequently one for global supply chain management.

Yet another issue of broader interest is the link between global supply chain management and uncertainty i.e. do globalization and uncertainty, as reflected in activities such as outsourcing, lead to supply chains and global supply chain management (Anand and Ward, 2000), or the other way? Furthermore, is environmental uncertainty (or complexity) necessarily a negative issue, one that needs to be addressed by e.g. modifying the information processing requirements of organizations (Flynn and Flynn, 1999)? These are some interesting perspectives that (yet) need to be critically considered in any ambitions of developing theory on global supply chain management, and may require revisiting the broader organisational and management roots of SCM field. From author's point of view, we are now beginning to understand the relevance of the construct with respect to supply chain management, as this dissertation has opened up a plethora of interesting problems and assumptions that need to be resolved. Some of these issues are now presented in the form of future research directions in the next chapter.

Chapter 9

Future Research

All the future research directions presented in this concluding chapter should be seen as a continuation of the research contributions, consequences and implications presented in the previous chapter. Depending on how one sees these, some may then be termed as contributions and implications, whereas others may be termed as delimitations that could not be addressed within the scope of this 3-year PhD process, but those that yet present interesting avenues for future research. As these have been made obvious throughout the dissertation, the chapter shall start out by presenting the most direct implications of the construct (model) on supply chain logistics environmental complexity under the heading of decision-making applications. It will then carve out future research areas within the scope of the decision-making applications presented in the first section. Finally, it will also present some future research directions in terms of applying other (appropriate) research paradigms that present interesting projects, and aid in verifying some basic assumptions underlying the construct.

9.1. Decision-making applications

This application is directly related to the environmental scanning problem that underlies this study with respect to the (environmental complexity) construct. As outlined in Chapter 2, since such an application requires a different research design and corresponds to a different modelling – model solving loop (2), this represents an important future research avenue. Developing and validating decisional, and measurement models related to supply chain logistics environmental complexity therefore represents this category of applications. Although representing a more incomplete construct as compared to the one presented in this study, some of these decisional applications were demonstrated and (peer) reviewed in Kinra and Kotzab (2008a; and 2008b), thereby embarking/demonstrating the modelling – model solving loop. This section shall then briefly consider one of these decisional models (Kinra and Kotzab, 2008a) in order to demonstrate construct application, and future research avenues of supply chain logistics environmental complexity.

Kinra and Kotzab (2008a) develop a decisional model based on a hypothetical (site-location) problem by posing it within a *goal-alternative* based multi-criteria decision-making system, whose goal is to reduce the exposure to environmental complexity by choosing that alternative that best meets this goal. The site-location alternatives represent individual (country) environments i.e. Denmark, Norway, Finland and Sweden, and the AHP approach is then applied to construct a decision-making hierarchy in order to choose the best alternative. Fig. 44 presents this hierarchy, whereas Fig. 45, also taken from Kinra and Kotzab (2008a), documents the entire model construction process, including suggestions for operationalisation in individual managerial contexts. The results of Kinra and Kotzab's (2008a) DSS model culminate into a descriptive index that ranks these different locations (countries) depending on how each performs on the supply chain logistics environmental complexity decision factors, measured by a set of (information) measures that provide information on each factor and the state of environmental complexity. As a result, by applying such a DSS model, a (logistics/supply chain) manager may then be able to resolve a site-location problem with respect to the construct of environmental complexity.

DSS model construction may then be seen as an important (managerial) implication. For example, now that we have a validated set of decision factors, and a validated set of measures that can be used to measure these factors, one may use the model construction process described in Fig. 45 to construct a DSS model in different managerial contexts. However, the entire DSS model construction process then opens up a string of interesting, future, scientific research endeavours that are related to further construct development, application and external validation of supply chain logistics environmental complexity. From this point of view, future research stages for this dissertation are envisaged to exclusively focus on DSS model construction and validity issues and may take the form of speculated research designs, within the scientific scope of the following future steps.

9.1.1. Future step – 'decision instrument' development

After having performed appropriate screening tests on the factors and measures of the construct in this study, this future step may be attainable within the near future (Lewis et al., 2005). Such a research endeavour would be necessary in order to generate (decision-making) responses for the construction of a DSS model. However, this may first require further "item screening" tests based on the rankings of the 187 measures short-listed in this study. The purpose would then be to arrange these measures in an information section of the data collection instrument, in a way that provides relevant information on each factor where a decision is sought. The AHP (1-9) ratio scales may then be used to frame and capture responses on each decision factor.

Figure 44

An AHP-based multi-criteria DSS model that applies the construct of supply chain logistics environmental complexity

(Kinra & Kotzab, 2008a)

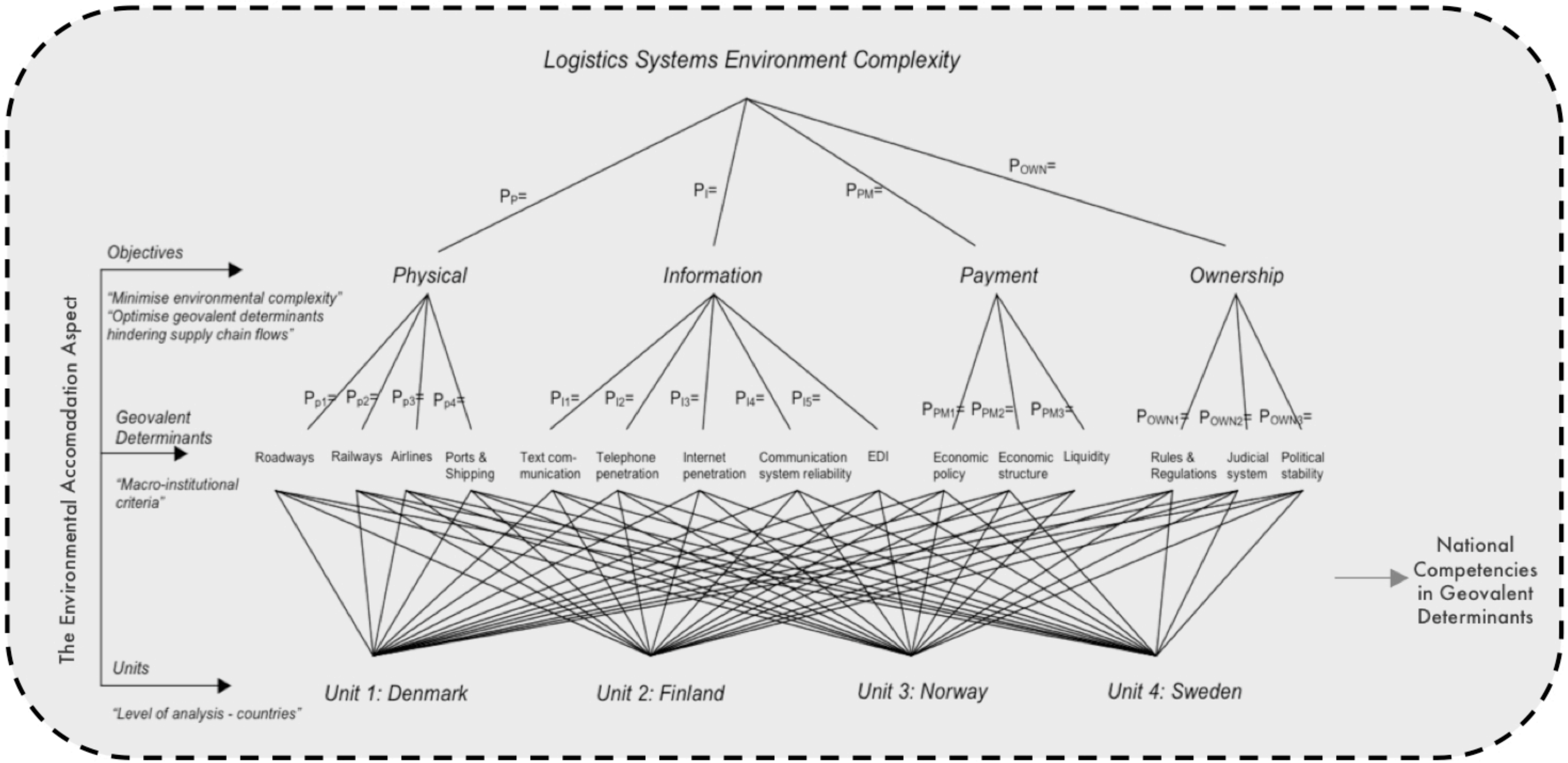


Figure 45

A detailed breakdown of the DSS model construction process

(Kinra & Kotzab, 2008a)

Level 1 hierarchy – the goal (Logistics Systems Environmental Complexity)

How it has been established and illustrated:
The overall goal is to minimise the macro-institutional logistics systems environment complexity, therefore logistics systems environment complexity is placed as the apex. The concept has been established within the theoretically derived conceptual framework (Figure 2).

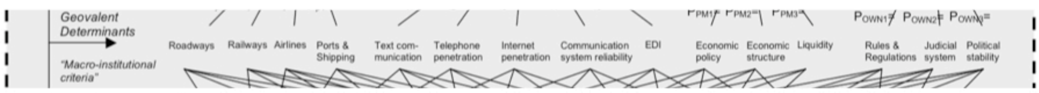
Suggestions for managerial use:
The focal point of the conceptual framework (Figure 2) i.e. environmental complexity accommodation, may actually be understood as a rational decision-making process, which emphasises on how the manager may apply the AHP decision-making methodology to understand and reach a systematic judgement on his or her context specific (e.g. industry) environmental complexity.

Level 2 hierarchy - the four flows (Physical, Information, Payment and Ownership)

How it has been established and illustrated:
The importance of the level 2 flows has been derived from extant literature. Following Handfield and Nichols (1999), Bowersox and Closs (1996) and Closs and Mollenkopf (2004), the objectives of minimising logistics systems environment complexity are established as the optimisation of those general environment components, which hinder or facilitate the four flows intrinsic to supply chain logistics operations: physical flows, information flows, payment flows and ownership flows. Rankings or priorities for these 4 flows are illustrated using rankings for these flows in a similar study (see Bagchi, 2001).

Suggestions for managerial use:
A good example for weighting the relative importance of these 4 flows using data collection by the individual supply chain manager is a survey (Chan and Lynn, 1991), where the respondents (e.g. 3-4 respondents from the same industry sector) answer a questionnaire, or use focus groups to reach consensus on the relative importance of these 4 flows in their specific context.

Level 3 hierarchy – geovalent determinants or macro-institutional criteria that affect optimisation of the level 2 flows

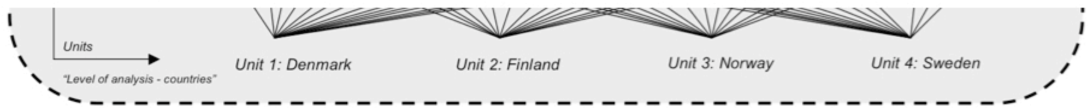


How it has been established and illustrated:
Following Bagchi (2001), the geovalent determinants (general environment components) mentioned in our conceptual framework that affect these four flows at a national (macro) level may be characterised as: physical infrastructure factors, institutional factors and technology diffusion factors; likewise Min (1994b) characterises the geovalent determinants considered here within the realm of cost, accessibility, risk and incentive criteria. In the present study, 15 factors (as in Figure 3) were considered initially and were later on consolidated into 13 evaluation criteria (as in Table 3). The importance of all factors have been assigned weights using Bachi (2001), except for quality of road, rail, air and water transportation where we have used primary data through a focus group conducted on 10/11-2005. Here judgements of 4 experts (SCM scholars) were used in order to reach these factors' relative priorities. Here a fifth factor i.e. "warehousing" was made redundant because the experts judged that it did not belong to the same hierarchy level (3).

Suggestions for managerial use:
Here there are a total of 13 factors, each factor corresponding to a certain flow i.e. 4 physical flow factors + 3 information flow factors + 3 payment flow factors + 3 ownership flow factors: the first step would be to repeat the process as in the previous level and to determine the rank/weight/contribution of each factor towards its corresponding flow. Here again, either a survey technique may be used where respondents answer a questionnaire (Chan and Lynn, 1991) ranking the 13 complexity attributes; or focus groups may be used where participants seek consensus reaching through the AHP based Expert Choice® software. It is interesting to note that each iteration in the supply chain or logistics manager's specific industry or business context shall result in different weights for these factors, not to mention that some of these factors may be irrelevant in some cases.

Figure 45 - *continued*

Level 4 hierarchy – units or countries compared to each other against the level 3 geovalent determinants



Data collection:

Next, a measurement scale for the level 3 geovalent determinants (13 factors) is defined in terms of broad metrics or indicators. This is needed in order to have some common evaluation measures for comparing the environments (units or countries) against each other and for synthesising the overall hierarchy. A grid containing the 13 factors, performance measures/metrics used to represent each factor and its corresponding value for each of the units (countries) examined, is subsequently manufactured. Then data is collected on these metrics for the 4 units (Nordic countries i.e. Denmark, Finland, Norway and Sweden and the standard i.e. US), presently available to the best possible extent. Here we use secondary and tertiary data collected via published and online research data-bases such as World Bank i.e. World Development Indicators (WDI) Online, World Competitiveness Yearbook (WCY) sources i.e. World Competitiveness Online, Economic Intelligence Unit (EIU), Eurostat Yearbook, Global Development Finance (GDF) Online and Source OECD.

It is important to recognise that data collection in this process has only been done to make the overall illustration more realistic. Firstly, the data collected for these factors, may not always be exactly representative viz. the metrics do not always have prefect correspondence with the determinants and neither was data uniformly available on all the metrics considered. Secondly, the data representing these metrics may be in a mix of qualitative and quantitative formats. This implies that certain metrics, especially those that are of a qualitative nature, have been measured using subjective surveys. The metrics and data collection measures adopted in this illustration may also vary, depending on the overall goal of this process e.g. a prescriptive index vs. an indicative decision-making model etc.

How it has been established and illustrated:

Lastly, the four Nordic countries (Denmark, Finland, Norway and Sweden) are compared in a pair-wise fashion to each other and a standard country, individually against each geovalent determinant of the level 3 hierarchy. The four Nordic countries are chosen because they represent the illustrative location decision-making problem; whereas the standard country is taken as USA not only because it represents the supply chain manager's home environment (see the supply chain manager in our hypothetical problem, "Application" section) but also because standard implies the benchmark in terms of all factors considered and is considered as the US, based on the consistently high overall ranking for the US in indexes e.g. IMD's World Competitiveness Index. In this sense, a goal-oriented approach is applied. This comparison demonstrates a measure for *logistics systems environment complexity of nations* in sustaining effective logistics operations of supply chains within a geographical scope. . In this step, we have foregone the comparative judgement process using different respondents, and for the purposes of illustration have used the grid (Table 2) of corresponding data values to rank the countries ourselves.

Suggestions for managerial use:

As a beginning of the synthesis process, one may (preferably) ask the respondents (e.g. through a questionnaire) to rank (on a 1-9 scale) different countries for each level 3 factor. As background information, one can also provide them with a more rigorous grid (Table 2) in conformance to statistical tests, so that they can make qualified decisions.

9.1.2. Future step – DSS model development in particular task environments

Next, an important future step would be to examine how the environmental complexity DSS performs in different task environments, e.g. specific industries. This is an interesting research endeavour, more so in consideration of the discussion surrounding specific contexts of decision-making systems, which was presented in Chapters 2 and 3. Such a future step may then involve looking either at the content or the process of decision-making and may be envisaged in terms of the following possibilities:

- Content of decision-making: *how do respondents (e.g. consultants/managers) utilise information measures and prioritise decision factors in (e.g. the textile) industry?*

- The decision-making process: *how does the DSS behave (implementation issues) under group decision-making scenarios in e.g. an industry sector like such as perishables in the FMCG industry?*

9.1.3. Future step – a test of robustness of model solutions

The next future step would involve testing the robustness of the solutions generated by the supply chain logistics environmental complexity model (e.g. Berrittella et al., 2007). Such a future step would then seek to perform further construct development on supply chain logistics environmental complexity. Such a research endeavour may be envisaged by:

- *Application of the construct to a "site selection" decision-making problem*
- *Demonstrating the (designed) process of managerial decision-making to generate relative rankings of alternative sites in the decisional problem*
- *Simulating the results and establishing the boundary conditions within which these results may be expected to hold*

9.1.4. Future step – DSS model validation

If the decision support system is found to be robust in terms of the solutions it generates, such a future step would then involve testing the validity of the entire DSS based on its usefulness in meeting the managerial needs on decision making (e.g. see Kanungo et al., 2001). Such a research endeavour could, for example, imply the following starting points:

- *Does the use of the DSS change the manager's perception of environmental complexity?*
- *Does the use of the DSS "enhance" (e.g. speed up) the "warehouse location" or "supplier selection" decision?*
- *Does the use of the DSS increase the manager's (e.g. perceived) confidence in dealing with these decisions?*
- *Does it increase satisfaction levels, improve selection capabilities, help in thought structuralisation, and provide more objectivity/subjectivity to subjective/objective evaluations?*
- *Does use of the DSS aid in achieving specific operational tasks e.g. JIT delivery?*

9.1.5. Future step – calculating environmental complexity of supply chains

Lastly, a future step that can be conceived at this point is one that works on ascribing a value to the environmental complexity surrounding each supply chain under analysis. Such a future step then follows the ideas of the use of "entropy based measures" in pair-wise comparison techniques (Sanchez and Soyer, 1998) and the calculation of Euclidean distances within and across different supply chains. Such a research step would for example involve comparing each supply chain type to the other in its environmental complexity value, based on the idea of capturing variation within supply chains by calculating internal environmental diversity, and then by using the "sum of squares method" (Forman and Selly, 2001) to calculate the total variation across the supply chain. In this way different supply chain types proposed in this dissertation may be pit against each other in order to create an index of environmental complexity based on their respective geographic dispersion. However, as it is still at a very young/conceptual stage, this step is open for further consideration.

9.2. Other future research directions: theory building and testing directions

In addition to the decision-making applications presented in the last section, this PhD dissertation also offers directions that correspond to other research paradigms and traditions. These research directions relate to the propositions made for the purpose of construct development, but which now require a closer examination in the form of scientific testing, in order to enhance the explanatory power of the construct. Some of these are briefly discussed here.

9.2.1. Future step – laying down propositions for future research

From one point of view, the present dissertation has theoretically deduced a set of propositions that made its progress possible. For example, in order to bring the construct of environmental complexity to the supply chain domain, in order to show its relevance, a contingency theory based 'fit' between supply chain environments, strategy and performance had to be deduced. As such, this proposition remains untested not only in the present dissertation, but also in the supply chain literature. Fig. 5 then presents one such research direction in terms of *cause-effect* research applications involving the E-S-P relationship in the supply chain context. Similarly, because environmental complexity co-varies with added geographic scope (Guisinger, 2001; Kotha & Orne, 1989), and added institutional scope

(Kostova and Zaheer, 1999; Guisinger, 2001), geographically dispersed supply chains should face more environmental complexity than those that are not.

Therefore, although it was not the study's main purpose to examine these beyond the conceptualisation stage, propositions in the above-mentioned spirit were laid down or arose at its different stages and may form impetus as research endeavours for the future. Some points of departure may then include:

- *"High environmental complexity has a negative impact on supply chain performance"*
- *"Different types of supply chains face different levels of environmental complexity"*
- *"Complexity of certain types of supply chain flows (e.g. information) is more important than others in a business/industry sector"*

9.2.2. Future step – a geographic scope-based typology of supply chains

> *"Typologies at their best are memorable, neat and evocative"…."It is unfortunate too that many typologies are never tested empirically, and those that are fail usually to be borne out (Doty, Glick, and Huber, 1993)",* (Miller, 1996, p. 506)

Similarly, in line with some of the propositions mentioned here, a geographic scope-based typology (Fig. 30) was also proposed in Chapter 4. The typology was an important outcome of the research process and as such, like its underlying propositions, remains untested and therefore only propositional in its nature. This typology then needs to be empirically tested in order to provide more explanatory power to the construct of supply chain logistics environmental complexity. An important research direction in terms of constructing a formal supply chain typology has then arisen out of this dissertation. Such a research endeavour may, for instance, be phrased as:

Typology construction in terms of proposed Environmental complexity (e.g. geographical dispersion) and Structural complexity (e.g. Supply Chain network structure).

9.2.3. Future step – calculating perceived environmental complexity of supply chains

Just like the decision-making applications presented earlier on, this future step may also be seen more in terms of an application. It is presented here because it bears greater methodological semblance to the paradigms implied here, and may involve posing environmental complexity as a perceptual construct; and then it may involve calculating perceived environmental complexity facing organisational forms by exploring cause-effect relationships. From this point of view, Kanwar et al. (1991) follow the Duncan (1972) tradition to devise formulae for calculating environmental complexity facing organisations and organisational operations. Following Kanwar et al.'s (1991) notions, one may then conceive a research endeavour in the supply chain logistics context, which for example seeks to calculate perceived environmental complexity in order to:

- *e.g. assess the impact of environmental complexity on a JIT delivery program involving globally dispersed supply chains*

Then there are others who offer more explanatory power to the construct of supply chain logistics environmental complexity from a different viewpoint, and a different scientific approach. As mentioned in Chapter 2, Flint (2008) also offers some theory building directions in terms of the construct, which may be posed in the form of the following illustrative research questions:

- *How do managers perceive and define supply chain environmental complexity?*
- *How does the concept of 'shared interpretation' manifest itself in terms of the construct?*

………………….

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List of figures and tables

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Appendix A

A list of abstracts from select publications during the PhD project

Appendix A.1. - Kinra, A.* and Kotzab, H. (2008a):

"Understanding and measuring macro-institutional complexity of logistics systems environment", published in the *Journal of Business Logistics*, Vol. 29, No. 1, pp. 327-346.

Abstract:

We explore the concept of macro-institutional environmental complexity surrounding logistics systems. Macro-institutional environmental complexity is formulated as the complexity posed by the diversity of macro-institutions and infrastructural capabilities of external environments involved in global supply chain logistics operations. This concept is then translated into a simple Analytic Hierarchy Process (AHP) model evaluating the macro-institutional logistics systems environmental complexity of the four Nordic countries.

Keywords:

Environmental complexity; global logistics operations; macro-institutional perspective; Analytic Hierarchy Process (AHP); Nordic countries.

Appendix A.2. - Kinra, A.* and Kotzab, H. (2008b):

"A macro-institutional perspective on supply chain environmental complexity", published in the *International Journal of Production Economics*, Vol. 115, No. 2, pp. 283-295.

Abstract:

Supply chain management is a practitioner-generated discipline, which has gained much popularity in the last two decades. Adopting a supply chain perspective also involves the address of structural decision criteria relating to capacity, size and location of supply chain activity, the 'supply chain' typified by a network of independent firms. As a result, it becomes important to address macro-institutional constraints, especially in any supply chain perspective because of the inherent global scope of supply chain operations. This paper uses the Environment-Strategy-Performance (E-S-P) paradigm as a means to understand the relevance of environment (complexity) facing supply chain operations, while proposing that an environmental analysis best represents a multi-criteria decision-making problem. Environmental complexity is translated using Guisinger's (2001) proposed taxonomy of macro institutions that are relevant and pose constraints to extended operations viz. with international or global outlook. Finally, this decision-making problem is illustrated by applying the Analytic Hierarchy Process (AHP) approach to an illustrative site-location problem with generic constraints.

Keywords:

Supply chain operations, Institutional constraints, Decision making, Environmental analysis, Analytic Hierarchy Process.

Appendix B:

Content Analysis 2 – *"CSCMP metrics analysis"*

B.1. Table CSCMP Total Measures (v.7)

Appendix B: Content Analysis 2 – *"CSCMP metrics analysis"*

B.1. Table CSCMP Total Measures (v.7)

Classification Scheme:
Data Source in the CSCMP publication, Measurement instruments & Measures

INST '1' = hard data
INST '2' = perceptions - survey based (P)
INST '3' = perceptions - author's personal perceptions (P)
INST '4' = perceptions – data-based perceptions –DESCRIPTION (D)

Note: only measures highlighted in green were selected for further empirical tests.

Data availability:

DMAOS = *"data may be available from other sources"*

WDI = World Bank's *World Development Indicators* (WDI database)

WCY = IMD's *World Competitiveness Yearbook* (WCY database)

LPI = World Bank's *Logistics Performance Index*

Table CSCMP Total Measures (v.7)

Factors	CSCMP Measure	CSCMP Data Source				Data Availability - WDI	Data Availability - WCY	Data Availability - LPI
Complexity from Hard Infrastructure by **Geographical Location**	Area in km^2	1				Yes - 1	Yes - 1	Country rankings under logistics unfriendly countries based on "Landlocked or not" & "Developing or developed countries", corresponding to fifth quintile in LPI - 1
	Km waterways	1						
	Km from border countries	1				DMAOS		
	Km seashore or coastline	1						
	Geographical location, position & attributes			3	4			
Complexity from Hard Infrastructure in **Roadways**	Km total roads	1				Total road network in km - 1		
	Km 4-lane highways & 2 way roads	1		3	4			
	% 4-lane highways and coverage	1						
	~~Km 4-lane highways and coverage~~	1			4			
	# accidents – road safety	1			4	DMAOS		DATA from LPI AVAILABLE HERE!
	# thefts/robberies - road safety	1			4			

	km/km^2 highway density/road density/net transportation density	1					Road density km/km^2 - 1	
	% total transportation network highway density/road density/net transportation density	1						
	% highways expressways	1						
	% highways paved	1				Paved roads as % of total roads - 1		
	% highways toll ways	1		3	4			
	Billion ton-km - freight volume	1				Million ton-km - 1		
	% tonnage/mile - freight volume	1						
	% shipments of domestic transport flows	1						
	% quantity of domestic transport flows							
	% quantity, % value of international transport flows	1						
	Total no. of vehicles	1				DMAOS		
	% of total # of vehicles	1						
	Road congestion			3	4			
	Km average trip distance	1						
	Highway flow infrastructure			3				
	Highway speeds			3	4			
	General road infrastructure				4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable "Infrastructure" in LPI - 1 "Quality of fixed transport infrastructure" in LPI - 2
	Toll way prices			3	4			
	Domestic transportation costs			3	4			
	Supply & demand of transportation services			3	4	% of commercial service exports – 1 % of commercial service imports - 1		
	Central highway system				4			
	Road connections, routes and corridors				4			
	Transportation laws & regulations				4	DMAOS		
	Government regulations intermodal infrastructure				4			
	Age, maintenance, practices of cargo transportation vehicles				4			
	Government regulations within physical distribution				4			
	Growth in total road length, highways & expressways					DMAOS		"Growth in quality of transport infrastructure" - 2

	Historical growth measure							
	Spending on new infrastructure *Future growth measure*	1				Investment in transportation with private participation (current usd) - 1		
	Number of new infrastructure projects & type of projects *Future growth measure*	1				DMAOS		
Complexity from Hard Infrastructure in **Railways**	Km total railways	1				Total route in km - 1		
	Quantity in # rail companies	1			4			
	Million tons per year freight volume *Haulage*	1				Goods hauled tons-km - 1		
	% of total import/export flows by rail *Haulage*	1				DMAOS		
	% of total weight/quantity by rail *Haulage*	1						
	% of total value of international transport flows by rail *Haulage*	1						
	Km/hours travel times - *distances*	1		3	4			
	% of the total operating railways in the world	1						
	Km/hours - *train speed*	1		3	4			
	% of total volume, billion per year volume growth *Historical growth measure*	1						“Growth in quality of transport infrastructure” - 2
	Km of new railways opened/planned per year *Future growth measure*	1				Investment in transportation with private participation (current usd) - 1		
	Billion ton per km freight turnover	1				DMAOS		
	Km/km^2 net transportation density	1					Network density km/km^2 - 1	
	% of the world’s total railway workload	1						
	# of accidents – *rail safety*	1			4	DMAOS		
	Rail logistics constraints to international trade		2					
	General rail infrastructure			3	4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable “Infrastructure” in LPI - 1 “Quality of fixed transport infrastructure” in LPI - 2
	Rail connections, routes and corridors			3	4			
	Rail logistics constraints at policy level				4	DMAOS		
	Transportation laws & regulations				4			
	Government regulations intermodal				4			

	infrastructure							
	Type of goods				4			
	Rail micro-infrastructure				4			
	Government regulations within physical distribution				4			
Complexity from Hard Infrastructure in **Airways**	Quantity in # total, paved & unpaved runways	1				DMAOS		
	Million tons, billion tons per km, thousand tons per year, % volume, % company utilization					Freight in million tons-km - 1 DA		
	% of total weight/quantity by air	1						
	% of total value of international transport flows by air	1						
	# of scheduled international flights – *flight network*	1			4	Registered carrier departures worldwide - 1 DMAOS		
	# of scheduled national flights – *flight network*	1			4			
	Connection to # of cities – *flight network*	1			4			
	# of international airports – *flight network*	1			4			
	% of total import/export at major hubs	1						
	# of import requests through a customs agent at major hubs	1						
	# of export requests through a customs agent at major hubs	1						
	# of airports in a specific region	1						
	Million tons freight at major hubs	1				DMAOS		
	# of takeoffs and landings in specific airports at major hubs							
	% of total import/export flows by air	1						
	% growth in total international freight *Historical growth measure*	1				DMAOS		"Growth in quality of transport infrastructure" - 2
	% growth in total national freight *Historical growth measure*	1						
	Spending on new infrastructure - millions investment *Future growth measure*				4	Investment in transportation with private participation (current usd) - 1		
	Number of new infrastructure projects & type of projects *Future growth measure*				4	DMAOS		
	No. of heliports	1						
	No. of airports	1				DMAOS		

	Air logistics constraints to international trade		2					
	General air infrastructure			3	4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable “Infrastructure” in LPI - 1 “Quality of fixed transport infrastructure” in LPI - 2
	Main airway corridors			3	4			
	Transportation laws & regulations				4	DMAOS		
	Air logistics constraints at policy level				4			
	Connections between major hubs & ports				4			
	Government regulations within physical distribution				4			
Complexity from Hard Infrastructure in **Waterways**	# of cities with a port	1			4	DMAOS		
	Km total waterways	1						
	No. of major ports	1			4			
	Distance in days	1						
	# of processed twenty-foot TEU’s in millions	1				# of containers TEU’s - 1		
	Million tons per port per year	1				DMAOS		
	# of containers per port per year	1						
	Million solid bulk tons	1						
	Million liquid bulk tons	1						
	Million tons general cargo	1						
	% of total import/export flows by waterways	1						
	% of total weight/quantity by waterways	1						
	% of total value of international transport flows by waterways	1						
	Dock shipping length in mt	1			4			
	Warehousing area in m^2 - *ports*	1			4			
	Developed intermodal facilities	1			4			
	# of industrial parks located in ports	1			4			
	Total # of berths	1			4			
	Handling capacity of containers in million	1			4			
	Containers per hour	1						
	# of foreign owned carriers	1						
	Growth in % per year water freight *Historical growth measure*	1						“Growth in quality of transport infrastructure” - 2
	Investments				4	Investment in transportation with		

	Future growth measure					private participation (current usd) - 1		
	% of total import/export at major ports	1						
	# of import requests through a customs agent at major ports	1						
	# of cargos per year at major ports	1						
	Total # of ships	1						
	# of ships per category	1						
	Km/km^{2}net transportation density	1				DMAOS		
	Water logistics constraints to international trade		2				Water transportation meets basic requirements - 2	
	General water infrastructure			3	4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable “Infrastructure” in LPI - 1 “Quality of fixed transport infrastructure” in LPI - 2
	Transportation laws & regulations					DMAOS		
	Main coastal corridors			3	4			
	Water logistics constraints at policy level				4			
	Connections between major hubs & ports				4			
	Port congestion				4	DMAOS		
	Government regulations intermodal infrastructure				4			
Complexity from Hard Infrastructure in **Intermodal**	Total #, # of total terminals, # of locations, # of port to port *Intermodal facilities*	1			4	DMAOS		
	# of companies using intermodal transportation or infrastructure	1						
	Intermodal logistics constraints to international trade		2					
	General intermodal infrastructure			3	4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable “Infrastructure” in LPI - 1 “Quality of fixed transport infrastructure” in LPI - 2
	Developed intermodal facilities				4			
	Main intermodal corridors				4			
	Growth in quality of transport infrastructure *Historical growth measure*							“Growth in quality of transport infrastructure” - 2
	Development of/investment in intermodal corridors				4	Investment in transportation with private participation (current usd) - 1		

	Future growth measure							
	Transportation laws & regulations				4			
	Government regulations intermodal infrastructure				4	DMAOS		
	Government regulations within physical distribution				4			
Complexity from Hard Infrastructure by Public **Warehousing**	Warehousing and storage area in million m^2	1				DMAOS		
	Ports Warehousing and storage area in m^2	1						
	Industrial parks & Warehousing by total #	1						
	Cities Warehousing and storage area in million m	1						
	% of total companies using in-house Warehousing	1			4	DMAOS		
	% of total warehouses in freight villages	1						
	Warehousing rent per Meter in freight villages	1						
	# of companies in Warehousing	1						
	# of companies in refrigerated storage	1						
	# of SKU moved	1						
	# of orders issued per category	1						
	Total # of units for agricultural storage	1				DMAOS		
	Total # of tons for agricultural storage	1						
	Dry port usage in %	1						
	% per year storage growth *Historical growth measure*	1						
	Growth in quality of transport infrastructure *Historical growth measure*							"Growth in quality of transport infrastructure" - 2
	New constructions and restructuring *Future growth measure*				4			
	Investment in Warehousing *Future growth measure*				4	Investment in transportation with private participation (current usd) - 1		
	Storage costs growth				4			
	Storage costs in billions	1						
	Storage costs as a % of total logistics costs	1						
	% of total companies using outsourced Warehousing	1			4	DMAOS		

	Inventory turnover % per regular warehouse	1						
	Warehousing logistics constraints to international trade		2			Procedure to build a warehouse in # - 1 Procedure to build a warehouse in days - 1		“warehousing constraint by way of major delays due to compulsory warehousing” - 2
	General Warehousing infrastructure			3	4		Basic infrastructure (ranking) – 1 Distribution infrastructure efficiency - 2	Country rankings corresponding to the variable “Infrastructure” in LPI - 1 “Quality of fixed transport infrastructure” in LPI - 2
	Warehousing logistics constraints at policy level				4	Procedure to build a warehouse in # - 1 Procedure to build a warehouse in days - 1		“warehousing constraint by way of major delays due to compulsory warehousing” - 2
	Transportation laws & regulations				4	Procedure to build a warehouse in # - 1 Procedure to build a warehouse in days - 1		
Complexity from Supporting Institutions like **Customs**	Customs delays in # of days	1		3	4	DMAOS		
	Customs delays in total cost in billion	1		3	4			
	# of customs sites by geography	1			4			
	Customs rules & regulations			3	4	DMAOS		
								Country rankings corresponding to the variable “Customs” in LPI – 1 Rate of physical inspection (%) - 1 No. of border agencies for exports - 1 No. of border agencies for imports - 1 Possibility of a review procedure (%) – 1 Timeliness of export/import shipments – 2 Competence of customs agencies – 2 Competence of other border related government agencies – 2 Incidence of major delays due to pre-shipment inspection - 2
	Customs clearance process			3	4	Average time to clear customs in days – 1 Customs duties - 1	Customs authorities do facilitate the efficient transit of goods - 2	Customs clearance in (# days) - 1 Transparency of customs clearance process” - 2

	Growth in custom efficiency *Historical growth measure*							Growth in procedures relating to other border related government agencies - 2 Growth in procedures relating to customs clearance – 2
	Investment in customs *Future growth measure*					Investment in transportation with private participation (current usd) - 1		
Complexity from Supporting Institutions by **Logistics/ SCM HR**	Economic size by Labour force in million	1				Total labour force - 1		
	% of the total labour market	1						
	# of colleges & universities offering logistics major	1					Universities meets the need of a competitive economy - 2	
	Total # of majors offered by universities	1						
	Total # of Majors with a logistics/SCM education	1						
	# of universities	1			4			
	Literacy rate as a % of total population	1				Literacy rate (total, on gender) - 1	# of Nobel prize winners per capita – 1 Management practices ranking - 1	
	Economic size by Labour by occupation in %	1						
	Labour rotation as a market obstacle on a scale from 1-7		2					
	Labour costs as a market obstacle on a scale from 1-7		2					
	Skilled labour availability as a market obstacle on a scale from 1-7		2			Human resource rating – 2 Labour skills as a major business constraint - 2	Skilled labour is relatively available – 2 Foreign high skilled people are attracted to your economy - 2 Economy literacy amongst the population – 2 Educational system meets the need of a competitive economy - 2	
	Quality & cost of labour			3	4			
	Skilled & semiskilled labour				4	Labour force with primary education – 1 Labour force with secondary education – 1 Labour force with tertiary education - 1	% of science & engineering university degrees - 1	
	Major labour regulations				4	Labour skills as a major business constraint – 2 Labour regulations as a major business		

						constraint - 2		
	Labour unions				4	DMAOS		
	Labour productivity				4			
Complexity from Hard Infrastructure by **Post**	# of branches for post	1			4			
	# of regional centers for post	1			4			
	Volume in billion of postal services	1			4	DMAOS		
	Revenue in billion of postal services	1			4			
	Value-adding in billion of postal services	1			4			
	# of million handling areas for post	1				DMAOS		
	# of million m^2 postal warehousing & storage for post	1						
	Postal services to # of countries	1						
	General postal services			3	4	DMAOS		Country rankings corresponding to the variable “Infrastructure” in LPI - 1
	Network, coverage and investment in post *Future growth measure*				4	DMAOS		
	Postal communication logistics constraints at policy level				4			
Complexity from Hard Infrastructure by **Telecom**	General IT infrastructure						Communication technologies does not meet business requirements - 2	Country rankings corresponding to the variable “Infrastructure” in LPI – 1 “Quality of telecommunication infrastructure and services” – 2
	Growth in IT infrastructure *Historical growth measure*							“Growth in quality of telecommunications infrastructure” - 2
	Investments in telecommunications *Future growth measure*				4	Investment in telecom - 1	Investments in telecommunication % of GDP - 1	
	~~Network, coverage and~~ foreign investment in telephone sector *Future growth measure*				4	Total # of pcs - 1	Communication technologies does not meet business requirements - 2	
	Mobile telephone installation rate	1				Population covered by mobile phones - 1	Mobile telephone costs - 1	
	% mobile telephone installation rate	1						
	Telephone coverage in %,	1		3	4			
	# of ports of telephone	1				Telephone main lines per 1000 people – 1 Telephone faults per 100 mainlines - 1	# of fixed telephone lines per 1000 people –1 Fixed telephone costs - 1	
	~~Volume in billion~~	~~1~~				~~Telecommunications business/industry~~		
	~~Revenue in billion~~							

	~~Value-adding in billion~~							
	~~Export in billion~~							
	~~% in 3rd industry~~							
	~~% of GDP~~							
	ICT expenditures					ICT expenditures volume in usd – 1 ICT expenditures per capita - 1 ICT expenditures % of GDP - 1		
	Long distance telephone switch capacity in millions	1						
	Long distance business circuits in millions	1				DMAOS (check)		
	% fixed telephone installation rate	1						
	Mobile telephone switch capacity in millions	1						
	Optical fiber length in million	1						
	Optical fiber length in km	1						
	~~# world ranking~~	1				~~Information industry size~~		
	~~Volume in billion~~	1				~~Telecommunications business/industry~~		
	~~Revenue in billion~~							
	~~Value-adding in billion~~							
	~~Export in billion~~							
	~~% of total export~~							
	Broadband lines in million km			3	4	Internet broadband width (mbps) - 1		
	Telecommunication centers and network				4			
	Telecommunication logistics constraints at policy level				4	Secure internet servers – 1 Telephone average cost per calls to us - 1	Cyber security - 2	
	Telecommunication logistics constraints business						Internet costs – 1 Broadband costs - 1	
Complexity from Technology **Use & Adoption in Computers**	Million Computers with Internet access	1				Internet users total – 1 Internet users per 1000 people – 1 Schools connected to internet in % - 1	Internet users per 1000 people - 1	
	# world ranking	1				DMAOS		
	~~Volume in billion~~					~~Telecommunications business/industry~~		
	~~Revenue in billion~~							
	~~Value-adding in billion~~							
	~~Export in billion~~							
	~~% of total export~~							
	Million computer users	1				# of pcs per 1000 people - 1	# of computers per 1000 people - 1	
Complexity from Technology	CSCMP Website usage in %	1				DMAOS		
	Customer-integrated information systems in %	1						

Use & Adoption in EDI	ERP systems in %	1						
	Decision support systems in %	1						
	Company usage of IT				4			
	# world ranking	1						
	~~Volume in billion~~					~~Telecommunications business/industry~~		
	~~Revenue in billion~~							
	~~Value-adding in billion~~							
	~~Export in billion~~							
	~~% of total export~~							
	EDI in customs							"Can customs declarations be submitted and processed electronically" – 2
Complexity from Technology **Use & Adoption in Telecom**	Million mobile telephone users	1			4	Mobile telephone subscribers total – 1 Mobile telephone subscribers per 1000 people – 1	Mobile telephone subscribers per 1000 people - 1	
	Million of internet users	1			4	Internet users total – 1 Internet users per 1000 people – 1 Schools connected to internet in % - 1		
	World ranking # of internet users	1					Internet users per 1000 people - 1	
	Ranking in specific areas/countries of internet users	1				DMAOS		
	# of telephone access per 100 inhabitants, ranking in specific areas/countries	1				Telephone subscribers total – 1 Telephone subscribers per employee - 1		
	~~% mobile telephone installation rate~~	1			4			
	~~Volume in billion~~					~~Telecommunications business/industry~~		
	~~Revenue in billion~~							
	~~Value-adding in billion~~							
	~~Export in billion~~							
	~~% of GDP~~							
	~~% in 3rd industry~~							
	Million fixed telephone users	1				Fixed telephone line subscribers total – 1 Fixed telephone line subscribers per 1000 people - 1		
	Growth in % broadband internet usage *Historical growth measure*	1				DMAOS		
	# internet hosts per capita	1						
	~~% fixed telephone installation rate~~	1						
	World ranking # in terms of telephone usage	1				DMAOS		
	% of total # are program-controlled	1						

	telephones							
	# of web sites per capita	1						
	# of national domain names per capita	1						
	Million Computers with Internet access	1				Internet users total – 1 Internet users per 1000 people – 1 Schools connected to internet in % - 1		
	Million broadband internet users	1				Broadband subscribers total – 1 Broadband subscribers per 1000 people - 1	Broadband subscribers per 1000 people - 1	
	# world ranking	1				Information industry size		
	~~Volume in billion~~					~~Telecommunications business/industry~~		
	~~Revenue in billion~~							
	~~Value adding in billion~~							
	~~Export in billion~~							
	~~% of total export~~							
	~~Internet penetration & usage~~			~~3~~	4			
	~~Telephone penetration & usage~~			~~3~~	4			
	Telecommunication logistics constraints at policy level				4	DMAOS		
Complexity from Economic Institutions in **Financial Institutions & Services**	# of financial institutions	1						
	# of banks	1					Retail banking # of bank offices - 1	
	# of insurance companies							
	Import/export of insurance & financial services					Insurance & financial services as % of commercial exports/imports – 1		
	Liquidity					Bank liquid reserve to bank asset ratio – 1		
	General financial infrastructure					Financial sector rating – 2 Domestic credit provided by banking sector % of GDP – 1 Domestic credit to private sector % of GDP – 1 Domestic credit provided in banking sector as % of GDP – 1 Quality of budgetary & financial management – 2		
	Financial institutions & services as a constraint to business activity					Quality of budgetary & financial management – 2 Credit information availability index - 1	Banking and financial services support business activities – 2 Financial institutions are transparent – 2 Easy to obtain bank credits – 2 Finance skills are relatively available – 2 Education in finance – 2	
	Loans access as a market obstacle on		2			Bank non performing loans to total	Easy to obtain bank credits – 2	

	a scale from 1-7					gross loans % - 1	Corporate debt does not restrain enterprises to compete - 2	
	Description of financial systems				4			
	Growth in quality of overall business environment							Growth in quality of overall business environment - 2
Complexity from Economic Institutions in **Economic policy**	Taxes in rate % i.e. Personal income tax	1				Total tax rate – 1 Personal tax - 1	Personal income tax as % of GDP – 1 Personal taxes discourages people from working – 2	
	Tax on royalties	1						
	Corporate tax	1				Corporate tax - 1	Corporate tax as % of GDP - 1 Corporate taxes discourages entrepreneurial activities - 2 Tax invasion hampers business activity – 2	
	Tax on assets	1					Tax on assets as % of GDP - 1	
	Value-added tax	1				DMAOS		
	VAT on imports	1				Tax on international trade - 1		
	~~Unemployment rate in %~~	~~1~~			4			
	# of countries with whom Commercial free trade agreements	1			4			
	Theft & property loss – decrease in %	1					Personal security and private property are adequate protected - 2	Incidence of criminal activities e.g. stolen cargo - 2
	Theft & property loss – # of reported incidents	1				DMAOS		
	Theft & property loss – # of thefts a day	1						
	Fiscal policies as an obstacle to business development		2		4	Fiscal policy rating - 2	Government efficiency by fiscal policy ranking - 1	
	Foreign commerce operation requirements as an obstacle to business development		2			DMAOS		
	Corruption world rank in #	1	2		4	Transparency, accountability & corruption in the public sector rating – 2		Incidence of solicitation of informal payments – 2 Growth in good governance & eradication of corruption - 2
	Bribery - Informal economy as an obstacle to business development on a scale from 1-7		2		4	Transparency, accountability & corruption in the public sector rating – 2 % of managers ranking corruption as a major constraint - 2		
	Lack of transparency in policies and regulations as an obstacle to business development		2			Transparency, accountability & corruption in the public sector rating – 2	Transparency of government policies – 2 Existence of bribery & corruption - 2	

						% of managers ranking corruption as a major constraint - 2		
	Service management government performance as an obstacle to business development		2			Quality of public administration – 2 Macro economic management rating - 2		
	General economic policy			3	4	Structural policies - 2	Policy direction of the government is consistent – 2 High adaptability of government policy to economic changes - 2	
	Economic strategies of government				4	Debt policy rating - 2		
	Political effectiveness & stability with regards to economic policy				4	Policy uncertainty as a major business restraint - 2		
	Laws and regulations in relation to economic policy				4	DMAOS		
	Taxation rules and regulations				4			
	Laws and rules for foreign investment				4			
	Rules on investments				4			
	Economic reforms				4			
	Economic cooperation agreements				4			
	Privatisation of economy				4			
	Market economy goals				4			
	Free-market policies				4			
	Continuity & coherence				4			
	Privatisation of economy				4			
	Interests rates				4	Yes - 1	Short term & interest rate spread – 1	
	Inflation rates				4	Yes - 1	Inflation forecast & consumer price inflation - 1	
	Safety as an obstacle to business development on a scale from 1-7		2					
	Plagiarism as an obstacle to business development on a scale from 1-7		2					
	Trade unions as an obstacle to business development on a scale from 1-7		2					
	Skilled labour availability as a market obstacle on a scale from 1-7		2			Labour skills as a major business constraint - 2		
	Labour rotation as a market obstacle on a scale from 1-7		2					
	Labour costs as a market obstacle on a scale from 1-7		2					
	Raw material, spares, and equipment availability as a market obstacle on a scale from 1-7		2					

	Supplier reliability as a market obstacle on a scale from 1-7		2					
Complexity from Economic Institutions in **Economic Structure**	Economic size by export trade in billion	1				DMAOS		
	Export trade volume in billion	1						
	Export trade volume in %	1						
	Export trade in % of GDP	1						
	Growth in quality of overall business environment							Growth in quality of overall business environment - 2
	Export trade in % per category	1				% of manufacturing exports – 1 Growth in exports – 1 Transport services as % of exports - 1		
	Export trade in billion usd per category	1					Export of goods & services in us billion – 1 Growth in exports - 1	
	Export trade in % and billion usd to top 4 exporters	1						
	Export trade in % of workers	1						
		1				Exported goods & services % of GDP - 1	Trade to GDP ratio - 1	
	Export trade partners in % per country	1						
	Economic size by import trade in billion	1						
	Import trade volume in billion	1						
	Import trade volume in %	1						
	Import trade in % of GDP	1				Imported goods & services % of GDP - 1	Trade to GDP ratio - 1	
	Import trade in % per category	1				% of manufacturing imports – 1 Growth in imports – 1 Transport services as % of imports - 1	Import of goods & services in us billion – 1 Growth in imports - 1	
	Import trade in billion usd per category	1						
	Import trade in % of workers	1						
	Import trade partners in % per country	1						
	Economic capacity and output by allocation in main geographic locations	1						
	Economic capacity and output by 100 usd per inhabitants	1						
	Economic capacity and output by growth rate in %	1				GDP growth rate – 1		
	Economic capacity and output by trillion Yuan/Euro per year	1						

	Economic capacity and output by real growth rate in %	1						
	Economic capacity and output by % on specific industries/sectors	1				Industry value added on manufacturing - 1		
	Economic capacity and output by world rank in #	1				DMAOS		
	Economic capacity and output by per capita	1				DGP growth rate per capita – 1	GD savings per capita - 1	
	Economic size by domestic consumption & demand - # of consumers	1				Household consumption growth rates - 1	Household consumption expenditures total value – 1 Household consumption expenditures per capita- 1 Government consumption expenditures total value – 1 Government consumption expenditures per capita- 1	
	Economic size by domestic consumption & demand - value in trillion us	1						
	Unemployment rate in %	1			4	Many types of unemployment rates - 1	Unemployment rate as % of labour force - 1	
	Growth in jobs in million *Historical growth measure*	1				Unemployment rate - 1	Employment growth % change estimate - 1	"Growth in quality of overall business environment" - 2
	Investments *Future growth measure*				4		FDI data available - 1	
	Growth & development as a result of policy *Future growth measure*				4	Policy and institutions for environmental sustainability - 2	Central bank policy has a positive impression on economic development - 2	
	Economic size by labour force in million	1				DMAOS		
	Economic capacity and output in regions, zones and sectors by GDP per zone	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per output in tons	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per % of total economic capacity	1			4	GDP figures available – 1		
	Economic capacity and output in regions, zones and sectors by GDP per turnover in billion	1			4			
	Economic capacity and output in regions, zones and sectors by GDP	1			4			

	per # of enterprises							
	Economic capacity and output in regions, zones and sectors by GDP per# of overseas interests	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per controlled interests in %	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per # of workers	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per employment in millions	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per ranks in Europe	1			4			
	Economic capacity and output in regions, zones and sectors by GDP per market share in %	1			4			
	Economic development by logistics value-added as a % of GDP	1				DMAOS		
	Economic capacity and output by government revenue in billions	1			4			
	Economic costs by total costs of logistic sector in billion	1			4	Cost of business start up procedures GNI per capita – 1 Cost of hiring & firing - 1		
	Economic costs by % of GDP	1						
	Economic costs by growth in %	1						
	Economic growth rates in % *Historical growth measure*	1			4	GDP growth rate – 1 Growth in exports – 1 Growth in imports – 1 GDP growth rate per capita – 1 Household consumption growth rates - 1 Growth rate in expenditures - 1		
	Growth in international trade in billion, %	1						
	Growth in personal income in %	1						
	Economic size by total expenditure of logistic sector in billion	1			4	Growth rate in expenditures - 1		
	Economic size by total expenditure of logistic sector in % of GDP	1			4			
	Economic openness by way of Foreign investment from top 20	1			4			

	companies, %							
	Privatisation of economy by % of State-owned vs. collectively owned enterprises	1				DMAOS		
	Growth in jobs in million	1						
	Competitiveness rank in #	1						
	Trade deficit or surplus in billion	1						
	Trade deficit or surplus in % of GDP	1						
	Budget deficit % of GDP	1				Use of IMF credit – 1	Surplus & deficit in billion usd – 1 Surplus & deficit as % of GDP - 1	
	Public debt in billion	1				Central Government debt – 1 External debt – 1 Long term debt - 1	Total government debt - 1	
	Public debt in % of GDP	1						
	National debt % of GDP	1						
	Economic size by Labour by occupation in %	1						
	Economic business model			3	4			
	Economic system - # of manufacturing & service firms, private non-profit and public institutions	1				DMAOS		
	Economic system - # of enterprises	1						
	Economic reforms				4			
	Personal income				4	Personal income according to income level 1 Many available income data - 1	Income distribution - 1	
	Prices & price stability				4	Consumer price index – 1 Wholesale price index -1	Consumer price inflation rate – 1 Ranking economical structure using prices, consumer price inflation, costs of living index, apartment rent & office rent - 1	
	Economic "hot spots"				4			
	Economic opportunities				4			
	Economic capacity and output by influence				4			
	Outsourcing rate				4			
	Entrepreneurial initiative				4			
	Exchange rates				4	Official exchange rate – 1 Real effective exchange rate - 1	Stability – 1 Exchange support firm competitiveness - 2	
	Illegal transactions between companies as a market obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	

	Government monopolies as a market obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	
	Market restrictions to entry & establishment - Private companies' monopolies as a market obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking - 1	
	Logistics market entry rules				4		Business legislation ranking - 1	
Complexity from Technology **Use & Adoption in Electronic Banking & Commerce**	Growth in quality of overall business environment							Growth in quality of overall business environment - 2
	Technology development as a market obstacle on a scale from 1-7		2			DMAOS		
	Development within electronic banking & commerce				4		# of credit cards per capita – 1 Financial card transaction in usd per capita - 1	
Complexity from Judicial Institutions in **Business Legislation**	Growth in quality of overall business environment							Growth in quality of overall business environment - 2
	Judicial system in general by # of laws	1				Ease of doing business index - 1	Business legislation ranking - 1	
	Judicial system in general				4		Business legislation ranking - 1	
	Law enforcement					Ease of doing business index - 1	Business legislation ranking – 1	
	Legal system performance as a government related obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	
	Licenses and permits acquirement as a government related obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	
	Legal procedures to launch a company as a government related obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	
	Inadequacy of laws, policies, and regulations to companies necessities as a government related obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking - 1	
	Lack of transparency in law design, policies, and regulations as a government related obstacle on a scale from 1-7		2			Ease of doing business index - 1	Business legislation ranking – 1	
	Laws and regulations in relation to economic policy				4	Legal rights of borrows and lenders index -1	Business legislation ranking - 1	
	Legal entity				4		Business legislation ranking - 1	
	~~Laws for foreign investment~~				4		~~Business legislation ranking – 1~~	
	~~Market rules and legal systems~~				4		~~Business legislation ranking – 1~~	
	Laws and rules for foreign investment				4		Business legislation ranking – 1	

	Major commercial laws, such as contract law, procedural law, and maritime law				4		Business legislation ranking – 1	
	Taxation rules and regulations				4		Business legislation ranking – 1	
	~~Laws and rules for foreign investment~~				4		~~Business legislation ranking – 1~~	
	~~Rules on investments~~				4		~~Business legislation ranking – 1~~	
	Transparency laws				4		Business legislation ranking – 1	
	Distribution laws				4		Business legislation ranking – 1	
	Laws that facilitate an increase in employment levels *Future growth measure*				4		Business legislation ranking - 1	
	~~Regulations facilitating the start-up of new businesses~~				4		~~Business legislation ranking – 1~~	
	Local regulations regarding government assistance to companies				4		Business legislation ranking – 1	
	Regulation of governmental incentives				4		Business legislation ranking – 1	
	~~Legal limits for cargo~~				4		~~Business legislation ranking – 1~~	
	Environmental laws & regulations				4		Business legislation ranking – 1	
	Growth regulations				4		Business legislation ranking – 1	
	Retail regulations				4		Business legislation ranking - 1	
	~~Environmental regulations~~				4		~~Business legislation ranking - 1~~	
Complexity from Political Institutions by **Political Climate**	Growth in quality of overall business environment							Growth in quality of overall business environment - 2
	# of parties	1					Political parties do not understand today's economical challenges - 2	
	# of provinces	1						
	Total government revenue in billion	1						
	General political situation			3	4	DMAOS		
	Political stability			3	4		Risk of political instability - 2	
	Political system				4			
	Important political changes				4	DMAOS		
	Political effectiveness			3	4			Growth in quality of regulatory regime - 2
	Political issues as logistics barriers				4			
	Political reforms				4		Need for economic & social reforms is generally well understood - 2	
	Political assets				4			
	Bureaucracy				4		Bureaucracy does not hinder business activity - 2	
	Governmental influence & control				4		Public service is independent from political interference - 2	

Appendix C: Expert Opinion Sheets

C.1. Pretest version – EO sheet (v.1)

C.2. Modified version - EO sheet (v.2)

Appendix C.1. Pretest version – EO sheet (v.1)

Expert name:	***Expert position:***	***Date:***

Variable	***Measure***	***Expert Opinion***
Complexity from Hard Infrastructure by **Geographical Location**	Geographical position & attributes by country rankings in "landlockedness"	
	Country area in km^2	
	Km seashore or coastline	
	Km from border countries	
	Expert Comments:	
Complexity from Hard Infrastructure in **Roadways**	General road infrastructure by country rankings in infrastructure	
	General road infrastructure by "Quality of fixed transport infrastructure"	
	General road infrastructure by "Distribution infrastructure efficiency"	
	Km total roads	
	Km 4-lane highways & 2 way roads	
	% 4-lane highways and coverage	
	Km/km^2 highway density/road density/net transportation density	
	% Total transportation network highway density/road density/net transportation density	
	% Highways paved	
	% Highways toll ways	
	Billion ton-km - freight volume	
	% Tonnage/mile - freight volume	
	A description of road congestion	
	Total # of vehicles	
	% Of total # of vehicles	
	# Accidents – road safety	
	# Thefts/robberies - road safety	
	Growth in total road length, highways & expressways	
	"Growth in quality of transport infrastructure"	
	Spending on new infrastructure by # of new infrastructure projects & type of projects	
	Investment in transportation with private participation in USD	
	A description of transportation laws & regulations	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Hard Infrastructure in **Railways**	General rail infrastructure by country rankings in infrastructure	
	General rail infrastructure by "Quality of fixed transport infrastructure"	
	General rail infrastructure by "Distribution infrastructure efficiency"	
	Km total railways	
	Km/km^2 net transportation density	
	Billion ton per km freight turnover	
	Million tons per year freight volume - haulage	
	% Of total import/export flows by rail - haulage	
	% Of total weight/quantity by rail - haulage	
	% Of total value of international transport flows by rail - haulage	
	# Of accidents – rail safety	
	% Of total volume, billion per year volume growth	
	"Growth in quality of transport infrastructure"	
	Km of new railways opened/planned per year	
	Investment in transportation with private participation in USD	
	"Rail flow logistics as a constraints at policy level"	
	A description of transportation laws & regulations	
	Expert Comments:	
Complexity from Hard Infrastructure in **Airways**	General air infrastructure by country rankings in infrastructure	
	General air infrastructure by "Quality of fixed transport infrastructure"	
	General air infrastructure by "Distribution infrastructure efficiency"	
	# Of airports	
	# Of total, paved & unpaved runways	
	# Of scheduled international flights – flight network	
	# Of scheduled national flights – flight network	
	Connection to # of cities – flight network	
	# Of international airports – flight network	
	Million tons, per year - airfreight	
	% Of total weight/quantity by air - airfreight	
	% Of total value of international transport flows by air	
	Million tons freight at major hubs	
	% Of total import/export flows by air	
	# Of takeoffs and landings in specific airports at major hubs	
	% Growth in total international freight	
	% Growth in total national freight	
	"Growth in quality of transport infrastructure"	
	Spending on new infrastructure - millions investment	
	Number of new infrastructure projects & type of projects	
	Investment in transportation with private participation in USD	
	"Air flow logistics as a constraints to international trade"	
	"Air flow logistics as a constraints at policy level"	
	A description of transportation laws & regulations	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Hard Infrastructure in **Waterways**	General water infrastructure by country rankings in infrastructure	
	General water infrastructure by "Quality of fixed transport infrastructure"	
	General water infrastructure by "Distribution infrastructure efficiency"	
	Km total waterways	
	# Of major ports	
	Distance in days between main international operations	
	Km/km^{2}net transportation density	
	# Of cities with a port	
	Handling capacity of containers in million – port size & capacity	
	Containers per hour – port size & capacity	
	Total # of berths – port size & capacity	
	Dock shipping length in mt – port size & capacity	
	Warehousing area in m^2 – port size & capacity	
	Description of level of development of intermodal facilities	
	# Of industrial parks located in ports	
	# Of processed twenty-foot TEU's in millions	
	Million tons general cargo - freight	
	Million tons per port per year - freight	
	# Of containers per port per year - freight	
	% Of total import/export flows by waterways	
	% Of total weight/quantity by waterways - freight	
	% Of total value of international transport flows by waterways	
	Growth in % per year water freight	
	"Growth in quality of transport infrastructure"	
	A description of Investments in water transportation	
	Investment in transportation with private participation in USD	
	"Water transportation logistics as a constraints to international trade"	
	"Water transportation logistics as a constraints at policy level"	
	A description of transportation laws & regulations	
	Expert Comments:	
Complexity from Hard Infrastructure in **Intermodal**	General intermodal infrastructure by country rankings in infrastructure	
	General intermodal infrastructure by "Quality of fixed transport infrastructure"	
	General intermodal infrastructure by "Distribution infrastructure efficiency"	
	Total # of intermodal facilities	
	# Of total terminals with Intermodal facilities	
	# Of locations with Intermodal facilities	
	# Of port to port Intermodal facilities	
	A description of developed intermodal facilities	
	"Growth in quality of transport infrastructure"	
	Development of/investment in intermodal corridors	
	Investment in transportation with private participation	
	A description of government regulations on intermodal infrastructure	
	A description of transportation laws & regulations	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Hard Infrastructure by Public **Warehousing**	General Warehousing infrastructure by country rankings in infrastructure	
	General Warehousing infrastructure by “Quality of fixed transport infrastructure”	
	General Warehousing infrastructure by “Distribution infrastructure efficiency”	
	Warehousing and storage area in million m^2	
	Ports warehousing and storage area in m^2	
	# Of total industrial parks & warehousing	
	% Of total warehouses in freight villages	
	# Of total units for agricultural storage	
	# Of total tons for agricultural storage	
	% Of total companies using in-house Warehousing	
	% Of total companies using outsourced Warehousing	
	% Per year storage growth	
	“Growth in quality of transport infrastructure”	
	A description of new constructions and restructuring	
	A description of investment in Warehousing	
	Investment in transportation with private participation in USD	
	“Warehousing logistics as a constraints to international trade”	
	“Warehousing logistics as a constraints at policy level”	
	Procedure to build a warehouse in #	
	Procedure to build a warehouse in days	
	A description of transportation laws & regulations	
	Expert Comments:	
Complexity from Supporting Institutions like **Customs**	Customs clearance process by country rankings in infrastructure	
	A description of customs clearance process	
	Customs duties in amount	
	Customs clearance in # of days	
	# Of border agencies for imports/exports	
	“Competence of customs agencies”	
	“Competence of other border related government agencies”	
	Review procedures in %	
	Customs delays in # of days	
	“Incidence of major delays due to pre-shipment inspection”	
	Growth in customs efficiency	
	Investment in customs	
	Investment in transportation with private participation in USD	
	“Customs authorities facilitations”	
	“Transparency of customs clearance process”	
	A description of customs rules & regulations	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Supporting Institutions by **Logistics/SCM HR**	Economic size by labour force in million	
	Skilled & semiskilled labour as % of the total labour market	
	"Skilled labour availability as a market obstacle"	
	Literacy rate as a % of total population	
	Labour force with primary/secondary/tertiary education	
	"Economy literacy amongst the population"	
	"Human resource rating"	
	Management practices ranking	
	# Of universities	
	Total # of majors offered by universities	
	Total # of majors with a logistics/SCM education	
	# Of colleges & universities offering logistics major	
	"Educational system meets the need of a competitive economy"	
	A description of labour unions	
	"Labour skills as a major business constraint"	
	"Labour regulations as a major business constraint"	
	A description of major labour regulations	
	Expert Comments:	
Complexity from Hard Infrastructure by **Post**	General postal services by country rankings in infrastructure	
	A description of general postal service	
	Postal services to # of countries	
	Million handling areas for post	
	Million m^2 postal warehousing & storage for post	
	Volume in billion of postal services	
	Revenue in billion of postal services	
	Network, coverage and investment in post	
	"Postal logistics as a constraint at policy level"	
	Expert Comments:	
Complexity from Hard Infrastructure by **Telecom**	General IT infrastructure by country rankings in infrastructure	
	General IT infrastructure by "Quality of telecommunication infrastructure and services"	
	General IT infrastructure by "Communication technologies does not meet business requirements"	
	# Of ports of telephone	
	# Of fixed telephone lines per 1000 people	
	% Fixed telephone installation rate	
	Long distance business circuits in millions	
	Population covered by mobile phones	
	Mobile telephone installation rate	
	% Mobile telephone installation rate	
	Optical fiber length in km	
	Broadband lines in million km	
	# Of total pc's	
	Growth in IT infrastructure	

	Investments in telecommunications in billion USD	
	Investments in telecommunications as a % of GDP	
	A description of foreign investment in telephone sector	
	Secure internet servers	
	“Cyber security”	
	“Telecommunication logistics as a constraint to business”	
	“Telecommunication logistics as a constraint at policy level”	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Technology **Use & Adoption in Computers**	Million computer users	
	# Of pc’s per 1000 people	
	# Of total internet users	
	Internet users per 1000 people	
	# World ranking in computer usage	
	Million computers with Internet access	
	Expert Comments:	
Complexity from Technology **Use & Adoption in EDI**	General website usage in %	
	CSCMP Website usage in %	
	A description of company usage of IT	
	Customer-integrated information systems in %	
	Companies in % using ERP systems	
	Companies in % using Decision Support Systems	
	A description of EDI in customs	
	“Can customs declarations be submitted and processed electronically” - EDI in customs	
	Expert Comments:	
Complexity from Technology **Use & Adoption in Telecom**	Million fixed telephone users	
	# Of telephone access per 100 inhabitants, ranking in specific areas/countries	
	Million mobile telephone users	
	World ranking # in terms of telephone usage	
	Millions of internet users	
	World ranking # of internet users	
	Ranking in specific areas/countries of internet users	
	Million computers with Internet access	
	Million broadband internet users	
	# Of Internet hosts per capita	
	# Of web sites per capita	
	# Of national domain names per capita	
	Growth in % broadband internet usage	

	"Telecommunication logistics as a constraints at policy level"	
	Expert Comments:	

Variable	***Measure***	***Expert Opinion***
Complexity from Economic Institutions in **Financial Institutions & Services**	General financial infrastructure by "Country financial sector rating"	
	General financial infrastructure by "Quality of budgetary & financial management"	
	General financial infrastructure by domestic credit provided by banking sector % of GDP	
	General financial infrastructure by domestic credit to private sector % of GDP	
	# Of financial institutions	
	# Of banks	
	# Of insurance companies	
	Liquidity situation	
	"Loans access as a market obstacle"	
	"Financial institutions & services as a constraint to business activity"	
	Import/export of insurance & financial services	
	"Growth in quality of overall business environment"	
	Expert Comments:	
Complexity from Economic Institutions in **Economic policy**	A description of general economic policy	
	General economic policy by "Policy direction of the government is consistent"	
	General economic policy by "High adaptability of government policy to economic changes"	
	Economic strategies of government by "Debt policy rating"	
	"Fiscal policies as an obstacle to business development"	
	A description of laws and regulations in relation to economic policy	
	A description of taxation rules and regulations	
	A description of laws and rules for foreign investment	
	A description of rules on investments	
	Personal income tax – rate %	
	Corporate tax – rate %	
	Tax on assets – rate %	
	Value-added tax – rate %	
	VAT on imports – rate %	
	Interests rates in %	
	Inflation rates in %	
	Theft & property loss – decrease in %	
	Theft & property loss – # of reported incidents	
	Theft & property loss – # of thefts a day	
	"Foreign commerce operation requirements as an obstacle to business development"	
	"Service management government performance as an obstacle to business development"	
	Corruption world rank in #	
	"Bribery - Informal economy as an obstacle to business development"	
	"Lack of transparency in policies and regulations as an obstacle to business development"	

	“Political effectiveness & stability with regards to economic policy”	
	“Plagiarism as an obstacle to business development”	
	"Trade unions as an obstacle to business development”	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Economic Institutions in **Economic Structure**	Competitiveness rank in #	
	Economic capacity and output by growth rate in %	
	Economic capacity and output by world rank in #	
	Economic capacity and output by per capita	
	Economic size by domestic consumption & demand by # of consumers	
	Economic size by domestic consumption & demand by value	
	Economic size household consumption growth rates	
	Economic size government consumption expenditures # value	
	Economic size government consumption expenditures per capita	
	Economic size by export trade in billion	
	Economic size by import trade in billion	
	Economic size by labour force in million	
	Economic development by logistics value-added as a % of GDP	
	Economic system by - a description of economic business model	
	Economic system by # of manufacturing & service firms, private non-profit and public institutions	
	Economic system by # of enterprises	
	Personal incomes – total distribution	
	Prices & price stability – index #	
	Exchange rates – official & real effective exchange rates	
	Unemployment rate in %	
	Export trade volume in billion	
	Export trade volume in %	
	Export trade in % of GDP	
	Import trade volume in billion	
	Import trade volume in %	
	Import trade in % of GDP	
	Trade deficit or surplus in billion	
	Trade deficit or surplus in % of GDP	
	Budget deficit % of GDP	
	Public debt in billion	
	Public debt in % of GDP	
	National debt % of GDP	
	Growth in jobs in million	
	Total investments in billion USD	
	“Growth & development as a result of policy”	
	“Growth in quality of overall business environment”	
	Economic growth rates in %	
	Privatisation of economy by % of state-owned vs. collectively owned enterprises	
	“Illegal transactions between companies as a market obstacle”	
	“Government monopolies as a market obstacle”	
	“Market restrictions to entry & establishment - as a market obstacle”	
	“Private companies’ monopolies as a market obstacle”	
	A description of logistics market entry rules	

	Logistics market entry rules by country business legislation ranking	
	Expert Comments:	

Variable	*Measure*	*Expert Opinion*
Complexity from Technology **Use & Adoption in Electronic Banking & Commerce**	"Growth in quality of overall business environment"	
	Development within electronic banking & commerce by # of credit cards per capita	
	Development within electronic banking & commerce by financial card transactions in USD per capita	
	"Technology development as a market obstacle"	
	Expert Comments:	
Complexity from Judicial Institutions in **Business Legislation**	Judicial system in general by # of laws	
	"Growth in quality of overall business environment"	
	Law enforcement by country business legislation ranking	
	Law enforcement by Ease of doing business index	
	"Legal system performance as a government related obstacle"	
	"Licenses and permits acquirement as a government related obstacle"	
	"Legal procedures to launch a company as a government related obstacle on a scale"	
	"Inadequacy of laws, policies, and regulations to companies necessities as a government related obstacle"	
	"Lack of transparency in law design, policies, and regulations as a government related obstacle"	
	Laws and regulations in relation to economic policy by country business legislation ranking and by Ease of doing business index	
	Laws and rules for foreign investment by country business legislation ranking and by Ease of doing business index	
	Taxation rules and regulations by country business legislation ranking and by Ease of doing business index	
	A description of transparency laws	
	A description of distribution laws	
	A description of laws that facilitate an increase in employment levels	
	A description of local regulations regarding government assistance to companies	
	Environmental laws & regulations by country business legislation ranking	
	A description of growth regulations	
	A description of retail regulations	
	Expert Comments:	

Complexity from Political Institutions by **Political Climate**	A description of general political situation	
	A description of important political changes	
	Political system by # of parties	
	Political stability by “Risk of political instability”	
	Political effectiveness by “Growth in quality of regulatory regime”	
	Bureaucracy by “Bureaucracy does not hinder business activity”	
	Governmental influence & control by “Public service is independent from political interference”	
	“Political issues as logistics barriers”	
	Political reforms by “Need for economic & social reforms is generally well understood”	
	“Growth in quality of overall business environment”	
	Expert Comments:	

Appendix C.2. Modified version - EO sheet (v.2)

Name:	***Position:***	***Date:***

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Physical Infrastructure complexity by **Geographical Location**	Geographical position & attributes by country rankings in "landlockedness"			
	Country area in km^2			
	Km seashore or coastline			
	Km from border countries			
	Expert Comments:			
Physical Infrastructure complexity in **Roadways**	General road infrastructure by country rankings in infrastructure			
	General road infrastructure by "Quality of fixed transport infrastructure"			
	General road infrastructure by "Distribution infrastructure efficiency"			
	Km total roads			
	Km 4-lane highways & 2 way roads			
	% 4-lane highways and coverage			
	Km/km^2 highway density/road density/net transportation density			
	% Total transportation network highway density/road density/net transportation density			
	% Highways paved			
	% Highways toll ways			
	Billion ton-km - freight volume			
	% Tonnage/mile - freight volume			
	A description of road congestion			
	Total # of vehicles			
	% Of total # of vehicles			
	# Accidents – road safety			
	# Thefts/robberies - road safety			
	Growth in total road length, highways & expressways			
	"Growth in quality of transport infrastructure"			
	Spending on new infrastructure by # of new infrastructure projects & type of projects			
	Investment in transportation with private participation in USD			
	A description of transportation laws & regulations			
	Expert Comments:			

Variables	*Measures*	*Expert Opinion*		
		Unimportant	**Maybe Important**	**Important**
Physical Infrastructure complexity in **Railways**	General rail infrastructure by country rankings in infrastructure			
	General rail infrastructure by "Quality of fixed transport infrastructure"			
	General rail infrastructure by "Distribution infrastructure efficiency"			
	Km total railways			
	Km/km^2 net transportation density			
	Billion ton per km freight turnover			
	Million tons per year freight volume - haulage			
	% Of total import/export flows by rail - haulage			
	% Of total weight/quantity by rail - haulage			
	% Of total value of international transport flows by rail - haulage			
	# Of accidents – rail safety			
	% Of total volume, billion per year volume growth			
	"Growth in quality of transport infrastructure"			
	Km of new railways opened/planned per year			
	Investment in transportation with private participation in USD			
	"Rail flow logistics as a constraints at policy level"			
	A description of transportation laws & regulations			
	Expert Comments:			
Physical Infrastructure complexity in **Airways**	General air infrastructure by country rankings in infrastructure			
	General air infrastructure by "Quality of fixed transport infrastructure"			
	General air infrastructure by "Distribution infrastructure efficiency"			
	# Of airports			
	# Of total, paved & unpaved runways			
	# Of scheduled international flights – flight network			
	# Of scheduled national flights – flight network			
	Connection to # of cities – flight network			
	# Of international airports – flight network			
	Million tons, per year - airfreight			
	% Of total weight/quantity by air - airfreight			
	% Of total value of international transport flows by air			
	Million tons freight at major hubs			
	% Of total import/export flows by air			
	# Of takeoffs and landings in specific airports at major			

	hubs			
	% Growth in total international freight			
	% Growth in total national freight			
	"Growth in quality of transport infrastructure"			
	Spending on new infrastructure - millions investment			
	Number of new infrastructure projects & type of projects			
	Investment in transportation with private participation in USD			
	"Air flow logistics as a constraints to international trade"			
	"Air flow logistics as a constraints at policy level"			
	A description of transportation laws & regulations			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Physical Infrastructure complexity in **Waterways**	General water infrastructure by country rankings in infrastructure			
	General water infrastructure by "Quality of fixed transport infrastructure"			
	General water infrastructure by "Distribution infrastructure efficiency"			
	Km total waterways			
	# Of major ports			
	Distance in days between main international operations			
	Km/km^{2}net transportation density			
	# Of cities with a port			
	Handling capacity of containers in million – port size & capacity			
	Containers per hour – port size & capacity			
	Total # of berths – port size & capacity			
	Dock shipping length in mt – port size & capacity			
	Warehousing area in m^2 – port size & capacity			
	Description of level of development of intermodal facilities			
	# Of industrial parks located in ports			
	# Of processed twenty-foot TEU's in millions			
	Million tons general cargo - freight			
	Million tons per port per year - freight			
	# Of containers per port per year - freight			
	% Of total import/export flows by waterways			
	% Of total weight/quantity by waterways - freight			
	% Of total value of international transport flows by waterways			
	Growth in % per year water freight			
	"Growth in quality of transport infrastructure"			
	A description of Investments in water transportation			
	Investment in transportation with private participation in			

	USD			
	"Water transportation logistics as a constraints to international trade"			
	"Water transportation logistics as a constraints at policy level"			
	A description of transportation laws & regulations			
	Expert Comments:			

Variables	*Measures*	*Expert Opinion*		
		Unimportant	**Maybe Important**	**Important**
Physical Infrastructure complexity in **Intermodal**	General intermodal infrastructure by country rankings in infrastructure			
	General intermodal infrastructure by "Quality of fixed transport infrastructure"			
	General intermodal infrastructure by "Distribution infrastructure efficiency"			
	Total # of intermodal facilities			
	# Of total terminals with Intermodal facilities			
	# Of locations with Intermodal facilities			
	# Of port to port Intermodal facilities			
	A description of developed intermodal facilities			
	"Growth in quality of transport infrastructure"			
	Development of/investment in intermodal corridors			
	Investment in transportation with private participation			
	A description of government regulations on intermodal infrastructure			
	A description of transportation laws & regulations			
	Expert Comments:			
Physical Infrastructure complexity in **Public Warehousing**	General Warehousing infrastructure by country rankings in infrastructure			
	General Warehousing infrastructure by "Quality of fixed transport infrastructure"			
	General Warehousing infrastructure by "Distribution infrastructure efficiency"			
	Warehousing and storage area in million m^2			
	Ports warehousing and storage area in m^2			
	# Of total industrial parks & warehousing			
	% Of total warehouses in freight villages			
	# Of total units for agricultural storage			
	# Of total tons for agricultural storage			
	% Of total companies using in-house Warehousing			

	% Of total companies using outsourced Warehousing			
	% Per year storage growth			
	"Growth in quality of transport infrastructure"			
	A description of new constructions and restructuring			
	A description of investment in Warehousing			
	Investment in transportation with private participation in USD			
	"Warehousing logistics as a constraints to international trade"			
	"Warehousing logistics as a constraints at policy level"			
	Procedure to build a warehouse in #			
	Procedure to build a warehouse in days			
	A description of transportation laws & regulations			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Institutional complexity from **Customs**	Customs clearance process by country rankings in infrastructure			
	A description of customs clearance process			
	Customs duties in amount			
	Customs clearance in # of days			
	# Of border agencies for imports/exports			
	"Competence of customs agencies"			
	"Competence of other border related government agencies"			
	Review procedures in %			
	Customs delays in # of days			
	"Incidence of major delays due to pre-shipment inspection"			
	Growth in customs efficiency			
	Investment in customs			
	Investment in transportation with private participation in USD			
	"Customs authorities facilitations"			
	"Transparency of customs clearance process"			
	A description of customs rules & regulations			
	Expert Comments:			
Institutional complexity from **Logistics / SCM educational institutions**	Economic size by labour force in million			
	Skilled & semiskilled labour as % of the total labour market			
	"Skilled labour availability as a market obstacle"			
	Literacy rate as a % of total population			
	Labour force with primary/secondary/tertiary education			

	"Economy literacy amongst the population"			
	"Human resource rating"			
	Management practices ranking			
	# Of universities			
	Total # of majors offered by universities			
	Total # of majors with a logistics/SCM education			
	# Of colleges & universities offering logistics major			
	"Educational system meets the need of a competitive economy"			
	A description of labour unions			
	"Labour skills as a major business constraint"			
	"Labour regulations as a major business constraint"			
	A description of major labour regulations			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Physical Infrastructure complexity in **Post**	General postal services by country rankings in infrastructure			
	A description of general postal service			
	Postal services to # of countries			
	Million handling areas for post			
	Million m^2 postal warehousing & storage for post			
	Volume in billion of postal services			
	Revenue in billion of postal services			
	Network, coverage and investment in post			
	"Postal logistics as a constraint at policy level"			
	Expert Comments:			
Physical Infrastructure complexity in **Telecom**	General IT infrastructure by country rankings in infrastructure			
	General IT infrastructure by "Quality of telecommunication infrastructure and services"			
	General IT infrastructure by "Communication technologies does not meet business requirements"			
	# Of ports of telephone			
	# Of fixed telephone lines per 1000 people			
	% Fixed telephone installation rate			
	Long distance business circuits in millions			
	Population covered by mobile phones			
	Mobile telephone installation rate			
	% Mobile telephone installation rate			
	Optical fiber length in km			
	Broadband lines in million km			

	# Of total pc's			
	Growth in IT infrastructure			
	Investments in telecommunications in billion USD			
	Investments in telecommunications as a % of GDP			
	A description of foreign investment in telephone sector			
	Secure internet servers			
	"Cyber security"			
	"Telecommunication logistics as a constraint to business"			
	"Telecommunication logistics as a constraint at policy level"			
	Expert Comments:			
Complexity from **Technology Use & Adoption in Computers**	Million computer users			
	# Of pc's per 1000 people			
	# Of total internet users			
	Internet users per 1000 people			
	# World ranking in computer usage			
	Million computers with Internet access			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Complexity from **Technology Use & Adoption in EDI**	General website usage in %			
	CSCMP Website usage in %			
	A description of company usage of IT			
	Customer-integrated information systems in %			
	Companies in % using ERP systems			
	Companies in % using Decision Support Systems			
	A description of EDI in customs			
	"Can customs declarations be submitted and processed electronically" - EDI in customs			
	Expert Comments:			
Complexity from **Technology Use & Adoption in Telecom**	Million fixed telephone users			
	# Of telephone access per 100 inhabitants, ranking in specific areas/countries			
	Million mobile telephone users			
	World ranking # in terms of telephone usage			
	Millions of internet users			
	World ranking # of internet users			
	Ranking in specific areas/countries of internet users			
	Million computers with Internet access			
	Million broadband internet users			
	# Of Internet hosts per capita			

	# Of web sites per capita			
	# Of national domain names per capita			
	Growth in % broadband internet usage			
	"Telecommunication logistics as a constraints at policy level"			
	Expert Comments:			
Institutional complexity from **Financial Institutions & Services**	General financial infrastructure by "Country financial sector rating"			
	General financial infrastructure by "Quality of budgetary & financial management"			
	General financial infrastructure by domestic credit provided by banking sector % of GDP			
	General financial infrastructure by domestic credit to private sector % of GDP			
	# Of financial institutions			
	# Of banks			
	# Of insurance companies			
	Liquidity situation			
	"Loans access as a market obstacle"			
	"Financial institutions & services as a constraint to business activity"			
	Import/export of insurance & financial services			
	"Growth in quality of overall business environment"			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Institutional complexity from **Economic policy**	A description of general economic policy			
	General economic policy by "Policy direction of the government is consistent"			
	General economic policy by "High adaptability of government policy to economic changes"			
	Economic strategies of government by "Debt policy rating"			
	"Fiscal policies as an obstacle to business development"			
	A description of laws and regulations in relation to economic policy			
	A description of taxation rules and regulations			
	A description of laws and rules for foreign investment			
	A description of rules on investments			
	Personal income tax – rate %			
	Corporate tax – rate %			
	Tax on assets – rate %			
	Value-added tax – rate %			
	VAT on imports – rate %			

	Interests rates in %			
	Inflation rates in %			
	Theft & property loss – decrease in %			
	Theft & property loss – # of reported incidents			
	Theft & property loss – # of thefts a day			
	“Foreign commerce operation requirements as an obstacle to business development”			
	“Service management government performance as an obstacle to business development”			
	Corruption world rank in #			
	“Bribery - Informal economy as an obstacle to business development”			
	“Lack of transparency in policies and regulations as an obstacle to business development”			
	“Political effectiveness & stability with regards to economic policy”			
	“Plagiarism as an obstacle to business development”			
	"Trade unions as an obstacle to business development”			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Institutional complexity from **Economic Structure**	Competitiveness rank in #			
	Economic capacity and output by growth rate in %			
	Economic capacity and output by world rank in #			
	Economic capacity and output by per capita			
	Economic size by domestic consumption & demand by # of consumers			
	Economic size by domestic consumption & demand by value			
	Economic size household consumption growth rates			
	Economic size government consumption expenditures # value			
	Economic size government consumption expenditures per capita			
	Economic size by export trade in billion			
	Economic size by import trade in billion			
	Economic size by labour force in million			
	Economic development by logistics value-added as a % of GDP			
	Economic system - a description of economic business model			
	Economic system by # of manufacturing & service firms, private non-profit and public institutions			
	Economic system by # of enterprises			
	Personal incomes – total distribution			
	Prices & price stability – index #			

	Exchange rates – official & real effective exchange rates			
	Unemployment rate in %			
	Export trade volume in billion			
	Export trade volume in %			
	Export trade in % of GDP			
	Import trade volume in billion			
	Import trade volume in %			
	Import trade in % of GDP			
	Trade deficit or surplus in billion			
	Trade deficit or surplus in % of GDP			
	Budget deficit % of GDP			
	Public debt in billion			
	Public debt in % of GDP			
	National debt % of GDP			
	Growth in jobs in million			
	Total investments in billion USD			
	"Growth & development as a result of policy"			
	"Growth in quality of overall business environment"			
	Economic growth rates in %			
	Privatisation of economy by % of state-owned vs. collectively owned enterprises			
	"Illegal transactions between companies as a market obstacle"			
	"Government monopolies as a market obstacle"			
	"Market restrictions to entry & establishment - as a market obstacle"			
	"Private companies' monopolies as a market obstacle"			
	A description of logistics market entry rules			
	Logistics market entry rules by country business legislation ranking			
	Expert Comments:			
Complexity from **Technology Use & Adoption in Electronic Banking & Commerce**	"Growth in quality of overall business environment"			
	Development within electronic banking & commerce by # of credit cards per capita			
	Development within electronic banking & commerce by financial card transactions in USD per capita			
	"Technology development as a market obstacle"			
	Expert Comments:			

Variables	***Measures***	***Expert Opinion***		
		Unimportant	**Maybe Important**	**Important**
Complexity from Judicial Institutions in **Business Legislation**	Judicial system in general by # of laws			
	"Growth in quality of overall business environment"			
	Law enforcement by country business legislation ranking			
	Law enforcement by Ease of doing business index			

	"Legal system performance as a government related obstacle"			
	"Licenses and permits acquirement as a government related obstacle"			
	"Legal procedures to launch a company as a government related obstacle on a scale"			
	"Inadequacy of laws, policies, and regulations to companies necessities as a government related obstacle"			
	"Lack of transparency in law design, policies, and regulations as a government related obstacle"			
	Laws and regulations in relation to economic policy by country business legislation ranking and by Ease of doing business index			
	Laws and rules for foreign investment by country business legislation ranking and by Ease of doing business index			
	Taxation rules and regulations by country business legislation ranking and by Ease of doing business index			
	A description of transparency laws			
	A description of distribution laws			
	A description of laws that facilitate an increase in employment levels			
	A description of local regulations regarding government assistance to companies			
	Environmental laws & regulations by country business legislation ranking			
	A description of growth regulations			
	A description of retail regulations			
	Expert Comments:			
Complexity from Political Institutions by **Political Climate**	A description of general political situation			
	A description of important political changes			
	Political system by # of parties			
	Political stability by "Risk of political instability"			
	Political effectiveness by "Growth in quality of regulatory regime"			
	Bureaucracy by "Bureaucracy does not hinder business activity"			
	Governmental influence & control by "Public service is independent from political interference"			
	"Political issues as logistics barriers"			
	Political reforms by "Need for economic & social reforms is generally well understood"			
	"Growth in quality of overall business environment"			
	Expert Comments:			

Appendix D: Communiqué examples

D.1. Introductory letter requesting respondent participation

D.2. Covering letter explaining the study and purpose of the instrument

D.3. Instructions for filling out the instrument

Appendix D.1. Introductory letter requesting respondent participation

Aseem Kinra Thu, Oct 16, 2008 4:58 PM

Subject: Expert Opinion on Logistics Environmental Complexity
Date: Thursday, April 10, 2008 8:19 PM
From: Aseem Kinra <aki.om@cbs.dk>
Conversation: Expert Opinion on Logistics Environmental Complexity

Dear Dr. [illegible]:

I'm familiar with your work on global logistics and supply chain management, and have read it with great interest. I research and teach within SCM at the Copenhagen Business School, Denmark.

As part of my Phd dissertation, I'm currently conducting a study on a range of (macro-level) decision-variables that managers need to incorporate in their global logistics & SCM decisions. For this reason, I'm building a panel of experts to short-list variables & measures for this study. Since you are particularly familiar with these decision-variables within global logistics and SCM (especially so in view of your interesting IJPDLM publication - [illegible] & [illegible] 2003), your expert opinion is highly relevant for this study.

Please let me know how you feel about contributing to this study as an expert. If you agree to this, I will send you an expert opinion sheet (with a list of instructions) for you to fill out. The entire process should take about 20-30 minutes of your time.

Looking forward to your reply,

Best,

Aseem Kinra
--

Aseem Kinra
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Appendix D.2.
Covering letter explaining the study and purpose of the instrument

Copenhagen Business School
HANDELSHØJSKOLEN

Department of
Operations Management

Solbjerg Plads 3, B5
2000 Frederiksberg
Denmark

Tel.: +45 · 3815 3400
Fax: +45 · 3815 2440
www.om.cbs.dk

……….

AKI

Aseem Kinra
PhD Fellow
aki.om@cbs.dk

Expert opinion on logistics environmental complexity

Dear ……………,

Thank you for participating in this expert opinion. You have been selected as an expert on the subject matter based on your outstanding qualifications and credentials in the field of Logistics and Supply Chain Management. Your feedback shall be achieved by way of **your choice of the most important measures** for each variable, which poses environmental complexity to logistics operations and systems. Enclosed please find a document and instructions that seek to capture your opinion.

The output of your opinion will be used to create a simple (Analytic Hierarchy Process) decision-making model. More specifically, your expert opinion will aid logistics and supply chain managers in reaching qualified judgements with respect to geographical dispersion, and environmental complexity surrounding their operations.

Environmental complexity in logistics arises because of the geographical dispersion of logistics activities, and primarily because of International/Global logistics operations. Environmental complexity has thus to do with how different country environments support or impede logistics operations and pose complexity as a result. In this project, environmental complexity deals with cross-country differences in macro-institutional, macro-infrastructural and technology use and diffusion variables.

This research over the last 3 years points out to the existence of 20 such decision variables, especially in the context of International/Global logistics. In the enclosed document there are 20 decision variables along with a set of corresponding measures that may assist managers in making qualified decisions about each variable. Each of these measures is relevant for the logistics and SCM domain, and has been comprehensively collected through *CSCMP Global Perspectives*, an alternating trade publication by the Council of Supply Chain Management Professionals. After a thorough screening, only those measures where data (archival hard data or perceptual data) is readily available are presented to you for your expert opinion on their importance.

I look forward to your feedback in terms of:

1. Choice - of the most important measures that operationalise each variable.
2. Adequacy – of these measures, a prompt on any measures you miss in this list, and whether these measures appropriately capture the variable.

I thank you for your time and highly valued expert opinion on the subject matter.

Yours faithfully,

Aseem Kinra

Appendix D.3. Instructions for filling out the instrument

Instructions - Expert Opinion on Logistics Environmental Complexity

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Thank you for participating in this expert opinion. The following 10-page pdf document contains a list of measures. Each measure is grouped with its corresponding variable and seeks to capture the construct of logistics environmental complexity. There are 3 broad types of measures i.e. those relying on hard data, those relying on perceptions and those relying on descriptions. Please note that measures listed in “quotes” are perceptual measures, and are based on survey data. All measures in this list are presented randomly, and are not governed by any priority or ranking order. Please follow these instructions to provide your expert opinion:

1. **Please evaluate each measure and tick either one (“Unimportant”, “Maybe Important” or “Important”)** that according to you best describes its corresponding variable. It is important that you evaluate each measure.

2. Please provide a note on the **adequacy of these measures** in the Expert Comments box, if appropriate.

3. Please remember to **save the pdf document** while and after completing your expert opinion.

4. Please provide your opinion and return the expert opinion sheet by dt…………, by **e-mail to**:

Aseem Kinra

aki.om@cbs.dk

Appendix E: Data Analysis and Findings

E.1. A snapshot of the expert data

E.2. Lawshe Ratio results

E.3. Selected measures and (decision-) factors

Appendix E.1. A snapshot of the expert data

Name					
Position					
Measure1.0.0	Important	Important	Maybe Important	Maybe Important	Important
Measure1.1.0	Maybe Important	Maybe Important	Maybe Important	Maybe Important	Unimportant
Measure1.2.0	Maybe Important	Maybe Important	Important	Maybe Important	Unimportant
Measure1.3.0	Maybe Important	Unimportant	Maybe Important	Important	Unimportant
Measure10.0.0	Important	Maybe Important	Unimportant	Unimportant	Unimportant
Measure10.1.0	Important	Unimportant	Unimportant	Unimportant	Important
Measure10.2.0	Unimportant	Unimportant	Unimportant	Unimportant	Unimportant
Measure10.3.0	Unimportant	Maybe Important	Unimportant	Unimportant	Unimportant
Measure10.4.0	Unimportant	Maybe Important	Unimportant	Unimportant	Unimportant
Measure10.5.0	Important	Maybe Important	Unimportant	Unimportant	Important
Measure10.6.0	Important	Maybe Important	Unimportant	Unimportant	Important
Measure10.7.0	Unimportant	Maybe Important	Off	Unimportant	Important
Measure10.8.0	Maybe Important	Maybe Important	Maybe Important	Unimportant	Unimportant
Measure11.0.0	Unimportant	Maybe Important	Maybe Important	Unimportant	Unimportant
Measure11.1.0	Unimportant	Important	Maybe Important	Maybe Important	Important
Measure11.10.0	Unimportant	Maybe Important	Maybe Important	Unimportant	Unimportant
Measure11.11.0	Unimportant	Maybe Important	Maybe Important	Unimportant	Unimportant
Measure11.12.0	Unimportant	Maybe Important	Unimportant	Maybe Important	Unimportant
Measure11.13.0	Unimportant	Maybe Important	Maybe Important	Maybe Important	Important
Measure11.14.0	Unimportant	Maybe Important	Maybe Important	Maybe Important	Important
Measure11.15.0	Unimportant	Maybe Important	Maybe Important	Maybe Important	Unimportant
Measure11.16.0	Unimportant	Maybe Important	Unimportant	Maybe Important	Unimportant
Measure11.17.0	Unimportant	Maybe Important	Maybe Important	Important	Unimportant
Measure11.18.0	Unimportant	Maybe Important	Maybe Important	Important	Important
Measure11.19.0	Unimportant	Important	Maybe Important	Maybe Important	Unimportant
Measure11.2.0	Unimportant	Maybe Important	Maybe Important	Maybe Important	Important
Measure11.20.0	Unimportant	Important	Maybe Important	Maybe Important	Unimportant
Measure11.3.0	Unimportant	Maybe Important	Unimportant	Unimportant	Unimportant

Appendix E.2. A snapshot of Lawshe Ratio results

	A	B	C	M	N
1	Name	Expert 1	Expert 2	11 experts - TEST 1	11 experts - TEST 2
2	Radio Button1.0.0	Important	Important	0.45	1.00
3	Radio Button1.1.0	Maybe Important	Maybe Important	-0.27	0.82
4	Radio Button1.2.0	Maybe Important	Maybe Important	0.09	0.64
5	Radio Button1.3.0	Maybe Important	Unimportant	-0.27	0.27
6	Radio Button10.0.0	Important	Maybe Important	-0.27	0.27
7	Radio Button10.1.0	Important	Unimportant	-0.27	0.27
8	Radio Button10.2.0	Unimportant	Unimportant	-0.64	-0.09
9	Radio Button10.3.0	Unimportant	Maybe Important	-0.64	-0.09
10	Radio Button10.4.0	Unimportant	Maybe Important	-0.82	-0.27
11	Radio Button10.5.0	Important	Maybe Important	-0.09	0.27
12	Radio Button10.6.0	Important	Maybe Important	-0.45	0.27
13	Radio Button10.7.0	Unimportant	Maybe Important	-0.27	0.27
14	Radio Button10.8.0	Maybe Important	Maybe Important	-0.64	0.45
15	Radio Button11.0.0	Unimportant	Maybe Important	-0.27	0.45
16	Radio Button11.1.0	Unimportant	Important	0.45	0.82
17	Radio Button11.10.0	Unimportant	Maybe Important	-0.27	0.27
18	Radio Button11.11.0	Unimportant	Maybe Important	-0.27	0.27
19	Radio Button11.12.0	Unimportant	Maybe Important	-0.27	0.27
20	Radio Button11.13.0	Unimportant	Maybe Important	-0.45	0.64
21	Radio Button11.14.0	Unimportant	Maybe Important	0.09	0.64
22	Radio Button11.15.0	Unimportant	Maybe Important	-0.09	0.45
167	Radio Button19.7.0	Important	Maybe Important	-0.09	0.82
168	Radio Button19.8.0	Important	Maybe Important	0.27	1.00
169	Radio Button19.9.0	Unimportant	Maybe Important	0.09	0.82
170	Radio Button2.0.0	Important	Maybe Important	0.45	0.82
171	Radio Button2.1.0	Important	Maybe Important	0.64	1.00
172	Radio Button2.10.0	Maybe Important	Important	-0.09	0.64
173	Radio Button2.11.0	Maybe Important	Important	-0.45	0.64
174	Radio Button2.12.0	Unimportant	Unimportant	-0.45	0.27
175	Radio Button2.13.0	3	Unimportant	-0.45	-0.45
176	Radio Button2.14.0	Maybe Important	Unimportant	-0.45	0.27
177	Radio Button2.15.0	Important	Unimportant	-0.64	0.45
178	Radio Button2.16.0	Maybe Important	Unimportant	-0.45	0.27
179	Radio Button2.17.0	Important	Maybe Important	-0.27	0.27
180	Radio Button2.18.0	Maybe Important	Maybe Important	-0.09	0.64
181	Radio Button2.19.0	Maybe Important	Unimportant	-0.27	0.27
182	Radio Button2.2.0	Maybe Important	Important	0.64	1.00
183	Radio Button2.20.0	Unimportant	Unimportant	-0.64	0.27
184	Radio Button2.21.0	Maybe Important	Maybe Important	-0.64	0.82
185	Radio Button2.3.0	Important	Unimportant	0.09	0.64
186	Radio Button2.4.0	Important	Maybe Important	0.09	0.82
187	Radio Button2.5.0	Unimportant	Unimportant	0.09	0.45
188	Radio Button2.6.0	Important	Maybe Important	-0.09	0.45

Appendix E.3. Selected measures and (decision-) factors

Classification Scheme:
Data Source, Measurement instruments & Measures

INST1 = hard data
INST2 = perceptions - survey based (P)
INST3 = perceptions - author's personal perceptions (P)
INST4 = perceptions – data-based perceptions –DESCRIPTION (D)

Details of the Lawshe (1975) test:

TEST 1:	Gold = *Essential Measures* = $CVR_i \geq 0.59$		Note only "Important" Measures came out in this test. (i.e. those that strictly follow Lawshe's (1975) definition of *essential* measures)
TEST 2:	Yellow = *Maybe Essential Measures* = $CVR_i \geq 0.59$	(1.00)	Note also "Maybe Important" Measures came out in this test.
	Yellow = *Maybe Essential Measures* = $CVR_i \geq 0.59$	(0.82)	Note also "Maybe Important Measures" came out in this test.
	Yellow = *Maybe Essential Measures* = $CVR_i \geq 0.59$	(0.64)	Note also "Maybe Important Measures" came out in this test.

Factors	CSCMP Measure	Radio button	CVR_i	CSCMP Data Source	Data Availability - WDI	Data Availability - WCY	Data Availability - LPI
Complexity from Hard Infrastructure by **Geographical Location**	Geographical location, position & attributes	1.0.0	1.00	3,4	DMAOS		Country rankings under logistics unfriendly countries based on "Landlocked or not" & "Developing or developed countries", corresponding to fifth quintile in LPI - 1
	Country area in km^2	1.1.0	0.82	1	Yes - 1	Yes - 1	
	Km seashore or coastline	1.2.0	0.64	1	DMAOS		
Complexity from Hard Infrastructure in **Roadways**	General road infrastructure	2.1.0	0.64 1.00	4			"Quality of fixed transport infrastructure" in LPI - 2
	General road infrastructure	2.2.0	0.64 1.00	4		Distribution infrastructure efficiency - 2	
	General road infrastructure	2.0.0	0.82	4		Basic infrastructure (ranking) – 1	Country rankings corresponding to the variable "Infrastructure" in LPI - 1
	Km 4-lane highways & 2 way roads	2.4.0	0.82	1,3,4			
	% highways paved	2.8.0	0.82	1	Paved roads as % of total roads - 1		
	A description of transportation laws & regulations	2.21.0	0.82	4	DMAOS		
	Km roads total	2.3.0	0.64	1	Total road network in km - 1		
	Billion ton-km – freight volume	2.10.0	0.64	1	Million ton-km - 1		
	% Tonnage/mile - freight volume	2.11.0	0.64	1			
	"Growth in quality of transport infrastructure"	2.18.0	0.64		DMAOS		"Growth in quality of transport infrastructure" - 2
Complexity from Hard Infrastructure in **Railways**	General rail infrastructure	3.1.0	1.00	3,4		Basic infrastructure (ranking) – 1	Country rankings corresponding to the variable "Infrastructure" in LPI - 1 "Quality of fixed transport infrastructure" in LPI - 2
	General rail infrastructure	3.2.0	1.00			Distribution infrastructure efficiency - 2	
	Km total railways	3.3.0	0.82	1	Total route in km - 1		

	Million ton per year freight volume - haulage	3.6.0	0.82	1	Goods hauled tons-km - 1		
	% of total volume, billion per year volume growth *Historical growth measure*	3.12.0	0.82	1			"Growth in quality of transport infrastructure" - 2
	A description of transportation laws & regulations	3.16.0	0.82	4	DMAOS		
	General rail infrastructure	3.0.0	0.64	3,4			Country rankings corresponding to the variable "Infrastructure" in LPI - 1
	Km/km^2 net transportation density	3.4.0	0.64	1		Network density km/km^2 - 1	
	Billion ton per km freight turnover	3.5.0	0.64	1	DMAOS		
	% Of total import/export flows by rail - haulage	3.7.0	0.64	1	DMAOS		
	% Of total weight/quantity by rail - haulage	3.8.0	0.64	1			
	% Of total value of international transport flows by rail - haulage	3.9.0	0.64	1			
	Km of new railways opened/planned per year *Future growth measure*	3.13.0	0.64	1	Investment in transportation with private participation (current usd) - 1		"Growth in quality of transport infrastructure" - 2
	"Rail flow logistics as a constraints at policy level"	3.15.0	0.64	4	DMAOS		
Complexity from Hard Infrastructure in **Airways**	General air infrastructure	4.1.0	1.00	3,4		Basic infrastructure (ranking) – 1	Country rankings corresponding to the variable "Infrastructure" in LPI - 1 "Quality of fixed transport infrastructure" in LPI - 2
	General air infrastructure	4.2.0	1.00			Distribution infrastructure efficiency - 2	
	# Of airports	4.3.0	0.82	1	DMAOS		

	# Of scheduled international flights – *flight network*	4.5.0	0.82	1,4	Registered carrier departures worldwide - 1 DMAOS		
	# Of scheduled national flights – *flight network*	4.6.0	0.82	1,4			
	Connection to # of cities – *flight network*	4.7.0	0.82	1,4			
	# of international airports – *flight network*	4.8.0	0.82	1,4			
	Million tons, billion tons per km, thousand tons per year, % volume, % company utilization	4.9.0	0.82	1	Freight in million tons-km - 1 DA		
	"Air flow logistics as a constraints to international trade"	4.21.0	0.82	2	DMAOS		
	"Air flow logistics as a constraints at policy level"	4.22.0	0.82	4			
	# Of total, paved & unpaved runways	4.4.0	0.64	1	DMAOS		
	% Of total value of international transport flows by air	4.11.0	0.64	1	Freight in million tons-km - 1 DA		
	% Of total import/export flows by air	4.13.0	0.64	1	DMAOS		
	% Growth in total international freight *Historical growth measure*	4.15.0	0.64	1	DMAOS		"Growth in quality of transport infrastructure" - 2
	% Growth in total national freight *Historical growth measure*	4.16.0	0.64	1	DMAOS		
	Spending on new infrastructure - millions investment	4.18.0	0.64	4	DMAOS	"Growth in quality of transport infrastructure" - 2	Spending on new infrastructure - millions investment *Future growth measure*

	Future growth measure						
	A description of transportation laws & regulations	4.23.0	0.64	4	DMAOS		
Complexity from Hard Infrastructure in **Waterways**	Km total waterways	5.3.0	0.64 1.00	1	DMAOS		
	Containers per hour	5.9.0	0.64 1.00	1			
	No. of major ports	5.4.0	0.64 0.82	1,4			
	Handling capacity of containers in million	5.8.0	0.64 0.82	1,4			
	General water infrastructure	5.1.0	1.00	3,4		Basic infrastructure (ranking) – 1	"Quality of fixed transport infrastructure" in LPI - 2
	General water infrastructure	5.2.0	1.00	3,4		Distribution infrastructure efficiency - 2	
	Dock shipping length in mt	5.11.0	1.00	1,4	DMAOS		
	Warehousing area in m^2 - *ports*	5.12.0	1.00	1,4			
	Distance in days	5.5.0	0.82	1			
	Km/km^2net transportation density	5.6.0	0.82	1	DMAOS		
	# Of cities with a port	5.7.0	0.82	1,4			
	Total # of berths – port size & capacity	5.10.0	0.82	1,4			
	# of processed twenty-foot TEU's in millions	5.15.0	0.82	1	# of containers TEU's - 1		
	Million tons general cargo - freight	5.16.0	0.82	1	DMAOS		
	Million tons per port per year	5.17.0	0.82	1			
	# Of containers per port per year - freight	5.18.0	0.82	1			
	Growth in % per year water freight	5.22.0	0.82	1			"Growth in quality of transport infrastructure" - 2

	Growth in % per year water freight *Historical growth measure*	5.22.0	0.82	1			“Growth in quality of transport infrastructure” - 2
	Growth in quality of transport infrastructure	5.23.0	0.82	1			
	“Water transportation logistics as a constraints to international trade”	5.26.0	0.82	2		Water transportation meets basic requirements - 2	
	A description of transportation laws & regulations	5.28.0	0.82		DMAOS		
	General water infrastructure	5.0.0	0.64	3,4			Country rankings corresponding to the variable “Infrastructure” in LPI - 1
	Description of level of development of intermodal facilities	5.13.0	0.64	1,4	DMAOS		
	# Of industrial parks located in ports	5.14.0	0.64	1,4			
	% Of total import/export flows by waterways	5.19.0	0.64	1			
	% Of total weight/quantity by waterways	5.20.0	0.64	1			
	% of total value of international transport flows by waterways	5.21.0	0.64	1			
	A description of investments in water transportation	5.24.0	0.64	4			
	Investment in transportation with private participation in USD *Future growth measure*	5.25.0	0.64	4	Investment in transportation with private participation (current usd) - 1		
	“Water transportation	5.27.0	0.64	4			

Complexity from Hard Infrastructure in **Intermodal**	General intermodal infrastructure	6.1.0	1.00	3,4			“Quality of fixed transport infrastructure” in LPI - 2
	General intermodal infrastructure	6.2.0	1.00	3,4		Distribution infrastructure efficiency - 2	
	Total # *Intermodal facilities*	6.3.0	1.00		DMAOS		
	# of locations *Intermodal facilities*	6.5.0	1.00				
	Development of/investment in intermodal corridors *Future growth measure*	6.9.0	1.00	4	Investment in transportation with private participation (current usd) - 1		
	# of total terminals *Intermodal facilities*	6.4.0	0.82		DMAOS		
	# of port to port *Intermodal facilities*	6.6.0	0.82				
	A description of transportation laws & regulations	6.12.0	0.82	4			
	General intermodal infrastructure	6.0.0	0.64	3,4		Basic infrastructure (ranking) – 1	Country rankings corresponding to the variable “Infrastructure” in LPI - 1
	A description of developed intermodal facilities	6.7.0	0.64	4			
	A description of government regulations on intermodal infrastructure	6.11.0	0.64	4	DMAOS		
Complexity from Hard Infrastructure by Public **Warehousing**	Warehousing and storage area in million m^2	7.3.0	1.00	1	DMAOS		
	# Of total Industrial parks & Warehousin	7.5.0	1.00	1			
	General Warehousing infrastructure	7.1.0	0.82	3,4			“Quality of fixed transport infrastructure” in LPI - 2
	General Warehousing infrastructure	7.2.0	0.82	3,4		Distribution infrastructure efficiency - 2	
	Ports Warehousing	7.4.0	0.82	1	DMAOS		

	and storage area in m^2						
	A description of investment in Warehousing	7.14.0	0.82	4			
	General Warehousing infrastructure	7.0.0	0.64			Basic infrastructure (ranking) – 1	Country rankings corresponding to the variable “Infrastructure” in LPI - 1
	# of total units for agricultural storage	7.7.0	0.64	1	DMAOS		
	# of total tons for agricultural storage	7.8.0	0.64	1			
	# of total companies using in-house Warehousing	7.9.0	0.64	1,4			
	% of total companies using in-house Warehousing	7.10.0	0.64	1,4	DMAOS		
	A description of new constructions and restructuring	7.13.0	0.64	4			
Complexity from Supporting Institutions like **Customs**	Customs delays in # of days	8.8.0	0.64 0.82	1,3,4	DMAOS		
	Customs clearance in # of days	8.3.0	0.82		Average time to clear customs in days – 1		Customs clearance in (# days) - 1
	Customs clearance process	8.0.0	0.64	3,4	Customs duties - 1	Customs authorities do facilitate the efficient transit of goods - 2	Country rankings corresponding to the variable “Customs” in LPI – 1 Rate of physical inspection (%) - 1 Possibility of a review procedure (%) – 1 Timeliness of export/import shipments – 2 Incidence of major delays due to pre-shipment inspection - 2
	A description of customs clearance process	8.1.0	0.64	4			
	No. of border agencies for imports/exports	8.4.0	0.64				No. of border agencies for exports - 1 No. of border agencies for imports - 1
	“Competence of customs agencies”	8.5.0	0.64				Competence of customs agencies – 2
	“Competence of	8.6.0	0.64				Competence of other border related

	other border related government agencies”						government agencies – 2
	“Transparency of customs clearance process”	8.14.0	0.64				Transparency of customs clearance process - 2
Complexity from Supporting Institutions by **Logistics/SCM HR**	Economic size by labour force in million	9.0.0	1.00	1	Total labour force - 1		
	Skilled & semiskilled labour	9.1.0	1.00	4	Labour force with primary education – 1 Labour force with secondary education – 1 Labour force with tertiary education - 1	% of science & engineering university degrees - 1	
	Skilled labour availability as a market obstacle on a scale from 1-7	9.2.0	0.82	2	Human resource rating – 2 Labour skills as a major business constraint - 2	Skilled labour is relatively available – 2 Foreign high skilled people are attracted to your economy - 2 Educational system meets the need of a competitive economy - 2	
	“Economy literacy amongst the population”	9.5.0	0.82			Economy literacy amongst the population – 2	
	Total # of Majors with a logistics/SCM education	9.10.0	0.82	1			
	# of colleges & universities offering logistics major	9.11.0	0.82	1			
	“Universities meets the need of a competitive economy”	9.12.0	0.82	1		Universities meets the need of a competitive economy - 2	
	Skilled labour availability as a market obstacle on a scale from 1-7	9.14.0	0.82	2	Human resource rating – 2 Labour skills as a major business constraint - 2	Skilled labour is relatively available – 2 Foreign high skilled people are attracted to your economy - 2 Economy literacy amongst	

						the population – 2 Educational system meets the need of a competitive economy - 2	
	Literacy rate as a % of total population	9.3.0	0.64		Literacy rate (total, on gender) - 1	# of Nobel prize winners per capita – 1 Management practices ranking - 1	
	"Labour skills as a major business constraint"	9.15.0	0.64	4	Labour skills as a major business constraint – 2		
Complexity from Hard Infrastructure by **Telecom**	General IT infrastructure	11.1.0	0.82				Country rankings corresponding to the variable "Infrastructure" in LPI – 1 "Quality of telecommunication infrastructure and services" – 2
	General IT infrastructure	11.2.0	0.82			Communication technologies does not meet business requirements - 2	
	Growth in IT infrastructure *Historical growth measure*	11.13.0	0.64				"Growth in quality of telecommunications infrastructure" - 2
	Investments in telecommunications *Future growth measure*	11.14.0	0.64		Investment in telecom - 1	Investments in telecommunication % of GDP - 1	
	Secure internet servers	11.17.0	0.64	4	Secure internet servers – 1		
	"Cyber security"	11.18.0	0.64	4	Telephone average cost per calls to us - 1	Cyber security - 2	
	"Telecommunication logistics as a constraints to business"	11.19.0	0.64				
Complexity from Technology **Use & Adoption in EDI**	Companies in % using ERP systems	13.4.0	0.82		DMAOS		
	Companies in % using Descision Support Systems	13.5.0	0.82				
	"Can customs declarations be submitted and processed	13.7.0	0.82				Can customs declarations be submitted and processed electronically – 2

	electronically”						
	EDI in customs	13.6.0	0.64		DMAOS		
Complexity from **Financial Institutions & Services**	General financial infrastructure by “Country financial sector rating”	15.0.0	0.82		Financial sector rating – 2		
	Liquidity situation	15.7.0	0.82		Bank liquid reserve to bank asset ratio – 1		
	General financial infrastructure by “Quality of budgetary & financial management”	15.1.0	0.64		Quality of budgetary & financial management – 2		
	“Loans access as a market obstacle”	15.8.0	0.64	2	Bank non performing loans to total gross loans % - 1	Easy to obtain bank credits – 2 Corporate debt does not restrain enterprises to compete - 2	
	Financial institutions & services as a constraint to business activity	15.9.0	0.64		Quality of budgetary & financial management – 2 Credit information availability index - 1	Banking and financial services support business activities – 2 Financial institutions are transparent – 2 Easy to obtain bank credits – 2 Finance skills are relatively available – 2 Education in finance – 2	
Complexity from Economic Institutions in **Economic policy**	Political effectiveness & stability with regards to economic policy	16.24.0	1.00	4	Policy uncertainty as a major business restraint - 2		
	General economic policy by “Policy direction of the government is consistent”	16.2.0	0.82	3,4		Policy direction of the government is consistent – 2	
	Economic strategies of government by “Debt policy rating“	16.4.0	0.82	4	Debt policy rating - 2		
	Corporate tax	16.10.0	0.82	1	Corporate tax - 1	Corporate tax as % of GDP -	

						1 Corporate taxes discourages entrepreneurial activities - 2 Tax invasion hampers business activity – 2	
	Tax on assets – rate %	16.11.0	0.82	1		Tax on assets as % of GDP - 1	
	Interest rates in %	16.14.0	0.82	4	Yes - 1	Short term & interest rate spread – 1	
	"Foreign commerce operation requirements as an obstacle to business development"	16.19.0	0.82	2	DMAOS		
	Corruption world rank in #	16.21.0	0.82	1,2,4	Transparency, accountability & corruption in the public sector rating – 2		
	"Lack of transparency in policies and regulations as an obstacle to business development"	16.23.0	0.82	2	Transparency, accountability & corruption in the public sector rating – 2 % of managers ranking corruption as a major constraint - 2	Transparency of government policies – 2 Existence of bribery & corruption - 2	
	General economic policy by "High adaptability of government policy to economic changes"	16.3.0	0.64	3,4		High adaptability of government policy to economic changes - 2	
	A description of laws and regulations in relation to economic policy	16.6.0	0.64	4	DMAOS		
	Value-added tax	16.12.0	0.64	1			
	VAT on imports	16.13.0	0.64	1	Tax on international trade - 1		
	Inflation rates	16.15.0	0.64	4	Yes - 1	Inflation forecast & consumer price inflation - 1	
	"Bribery - Informal economy as an obstacle to business	16.22.0	0.64	2,4	Transparency, accountability & corruption in the public		

	development”				sector rating – 2		
	“Trade unions as an obstacle to business development”	16.26.0	0.64	2			
Complexity from Economic Institutions in **Economic Structure**	Export trade volume in billion	17.9.0	1.00	1	DMAOS		
	Economic size by import trade in billion	17.10.0	1.00	1			
	Economic development by logistics value-added as a % of GDP	17.12.0	1.00	1	DMAOS		
	Economic capacity and output by growth rate in %	17.1.0	0.82	1	GDP growth rate – 1		
	Total investment in billion USD	17.33.0	0.82	4		FDI data available - 1	
	Economic growth rates in % *Historical growth measure*	17.36.0	0.82	1,4	GDP growth rate – 1 Growth in exports – 1 Growth in imports – 1 GDP growth rate per capita – 1 Household consumption growth rates - 1 Growth rate in expenditures - 1		
	“Private companies’ monopolies as a market obstacle”	17.41.0	0.82	2	Ease of doing business index - 1	Business legislation ranking – 1	
	Competitiveness rank in #	17.0.0	0.64	1	DMAOS		
	Economic capacity and output by world rank in #	17.2.0	0.64	1			
	Economic capacity and output by per capita	17.3.0	0.64	1	DGP growth rate per capita – 1	GD savings per capita - 1	
	Economic size by domestic consumption & demand by # of	17.4.0	0.64	1	Household consumption growth rates - 1	Household consumption expenditures per capita- 1 Government consumption expenditures per capita- 1	

	consumers					
	Economic size by domestic consumption & demand by value	17.5.0	0.64			Household consumption expenditures total value – 1 Government consumption expenditures total value – 1
	Economic size by labour force in million	17.11.0	0.64	1	DMAOS	
	Economic system - # of manufacturing & service firms, private non-profit and public institutions	17.14.0	0.64	1		
	Price & price stability – index #	17.17.0	0.64	4	Consumer price index – 1 Wholesale price index -1	Consumer price inflation rate – 1 Ranking economical structure using prices, consumer price inflation, costs of living index, apartment rent & office rent - 1
	Unemployment rate in %	17.19.0	0.64	1,4	Many types of unemployment rates - 1	Unemployment rate as % of labour force - 1
	Export trade volume in billion	17.20.0	0.64	1	DMAOS	
	Export trade volume in %	17.21.0	0.64	1		
	Export trade in % of GDP	17.22.0	0.64	1		
	Import trade volume in billion	17.23.0	0.64	1		
	Import trade volume in %	17.24.0	0.64	1		
	Trade deficit or surplus in billion	17.26.0	0.64	1		
	Privatisation of economy by % of state-owned vs. collectively owned enterprises	17.37.0	0.64	1		
	“Government monopolies as a	17.39.0	0.64	2	Ease of doing business index - 1	Business legislation ranking – 1

	market obstacle”						
	“Market restrictions to entry & establishment - as a market obstacle”	17.40.0	0.64	2	Ease of doing business index - 1	Business legislation ranking - 1	
	A description of logistics market entry rules	17.42.0	0.64	4			
	Logistics market entry rules by country business legislation raking	17.43.0	0.64			Business legislation ranking - 1	
Complexity from **Technology Use & Adoption in Electronic Banking & Commerce**	“Growth in quality of overall business environment”	18.0.0	0.64				Growth in quality of overall business environment - 2
Complexity from Judicial Institutions in **Business Legislation**	“Lack of transparency in law design, policies, and regulations as a government related obstacle”	19.8.0	1.00	2	Ease of doing business index - 1	Business legislation ranking – 1	
	“Inadequacy of laws, policies, and regulations to companies necessities as a government related obstacle”	19.7.0	0.82	2	Ease of doing business index - 1	Business legislation ranking - 1	
	Laws and regulations in relation to economic policy by Ease of doing business index	19.9.0	0.82	4	Legal rights of borrows and lenders index -1	Business legislation ranking - 1	
	Environmental laws & regulations by country business legislation ranking	19.16.0	0.82			Business legislation ranking – 1	
	“Growth in quality	19.1.0	0.64				Growth in quality of overall business

	"Growth in quality of overall business environment"	19.1.0	0.64				Growth in quality of overall business environment - 2
	Law enforcement by country business legislation ranking	19.2.0	0.64			Business legislation ranking – 1	
	Law enforcement by Ease of doing business index	19.3.0	0.64		Ease of doing business index - 1		
	"Licenses and permits acquirement as a government related obstacle"	19.5.0	0.64	2	Ease of doing business index - 1	Business legislation ranking – 1	
	Laws and rules for foreign investment by country business legislation ranking and by Ease of doing business index	19.10.0	0.64	2	Ease of doing business index - 1	Business legislation ranking – 1	
	Taxation rules and regulations by country business legislation ranking and by Ease of doing business index	19.11.0	0.64	2	Ease of doing business index - 1	Business legislation ranking – 1	
Complexity from Political Institutions by **Political Climate**	A description of general political situation	20.0.0	0.82	3,4	DMAOS		
	Political stability	20.3.0	0.82	3,4		Risk of political instability - 2	
	Bureaucracy	20.5.0	0.82	4		Bureaucracy does not hinder business activity - 2	
	Political issues as	20.7.0	0.64	4			Growth in quality of regulatory regime - 2

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