LUND UNIVERSITY

Department of Industrial Management and Logistics

Division of Engineering Logistics

Evaluation of the supply chain network design at United Nations Population Fund (UNFPA)

Through the development of a performance measurement system

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Preface

This thesis is the final part of the authors' Master of Science degree in Industrial Engineering and Management at Lund University, Sweden. The thesis has been conducted on behalf of Lund University and United Nations Population Fund's Procurement Services Branch in Copenhagen during the spring of 2012.

It has been a challenging but most of all fun and interesting period where we have learned a lot. We would like to dedicate special thanks to our supervisors at Lund University and UNFPA, Joakim Kembro and Morten Sørensen, for all your support and valuable comments. We would also like to express our gratitude to all the employees at UNFPA and everyone who has been interviewed for this thesis for their great help and patience with our endless questions.

As this marks the end of our five-year long journey towards a degree in Industrial Engineering and Management, we would finally like to thank all of our lovely classmates out of which many have become friends for life.

Lund, June 2012

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Emilia Wiking

Abstract

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Background: UNFPA is a subsidiary organ to the United Nations (UN) with a primary focus on population and development strategies, sexual and reproductive health and gender equality. In March 2005 the UNDP/UNFPA Executive Board had realized that for the UNFPA Procurement Services Branch (PSB) to operate in line with its mission, focus would need to be directed specifically towards improvements in the areas of procurement, supply and logistics. Several studies were conducted that resulted in a recommendation to implement regional warehouses. However, the conclusion of the studies was that further quantitative analysis was needed in terms of performance measures for transportation, warehousing costs and lead-times to make an informative decision. PSB now has an opportunity to utilize United Nations Humanitarian Response Depots (UNHRDs) as regional warehouses.

Purpose: The purpose of this study was to develop a performance measurement system for PSB's supply chain network design. In addition, the purpose was to use the performance measurement system in an evaluation of the alternative supply chain network design with regional warehouses.

Research questions: *1. Which performance measures need to be considered when developing a new performance measurement system for PSB?*

2. Should PSB keep its current supply chain network design or switch to a supply chain network design with regional warehouses in the UNHRDs?

Method: First, exploratory interviews were held to get an understanding for PSB, its supply chain and where to direct the focus for this study. Second, several interviews were held with employees at PSB regarding PSB's supply chain, supply chain strategy and performance measurement system. A performance measurement

system could thereby be developed through these interviews and the frame of reference developed for this study. Third, order data from PSB's information was used to determine the performance for the current and alternative supply chain. Finally, the performance of the two supply chain network designs was compared and a recommendation regarding PSB's supply chain network design was presented.

Conclusions: A new performance measurement system was developed for PSB. It was developed to contain measures from the three categories; resource, output and flexibility. The developed performance measurement system was used to analyze and compare the current supply chain network design to a supply chain network design with regional warehouses in the UNHRDs. It was found that the supply chain network design performed better or equal to the current supply chain for 11 out of the 13 performance measures. The supply chain with regional warehouses scored high in the areas that PSB had expressed as important to their strategy such as freight performance, responsiveness and customer satisfaction. All regional warehouses except for the one in Brindisi were found suitable. Therefore, the authors recommend PSB to start utilizing the UNHRDs in Accra, Dubai, Panama and Subang.

Keywords: Performance measurement system, performance measures, supply chain network design, regional warehouse, UNFPA

Abstract in Swedish

Titel: Evaluation of the supply chain network design at United Nations Population Fund (UNFPA)

Författare: Olof Petersson och Emilia Wiking

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Bakgrund: UNFPA är en underorganisation till Förenta Nationerna (FN). UNFPA fokuserar på populations- och utvecklingsstrategier och jämlikhet mellan könen. I mars 2005 bestämdes det i UNDP/UNFPAs styrelse att UNFPAs inköpsavdelning (PSB) skulle behöva förbättras om de skulle nå upp till sina mål. Flera studier har genomförts och resultatet av dessa visade bland annat på en rekommendation att införa regionala lager för att kunna minska ledtiderna mot kund. De visade dock också på att en mer kvantitativ analys skulle behövas med avseende på potentiella transport- och lagerkostnader innan ett informativt beslut skulle kunna tas.

Syfte: Syftet med denna studie var att utveckla ett system med mätetal för att utvärdera PSBs försörjningskedja. Syftet var också att med hjälp av detta system utvärdera fördelarna och nackdelarna för PSB att ha regionala lager för att slutligen kunna ge en rekommendation angående huruvida PSB ska börja lagra produkter i UNHRDs eller ej.

Forskningsfrågor: *1. Vilka mätetal behöver inkluderas för att kunna utvärdera PSBs försörjningskedja med avseende på regionala lager?*

2. Borde PSB behålla sin nuvarande design på försörjningskedjan eller ändra till en design som inkulderar regionala lager med UNHRD?

Metod: Inledande intervjuer hölls med anställda på PSB i studiens början för att få en djupare förståelse för PSB, dess försörjningskedja och var fokus skulle läggas. Ytterligare intervjuer hölls sedan angående PSB's försörjningskedja, strategi och system med mätetal. Genom dessa intervjuer och det teoretiska rameverket kunde ett system med mätetal utvecklas. Detta system andvändes sedan för att mäta skillnaden mellan den nuvarande försörjningskedjan och den

alternativa försörjningskedjan med regionala lager. Analysen av mätetalens resultat låg till grund för rekommendationen till PSB.

Slutsatser: Ett system med mätetal utvecklades för PSB utifrån de tre kategorierna; tillgångar, resultat och flexibilitet. Detta system användes för att analysera och jämföra PSBs nuvarande försörjningskedja med en försörjningskedja med regionala lager hos UNHRD. Resultatet visade att försörjningskedjan med regionala lager fick bättre resultat på 11 av de 13 mätetalen som användes i analysen. Försörjningskedjan med regionala lager fick höga poäng för mätetal som PSB hade uttryckt att de tyckte var extra viktiga, såsom leveranstid, möjligheten att snabbt kunna leverera akuta ordrar samt kundnöjdhet. Alla UNHRDs regionala lager ansågs vara passande förutom lagret i Brindisi på grund av för små och infrekventa ordrar. Författarna reklommenderar därför PSB att börja lagra sina produkter in UNHRDs lager i Accra, Dubai, Panama och Subang.

Nyckelord: Performance measurement system, performance measures, supply chain network design, regional warehouse, UNFPA

List of acronyms

AHP – Analytical Hierarchy Process

BSC – Balanced Scorecard

CO – Country Office

CSB – Commodity Service Branch

ICPD – International Conference on Population and Development

IFRC – International Federation of Red Cross and Red Crescent Societies

LTA – Long Term Agreement

NGO – Non-Governmental Organization

PO – Purchase Order

PSB – UNFPA Procurement Services Branch

RH kit – Emergency Reproductive Health kit

RQ – Research Question

SCOR – Supply Chain Operations Reference Model

UN – United Nations

UNDP – United Nations Development Programme

UNFPA – United Nations Population Fund

UNHRD – United Nations Humanitarian Resource Depot

UNICEF – United Nations (International) Children's Fund

UNOPS – United Nations Office for Project Services

WFP – United Nations World Food Programme

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Prologue

In 1994 at the International Conference on Population and Development (ICPD) in Cairo, 179 countries agreed on that; "*population and development are inextricably linked, and that empowering women and meeting people's needs for education and health, including reproductive health, are necessary for both individual advancement and balanced development."* The conference adopted a 20-year Programme of Action, which focused on individuals' needs and rights, rather than on achieving demographic targets (UNFPA, 2012a). The United Nations Population Fund (UNFPA) is the lead organization to help countries implement the ICDP Programme of Action and emphasized their mission statement after the conference to give *"the right of every woman, man and child to enjoy a life of health and equal opportunity. UNFPA supports countries in using population data for policies and programmes to reduce poverty and to ensure that every pregnancy is wanted, every birth is safe, every young person is free of HIV/AIDS, and every girl and woman is treated with dignity and respect* (UNFPA, 2012b)*."*

1. Introduction

The first chapter provides an introduction to this study, including the background and problem discussion followed by the purpose, research questions and delimitations. A disposition of the thesis is also provided.

1.1. Background

UNFPA is a subsidiary organ to the United Nations (UN) with a primary focus on population and development strategies, sexual and reproductive health and gender equality. The organization has 129 country offices (COs) across the world (UNFPA, 2012c). UNFPA was founded in 1967 and began operations in 1969. The organization has since the start gained more than 30 years of experience in procurement of reproductive health commodities and emergency reproductive health (RH) kits. Contraceptives mainly concern subdermal implants, injectable contraceptives and male condoms whereas RH kits for example can contain equipment needed for a safe delivery of a baby. The clean delivery kits can be used when hospitals are too far away or do not have the possibility to treat the people in need (Andries, 2012). Today, UNFPA's Procurement and Service Branch (PSB) is the largest public procurer of contraceptives. PSB has been located in Copenhagen, Denmark, since 2006 when this part of the organization was moved from New York (UNFPA, 2012d). See Appendix 1 for UNFPA's organizational chart. PSB's mission is "t*o provide access to impartial expert advice, encourage supplier neutrality in procurement; to respond quickly to urgent and emergency requests and to offer quality goods and services in appropriate quantities at the right price, at the right place and RIGHT time for use in projects"* and with this mission follow their objectives to "*reduce delivery times and prices through continuous improvement of our procedures and information sharing between ourselves, vendors, clients and other partners involved in procurement of reproductive health commodities"* (UNFPA, 2012d).Because focus for this study will be on PSB's operations, PSB will hereinafter be mentioned instead of UNFPA.

In March 2005 the UNDP/UNFPA Executive Board had realized that for PSB to operate in line with its mission, focus would need to be directed specifically towards improvements in the areas of procurement, supply and logistics (Steele, 2009). When approaching these areas there are challenges to consider. First, the complexity of the demand situations is a challenge that requires different types of actions. Emergency aid is required in sudden demand situations such as natural or man-made disasters whereas development work is required on a more regular basis in areas that suffer from long-term disasters. Development work is also known as continuous aid or aid during slow on-set disasters but will hereafter be referred to as development work. PSB's two main product types, contraceptives and RH kits, are demanded during the two different aid situations. Contraceptives are most frequently requested for development work (Nielsen, 2012) such as the continuous conflict in Darfur. The RH kits are usually requested in emergency situations such as for the earthquake in Haiti in 2010. The difference in characteristics for these disasters implies that different requirements exist for the two product types with respect to lead-time, costs and demand.

In emergency aid situations, demand is sudden and the lead-time is critical whereas costs are of less importance (Andries, 2012). Lead-times are less important for products requested for development work and consequently there will be more focus on reducing costs. However, lead-times cannot be disregarded when designing the supply chain for contraceptives (Nielsen, 2012). Second, there is a challenge related to the demand planning. Due to their expertise in the procurement of reproductive health commodities, PSB has the role of a procurement agency internally for the COs and externally for its third-party clients. The third party clients can be other UN agencies or non-governmental organizations (NGOs). Since the NGOs and the COs rely upon donations it is difficult to plan the demand which applies to both contraceptives and RH kits. Third, the long manufacturing lead-times are contributing to the challenges for PSB. Due to thorough testing and inspections, especially for contraceptives, the manufacturing lead-times can be several months. The suppliers are also often located far from the receiving customers. This is another challenge in terms of logistics as it further increases the delivery lead-time (Nielsen, 2012). Lastly, PSB has a history of being an administrative function on the same level in the organization as finance and IT. PSB has recently been moved to a more strategic level higher up in the organizational hierarchy. However, PSB is still sometimes seen as an administrative function. This provides a challenge for PSB in its development of a supply chain strategy (Dupont, 2012).

In response to the abovementioned challenges, two major studies were conducted. The first study from 2006 addressed the challenges of the complex demand situations, the difficulty of planning the demand, long lead-times and PSB's role within UNFPA. The study had a focus on RH kits and the emergency flow. The main conclusions from the report was that PSB should put logistics capability in place by hiring a logistics specialist, develop a supply chain strategy and take control of its stock and the sourcing at the earliest stage of the supply chain. It was also recommended that PSB should develop its supply chain network design with respect to global, regional and country supply arrangements and improve the demand planning (Bouverie-Brine, 2006). The study resulted in an agreement that allowed PSB to store finished goods at the suppliers' premises. As a result, the delivery lead-times could be reduced (Steele, 2009). In the second study made in 2009, an extension to the recommendations from the first study was presented. The report included a suggestion of a supply chain strategy for PSB, an action plan and a cost analysis for the implementation of the strategy. The strategy and action plan was comprised of developing professional human resources, such as regional and country logistics coordinators, and implementing logistics preparedness, such as pre-positioning stocks at a regional level (Steele, 2009). In difference to the first study, focus for this study was on contraceptives because "*UNFPA's ability to respond in a humanitarian emergency is largely based on its ability to manage logistics for its development work*" (Steele, 2009. p. 4). Although the development work has a fairly unstable demand situation, it is more stable than for the emergency aid. Hence, improving the strategy for this flow could be seen as a starting point towards the improvement of the emergency aid flow (Steele, 2009).The vision of the suggested strategy was:

> "…*to provide flexible, efficient and timely dispatch, clearance, transportation, tracking, storage and distribution of reproductive health commodities to meet the needs of beneficiaries. The strategy will aim to enhance the technical skills of UNFPA (and later, partners) to respond to reproductive health needs in emergency situations by integrating logistics into emergency response preparedness, national development plans and country programmes.* " (Steele, 2009, p. 15)

A pilot study was executed in Latin America in 2009 as a test of regional warehouses. PSB's role in emergency situations was investigated together with the available logistics infrastructure, such as warehousing, freight forwarding possibilities and information sharing among the NGOs in the region (Steele and Lkhagva, 2009). The conclusions from the study was that "*pre-positioning emergency stock at regional level will increase UNFPA's capacity to meet its core commitments to women and other vulnerable populations ONLY when other variables are fully known and addressed"* (Steele and Lkhagva, 2009, p. 16). Steele and Lkhagva (2009) concluded that further quantitative analysis was needed in terms of performance measures for transportation, warehousing costs and lead-times to make an informative decision (Steele and Lkhagva, 2009).

In 2011, PSB once again raised the question of changing its supply chain network design by implementing regional warehouses. The scenario concerned further utilization of the already existing agreement that allows PSB to store its products in the United Nation's Humanitarian Response Depots (UNHRDs). There are currently five such depots situated in Italy, Ghana, the United Arab Emirates, Malaysia and Panama (UNHRD, 2012a). However, this agreement has not yet been used (Sørensen, 2012a).

1.2. Problem discussion

The abovementioned reports all recommended further research. The pilot study specifically concluded that in order for a decision to be made regarding regional warehousing, a complementary quantitative analysis would be necessary. The use of regional warehouses would shorten the distance to the COs and could thereby reduce the order lead-times for both emergency and development orders (Sørensen, 2012). A pre-positioning of products in regional warehouses could also reduce the transportation costs for the COs due to that less air transportation would be needed (Tongxin, 2012). Concerns with pre-positioning include a greater risk for obsolete products and that the cost of keeping stock at regional warehouses is greater than the savings (Steele and Lkhagva, 2009). Expected transportation costs, changes in lead-times and expected inventory obsolescence are examples of quantitative measures that are needed to complement the previous studies (Steele and Lkhagva, 2009). The quantitative analysis requested in the pilot study was never performed and therefore a decision regarding regional warehouses could not be made. Consequently, the supply chain network design alternative with regional warehouses is still on the agenda (Sørensen, 2012).

1.3. Purpose and research questions

Several performance measures are usually needed to describe all aspects of the supply chain. The measures should be developed in line with the organization's strategy in order for the performance to determine if the organization is meeting its strategic goals. The measures should also complement each other to cover all aspects of the supply chain to avoid sub-optimization. For instance, by only measuring cost, lead-times might be neglected. An organization's chosen performance measures will form a performance measurement system (Beamon, 1999). The purpose of this study is to develop a performance measurement system for PSB's supply chain design. Furthermore, the purpose is to utilize the performance measurement system to compare the current supply chain network design to the supply chain network design with regional warehouses in the UNHRDs. The supply chain network design with regional warehouses in the UNHRDs will hereafter be referred to as "*the alternative supply chain network design*". To address the purpose and the issues mentioned in the problem discussion, the following research questions (RQs) were developed:

1. *What performance measures need to be considered when developing a performance measurement system for PSB to evaluate the organization's supply chain network design?*
2. *Should PSB keep its current supply chain network design or switch to a supply chain network design with regional warehouses in the UNHRDs?*

In order to answer the RQs, the four concepts supply chain, supply chain strategy, supply chain network design and performance measurement system will be used as a basis for developing a framework of reference for the study. See Figure 1.1 for the connection between the concepts and how they relate to the RQs.

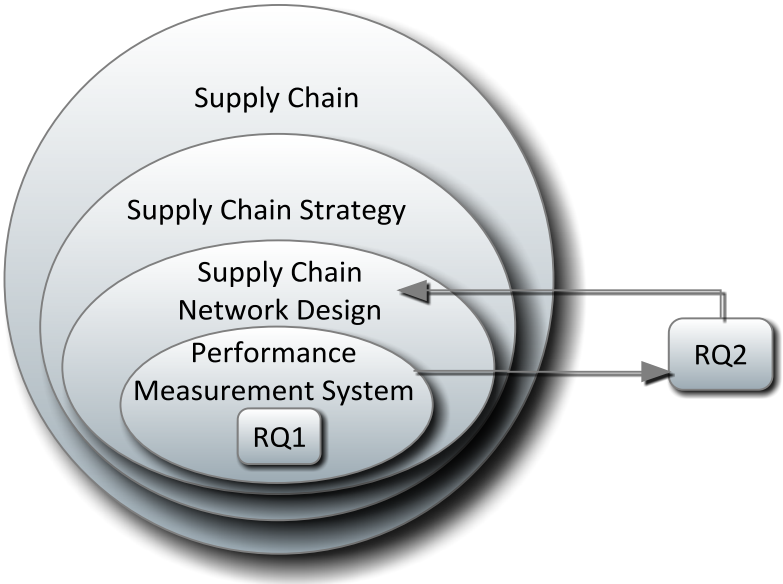

Figure 1.1. Visualization of the theory components and their connectivity (own creation)

The concept of supply chain was reviewed to get a holistic view of PSB's supply chain. The concept was applied when mapping UNFPA's supply chain. Changes in the supply chain are directed by the supply chain strategy (Beamon, 1999) and therefore this concept was studied. The supply chain strategy affects how the supply chain network is to be designed in order to fulfill the goals and objectives of the organization. The concept of supply chain network design was also studied in order to understand how a use of regional warehouses could affect PSB's performance. Performance measurement systems are used to evaluate the performance of alternative supply chain network designs (Chan and Qi, 2003; Gunasekaran and Kobu, 2007).

1.4. Focus and delimitations

Based on exploratory interviews (Andries, 2012; Nielsen, 2012; Sørensen, 2012; Dupont, 2012; Zhang, 2012), contraceptives and RH kits are considered to be representative for PSB's product portfolio and were therefore chosen to represent PSB's products in this study. These two product types are different in the sense that they are usually requested in different types of demand situations. By using them in this study, they provided a platform for determining a performance measurement system that was valid for both emergency aid and development work. The supply chain for contraceptives and RH kits, with the studied system circled, can be seen in Figure 1.2.

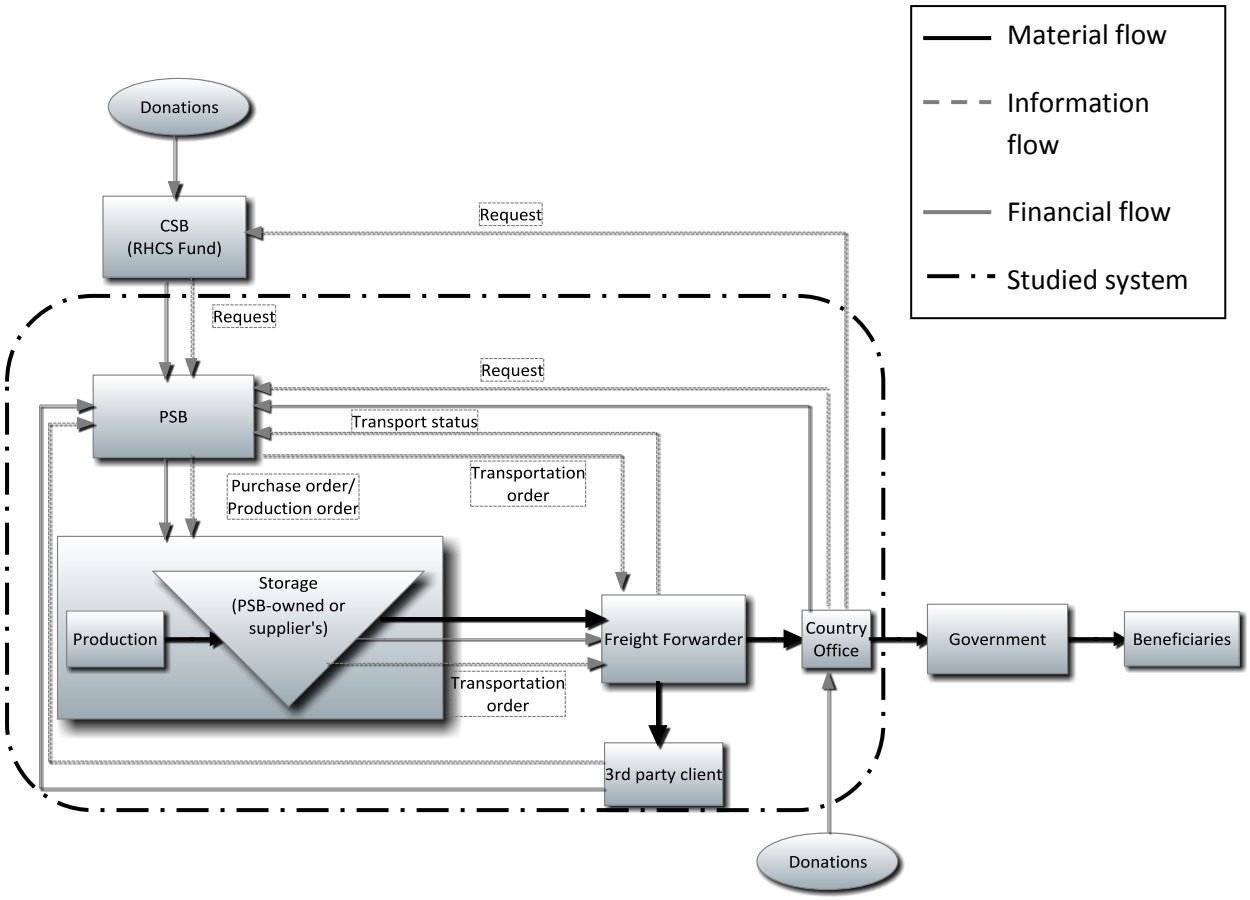

Figure 1.2. Logistics flow of contraceptives and RH kits for UNFPA

The thesis has been delimited to include the first tier of PSB's logistics flow. The first tier includes the flow from the suppliers to the COs and third party clients along with the links that tie the supply chain together. The thesis only considered air and ocean transportation because of the low share of road and rail transportation. The in-country logistics, concerning the hand-over from COs to the government and further on to the beneficiaries was not included in the study because this service is rarely provided by PSB and is therefore considered to be outside the studied system. The suppliers are included in the studied system but the specific performance concerning the manufacturing of the products was not considered. It was assumed that PSB would be allowed to store all contraceptives and RH kits outside the suppliers' premises. Rules and regulations regarding products have not been considered for the analysis. Furthermore, the analysis was delimited to using data from 2010 because some of the data only was available from this year. However, 2010 was considered to be a representative year for PSB (Nielsen, 2012). Therefore, data from this year was assumed to be reliable. Finally, the financial flow from donors was not included in the study to narrow down the scope for this thesis.

1.5. Disposition of thesis

The thesis is organized as shown in Figure 1.3.

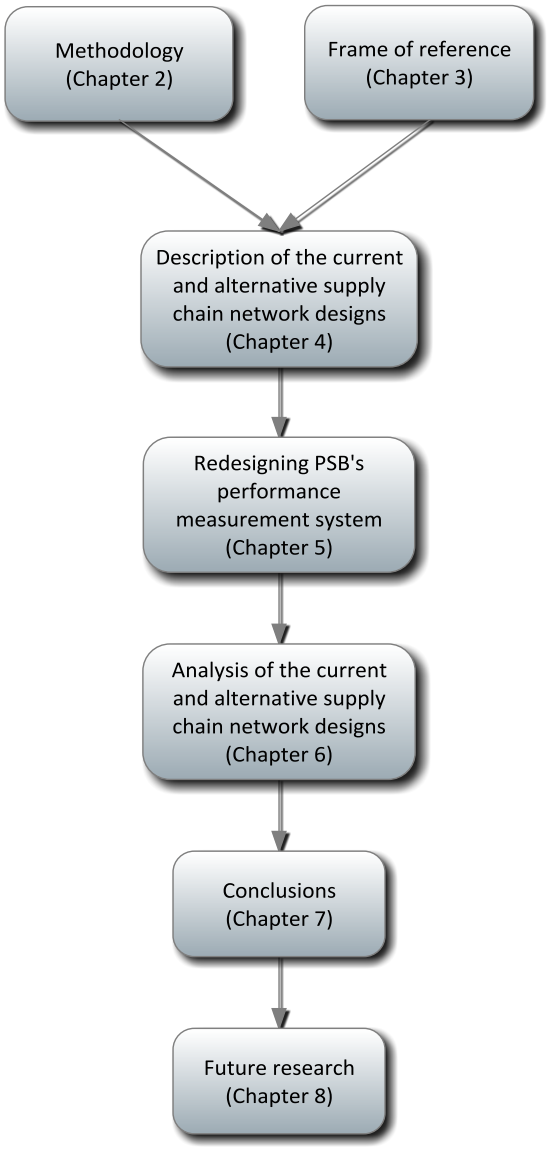

Figure 1.3. Disposition of the thesis

First, the methodology chapter guides the reader through the methodological choices made for this study. Second, the frame of reference is presented and connected to the research process described in the methodology. These two chapters are followed by the description of the current and alternative supply chain network design. Furthermore, the redesigning of PSB's performance is described and used in chapter 6 where the current and alternative supply chain network designs are analyzed. Finally, the conclusions and recommendations are presented along with a discussion regarding potential future research.

2. Methodology

In this chapter, the chosen methodology used to achieve the purpose of this study is discussed. The process for collecting and analyzing the literature and empirical data is also described.

Denscombe (2009) argues that the methodology needs to be discussed early in the research process or the study risk being unstructured and difficult to complete. Gammelgaard (2004) claims that by introducing a methodological framework, the researcher can secure that all chosen approaches are discussed and evaluated. Arbnor and Bjerke (2009) argue that a methodological framework should take its standpoint in the purpose and research questions to make sure that these are fulfilled and answered. The first standpoint is introduced as the scientific approach of a study. The choice of a scientific approach can further be used as a foundation for the choice of research method, type of data collection, choice of literature and research design strategy. See Figure 2.1 for how the methodological choices connect to each other.

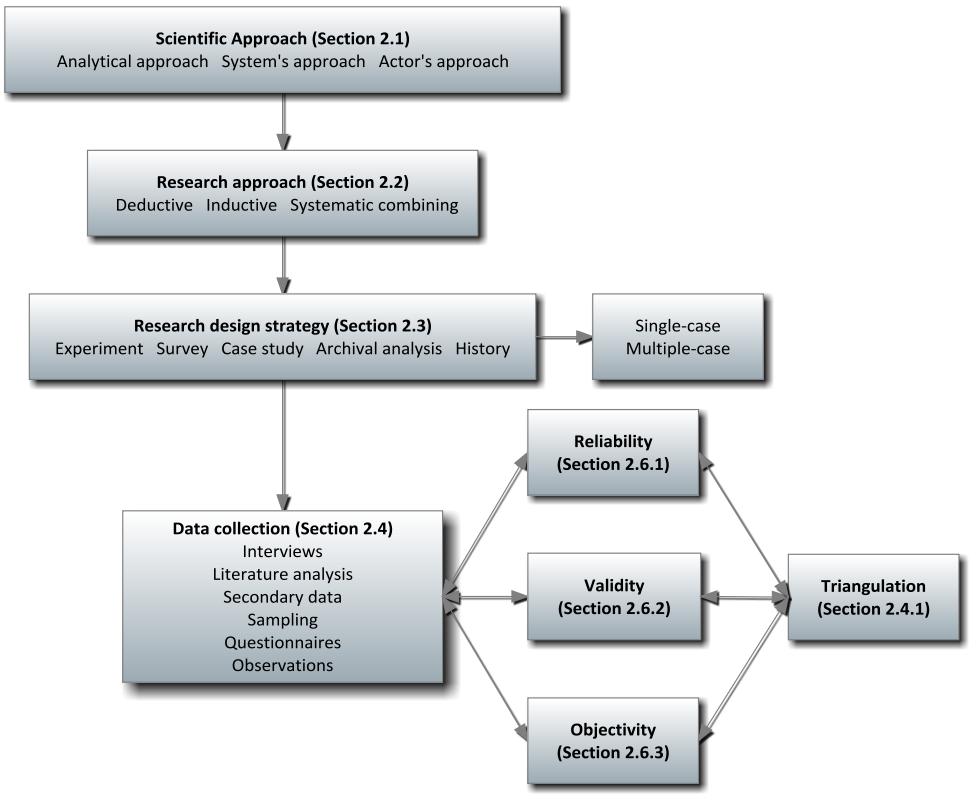

Figure 2.1. Illustration of the methodology chapter (own creation)

2.1. Scientific approach

According to Gammelgaard (2004), a scientific approach can be described as a combination of the characteristics of the research questions and the way the researchers look upon reality. Arbnor and Bjerke (2009) propose three scientific approaches; the *analytical approach*, the *systems approach* and the *actors approach.* They also suggest characteristics for the method, unit of analysis, data analysis and position of the researcher that would be

suitable for each of these approaches, see Table 2.1. According to Arbnor and Bjerke (2009), the systems approach is suitable in logistics research because it takes a holistic view that is suitable when solving logistics problem.

Table 2.1. Scientific approaches (Arbnor and Bjerke, 2009)

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

2.1.1. The analytical approach

In the analytical approach, the researcher remains outside the studied object and must not interact with it in any way. The objective of this approach is to come up with generalized results in order to predict future events. The use of quantitative data for statistical analysis is very common when applying this method. (Arbnor and Bjerke, 2009)

2.1.2. The systems approach

According to Arbnor and Bjerke (2009), the studied object cannot be seen as components that can stand alone but rather as a system with links and interdependencies when applying the systems approach. The researcher's objective is to identify these links in order to give recommendations for improvements. As for the analytical approach, in the systems approach the researcher generally stands outside the studied object and gathers information. Both qualitative and quantitative data is used for the analysis.

2.1.3. The actors approach

Arbnor and Bjerke (2009) argue that the actors approach view of reality is not seen as something objective as in the analytical approach but rather as something that has evolved through various social links. Therefore this approach focuses on qualitative studies to understand these links and the intentions of the people in the studied system.

2.1.4. The scientific approach for this study

The study conducted in this thesis has a problem-solving character. The research questions aim at solving the lack of a structured framework for evaluating changes in PSB's supply chain network design. In order to avoid a sub-optimized solution, a holistic view is preferable and a systems approach encompasses this. The position of the researchers in this study is outside the studied object even though close interaction with the study object will be a part of the study. This further strengthens the authors' choice of adopting a systems approach.

2.2. Research approach

Kovács and Spens (2006) argue that it is the reasoning over time that determines the research approach; inductive, deductive or systematic combining. In this section, these three approaches will be discussed.

2.2.1. Inductive, deductive and systematic combining research approach

Kovács and Spens (2005) found that research methods are traditionally divided into the inductive or deductive approach, see Figure 2.2. A deductive approach takes its' start in theory and is then applied into a specific case. Contrary, inductive approach studies the specific case and then tries to generalize it to existing theory. According to Taylor et al. (2002) the systematic combining, also referred to as abduction, originates from the insight that most great advances in science neither followed the method of merely deduction nor induction but rather a combination of the two.

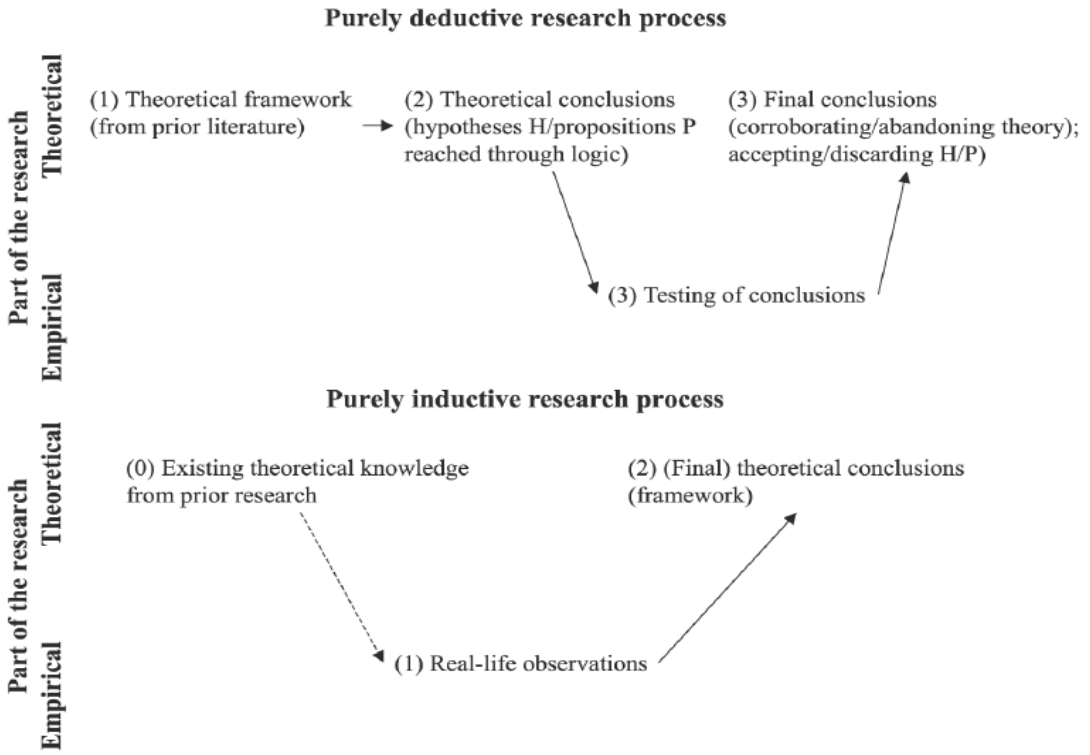

Figure 2.2. Illustration of deductive and inductive approach (Kovács and Spens, 2005)

2.2.2. The choice of research approach for this study

PSB approached the authors with a defined problem regarding the suitability for PSB to use regional warehouses. An inductive approach was appropriate because the problem was defined before the study was initiated. During the study the authors found relevant theory that could be used for analyzing the problem at hand.

2.3. Research strategies

Yin (2007) points out five different strategies that can be applied when conducting a research study. Each strategy and when to effectively apply it can be seen in Table 2.2.

Table 2.2. Five different research strategies and when to apply each of them (Yin, 2007)

Different research strategies			
Strategy	**Form of research question**	**Requires control of behavioral event**	**Focus on contemporary events**
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	How, why?	No	Yes/No
History	How, why?	No	No
Case study	How, why?	No	Yes

An experiment is a research strategy where a specific situation is investigated under controlled conditions. A survey refers to the activity of gathering data for mapping a situation. Surveys exist in many forms such as mail surveys or face to face interviews (Denscombe, 2009). An archival analysis is performed when documents within an area are studied. The research design of histories are used when no person is alive to report what happened and the researcher have to rely on historical documents, culture and artifacts as main sources (Yin, 2007). According to Denscombe (2009), case studies are characterized by studying only one or a few objects which allows for a more detailed investigation than for instance surveys can do. Ellram (1996) argues that a research strategy also can be chosen with respect to the type of data that will be used for the analysis, see Table 2.3.

Table 2.3. Different strategies positioned with respect to type of data and type of analysis (Ellram, 1996)

Type of data	Type of analysis: Primarily quantitative	Type of analysis: Primarily qualitative
Empirical	Survey data, secondary data in conjunction with statistical analysis such as: • Factor analysis • Cluster analysis • Discriminant analysis	Case studies, participant observations, ethnography. Characterized by: • Limited statistical analysis • Often non-parametric
Modeling	• Simulation • Linear programming • Mathematical programming • Decision analysis	• Simulation • Role playing

The empirical data is the kind of data that is gathered from the real world whereas modeled data is either hypothetically created or real data that has been manipulated (Ellram, 1996). Ellram (1996) states that case studies primarily are based on qualitative analysis. However, Eisenhardt (1989) and Yin (2003) argue that the case study in fact can be based on both qualitative and quantitative analysis' and that an advantage with case studies is that it combines multiple data collection methods such as archives, interviews and observations.

2.3.1. Research strategy for this study

The case study strategy was chosen for this study because the research questions focus on how PSB's supply chain network should be designed and there was no control of the behavioral event meaning that the researchers could not control the supply chain and its actors. Furthermore, focus was on contemporary events which imply that the recommendations will affect the contemporary supply chain and the type of data that was analyzed was empirical. As seen in Table 2.2, these characteristics are all suitable for case studies. The case study was also found suitable because of the detailed level that this study encompasses. Finally, the use of several data collection methods further enforced the choice to use a case study strategy.

2.3.2. Types of case studies

Yin (2007) argues that when using case studies in a research it is important to design the case study so that it will be consistent with the purpose of the research. Case studies can be constructed with either a single-case or a multiple-case design. A single-case design is often chosen when a unique or extreme case that is hard to replicate is studied or if the case is studied with a revelatory purpose. A multi-case design is more robust because the theory can be tested several times. Any case study can also consider one or multiple units of analysis (Yin, 2007). An example of using one unit of analysis can be if the purpose of the study is to analyze the global nature of an organization. The use of one unit of analysis is referred to as a holistic design. The opposite is when the business units and perhaps even

the individuals in the respective business unit are considered. The use of multiple units of analysis is then referred to as an embedded design. Yin (2007) has identified four different types of case studies that combine the dimensions of number of cases and number of units of analysis, see Figure 2.3.

	Single-case design	Multiple-case design
Holistic (single unit of analysis)	TYPE 1	TYPE 3
Embedded (multiple units of analysis)	TYPE 2	TYPE 4

Figure 2.3. Different types of case studies (Yin 2007)

A single case study of Type 1 was conducted in order for the authors to take on a holistic view and to avoid a sub-optimized recommendation. According to Benbasat et al. (1987), single-case studies are appropriate for testing the applicability of existing theory. A single case study was suitable because of the purpose of this study. During the study, a performance measurement system was developed and applied through the guidance of existing theory. However, Eisenhardt (1989) argues that a weakness with single case studies is that no generalization of the results can be guaranteed as a very specific problem is investigated. This issue will be addressed in the discussion of potential future research.

2.4. Research process

The research process is presented in Figure 2.4. It describes the activities that were performed in order to answer the research questions and fulfill the purpose of this study.

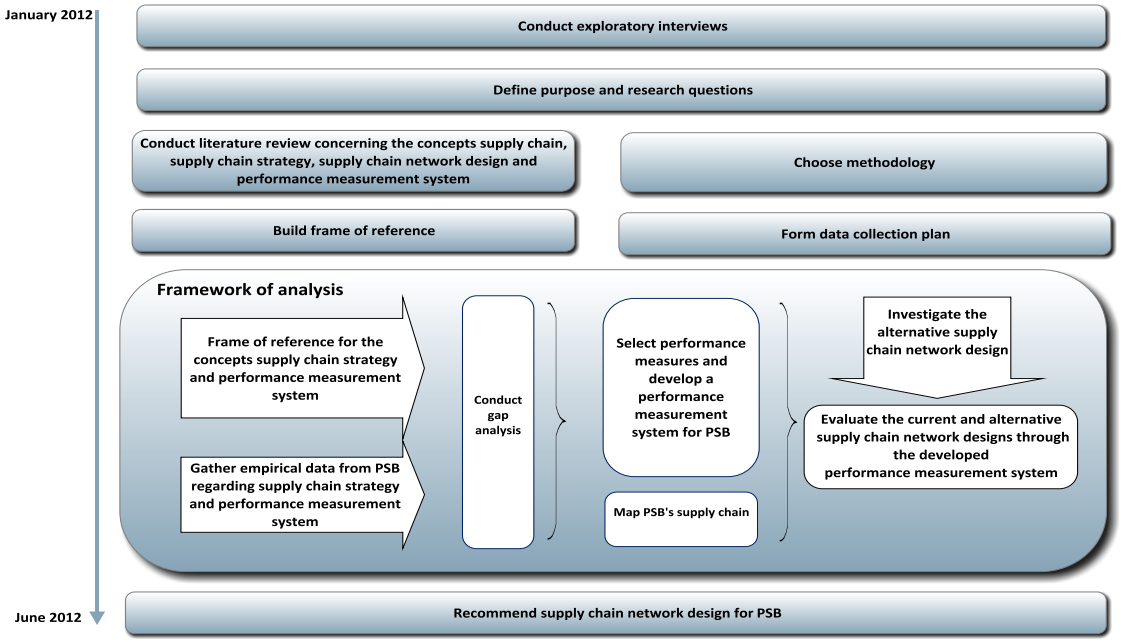

Figure 2.4. Research process for this study (own creation)

To narrow down the purpose and research questions for this study, exploratory interviews were held with employees at PSB. Relevant concepts that had to be studied in literature were identified from the purpose and research questions. A literature review was then conducted to create the frame of reference. In the literature review, the four concepts supply chain, supply chain strategy, supply chain network design and performance measurement system were defined to provide a foundation for the gathering of empirical data. Articles were found by searching in the databases Scopus, Summon and Web of Knowledge. Simultaneously, the methodological framework for this study was developed. The methods chosen provided a basis for the data collection plan. The frame of reference was compared to empirical data in a gap analysis. From the gap analysis, appropriate measures were identified and selected into the developed performance measurement system for PSB. The proposed measures were discussed with a manager and the two employees who were interviewed regarding the current performance measurement system to secure their suitability. After discussions, the measures were reviewed and the performance measurement system was finalized. In the next phase, the current and alternative supply chain network designs were analyzed to get an understanding of the components in the supply chain and how they are linked together. Finally, the current and potential supply chain network designs were evaluated with respect to the developed performance measurement system. This final step led up to a recommendation regarding PSB's supply chain network design.

2.5. Data collection

According to Yin (2007), there are three principles to apply when collecting data for a case study; the use of several reference points, creating a database for the case study and creating a reliable chain of proof.

2.5.1. The use of several reference points

Yin (2007) found that some studies only rely upon one single source of information for example due to the lack of other sources or internal resources. However, Yin (2007) argues that the strength in a case study is the possibility to use several sources of information and also several ways of gathering information to perform a stronger analysis. The use of multiple reference points is called triangulation.

Triangulation

There are four different kinds of triangulation. Patton (1987) describes them as seen in Table 2.4.

Table 2.4. Different types of triangulation (Patton, 1987)

Type of triangulation	Characteristics
Data triangulation	The use of several data sources
Investigator triangulation	Many investigators
Theory triangulation	Different theoretical perspective of the same data
Methodological triangulation	The use of several methods

According to Yin (2007) data triangulation and theory triangulation concern the use of several sources when gathering data. For empirical data, triangulation implies both the use of several different kinds of data and the use of several sources within the same type of data collection. Interviews and data from information systems are examples of different types of data whereas sources within the same type of data means for instance interviewing several people regarding the same issue. According to Thurmond (2004), investigator triangulation refers to many investigators being active in the same parts of the research to increase the possibilities of an unbiased study. Methodological triangulation can occur when both qualitative and quantitative methods are used but also when different types of methods are applied to the same study. According to Yin (2007) the purpose of triangulating is to analyze the same situation from different angles. For instance, if the researcher uses different reference points for different kinds of facts, his reference points are not considered to be triangulated. Triangulation of information is when the researcher uses several reference points for the same situation. Yin (2007) further argues that triangulation will strengthen the validity and reliability of the research. See Figure 2.5 and Figure 2.6 for illustrations of the two different approaches on the use of multiple reference points.

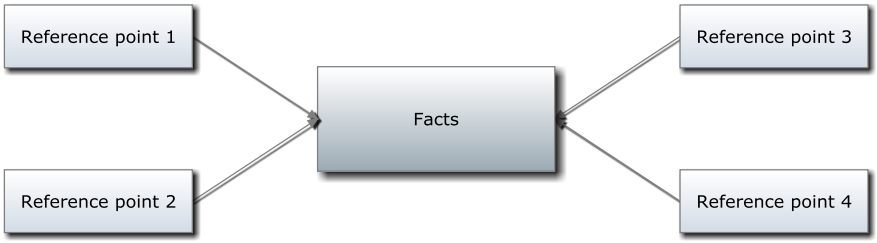

Figure 2.5. Triangulated reference points (Yin, 2007)

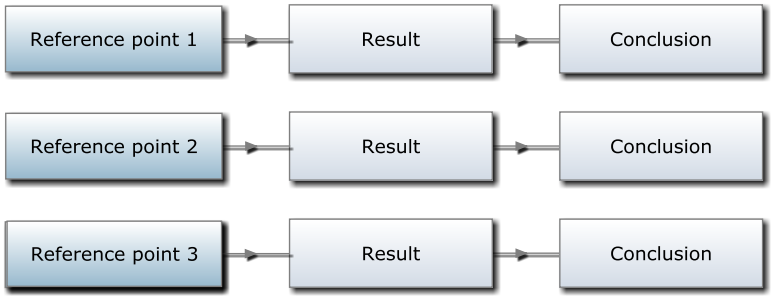

Figure 2.6. Risk of divergence in the conclusions when the reference points are not triangulated (Yin, 2007)

2.5.2. Creating a database for the case study

Yin (2007) discuss that the handling of the gathered information also is an important factor for the reliability and validity of the report. The information used in a report should be made accessible and understandable for an external part. Interviews should be recorded or written down, and saved in a database together with relevant documents and tables with quantitative data.

2.5.3. Creating a reliable chain of proof

This last principle aims at creating a solid chain of proof throughout the case study. It should be possible for an external party to follow all the decisions and steps taken throughout the entire study. This implies for example that a report should refer to the study's database in an adequate way and it should include the contextual factors regarding the study, for instance time and place for the interviews conducted. (Yin, 2007)

2.6. Data collection for this study

The data collection process for this study is displayed in Figure 2.7 and discussed in more detail below.

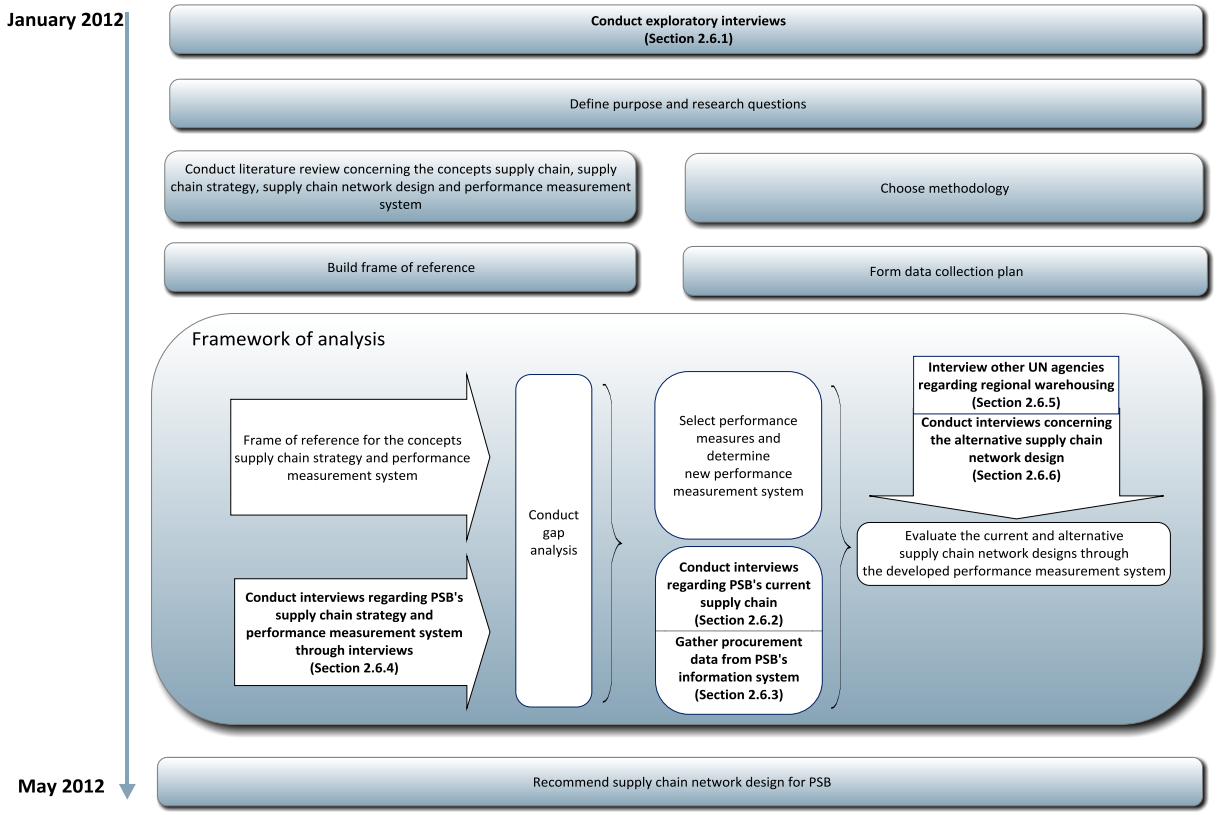

Figure 2.7. Data collection process for this study (own creation)

2.6.1. Exploratory interviews

Five exploratory interviews were held to get an understanding for PSB, its supply chain and where to direct the focus for this study. Two of the interviewees are in a managerial position at PSB and the remaining three were asked to participate because of their experience at PSB and their special knowledge within contraceptives and RH kits. The interviews were held in a semi-structured way to open up for reflections regarding the outline of this study, see Appendix 2 for interview guides. The information from the interview that was used for the study was confirmed by the interviewees.

2.6.2. Interviews regarding current supply chain network design

One of PSB's procurement specialists was interviewed to gather information in order to map the current supply chain. Two interviews were also conducted to determine the characteristics of contraceptives and RH kits. These interviews were held with two purchasers with special competence within their respective product type. A modified version of Lee's (2002) table for determining product characteristics was used as a complement to the procurement data.

The interviews for this section were held in a semi-structured manner, all interview guides can be found in Appendix 2. The information from the interview that was used for the study was confirmed by the interviewees.

2.6.3. Procurement data from PSB's information system

Information regarding the current and alternative supply chain network designs was retrieved from PSB's procurement data from 2010. The data from 2010 was used because PSB had not finished compiling the official data for 2011. However, 2010 was considered to be a representative year for PSB (Nielsen, 2012) and the data was therefore considered to be reliable for the analysis. The procurement data was analyzed by using Microsoft Excel®. If no other reference is cited, the information was extracted from this data. The procurement data from 2010 was also used to determine the expected performance of the alternative supply chain network design in order to be able to compare the performance of the two supply chain network designs. Contraceptives and RH kits were found to be representative product types for PSB and the current supply chain for these product types are therefore presented in this chapter. Each country of destination was assigned to its closest UNHRD warehouse in order to determine the distribution per region. The UNHRD in Brindisi is used to supply all parts of the world and not just the countries within its region but for the purpose of this study all countries have been dedicated to its closest regional warehouse, see Figure 2.8. See also Appendix 3 for a complete list of all regions and their respective countries.

Figure 2.8. The location of the UNHRDs and their respective areas

The countries that were assigned to a region were those that ordered items in 2010. The remaining countries have been categorized as Non Applicable (N/A). The regions are named Accra, Brindisi, Dubai, Panama and Subang after the cities where the UNHRDs are located.

2.6.4. Interviews regarding supply chain strategy and performance measurement system

An interview was held with the employee responsible for developing the current performance measurement system at PSB. The interviewee was chosen because of his specific insight on how measures are developed and used at PSB. The supply chain strategy was also used as part of the foundation for the development of the performance measurement system. In order to determine PSB's supply chain strategy, an interview was held with the Deputy Chief and one of the procurement specialists at PSB. They were interviewed because of their seniority within the organization and their high positions which implies that they have a good knowledge about the organization's strategy and goals. These interviews were held in a structured manner. See Appendix 2 for the interview guide. The information from the interview that was used for the study was confirmed by the interviewees.

2.6.5. Interviews with other UN agencies regarding regional warehousing

A comparative study was conducted with three UN agencies as part of the process for determining if PSB should start using regional warehouses. The three UN agencies were chosen for their experience of regional warehousing. The chosen UN agencies were the United Nations (International) Children's Fund (UNICEF), United Nations Office for Project Services (UNOPS) and WFP. WFP had two representatives where one was the coordinator of the UNHRDs. Structured interviews were held with employees at each organization to learn about their experiences, advantages and disadvantages of the setup with regional

warehouses. The interviewees were all active in the regional warehousing processes for their respective organization. See Appendix 2 for the interview guide.

2.6.6. Interviews concerning the supply chain network design alternatives for PSB

One additional structured interview was planned with the coordinator of the UNHRDs to gain more detailed knowledge of PSB's possibility of storing goods in the UNHRDs. See Appendix 2 for the interview guide. However, the authors were unable to get in touch with the coordinator. Therefore, the questions were sent to the responsible for the UNHRD in Dubai that answered the questions via e-mail.

2.7. Credibility in research

According to Höst et al. (2011), thought and planning is required to achieve credibility when conducting a research study. The credibility of a study can be broken down into three main areas; *reliability, validity* and *objectivity* (Höst et al., 2011). See Figure 2.9 for an illustration of the difference between validity and reliability.

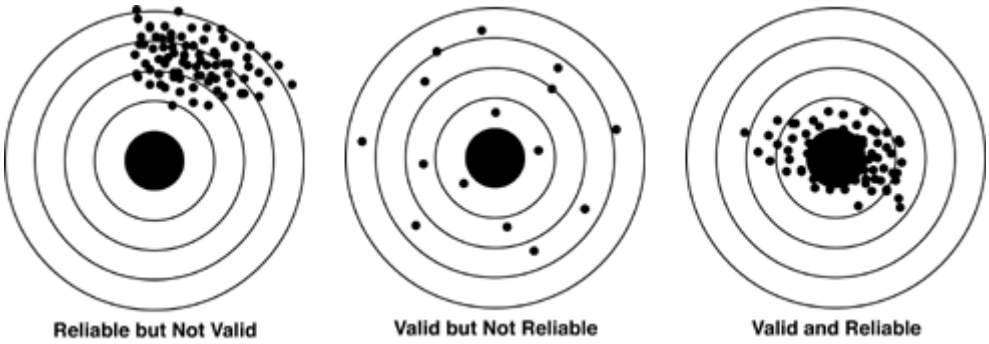

Figure 2.9. Illustration of reliability and validity (Björklund and Paulsson, 2003)

2.7.1. Reliability, validity and objectivity

Reliability can be described as the degree of accuracy in information that has been gathered and analyzed for the study. This can be achieved by careful planning and execution of the data collection. By thoroughly explaining the process, the reader can feel comfortable knowing that the results can be trusted (Höst, et al., 2011). According to Höst et al. (2011) validity concerns the connection between what the researcher is measuring and the studied object. Objectivity means the extent to which the results can be generalized. Of course, the objectivity depends upon the delimitations that are made. Höst et al. (2011) argue the objectivity is limited to the boundaries of the studied object.

2.7.2. Assessment of the validity, reliability and objectivity in this study

The reliability of this study has been ensured by using sources that either has been published in peer-reviewed journals or by a publisher for the literature study. The reliability of the empirical data has been secured by using several types of triangulation. Data triangulation has been applied by interviewing more than one person regarding the same topic while complementing with data from PSB's information system. Additionally, investigator

triangulation was used since the two authors have been present throughout the entire research process to discuss how information should be interpreted. The validity has been ensured by careful preparation of the interviews, quantitative data gathering and by continuously evaluating if the analysis and frame of reference is in line with the purpose and research questions. The choice of interviewees has also been evaluated to ensure that relevant people were chosen. The performance measurement system has been developed based on PSB's supply chain characteristics which imply that the objectivity is limited to the boundaries of the studied system. However, organizations with similar characteristics as PSB might find the system useful.

2.8. Methodology approach for this study

The methodological choices made for this study are highlighted in the Figure 2.10 below.

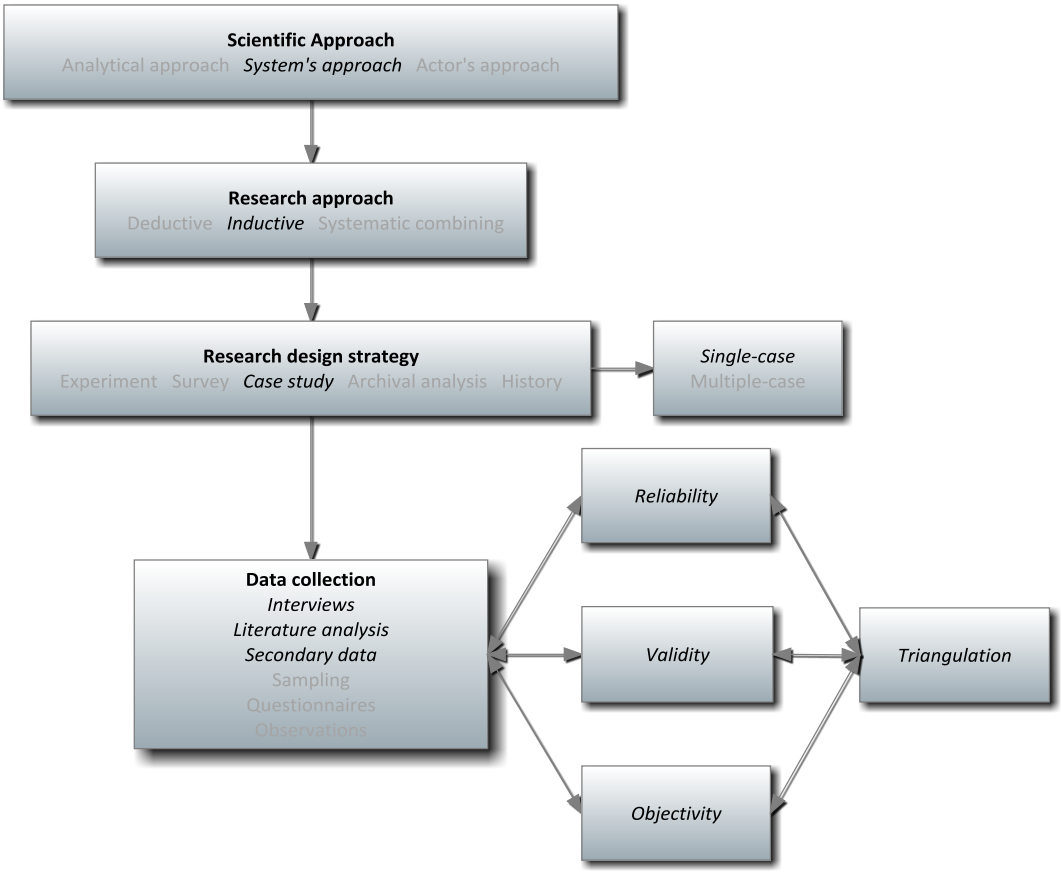

Figure 2.10. The methodological choices made for this study (own creation)

3. Frame of reference

The literature review describes the relevant concepts for this study; supply chain, supply chain strategy, performance measurement system and supply chain network design. See Figure 3.1 for the concepts and their connectivity. As a result of the frame of reference, a framework for analysis is developed.

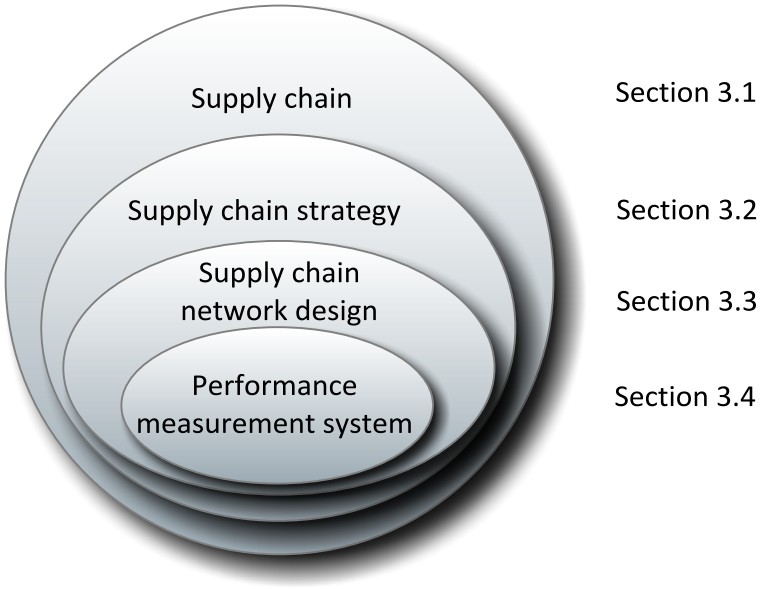

Figure 3.1. Relevant concepts for this study and their connectivity with the research questions (own creation)

3.1. Supply chain

Lambert and Cooper (2000), Metcalfe (2004) and Ambe and Badenhorst-Weiss (2011) argue that there has been a shift in the way business is made. In order to stay competitive, organizations now have to consider their supply chains and not just the organization itself. Assey Mbang (2012) presents a literature review with different definitions of supply chain. In the literature review, two categories of definitions were found; the first one focuses on the activities and characteristics connected to the material flow and the second category encompasses additional linkages other than the material flow, such as information and financial flow. See Table 3.1 for examples of definitions from both categories.

Table 3.1. Definitions of supply chain divided in the two categories identified by Assey Mbang (2012)

Definitions of supply chain	Source	Category
"a structured manufacturing process wherein raw materials are transformed into finished goods, then delivered to end customers"	Beamon (1998, p. 2)	Focus on material flow
"…the network of entities through which material flow. Those entities may include suppliers, carriers, manufacturing sites, distribution centers, retailers and customers"	Lummus, Krumwiede and Vokurka (2001, p. 427)	
"a set of entities (e.g. organizations or individuals) directly involved in the supply and distribution flows of goods, services, finances, and information from a source to a destination (customer)"	Mentzer et al. (2001, p. 4)	Extended definition including additional linkages such as information and financial flow
"…it facilitates the movement or flow of products, information and finances through a series of links from supplier to supplier, and on to the customer"	Metcalfe (2004, p. 55)	

For this study, the definition by Mentzer (2001, p.4) was chosen. Further, researchers found that the arrival of products on the right time and with the right quality has become crucial for maintaining an organization's competitiveness (Assey Mbang, 2012). Mentzer et al. (2001) emphasizes the importance of realizing that although supply chains exists regardless of the actions taken by the organization, it is how the organization chooses to manage them that can make the difference between a competitive and a non-competitive supply chain. To handle the many complex linkages and activities of a supply chain, a supply chain strategy is needed to guide the organization and thereby increase the supply chain's performance (Qi et al., 2009; Ambe and Badenhorst-Weiss, 2011).

3.2. Supply Chain Strategy

A supply chain strategy can be described as the way that an organization chooses to meet new challenges and opportunities in the supply chain (Lee, 2002). According to Harland et al. (2004), a first step in determining what kind of strategy to choose, the organization have to understand the supply chain and the actors that operate in it. A supply chain strategy should also be developed in line with the overall organizational strategy and it should fit to the product or service provided by the organization. Products can be divided into two categories depending on their characteristics. The two categories are defined as functional and

innovative products (Fisher, 1997). Lee (2002) presents the different characteristics for these two categories, see Table 3.2.

Table 3.2. Characteristics of functional and innovative products (freely from Lee (2002))

Characteristics of functional and innovative products	
Functional products	**Innovative products**
Low demand uncertainties	High demand uncertainties
More predictable demand	Difficult to forecast
Stable demand	Variable demand
Long product life	Short selling season
Low inventory costs	High inventory costs
Low profit margins	High profit margins
Low product variety	High product variety
Higher volume per SKU	Lower volume per SKU
Low stock-out costs	High stock-out costs
Low obsolescence	High obsolescence

Fischer (1997) argues that the functional and innovative products should have supply chain networks that are designed for their characteristics. He claims that a supply chain strategy can be divided into two categories; lean and agile strategies where a lean strategy aims at reducing costs and is suitable for functional products. Contrary, an agile strategy aims at reducing lead-times and requires a supply chain that is responsive to changes in demand. An agile strategy would be suitable for innovative products. The chosen strategy affects how the supply chain is operated. The goal of a lean strategy can be defined as having physically efficient processes while the goal of an agile strategy is to have market responsive processes. See Table 3.3 for the focus of these processes.

Table 3.3. Physically efficient versus market responsive supply chains (Fisher, 1997)

Physically efficient versus market responsive supply chains		
	Physically efficient process	**Market responsive process**
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand in order to minimize stock-outs, forced markdowns and obsolete inventory
Manufacturing focus	Maintain high average utilization rate	Deploy excess buffer capacity
Inventory strategy	Generate high turns and minimize inventory through the chain	Deploy significant buffer stock of parts or finished goods
Lead-time focus	Shorten lead-times as long as it does not increase cost	Invest aggressively in ways to reduce lead-time
Approach to choosing suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility and quality
Product-design strategy	Maximize performance and minimize cost	Use modular design in order to postpone product differentiation for as long as possible

However, the lean and agile strategies are not the only strategic options available (Lee, 2002; Qi, et al., 2009). These two strategies can be integrated into what is called a leagile strategy that aims at handling a volatile demand from the customers while trying to plan upstream in the supply chain and thereby reducing costs. Lo and Power (2010) found that organizations had several supply chain strategies which could support the existence and possibility of a leagile supply chain strategy. The organization's supply chain strategy is closely linked to decisions regarding the supply chain network design. The supply chain strategy is therefore important to consider when proposing changes to the supply chain (Ayers, 2006).

3.3. Supply Chain Network Design

Supply chain network design concerns questions regarding location of manufacturing, storage or transportation-related facilities and the allocation of capacity for each facility. The decision of where to locate a facility has a long-term impact on the performance of the supply chain as it is very expensive to relocate a facility or even shut it down. The facility location also sets constraints on how inventory, transportation and information can be used to reduce costs or improve responsiveness towards customers. An increased number of facilities could be desirable in order to reduce response time as seen in Figure 3.2. (Chopra and Meindl, 2001)

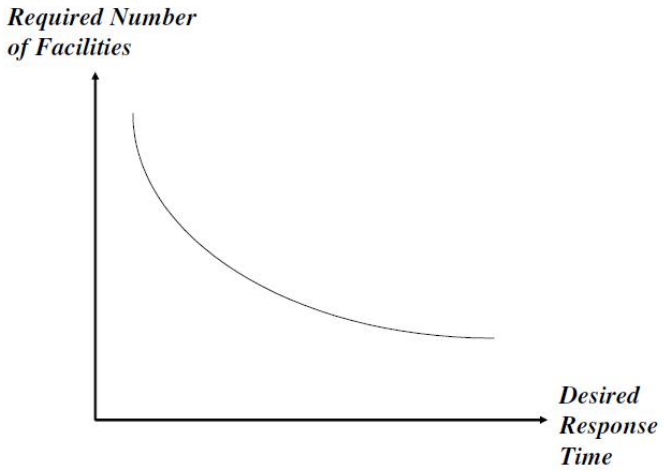

Figure 3.2. Relationship between desired response time and required number of facilities (Chopra and Meindl, 2001)

As the desired response time decreases, the number of facilities has to increase in order to get closer to the customers and thus be able to deliver faster and fulfill lead-time demands. According to Chopra and Meindl (2001), the main costs related to a supply chain network design are inventory-, transportation- and facility costs. See Figure 3.3 for the relationship between the different costs and number of facilities. (Chopra and Meindl, 2001)

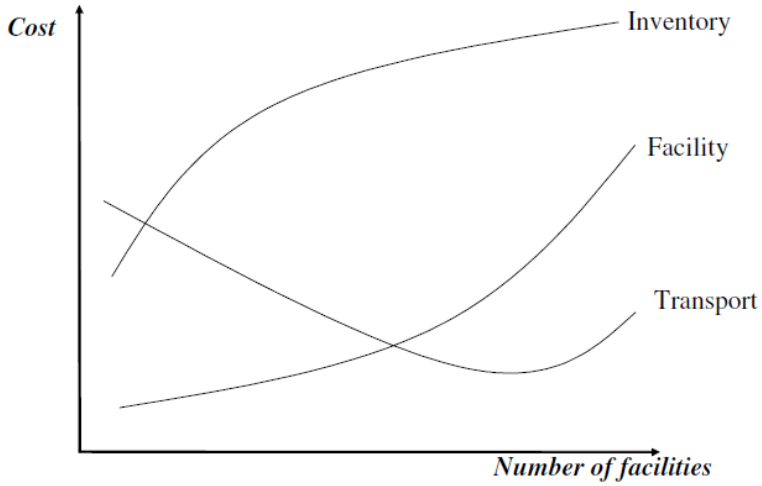

Figure 3.3. Relationship between number of facilities and logistics cost (Chopra and Meindl, 2001)

Inventory, and thus inventory costs, increases as the number of facilities increase. Transportation costs initially decrease with more facilities as the distance where an organization can use economically efficient full truckloads of goods increase. The distance where full truckloads can be used is the transportation from the suppliers to the facilities which is referred to as inbound logistics. The outbound logistics, usually characterized by smaller shipments, refers to the transportation between a facility and its customers. The distance for outbound logistics will be shortened due to the increased number of facilities, adding to the initial reduction in transportation costs. However, transportation costs

eventually increase with more facilities as the economics of scale are lost for the inbound transportation. Facility costs decrease with fewer facilities as an organization can take advantage of economies of scale when facilities are consolidated. Chopra and Meindl (2001) define the sum of inventory, transportation and facility cost as total logistics cost, see Figure 3.4 below.

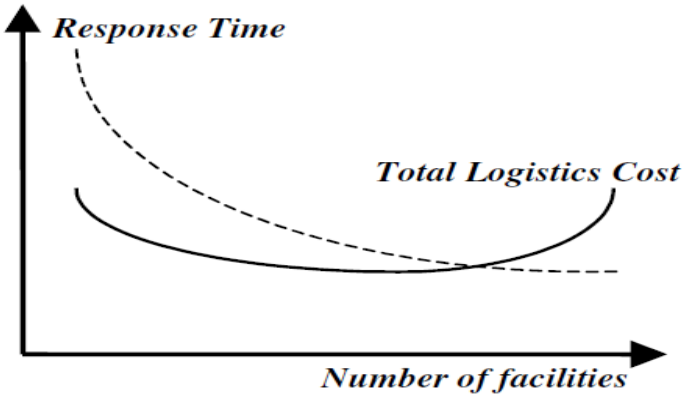

Figure 3.4. Variation in logistics cost and response time with number of facilities (Chopra and Meindl, 2001)

The logistics cost initially decreases as facilities increase. Every organization should have at least the number of facilities that minimize the total logistics cost. However, depending on the goals and objectives of the organization it might be desired to have more facilities in order to reduce the response time even if the total logistics cost increase. Different supply chain network designs are appropriate depending on the organization's supply chain strategy, the characteristics of the products and what requirements customers put on the organization (Chopra and Meindl, 2001)

3.3.1. Available supply chain network designs

Chopra and Meindl (2001) identify six different supply chain network designs with respect to the product and information flow; manufacturer storage with direct shipping, manufacturer storage with direct shipping and in-transit merge, distributor storage with package carrier delivery, distributor storage with last mile delivery, manufacturer/distributor storage with costumer pickup and retail storage with customer pickup.

Manufacturer storage with direct shipping

The retailer holds no inventory as all goods are stored at the manufacturer's facility. The retailer is only responsible for the information flow, such as handling orders and placing delivery requests to manufacturers. Products are shipped directly from manufacturer to customer as seen below in Figure 3.5.

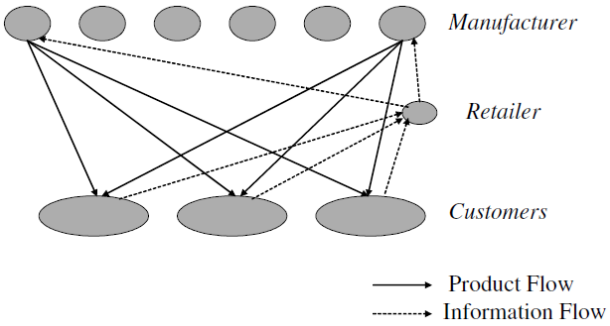

Figure 3.5. Manufacturer storage with direct shipping (Chopra and Meindl, 2001)

This supply chain network design is also referred to as drop-shipping. An advantage with drop-shipping is that inventory can be centralized and therefore the organization can maintain high availability towards customers with less inventory on-hand. The products that benefit most from a centralized inventory are characterized of high value as well as low and unpredictable demand. An issue with drop-shipping could occur if inventory at the manufacturer's facility is allocated to a specific retailer. Benefits of drop-shipping are only achieved if inventory is allocated on an as-need basis. Response time for drop-shipping is often longer as manufacturers are located further away from the customers and therefore shipping will take longer. Another issue is if the ordered products come from several manufacturers. The customer will then receive one shipment from each manufacturer and these shipments may vary in response time. (Chopra and Meindl, 2001)

Manufacturer storage with direct shipping and in-transit merge

This supply chain network design is very similar to "Manufacturer storage with direct shipment". The difference is that customers only receive one delivery even if sourcing has been made from several manufacturers as deliveries are consolidated at a carrier hub. See Figure 3.6 for an illustration of this supply chain network design.

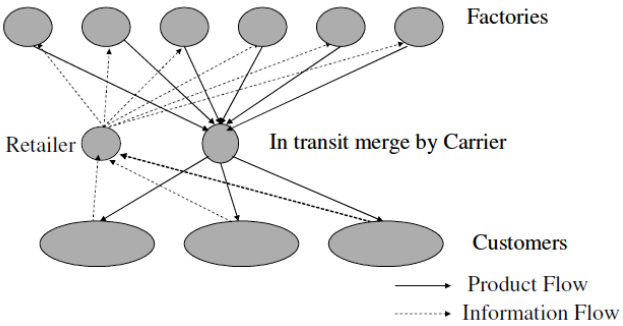

Figure 3.6. Manufacturer storage with direct shipping and in-transit merge (Chopra and Meindl, 2001)

This supply chain network design will improve the customer experience as receiving is easier for the customer. The transportation cost will also decrease as less outbound transportations are needed. The information infrastructure for this supply chain network design has to be well developed to synchronize the in-transit merge with all involved manufacturers. Response time is comparable to "Manufacturer storage with direct

shipment" but could be slightly longer due to the in-transit merge. (Chopra and Meindl, 2001)

Distributor storage with carrier delivery

Inventory is held at an intermediate warehouse owned by either the organization or a third party and transportation is carried out by a freight forwarder. See Figure 3.7 for an illustration of the supply chain network design.

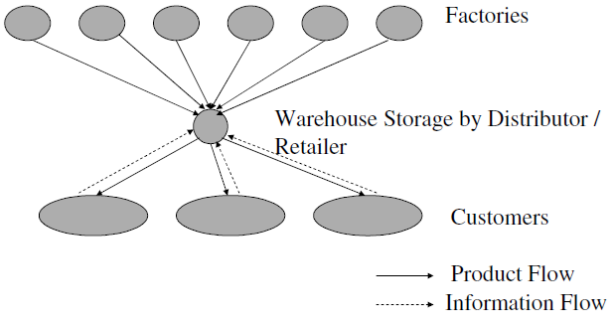

Figure 3.7. Distributor storage with package carrier delivery (Chopra and Meindl, 2001)

Distributor storage is effective for high-demand products. Transportation costs are lower for this supply chain network design compared to manufacturer storage since transportation is consolidated and full truckloads can be used for the transportation to the warehouse. The decrease in transportation cost will therefore be larger for high-demand products. Less complex information infrastructure is needed in this supply chain network design since the warehouse works as a buffer between the manufacturer and the customer, decreasing the need to synchronize these two. The response time in this supply chain network design will be better since the warehouse on average will be closer to the customer than the manufacturer. (Chopra and Meindl, 2001)

Distributor storage with last mile delivery

Last mile delivery means that the organization is responsible for the delivery to customer, as depicted below in Figure 3.8.

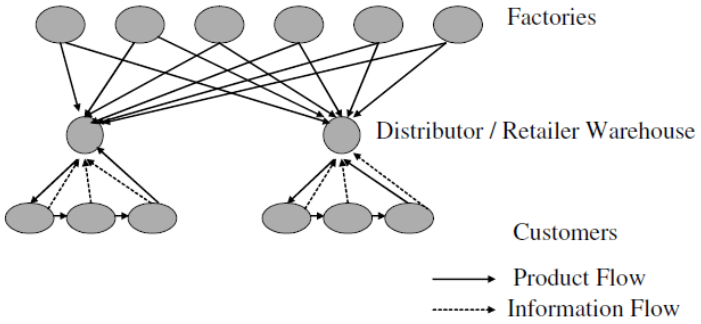

Figure 3.8. Distributor storage with last mile delivery (Chopra and Meindl, 2001)

This implies that the organization's warehouse has to be closer to the customer and therefore more warehouses are needed. Transportation costs for last mile delivery will be

the highest of all supply chain network design options due to the small shipments. Last mile delivery is not suitable in areas where labor costs are high. (Chopra and Meindl, 2001)

Manufacturer/distributor storage with customer pickup

In this approach, the customers place the order online or by phone and then collect the product at the pickup location as Figure 3.9 shows.

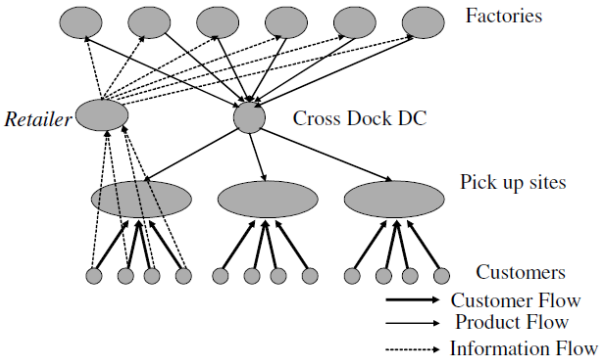

Figure 3.9. Manufacturer/distributor storage with costumer pickup (Chopra and Meindl, 2001)

Products are shipped as the orders are placed from a warehouse owned by the organization or a distributor. Transportation costs will be lower in this supply chain network design compared to any supply chain network design involving a freight forwarder since the customer is responsible for the otherwise costly outbound transportation. A good information infrastructure is needed to synchronize the coordination between the organization, the warehouse location and the pickup location. It is preferred to utilize existing facilities such as convenience stores as pickup locations. (Chopra and Meindl, 2001)

Retail storage with customer pickup

Inventory is stored locally at retail stores for this supply chain network design. A customer can therefore place an order with the retailer and get the product instantly if the product is available. Local storage has the highest inventory costs of all network supply chain network design options. The main disadvantage is the many facilities that are required in order reduce the distance the customer has to travel. (Chopra and Meindl, 2001)

Comparison between supply chain network designs

The six different supply chain network designs are ranked for a number of performance dimensions in Table 3.4 below. Table 3.5 displays how well different product and customer characteristics match the various supply chain network designs. (Chopra and Meindl, 2001)

Table 3.4. Comparative performance of delivery supply chain network designs (Chopra and Meindl, 2001)

Dimension	Retail storage with customer pickup	Manufacturer storage with direct shipping	Manufacturer storage with in-transit merge	Distributor storage with package carrier delivery	Distributor storage with last mile delivery	Manufacturer storage with pickup
Response time	1	4	4	3	2	4
Product variety	4	1	1	2	3	1
Product availability	4	1	1	2	3	1
Customer experience	5	4	3	2	1	5
Order visibility	1	5	4	3	2	6
Returnability	1	5	5	4	3	2
Inventory	4	1	1	2	3	1
Transportation	1	4	3	2	5	1
Facility and handling	6	1	2	3	4	5
Information	1	4	4	3	2	5

1: relatively best supply chain network design for the dimension – 6: relatively worst supply chain network design for the dimension

Table 3.5. Performance of delivery networks for different product/customer characteristics (Chopra and Meindl, 2001)

Characteristic	Retail storage with customer pickup	Manufacturer storage with direct shipping	Manufacturer storage with in-transit merge	Distributor storage with package carrier delivery	Distributor storage with last mile delivery	Manufacturer storage with pickup
High demand product	+2	-2	-1	0	+1	-1
Medium demand product	+1	-1	0	+1	0	0
Low demand product	-1	+1	0	+1	-1	+1
Very low demand product	-2	+2	+1	0	-2	+1
Many product sources	+1	-1	-1	+2	+1	0
High product value	-1	+2	+1	+1	0	-1
Quick desired response	+2	-2	-2	-1	+1	-2
High product variety	-1	+2	0	+1	0	+2
Low customer effort	-2	+1	+2	+2	+2	-1

+2: Very suitable; +1 Somewhat suitable; 0: Neutral; -1: Somewhat unsuitable; -2: Very unsuitable

According to Chopra and Meindl (2001), most organizations will include more than one supply chain network design. Only highly specialized organizations will use a single supply chain network design. Different supply chain network designs might be favorable depending on the characteristics of the products that an organization delivers and the demand of the organization's customers (Chopra and Meindl, 2001). To evaluate an organization's supply chain network design, models like the Balanced Scorecard and the Supply Chain Operations Reference model can be used (Stewart, 2001; Harmon, 2003).

3.3.2. Balanced Scorecard

The Balanced Scorecard (BSC) is a method for evaluating change within an organization and to find potential issues along with areas of improvement (Stewart, 2001). The BSC addresses four areas; the customer perspective, the financial perspective, learning and growth and the internal perspective (Kaplan and Norton, 1996; Stewart, 2001; Park and Huber, 2007; Hult, Ketchen, and Adams, 2008). See Figure 3.10 for an explanation of the four areas.

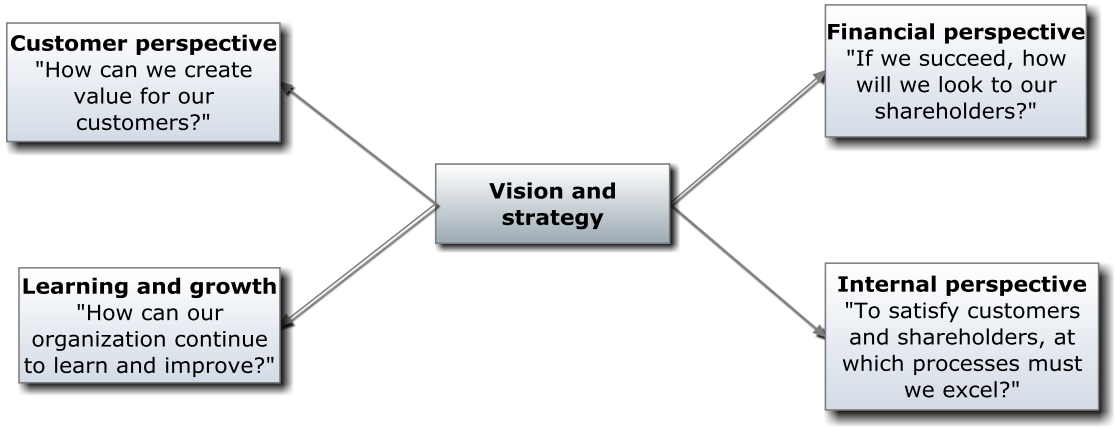

Figure 3.10. The Balanced Scorecard, based on (Kaplan and Norton, 1996)

The organization should choose the measures that reflect and will help the organization achieve its overall objectives (Stewart, 2001; Park and Huber, 2007). According to Stewart (2001), there is no one-size-fits-all. Each organization has to develop its own BSC and decide upon the level of details required for the measurements. Though in general, no more than 20 measures are desirable. In order for this method to succeed it is important that the organization sets up standards by which the performance will be measured and evaluated (Stewart, 2001). As the name states it is also important to have a balance, both between long-term and short-term objectives and between financial and non-financial measures (Park and Huber, 2007). Park and Huber (2007) argue that successful implementation depends upon the support from top management and their commitment to a successful implementation. During the implementation phase, communication, cooperation, continuous improvement and compliance are key aspects that need to be considered and continuously evaluated (Stewart, 2001). According to Park and Huber (2007), another important aspect to consider is time. BSC is a tedious process with an average implementation time of two years and it is therefore important to devote enough time for

the change to be implemented successfully (Park and Huber, 2007). The BSC is used in this study to ensure that not too many measures are used and that there is a balance between the categories of measures.

3.3.3. The Supply Chain Operations Reference model

The Supply Chain Operations Reference (SCOR) model is a framework for understanding, evaluating and redesigning the supply chain. It consists of six phases (Harmon, 2003):

Review corporate strategy
The organization needs to decide if the existing supply chain can be improved. If improvement possibilities are found, a project team will be set up.

Define the supply chain process
The supply chain is defined in terms of five subareas; Plan, Source, Make, Deliver and Return. These subareas can in turn be divided depending on the level of detail that is needed for the particular supply chain. In this phase, an As-Is geographical map is developed where the five subareas are mapped out. The scope of the mapping is also included in the definition of the supply chain processes. From the geographical map, a SCOR thread map can be created. The thread map describes the flow from the beginning to the end of the supply chain and the linkages between the processes.

Determine the performance of the existing supply chain
Historical data is used to determine the performance of the existing supply chain. As a complement, the historical data can be benchmarked against other companies with similar characteristics to see how the organization is performing compared to the rest of the industry.

Establish the supply chain strategy, goals and priorities
The supply chain strategy is revised to see if the supply chain needs to be changed and improved. If many improvement possibilities exist, the organization might have to prioritize and choose the one that will enhance the organization's performance the most.

Redesign the supply chain as needed
The supply chain is redesigned with the improvement alternatives in mind and a To-Be map is constructed. The To-Be map describes the supply chain as it is meant to be after the changes have been implemented.

Enable the redesign and implement
The last phase of the SCOR model is devoted to the implementation of the new supply chain. The implementation must be measured to ensure that the new supply chain meets the decided targets.

A modified version of the SCOR model is used to develop the framework of analysis. Phase six relates to implementation of a potential redesign. This is not part of the purpose of this

study and it is therefore not included in the analysis. For the remaining phases the underlying idea is used but not at the detailed level that is described in the SCOR model.

3.4. Performance measurement system

A performance measurement system is comprised of several performance measures that reflect how well the organization is performing (Gunasekaran and Kobu, 2007). Neely et al. (1995) present definitions of the concepts performance measurement, performance measure and performance measurement system, see Table 3.6.

Table 3.6. Definitions of performance measurement, performance measure and performance measurement system (Neely, et al., 1995, p. 3)

Concept	Definition
Performance measurement	*"…the process of quantifying the efficiency and effectiveness of action."*
Performance measure	*"…a metric used to quantify the efficiency and/or effectiveness of action."*
Performance measurement system	*"…the set of metrics used to quantify both the efficiency and effectiveness of actions."*

All three definitions from Table 3.6 include the concepts effectiveness and efficiency. Mentzer and Konrad (1991, p. 34) define efficiency as "*the extent to which goals are accomplished*". Effectiveness is defined as "*how well the resources expended are utilized*" (Mentzer and Konrad, 1991, p. 34). Neely et al. (1995) argues that performance measurement systems can be observed at three different levels; individual performance measures, designing a performance measurement system and the relationship with internal and external environments. The three levels and relevant considerations can be seen in Table 3.7.

Table 3.7. Key considerations for analyzing a performance measurement system (Neely, et al., 1995)

Level	Considerations
1. Individual performance measures	What performance measures are used?
	What are they used for?
	How much do they cost?
	What benefit do they provide?
2. Performance measurement system	Have all the appropriate elements been covered?
	Have measures which relate to the rate of improvement been introduced?
	Have measures which relate to long-term and short-term of objectives of the business been introduced?
	Have the measures been integrated, both vertically and horizontally?
	Do any of the measures conflict with one another?
3. Relationship with internal and external environments	Do the measures reinforce the firm's strategy?
	Do the measures match the organizational culture?
	Are they consistent with the recognition and reward structure?
	Do some measures focus on customer satisfaction?
	Do some measures focus on what the competition is doing?

The performance measurement system can be evaluated by answering the questions in Table 3.7 for each level to see the performance measurement system's completeness in terms of the organization's performance (Neely, et al., 1995). The first two levels for developing a performance measurement system will be discussed below. However, the third level will not be discussed further in this thesis because the studied system does not include the external environment. Therefore, the external environment will not be a part of the analysis for this study. The internal relationship concerning how the performance measurement system reinforces the organization's strategy will be discussed in the first two levels.

3.4.1. Individual performance measures

Various categorizations of performance measures can be found in literature. See Table 3.8 for a selection of these categorizations.

Table 3.8. Categories of performance measures in supply chains, based on (Gunasekaran and Kobu, 2007)

Categorization of performance measures	Source
Financial, internal process, innovation and improvement and customers	Kaplan and Norton (1997)
Resource, output and flexibility	Beamon (1999)
Time, quality, cost and flexibility	Neely et al. (1995)
Planning and product design, supplier, production, delivery and customer	Gunasekaran et al. (2001)
Strategic, tactic and operational	Gunasekaran and Kobu (2007)
Financial and non-financial	De Toni and Tonchia (2001)
Quantitative and non-quantitative	Gunasekaran et al. (2001)
Function based and value based	Bagchi (1996)

PSB emphasizes the importance of having short lead-times towards customers and being responsive to uncertainties in demand. However, the utilization of resources cannot be ignored. PSB's current measurement system does not include how well resources are utilized nor does it measure the flexibility of the organization. The categorization of performance measures presented by Beamon (1999) is used as a framework for the performance measurement system developed in this study in order to encompass all the categories that are important for PSB. Beamon (1999) sorts the measures in three categories; *resource, output* and *flexibility* and state that a performance measurement system should contain at least one measure from each category in order to be successful. The output is affected by how resources are utilized and the flexibility is in turn affected by the output. Resource measures are mostly related to costs and can reflect the efficiency of the supply chain. Output measures portrait how well the organization's mission and objectives are met. Kaplan (2001) argues that humanitarian organizations often measure the inputs of an operation, such as the sum of donations or hours dedicated to the operations, rather than the outputs. Flexibility measures are related to how well the system reacts to uncertainty (Beamon, 1999). A selection of performance measures was extracted from Shepard and Günter's (2006) literature review about performance measures and complemented by performance measures found in articles by Gunasekaran et al. (2004) and Beamon and Balcik (2008). Table 3.9 shows the performance measures divided in the three categories; resource, output and flexibility.

Table 3.9. Performance measures categorized in resource, output and flexibility (Gunasekaran, et al., 2004; Shepard and Günter, 2006; Beamon and Balcik, 2008)

Resources

Asset turns	Cost of goods sold	Delivery costs
Disposal costs	Economic order quantity	Incentive cost and subsides
Information carrying cost	Intangible cost	Inventory cost
Inventory days of supply	Inventory flow rate	Inventory investment
Inventory obsolescence	Inventory range	Inventory turnover ratio
Order entry methods	Order/setup costs	Overhead cost
Personnel costs per unit of volume moved	Return on investment	Sensitivity to long-term costs
Storage costs per unit of volume	Tied-up capital	Total cost of resources
Total logistics costs	Total supply chain management costs	Transport costs per unit of volume
Transportation costs	Use of new technology	Warehouse costs
Warranty/returns processing costs		

Output

Accuracy of forecasting techniques	Achievement of defect-free deliveries	Average backorder level
Average earliness of orders	Average item fill rate	Average lateness of orders
Cash-to-cash cycle time	Customer complaints	Customer query time
Customer response time	Customer satisfaction (or dissatisfaction)	Delivery efficiency
Delivery lead time	Delivery performance	Delivery reliability
Efficiency of purchase order cycle time	Frequency of delivery	Information accuracy
Information availability	Information timeliness	Inventory accuracy
Level of customer perceived value of product	Level of supplier's defect-free deliveries	Manufacturing lead time
Net profit vs. productivity ratio	Number of backorders	Number of items procured
Number of on-time deliveries	Number of stock-outs	Order fulfillment lead time
Order lead time	Perceived effectiveness of departmental relations	Percent of on-time deliveries
Percentage accuracy of delivery	Percentage of excess/lack of resource within a period	Percentage of late or wrong supplier delivery

Perfect order fulfillment	Product development cycle time	Product lateness
Product quality	Profit	Purchase order cycle time
Quality and frequency of exchange of logistics information between supplier and customer	Quality of delivered goods	Quality of delivery documentation
Share of transportation mode	Shipping errors	Stock-out probability
Supplier lead time against industry norm	Target fill rate achievement	Total amount of disaster supplies to each region
Delivery efficiency	Total supply chain cycle time	Target fill rate achievement
Total amount of each type delivered	Total cash flow time	Total supply chain cycle time
Total supply chain response time	Transport productivity	Variations against budget

Flexibility

Ability to respond to and accommodate demand variations, such as seasonality	Ability to respond to and accommodate new products, new markets, or new competitors	Ability to respond to and accommodate periods of poor delivery performance
Ability to respond to and accommodate periods of poor supplier performance	Capacity flexibility	Delivery flexibility
Expansion capability	Flexibility of service systems to meet particular customer needs	Increased customer satisfaction
Minimum response time	Mix flexibility	New product flexibility
Number of new products launched	Number of tasks worker can perform	Order flexibility
Production flexibility	Reduction in the number of late orders	Reduction in the number of lost sales
Reductions in the number of backorders	Responsiveness to urgent deliveries	Stock capacity
Time required to produce new product mix	Transport flexibility	Volume flexibility

3.4.2. Designing a performance measurement system

According to Parker (2000) and Gunasekaran, Patel and McGaughey (2004), the purpose of using performance measurement systems in organizations are; to identify success, identify customer satisfaction, map the organizations processes and create an understanding of the knowledge within the organization. Furthermore, a performance measurement system can identify improvement possibilities, guarantee that decisions are based on facts and data and to evaluate how implemented improvements have turned out. Maskell (1989) argues that a performance measurement system should be designed so it; correlates with the organization's strategy, includes both financial and nonfinancial measures, uses different measures depending on location, is easy to use the measures incorporated in the system and encourages further improvement.

In addition Beamon (1999) suggests four necessary characteristics for a performance measurement system; inclusiveness, universality, measurability and consistency. Inclusiveness means to measure all perspectives of the organization. Universality relates to the ability to compare measures between similar organizations. Measurability shows the possibility to measure the required data. Finally, consistency relates to measures being aligned with the organizations goals and strategy. Maskell (1989) and Beamon's (1999) guidelines are used as a complement to Neely's (1995) checklist in Table 3.7 to ensure the quality of the performance measurement system.

3.5. Framework of analysis

In section 3.1-3.4, relevant literature for this study has been presented. See Table 3.10 for an overview of the definitions and categorizations that will be used for this study.

Table 3.10. Definitions/categorizations that will be used for this study

Concept	Chosen definition/categorization	Source
Supply chain	*"a set of entities (e.g. organizations or individuals) directly involved in the supply and distribution flows of goods, services, finances, and information from a source to a destination (customer)"*	Mentzer (2001, p. 4)
Supply chain strategy	The way that an organization chooses to meet new challenges and opportunities in the supply chain	Freely from Lee (2002)
Effectiveness	*"How well the resources expended are utilized"*	Mentzer and Konrad, (1991, p. 34)
Efficiency	*"The extent to which goals are accomplished"*	Mentzer and Konrad, (1991, p. 34)
Performance measurement system	Output, resources and flexibility	Beamon (1999)

This section provides an overview for how the concepts discussed in the frame of reference connect to each other and how they have guided the researchers throughout the study, see Figure 3.11 below.

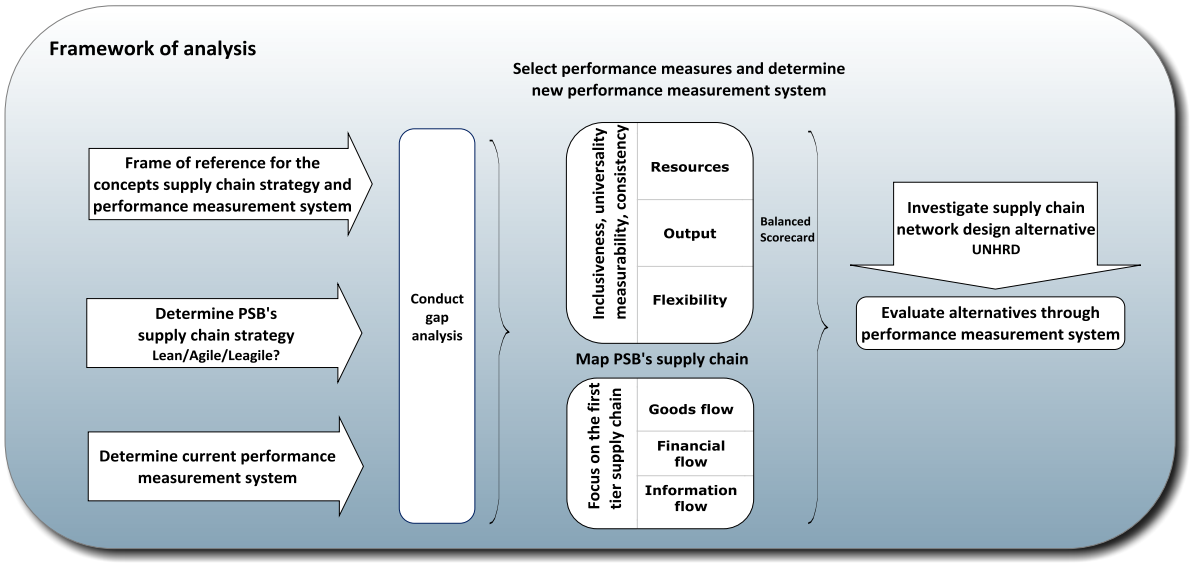

Figure 3.11. How the frame of reference connect to the framework of analysis (own creation)

A modified version of the phases in the SCOR model was used when forming the framework of analysis. First, a gap analysis was conducted between PSB's supply chain strategy, performance measurement system and the frame of reference for these concepts. Second, the gap analysis led up to a selection of new performance measures guided by Beamon's (1999) categorization; resources, output and flexibility. The inclusiveness, universality, measurability and consistency of the developed performance measurement system were evaluated. The concept of BSC, with limited number of measures and balance between the categories, was used when selecting performance measures according to Beamon's (1999) categorizations. Third, literature concerning supply chain was studied to find a common definition of the concept. The three aspects that are included in the chosen definition were used as a foundation for the mapping of PSB's first tier supply chain. Hence, PSB's supply chain was mapped with respect to its material-, information- and financial flow. Finally, the frame of reference for supply chain network design was used to determine the suitability of different supply chain network designs for PSB. Costs related to the alternative regarding regional warehousing were also investigated and compared.

4. Description of the current and alternative supply chain network designs

In this chapter, the current and alternative supply chain network designs as well as the current performance measurement system are described.

4.1. Current supply chain network design

The current supply chain, supply chain strategy and supply chain network design will be described in this section.

4.1.1. Supply chain

Figure 4.1 illustrates PSB's current supply chain for contraceptives and RH kits.

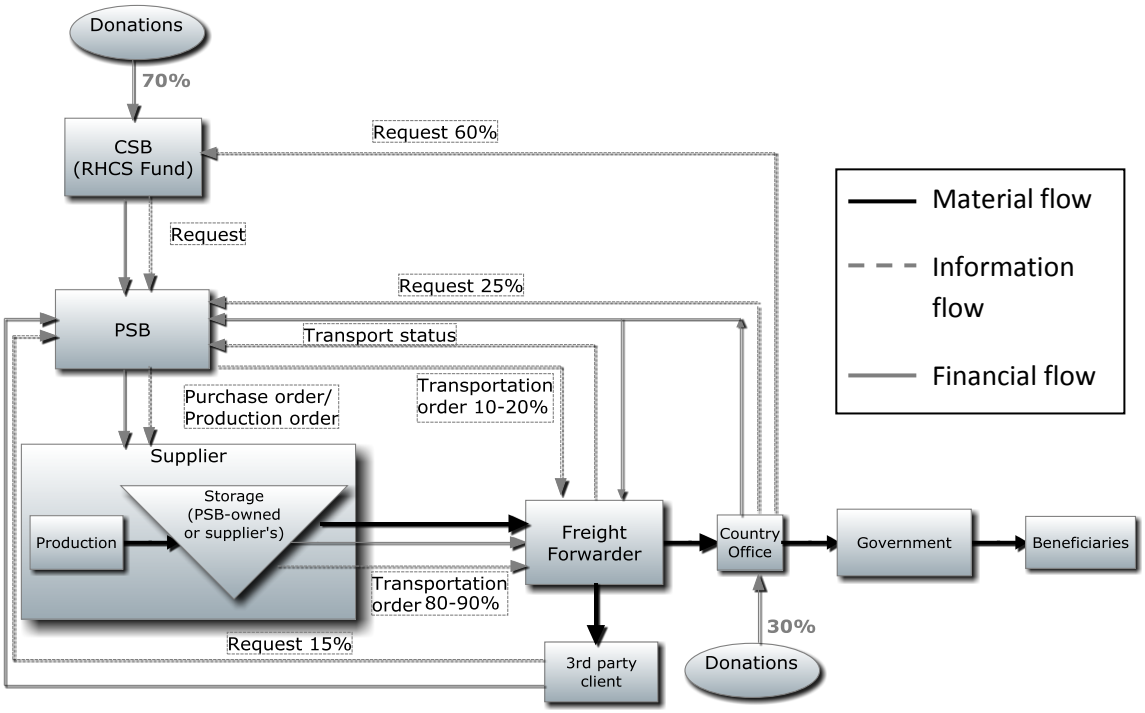

Figure 4.1. PSB's current supply chain for contraceptives and RH kits (developed together with Nordin (2012))

The supply chain for RH kits and contraceptives are designed in a similar way which is why it is possible to illustrate them in one figure. The COs receive approximately 70% of their donations from the UN through UNFPA's Commodity Services Branch (CSB) while the remaining 30% come from private donations that the countries gather themselves. Consequently, the COs place the majority (60%) of the requests to PSB through CSB whereas 25% are sent directly to PSB from the COs. Furthermore, 15% of the requests come from third-party clients. Regarding the transportation, PSB place 10-20% of the orders while 80-90% of the transportation orders are handled by the supplier. The supply chain is further described below with respect to the material-, information- and financial flow.

4.1.1.1. Material flow

Contraceptives and RH kits are either sent from the suppliers' storage or produced to order. For male condoms and RH kits, there is also a possibility for PSB to store products at the suppliers' premises free of charge (Nielsen, 2012). If the order cannot be taken from PSB's or the suppliers' stock, PSB has to account for a production lead-time of approximately 12 weeks for RH kits and 2-16 weeks for contraceptives depending on the product (Greifenstein, 2012). Before an order is sent, it has to be cleared by customs in the country of departure. The customs process takes approximately 1-2 weeks depending on the country. The orders are then sent to the customers by ocean or air freight (Sørensen, 2012b). Figure 4.2 shows a map of the suppliers' locations. The black pins represent the suppliers of contraceptives where PSB has storage, the grey pins represent the suppliers of contraceptives where PSB does not have storage and the white pins represent the suppliers of RH kits. The RH kits only have one color because PSB have storage at both of the suppliers.

Figure 4.2. Supplier locations

In 2010, PSB procured goods and services to a value of approximately USD 142 million distributed among 1562 POs. Of these USD 142 million, approximately USD 104 million (73%) constituted of contraceptives and RH kits, distributed among 760 separate POs (49%). Out of the USD 104 million, 97% was spent on contraceptives and 3% of the purchased value was represented by RH kits. See Table 4.1 for the distribution of the purchased value per region and Table 4.2 for the percentage of order lines per category and region. Furthermore, 88% of the POs were for contraceptives and 12% were for RH kits.

Table 4.1. Percentage of USD spent on contraceptives and RH kits per region, excluding the transportation cost

Percentage of USD spent on different contraceptives and RH kits per region, excluding the transportation cost (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Contraceptives	23.68%	0.28%	50.31%	17.27%	5.30%	**96.83%**
RH kits	0.55%	0.01%	1.48%	0.65%	0.47%	**3.17%**
Total	**24.23%**	**0.29%**	**51.80%**	**17.92%**	**5.77%**	**100.00%**

Table 4.2. Percentage of number of POs for contraceptives and RH kits

Percentage of number of POs for contraceptives and RH kits (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Contraceptives	25.39%	1.71%	32.11%	15.26%	13.16%	**87.63%**
RH kits	3.16%	0.66%	4.47%	2.50%	1.58%	**12.37%**
Total	**28.55%**	**2.37%**	**36.58%**	**17.76%**	**14.74%**	**100.00%**

As seen in Table 4.1, the Dubai region represented half of the purchased value for contraceptives and RH kits. However, the Dubai region only represented 37% of the POs. The Brindisi region had the lowest percentage of both the POs and value spent. Out of the total number of POs for contraceptives and RH kits in 2010, 12% were emergency orders and 88% were dedicated to development work for COs and third party clients. The reason why the emergency flow only represented 3% of the value spent, but 12% of the POs, was due to the small orders that were requested for emergency aid. See Appendix 4 for the distribution of emergency and development orders across the regions.

Contraceptives

The contraceptives procured by PSB include; combined low dose OC pills, progestagen-only pills emergency contraceptives, intra uterine devices, male and female condoms, subdermal implants and injectable contraceptives (Nielsen, 2012). 1% of the value spent on contraceptives was requested for emergency aid and 99% were for development work in 2010. See Table 4.3 for the distribution of the contraceptives with respect to number of order lines and value of purchased goods within the contraceptives category.

Table 4.4 shows the characteristics of the different products where high and low are defined as the relative perception of the situation based on the experience of PSB's demand planner. See also Appendix 4 for the distribution among the different products per region.

Table 4.3. Procurement statistics from 2010 for contraceptives

Procurement statistics from 2010 for contraceptives						
Contraceptive	**Number of order lines**	**Percentage of order lines (%)**	**Number of units purchased***		**Purchased value (USD)**	**Percentage of purchased value (%)**
Combined low dose OC pills	142	11.74%	37 515 400	$	11 640 000	11.54%
Progestagen-only pills	73	6.03%	9 892 600	$	4 080 000	4.05%
Emergency contraceptives	53	4.38%	1 734 000	$	440 000	0.44%
Intra uterine devices	133	10.99%	5 173 100	$	1 860 000	1.85%
Male condoms	268	22.15%	9 355 600	$	28 230 000	28.01%
Female condoms	91	7.52%	9 591 000	$	5 590 000	5.55%
Injectable contraceptives	357	29.50%	66 164 300	$	25 380 000	25.18%
Subdermal implants	93	7.69%	1 139 800	$	23 570 000	23.39%

***Male condoms are measured in gross where 1 gross = 144 male condoms**

Table 4.4. Product characteristics for contraceptives (Nielsen, 2012)

Product characteristics for contraceptives					
Contraceptive	Demand uncertainties (high/low)	Inventory costs (high/low)	Product variety (high/low)	Purchased volume per order (Pareto Principle) (number of items*)	Shelf-life (months)
Combined low dose OC pills	H	L	L	350 000	60
Progestagen-only pills	H	L	L	156 000	60
Emergency contraceptives	H	L	L	30 000	60
Intra uterine devices	H	L	L	35 000	84
Male condoms	H	L	L	60 000	60
Female condoms	H	L	L	135 000	60**
Injectable contraceptives	H	N/A	L	250 000	60
Subdermal implants	H	L	L	14 000	60

*Male condoms are measured in gross where 1 gross = 144 male condoms
**The current shelf-life for female condoms is 48 months but it will be increased to 60 months in October 2012 (Sørensen, 2012a)

Demand uncertainty - PSB is experiencing a high demand uncertainty for all contraceptives despite that the majority is ordered for development work. The demand is highly dependent of when donor funds are available to the COs and this can vary from year to year. The amount of donor funds is dependent of the global financial environment which creates further uncertainties. (Nielsen, 2012)

Inventory cost - The inventory cost was set to low for all contraceptives. Today, PSB only keeps inventory for male condoms and only at three suppliers. This storage is free of charge. The cost was however estimated for all products by considering their requirements in a warehouse. Due to that all contraceptives are light, small and do not have any special requirements for storage, the cost was considered low. An exception is the injectable contraceptives where the requirements are unknown. (Nielsen, 2012)

Product variety - The product variety is low for all contraceptives because only one type exists for each product. However, due to that some of the products are purchased from several suppliers, variations within the same type of product exist. (Nielsen, 2012)

Purchased volume - The purchased volume per order was calculated by using the Pareto principle, i.e. the 80/20 rule. This principle was used to understand the size of the majority of the orders. The Pareto principle is also used by PSB when determining how much stock to keep at the supplier premises for male condoms (Nielsen, 2012). The lowest 80% of the orders, with respect to volume, were determined by sorting the orders by quantity. 80% of the orders for each category have a volume lower or equal to the volume presented in Table 4.4.

Shelf-life - All contraceptives have a shelf-life of five years except for the intra uterine device category that has a shelf-life of seven years. PSB has a standard that 75% of this shelf-life has to remain at the time of shipping to the COs (Nielsen, 2012). The shelf-life requirement implies that the intra uterine devices can be stored for 1.75 years while the remaining contraceptives can be stored for a maximum of 1.25 years before they would become obsolete.

RH kits

PSB procures 17 different types of kits. In 2012, kit 6A and 6B were divided into two separate kits. However, in 2010 they were a combined kit and is therefore shown as one in this thesis. Currently there are only two suppliers, the main one in Holland and the second supplier in China. However, the supplier in China is new and was therefore not contracted in 2010 (Andries, 2012). 99% of the value spent on contraceptives was requested for emergency aid and only 1% for development work. See Table 4.5 for the distribution of the RH kits with respect to number of order lines and value of purchased goods and Appendix 4 for the quantities ordered per region for the each kit.

Table 4.5. Procurement statistics from 2011 for RH kits

Procurement statistics from 2011 for RH kits						
	Number of order lines	Percentage of order lines	Number of units purchased		Purchased value	Percentage of purchased value
RH kit 0	3	0.59%	8	$	1 000	0.03%
RH kit 1A	25	4.90%	253	$	146 000	4.44%
RH kit 1B	22	4.31%	170	$	95 000	2.88%
RH kit 2A	46	9.02%	2369	$	1 214 000	36.84%
RH kit 2B	29	5.69%	740	$	69 000	2.10%
RH kit 3	91	17.84%	1021	$	40 000	1.22%
RH kit 4	23	4.51%	233	$	9 000	0.28%
RH kit 5	39	7.65%	624	$	240 000	7.29%
RH kit 6A and 6B	50	9.80%	573	$	507 000	15.37%
RH kit 7	20	3.92%	195	$	26 000	0.79%
RH kit 8	27	5.29%	287	$	146 000	4.43%
RH kit 9	36	7.06%	260	$	98 000	2.97%
RH kit 10	21	4.12%	278	$	20 000	0.61%
RH kit 11A	30	5.88%	116	$	26 000	0.78%
RH kit 11B	28	5.49%	148	$	560 000	16.98%
RH kit 12	20	3.92%	90	$	98 000	2.98%

The characteristics of the RH kits are presented in Table 4.6. The table was compiled together with a PSB emergency procurement assistant who is responsible for RH kits.

Table 4.6. Product characteristics for RH kits (Andries, 2012)

Product characteristics for RH kits					
	Demand uncertainties (high/low)	Inventory costs (high/low)	Product variety (high/low)	Purchased volume per order by using the Pareto Principle (number of kits)	Shelf-life (months)
RH kit 0	H	L	L	3	N/A
RH kit 1A	H	H	L	13	60
RH kit 1B	H	L	L	10	60
RH kit 2A	H	H	L	50	36
RH kit 2B	H	L	L	27	36
RH kit 3	H	L	L	17	24
RH kit 4	H	L	L	6	36
RH kit 5	H	H	L	15	24
RH kit 6A and 6B	H	H	L	15	>16
RH kit 7	H	L	L	10	36
RH kit 8	H	H	L	10	24
RH kit 9	H	L	L	10	36
RH kit 10	H	L	L	20	N/A
RH kit 11A	H	L	L	7	>16
RH kit 11B	H	H	L	7	24
RH kit 12	H	H	L	5	12

Demand uncertainty - The demand uncertainty was considered to be high for all kits. The kits were originally developed as emergency kits but today, some COs buy them in advance (Andries, 2012). In 2010 more than 99% of the orders for kits were ordered as a response to an emergency, in 2011 this number had reduced to 90%. The majority of the kits are still procured as emergency aid and the demand uncertainty is therefore considered to be high (Andries, 2012).

Inventory cost – The storage of RH kits is currently free of charge but an estimated cost for storing each kit was calculated. The estimated inventory cost for RH kits was determined with respect to weight, volume and special requirements. Kits with a weight above 20kg and/or a volume of more than $0.1m^3$ were assumed to have a relatively high inventory cost due to handling and space requirements. Kits that require cold storage were automatically assumed to have a high inventory cost due to the special requirements of a cold storage.

Product variety - The product variety is low for all RH kits since only one type exists for each kit. Also, there are no variations between the two suppliers' products. (Andries, 2012)

Purchased volume - The purchased volume per order was calculated by using the Pareto principle in the same way as for contraceptives. 80% of the orders for each kit have a volume lower or equal to the volumes presented in Table 4.6.

Shelf-life - Kit number 0 and 10 have no expiration date as they contain training supplies and a vacuum extraction device. Kit 6A and 11A have a shelf-life that depends on the shelf-life of the resuscitation bags they contain. Kit 6B, 8, 11B and 12 requires cold storage. These kits all have a relatively shorter shelf-life compared to the other kits.

Transportation

The yearly combined transportation cost for contraceptives and RH kits was USD 7.4 million in 2010. See Table 4.7 for the percentage of transportation cost devoted to each region.

Table 4.7. Percentage of transportation costs between region, freight mode and product type in 2010

Percentage of USD for transportation of different product types and transportation modes						
Product type/ transportation mode	**Accra**	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Contraceptives	15.38%	0.77%	39.05%	16.36%	3.08%	**74.66%**
Air	4.23%	0.12%	11.14%	4.86%	1.81%	**22.16%**
Ocean	11.15%	0.65%	27.91%	11.50%	1.28%	**52.50%**
RH kits	4.56%	0.14%	13.99%	5.28%	1.38%	**25.34%**
Air	4.22%	0.14%	11.73%	5.28%	1.13%	**22.50%**
Ocean	0.34%	0.00%	2.26%	0.00%	0.24%	**2.84%**
Total	**19.95%**	**0.91%**	**53.04%**	**21.64%**	**4.46%**	**100.00%**

The transportation cost for RH kits made up 25% of the total transportation cost for RH kits and contraceptives whereas the USD spent on RH kits only made up 3%. The transportation cost for RH kits was proportionally higher compared to the USD spent because of the larger share of urgent orders that require air transportation. Among the regions, Dubai had by far the highest percentage of the transportation cost due to the large orders that were transported to the countries within this region. The distribution of the transportation cost for each category was also analyzed, see Table 4.8. The distributions were used to compare each category's potential saving in the alternative supply chain network design with regional warehouses.

Table 4.8. Percentage of transportation cost for each category and region

Percentage of transportation costs for each category and region						
Product category	**Accra**	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Combined low dose OC pills	0.73%	0.01%	2.17%	1.05%	0.71%	**4.66%**
Progestagen only pills	0.12%	0.00%	0.62%	0.00%	0.51%	**1.25%**
Emergency contraceptives	0.00%	0.00%	0.15%	0.11%	0.00%	**0.26%**
Intra uterine devices	0.14%	0.03%	0.80%	0.30%	0.06%	**1.33%**
Male condoms	4.74%	0.15%	13.87%	14.20%	0.47%	**33.43%**
Female condoms	0.32%	0.00%	0.76%	0.22%	0.03%	**1.33%**
Injectable contraceptives	12.71%	0.02%	13.34%	15.06%	3.71%	**44.85%**
Subdermal implants	0.08%	0.00%	1.12%	0.00%	0.01%	**1.22%**
RH kits	1.92%	0.01%	4.20%	4.18%	1.36%	**11.66%**
Total	**20.77%**	**0.23%**	**37.03%**	**35.11%**	**6.86%**	**100.00%**

In order to calculate the transportation cost per category, an estimated transportation cost had to be determined due to lack of specific transportation information for each order. The transportation cost was defined in two ways; the transportation cost per order and the transportation cost per USD spent. An assumption was made that the transportation cost depended on the distance traveled as well as the weight and volume of the goods. There was no possibility of extracting the cost per category and region directly from the order data because of the numerous orders that contained products from different categories.

The purchase orders that contained more than one type of product were counted as separate orders. The total percentage for each region differs from the actual totals due to the estimations and assumptions made for the calculation of the transportation cost seen in Table 4.7. The same assumptions were made for the transportation cost for both the current and alternative supply chain network designs. Therefore, the estimated transportation cost per category was still considered to be valid for a comparison between the products. The injectable contraceptives, male condoms and RH kits stood for the majority of the transportation cost. The reason why these categories represented the majority of the transportation cost is because of the high share of large orders for categories' in 2010. See Appendix 5 for a full description of how the transportation cost was calculated. A detailed table of the percentage of transportation cost for each kit is displayed in Appendix 4.

4.1.1.2. Information flow

The COs and third-party clients send requests to PSB and it is thereafter PSB that handles the contact with the supplier (Nordin, 2012). Recently a project has been launched that allows the COs to place the orders directly with the suppliers. However, this project has only involved a few of the COs (Dupont, 2012). PSB's procurement process is presented in Figure 4.3.

Figure 4.3. Purchase process at PSB (UNFPA, 2008)

If no agreement is in place for the products requested, PSB would have to go through all steps in the procurement process. However, if a Long Term Agreement (LTA) is in place with a supplier, the procurement process can be shortened and the purchaser can move directly to the step that concerns the actual purchase. In the case of a sudden-onset disaster, PSB can also disregard some of the steps in the ordering process. In this case, the cost of goods and transportation is of less importance than lead time, air transportation is therefore most often used. (UNFPA, 2008)

For the development work, the COs are encouraged to plan their need for the coming five years and also on an annual basis. The demand plans give PSB a chance to shorten the lead-times by ordering the products in advance. The demand plans are also used together with procurement statistics to estimate the size of the PSB-owned stock that they keep at the suppliers' premises. However, due to lack of, and inaccurate planning, it is difficult for PSB to estimate the yearly demand in advance. (Andries, 2012; Nielsen, 2012)

It is usually the supplier that orders the transportation although it is the COs that pay for it. PSB can choose to arrange the transportation independently or look at the possibility of utilizing one of the LTA's that exist in other UN agencies for transportation. PSB is responsible for the goods until it reaches the port in the receiving country where it will be taken care of by representatives for the COs or by the government of the receiving country. (Andries, 2012)

4.1.1.3. Financial flow

COs need to receive donations from the Commodity Service Branch (CSB) or private donors to be able to place a request. CSB gets donations from several donors (governments, the UN and private donors) that are distributed once a year according to an annual forecast. The private donations can be given to the country at any time during the year and is a reason why it is hard to predict when COs will place a request. The demand is therefore very dependent on the donations which makes it difficult for the COs and third-party clients to plan in advance. (Nordin, 2012)

4.1.2. Supply chain strategy

In the past, PSB has not had an official supply chain strategy. However, in 2012 a strategy has been developed (Nordin, 2012). The strategy consists of three pillars; implement an empowered and dynamic procurement and supply chain practice and to shift the procurement function from process oriented activities towards supply chain management. The third focus is to develop offerings to third party clients for procurement and related services. The third-party procurement concerns the share that PSB procures for other UN agencies and NGOs. PSB takes a 5% management fee for these services (Sørensen, 2012b). PSB would like to be a lean organization but primarily strives towards an agile supply chain that is responsive and offers short lead-times to their customers. Therefore, time is always prioritized over costs. PSB's missions and objectives also have a clear focus on time (Sørensen, 2012b).

4.1.3. Supply chain network design

PSB's current supply chain network design can be compared to what Chopra and Meindl (2001) define as "Manufacturer storage with direct shipping", also called drop-shipping. The products are stored at the retailers' premises and PSB only handles the ordering and delivery requests for its clients, in PSB's case COs and third-party clients. The products are then shipped directly to the clients without passing through PSB.

4.2. Alternative supply chain network design

The option of regional warehousing in the UNHRDs is described in this section. The first UNHRD was set up in Brindisi (Italy) in the year 2000. Since then, four more warehouses have been established in Accra (Ghana), Dubai City (United Arab Emirates), Panama City (Panama) and Subang (Malaysia). The UNHRDs all have strategic locations in terms of logistics capabilities and proximity to the beneficiaries. The network is a preparedness tool that helps UN-agencies and other humanitarian organizations to store different relief items. This gives them the opportunity to respond faster to emergencies across the world. The UNHRDs are operated by WFP. (UNHRD, 2012a)

All regional warehouses have at least 5000 m^2 of storage space with Dubai and Brindisi being the two largest ones. The UNHRDs offer receiving, storing, inspection and preparation for departure free of charge to its partners. All regional warehouses also have the capacity to provide cold storage which is free of charge. Customs processes are handled by the UNHRDs. Several of the regional warehouses are located in countries where customs processes are managed efficiently and it would therefore be easier to get products out faster. Other services such as kitting or ordering of transportation are also provided but the organizations would be charged for these services. In addition to the actual cost of the service, WFP adds a 7% management fee. (UNHRD, 2011b)

4.2.1. Supply chain

The alternative supply chain for contraceptives and RH kits is displayed in Figure 4.4.

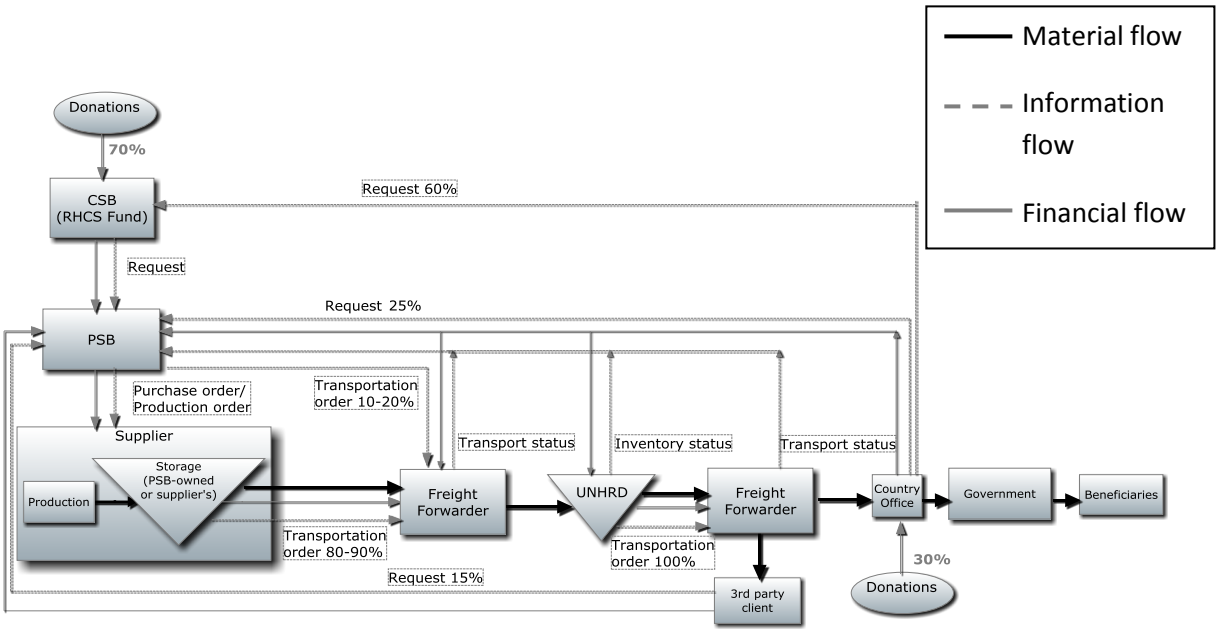

Figure 4.4. Supply chain for regional warehouses (own creation)

It was assumed that the donations and request would follow the same distribution as in the current supply chain. The transportation was assumed to be handled by the suppliers or PSB from their premises to the regional warehouses and it is assumed that the transportation from the regional warehouses would be handled by the UNHRDs.

4.2.1.1. Material flow

In the alternative supply chain, the contraceptives and RH kits would be sent from the suppliers to the regional warehouses. As for today's storage of male condoms at the suppliers' premises, the target fill rate is assumed to be 80% for all contraceptives. For RH kits, the targeted rate would be to fulfill close to 100% of the orders from the warehouses suppliers. It was also assumed that PSB would keep the possibility to store some of the goods at the suppliers' premises. This could for example be useful when delivering goods to COs or third-party clients that are situated closer to the supplier than to the regional warehouses. However, when calculating potential savings this option would not be considered.

4.2.1.2. Information flow

The difference from the current supply chain is that communication would be maintained with the regional warehouses as well as with the suppliers in the alternative supply chain. The suppliers would need to be informed of the new supply chain and directed in how to deliver goods to the regional warehouses. They would for example need to be informed of the standards regarding packaging and documentation that the UNHRDs require. It would still be PSB who places the orders at the suppliers and PSB would then notify the regional warehouse/warehouses of the incoming delivery. PSB would also notify the regional warehouses when a delivery is to be sent out to a CO or a third-party client.

It is assumed that the transportation from the suppliers' to the UNHRDs can be handled by either PSB or the suppliers as it is today. PSB might benefit from negotiating a long-term

agreement with a freight forwarder due to that there would only be five destinations. The transportation between the UNHRDs and the COs or third-party clients could be arranged by the UNHRDs. The UNHRD would then charge a 7% management fee in addition to the cost of the transportation.

4.2.1.3. Financial flow

The storage of goods is free of charge for humanitarian organizations within the UNHRDs. They would however charge PSB for the handling of transportation to the beneficiary countries which would create a financial flow between the UNHRDs and PSB.

4.2.2. Supply chain strategy

The current supply chain strategy for PSB has a focus on developing a dynamic supply chain. The organization's main focus is on reducing lead-times towards their customers and to develop their offers to third-party clients. These aspects are all in line with a supply chain that utilizes regional warehouses. The lead-times could be reduced and there would be an increased opportunity to offer products to third-party clients due to that many of these clients already have storage in the UNHRDs. Therefore, the alternative supply chain network design would not require PSB to switch focus; it would rather help enforce the existing strategy.

4.2.3. Supply chain network design

The alternative supply chain network design can be called "distributor storage with carrier delivery". Inventory is held at an intermediate warehouse owned by either the organization or a third party and transportation is carried out by a freight forwarder (Chopra and Meindl, 2001). In PSB's case, inventory would be held in a third-party warehouse but the goods would be owned by PSB. Furthermore, the COs could benefit from consolidated orders instead of getting one order from each supplier.

4.3. PSB's current performance measurement system

PSB developed their first performance measurement system in 2007 upon the initiative of one of their auditors. It was a requirement for the ISO9000-certification that PSB received in 2007. The performance measures were chosen to ensure that every procurement process could be tracked (Greifenstein, 2012). See Table 4.9 for the performance measurement system that was developed for PSB's ISO9000-certification.

Table 4.9. Performance measurement system developed for PSB's ISO9000-certificaiton (Greifenstein, 2012)

Performance measurement system developed for PSB's ISO9000-certification	
Performance measure	**Definition**
PSB overall delivery performance	Time between request approval and actual arrival date
PSB overall process performance	Time between request approval and PO closure date
PSB PO issuance performance	Time between request approval and date of PO creation
PSB PO closing performance	Time between PO payment date and PO closure date
Supplier shipping accuracy performance	Time between PO due date and actual departure date
Supplier production time performance per supplier	Time between PO dispatch date and actual departure date
Freight performance	Time between actual time of departure date and actual time of arrival

The PO issuance performance can be somewhat misleading due to that the buyers at PSB sometimes consolidates several requests into one PO. Therefore, this time can be long but the savings from consolidating the orders are not displayed. The PO closing performance measure can also be misleading due to that the orders have to be closed manually and it is therefore not always done in direct connection to the payment (Nordin, 2012). In 2011, a decision was made to add two new performance measures; delivery performance and customer satisfaction. See Table 4.10 for the definitions of these new performance measures. The new performance measurement system was designed to provide PSB's customers and donors with the primary information that they requested. It was developed with respect to the data that was available in PSB's information system (Greifenstein, 2012).

Table 4.10. Added performance measures to PSB's performance measurement system (Greifenstein, 2012)

Added performance measures to PSB's performance measurement system	
Performance measurement	**Definition**
Delivery performance	Time from requisition approval until time of arrival at the port (but before customs clearance)(upon request from customers)
Customer satisfaction	Through annual customer survey (upon request from donors)

The customer satisfaction level is measured through an annual customer survey that is sent out to the COs and the UNFPA HQ (Greifenstein, 2012). Currently, PSB is using their performance measurement system to determine lead-times and to evaluate the customer

satisfaction. Also, it has to some extent been used to evaluate the suppliers' performance (Greifenstein, 2012).

5. Redesigning PSB's performance measurement system

In this chapter, the current performance measurement system is reviewed. New performance measures are chosen in to a new performance measurement system.

5.1. Analysis of PSB's current performance measurement system

The three categories of measures chosen for this study are Beamon's (1999) resource, output and flexibility. As seen in Table 5.1 below, all of PSB's current performance measures belong to the output category.

Table 5.1. Categorization of current performance measurement system

Categorization of current performance measurement system			
Performance measure	**Resource**	**Output**	**Flexibility**
Delivery performance / PSB overall delivery performance		X	
PSB overall process performance		X	
PSB PO issuance performance		X	
PSB PO closing performance		X	
Supplier shipping accuracy performance		X	
Supplier production time performance per supplier		X	
Freight performance		X	
Customer satisfaction		X	

Because PSB only measures the output in their current performance measurement system it was decided that a new performance measurement system was needed for the evaluation of the current and alternative supply chain network designs.

5.2. Selection of performance measures

In this section, a performance measurement system was developed with the purpose of evaluating PSB's current and alternative supply chain network designs. As mentioned in the frame of reference, the performance measurement system was evaluated with respect to the first two levels presented by Neely et. al. (1995) which consist of the selection of individual performance measures and the development of a performance measurement system.

Individual performance measures

From the performance measures found in literature, a first selection of new measures was made. These measures are presented in Table 5.2.

Table 5.2. First selection of new performance measures for PSB

Resources		
Cost of goods sold	Economic order quantity	Information carrying cost
Inventory cost	Inventory obsolescence	Inventory turnover ratio
Order/setup cost	Return on investment	Sensitivity to long-term cost
Tied-up capital	Total logistics cost	Transportation cost
Warehouse cost		
Output		
Accuracy of forecasting techniques	Average backorder level	Average lateness/earliness of orders
Customer query time	Customer response time	Customer satisfaction (or dissatisfaction)
Delivery lead time	Delivery performance	Delivery reliability
Frequency of deliveries	Inventory accuracy	Number of stock-outs
Order lead time	Percent of on-time deliveries	Percentage of excess/lack of resources within a period
Percentage of late or wrong supplier deliveries	Profit	Purchase order cycle time
Sales	Share of transportation mode	Target fill rate achievement
Total amount delivered	Total amount of supplies to each region	Total supply chain response time
Flexibility		
Ability to respond to and accommodate demand variations, such as seasonality	Capacity flexibility	Delivery flexibility
Increased customer satisfaction	Minimum response time	Mix flexibility
Order flexibility	Reductions in the number of backorders	Reduction in the number of late orders
Responsiveness to urgent deliveries	Stock capacity	Volume flexibility

PSB's supply chain strategy was analyzed in order to determine this first selection of performance measures. It was found during interviews that PSB focuses on reducing the lead-times towards customer. Although PSB wishes to be a lean organization, an agile supply chain that is responsive towards the uncertainty in demand has a higher priority (Sørensen, 2012b). The measures in the first selection were chosen for their suitability with respect to PSB's strategy and their usefulness when evaluating a supply chain network design with regional warehouses. A balance between the measures with respect to the three categories of resource, output and flexibility was created and according to the recommendation by Maskell (1989), both financial and non-financial measures were selected. The performance measures from the first selection are all considered relevant for PSB. However, not all measures were chosen to represent the performance measurement system used to evaluate the supply chain network designs.

5.3. The development of a performance measurement system for PSB

The current performance measurement system is lacking in inclusiveness because it does not measure all aspects of the supply chain. Regarding the measurability, the current performance measures have been chosen with respect to the data available in PSB's information system and therefore the measurability is considered to be high. The performance measures are not PSB specific which means that the universality also can be considered as high. Finally, since the main objective for PSB is to reduce the lead-times, the performance measurement system can be considered as consistent since PSB does measure different lead-times in the system.

Table 5.3. Compliance of current performance measurement system with respect to Beamon's (1999) characteristics for successful performance measurement systems

Compliance of current performance measurement system with respect to Beamon's (1999) characteristics for successful performance measurement systems	
Characteristic	**Compliance of current performance measurement system**
Inclusiveness	Low
Universality	High
Measurability	High
Consistency	High

Out of the four characteristics required for a successful performance measurement system, inclusiveness is not fulfilled in PSB's current performance measurement system. The first selection of performance measures was evaluated with respect to all four characteristics. The measures were chosen for their suitability in evaluating the alternative of a supply chain network design with regional warehouses. The balanced scorecard principle was used to keep the number of measures below 20 and to ensure that both financial and non-financial measures were included. See Table 5.4 for the second selection of performance measures and Table 5.5 for the definitions of these measures. The definitions were developed by the authors after discussions with one of PSB's procurement specialists. During these

discussions, it was determined what aspects of the measures that would be useful for PSB to measure and what data that was available to make it possible to measure.

Table 5.4. Developed performance measurement system for evaluating PSB's supply chain network design

Developed performance measurement system for evaluating PSB's supply chain network design			
Performance measure	**Resource**	**Output**	**Flexibility**
Transportation cost (USD/order, transportation mode and region)	X		
Inventory cost (USD)	X		
Inventory turnover ratio (times/year)	X		
Inventory obsolescence (USD)	X		
Tied-up capital (USD)	X		
Customer Satisfaction (score out of maximum 5)*		X	
On-time delivery (average lateness) (days)		X	
Target fill rate achievement		X	
Freight Performance (days)*		X	
Share of transportation mode		X	
Volume flexibility			X
Responsiveness to urgent deliveries			X
Stock capacity			X
* implies that the measure already is a part of PSB's current performance measurement system			

Table 5.5. Definitions of the performance measures in the developed performance measurement system. The definitions were developed together with Nordin (2012).

Definitions of the performance measures in the developed performance measurement system		
Performance measure	**Definition**	**Source**
Transportation cost	Transportation cost per order, category and USD spent	PO data from PSB's information system
Inventory cost	Cost of keeping inventory, including warehouse and materials handling costs	Interviews with PSB and UNHRD employees
Inventory turnover	The number of times that the inventory is sold and replaced within a year	Interviews with PSB employees
Inventory obsolescence	Value of obsolete goods	Interviews with PSB employees
Tied-up capital	Value of the goods in stock	Interviews with PSB employees and PO data from PSB's information system
Customer satisfaction	Measure of the customers' perceived service, through annual customer survey	PSB's current performance measurement system
On-time delivery	Difference between actual time of arrival and estimated time of arrival	PSB's current performance measurement system
Target fill rate achievement	The number of orders that can be completed from inventory in relation to the target rate	Interviews with PSB employees and PO data from PSB's information system
Freight performance	Time between actual time of departure and actual time of arrival	PSB's current performance measurement system
Share of transportation mode	The share of ocean and air transportation	PO data from PSB's information system
Volume flexibility	Possibility to adapt to changes in volume	Interviews with PSB employees
Responsiveness to urgent deliveries	How fast a delivery can reach the recipient for emergency deliveries	Calculations based on suppliers', UNHRD's and customers' locations
Stock capacity	Possibility to increase the storage capacity when needed	Interviews with PSB and UNHRD employees

Neely et al. (1995) key considerations of how to analyze a performance measurement system was taken into account when developing the new system. None of the measures are in conflict with each other, the measures concern both the long-term and short-term objectives and the measures fully cover the focus area of this thesis. Data from PSB's

purchase order, interviews and PSB's current performance measurement system was used to quantify each performance measure. Apart from the discussions with the procurement specialist at PSB, the performance measurement system was also discussed with the Deputy Chief to determine the system's suitability for PSB. In the discussions with the Deputy Chief and the procurement specialist it was determined that the output measures were the most valuable measures for PSB. The output category was followed in priority by the flexibility measures since PSB finds it important to increase their responsiveness, especially in emergency situations (Nordin, 2012; Sørensen, 2012b).

6. Analysis of the current and alternative supply chain network designs

In this chapter, the performance of the two supply chain network designs is calculated and a comparative analysis is performed to determine which is more suitable for PSB.

6.1. Performance for current supply chain network design according to developed performance measurement system

Transportation cost

The transportation cost per order and the transportation cost per purchased value were calculated using the same assumptions as in section 4.1.1. See Table 6.1 and Table 6.2 for the result.

Table 6.1. Transportation cost per order for each category and region for the current supply chain

Transportation cost per order for each category and region in 2010 for the current supply chain network design (USD)						
Category	**Accra**	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total average**
Combined low dose OC pills	$ 2 157	$ 544	$ 4 992	$ 4 293	$ 4 018	**$ 3 862**
Progestagen only pills	$ 499	$ 77	$ 2 534	$ N/A	$ 7 516	**$ 2 196**
Emergency contraceptives	$ 57	$ 347	$ 922	$ 1 942	$ 46	**$ 814**
Intra uterine devices	$ 437	$ 992	$ 1 604	$ 1 559	$ 328	**$ 1 079**
Male condoms	$ 14 567	$ 2 276	$ 24 945	$ 47 584	$ 1 720	**$ 22 009**
Female condoms	$ 1 476	$ 210	$ 2 437	$ 1 779	$ 316	**$ 1 727**
Injectable contraceptives	$ 19 133	$ 682	$ 25 230	$ 34 716	$ 18 224	**$ 24 140**
Subdermal implants	$ 228	$ N/A	$ 2 846	$ 60	$ 121	**$ 1 287**
RH Kits	$ 5 434	$ 392	$ 8 845	$ 16 229	$ 9 097	**$ 9 248**
Total average	**$ 7 225**	**$ 1 113**	**$ 10 266**	**$ 21 051**	**$ 5 111**	**$ 10 314**

Table 6.2. Transportation cost per purchased value for each category and region in 2010

Share of transportation cost per purchased value of each category and region in 2010 for current supply chain network design (%)						
Category	**Accra**	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Combined low dose OC pills	1.86%	1.92%	3.85%	5.24%	10.38%	**3.80%**
Progestagen only pills	1.38%	1.40%	2.13%	N/A	7.68%	**2.81%**
Emergency contraceptives	1.31%	4.63%	3.52%	12.23%	1.96%	**4.80%**
Intra uterine devices	18.04%	16.82%	4.67%	18.97%	3.90%	**6.25%**
Male condoms	10.92%	6.27%	7.48%	12.54%	2.94%	**9.28%**
Female condoms	2.19%	8.74%	1.69%	12.02%	0.33%	**1.86%**
Injectable contraceptives	10.32%	6.50%	11.77%	24.48%	23.75%	**14.28%**
Subdermal implants	0.15%	N/A	0.55%	0.12%	0.20%	**0.45%**
RH Kits	24.66%	8.72%	20.02%	45.45%	22.46%	**26.45%**
Total	**7.03%**	**6.25%**	**5.47%**	**16.60%**	**9.77%**	**7.95%**

Transportation to countries in the Panama region was found to be high both per order and per purchased value relative to the other regions. The column "Total average" in Table 6.2 is the average for all purchase orders. Since the purchase orders are not evenly distributed between the regions the average for the regions "Total average" is not the same as the "Total average" for all the purchase orders.

Inventory cost

PSB is currently keeping inventory for male condoms and RH kits at the suppliers' premises. PSB wishes to supply all of the RH kits from stock and the smallest 80% of the orders for male condoms. The storage at the suppliers' is free of charge. For the remaining contraceptives, PSB does not own any inventory. (Andries, 2012; Nielsen, 2012)

Inventory turnover ratio

For RH kits, the turnover ratio was in average six times per year. See Appendix 6 for the turnover ratio for each kit. Regarding male condoms, the turnover ratio was found to be approximately three times per year (Nielsen, 2012).

Inventory obsolescence

The PSB-owned storage of male condoms has practically not had any obsolete items due to the relatively low level of inventory and long shelf-life that these products have (Nielsen, 2012). So far, there has been no obsolescence among RH kits either. However, some of the kits that are currently in storage are about to expire. PSB have not decided whether to replace the entire kits or merely the obsolete parts (Andries, 2012).

Tied-up capital

For RH kits, the tied-up capital was approximately USD 1.3 million (Andries, 2012). The tied-up capital for male condoms was approximately USD 2 million (Nielsen, 2012).

Customer satisfaction

In the customer satisfaction survey, 177 COs and HQ departments responded to the questionnaire. PSB got a rating of 4.44 out of 5 on the comment "*I am satisfied with the overall service provided"* and a score of 4.24 when taking the average of all other rated comments. The comment with the lowest score, 3.92, was "*Shipment(s) scheduled to be delivered in 2010 arrived on time according to PSB's schedule*". Most of the negative feedback provided by the respondents was concerning the delivery time, such as "*long delivery times*", "*delivery dates are not met*" and "*emergency shipments still take too long to arrive*" (UNFPA, 2012). See PSB performance in customer satisfaction according to current measurements in Appendix 6.

On-time delivery

For contraceptives, 40% of the orders were on time. For the remaining orders, 39% were late with an average of 17.4 days and 21% were early with an average of 5.9 days. Lead-times for RH kits were first measured in 2012 and data is therefore missing for this category.

Target fill rate achievement

Since male condoms are the only products that are currently kept in stock for contraceptives, it is used for this measure. The target fill rate for male condoms is 80% of the orders (Nielsen, 2012). The actual fill rate in 2010 was 60%. For RH kits, the target fill rate is 100% due to that they are requested in emergency aid situations where it is required that all emergency orders can be filled from stock (Andries, 2012). The actual fill rate was 91% in 2010. The 91% fill rate for RH kits is considered to be normal due to the extremely high inventory levels that would be needed to reach 100%. For the male condoms, it was assumed that part of the reason why PSB did not reach the target was the novelty of keeping inventory this way. By gaining more experience and get more statistics of trends and forecasts, it would be easier for the demand planners to reach the 80% fill rate.

Freight performance

In average, the transportation of contraceptives took 6.0 days for air and 39.7 days for ocean freight in 2010. See Table 6.3 for the freight performance of each region.

Table 6.3. Freight performance for contraceptives in 2010 for the current supply chain

Freight performance for contraceptives for the current supply chain network design (number of days)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total average**
Air	3.76	12.50	7.87	6.11	4.97	**5.95**
Ocean	52.60	37.00	33.67	38.84	23.41	**39.69**
Total average	**21.04**	**17.40**	**16.61**	**19.10**	**12.77**	**18.09**

Brindisi had a relatively long lead-time for the air freight compared to the other regions. This is because Brindisi only had three orders that measured freight performance. An explanation for the short lead-time for the ocean freight to the Subang region could be that this region is

close to many of the suppliers. Lead-times for RH kits were first measured in 2012 and data is therefore missing for this product type.

Share of transportation mode

The share of ocean and air transport was calculated with respect to the distance traveled. In 2010, the total share of air transport was 56% and the share of ocean was consequently 44%. See Table 6.4 for the share per region.

Table 6.4. Share of air and ocean transportation in 2010 for the current supply chain network design

Share of air and ocean transportation in 2010 for the current supply chain network design (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Air	54%	56%	53%	60%	61%	**56%**
Ocean	46%	44%	47%	40%	39%	**44%**

Volume flexibility

PSB expressed a wish to increase the number of suppliers to be able to respond to changes in volume. They currently have two or more suppliers for many of the items but as mentioned, they wish to further mitigate the risk of not being able to provide the requested products to their customers in a timely manner. (Nordin, 2012)

Responsiveness to urgent deliveries

The responsiveness to urgent deliveries for contraceptives and RH kits is represented by the availability of products in stock as well as the proximity to an airport since the emergency orders are delivered by air. It is assumed that once the plane is in the air, the time to any destination takes maximum one day and the distance to the receiving country is therefore not included as a factor for responsiveness. The time it takes to get to the airport and through the customs are however factors that should be taken into consideration. It was only RH kits and male condoms that were requested for emergency orders in 2010. The availability for RH kits is targeted to 100% and the availability for male condoms is targeted to 80%. Even though the male condoms only have 80% target fill rate, emergency orders would have first priority so the availability of products for emergency orders is considered very high. The suppliers of these items are located within 40 km of an airport so the distance to the airport should not affect the responsiveness. The customs procedures could however take several days to complete (Sørensen, 2012b) and this could therefore slow down the delivery process.

Stock capacity

For the RH kits, there is no agreement with the suppliers regarding how much PSB is allowed to keep in stock. It can therefore be assumed that there is high stock capacity at the suppliers (Andries, 2012). The stock capacity is also considered high for male condoms based on previous inventory levels and the fact that no restrictions have been given regarding the volume that PSB is allowed to store (Nielsen, 2012).

Summary of performance

The performance of the current supply chain according to the developed performance measurement system is seen Table 6.5 below.

Table 6.5. Summary of performance for current supply chain network design

Performance for current supply chain network design with respect to developed performance measurement system	
Performance measure	**Performance**
Transportation cost	$ 10 314 per order
Inventory cost	Free of charge
Inventory turnover ratio	6 times/year for RH kits and 3 times/year for male condoms
Inventory obsolescence	0%
Tied-up capital	$ 3 300 000 in average
Customer satisfaction	4.24/5.00
On-time delivery	40%
Target fill rate achievement	60% for male condoms and 91% for RH kits
Freight performance	6.0 days for air and 39.7 days for ocean
Share of transportation mode	56% air and 44% ocean
Volume flexibility	No issues
Responsiveness to urgent deliveries	Ok, but complex customs processes
Stock capacity	No known restrictions

6.2. Performance for alternative supply chain network design according to the developed performance measurement system

Transportation cost

A few assumptions had to be made in order to calculate the potential transportation cost for the alternative supply chain network design. First, it was assumed that the transportation between the suppliers and the regional warehouses would only require ocean transportation. The products would be ordered to stock in the warehouses and therefore the transportation lead-time would be of less importance. Second, it was assumed that the transportation between the regional warehouse and the country of destination would use the same mode of transport as the orders from 2010. Finally, an assumption was made that the number of orders targeted to be fulfilled from stock would be the same as today. Contraceptives were given the same target fill rate as male condoms have today. The target fill rate implies that the smallest 80% of the orders for contraceptives would be sent from a regional warehouse whereas close to 100% of the RH kits would be sent from the regional warehouses. The remaining products would be sent directly from the suppliers. The transportation cost for the alternative supply chain network design was calculated accordingly; first, the ocean- and air distances between each country of destination and its closest warehouse were calculated. The distances between each supplier and the regional warehouses were also calculated. The orders with destination of a land-locked country were assumed to be shipped to the closest port. The in-land transportation cost was not

accounted for in the calculations. Second, it was determined for each order whether they would be sent from the regional warehouses or directly from the suppliers. Third, the transportation equation described on page 55 was used to determine the estimated transportation cost per product and region. Finally, a 7% management fee for the UNHRDs was added to the transportation cost for the orders that were calculated to be taken from the regional warehouses. The management fee was calculated to USD 425 000. Table 6.6 shows the estimated cost per order for the regional warehouse alternative and Table 6.7 displays the share of transportation cost for the purchased value based on the estimated transportation cost.

Table 6.6. Transportation cost per order for the alternative supply chain network design

Transportation cost per order for the alternative supply chain network design (USD)																
		Accra		**Brindisi**		**Dubai**		**Panama**		**Subang**		**Total average**
Combined low dose OC pills	$	2 275	$	403	$	4 912	$	2 480	$	2 428	**$**	**3 266**
Progestagen only pills	$	546	$	57	$	2 575	$	N/A	$	7 369	**$**	**2 216**
Emergency contraceptives	$	22	$	347	$	927	$	1 596	$	53	**$**	**755**
Intra uterine devices	$	181	$	332	$	1 574	$	735	$	315	**$**	**856**
Male condoms	$	14 964	$	2 821	$	26 213	$	48 077	$	1 596	**$**	**22 657**
Female condoms	$	1 288	$	40	$	2 218	$	603	$	325	**$**	**1 398**
Injectable contraceptives	$	15 660	$	407	$	24 176	$	26 891	$	16 074	**$**	**20 530**
Subdermal implants	$	121	$	N/A	$	2 802	$	19	$	54	**$**	**1 216**
RH kits	$	2 260	$	403	$	7 214	$	5 832	$	7 017	**$**	**5 377**
Total average	**$**	**6 039**	**$**	**1 149**	**$**	**10 057**	**$**	**17 039**	**$**	**4 307**	**$**	**9 084**

Table 6.7. Share of transportation cost per purchased value for the alternative supply chain network design

Share of transportation cost per purchased value for the supply chain network design (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	1.96%	1.43%	3.79%	3.03%	6.27%	**3.21%**
Progestagen only pills	1.51%	1.04%	2.17%	N/A	7.53%	**2.83%**
Emergency contraceptives	0.52%	4.63%	3.54%	10.05%	2.26%	**4.45%**
Intra uterine devices	7.46%	5.64%	4.59%	8.94%	3.74%	**4.96%**
Male condoms	11.21%	7.77%	7.86%	12.67%	2.73%	**9.55%**
Female condoms	1.91%	1.68%	1.54%	4.07%	0.34%	**1.51%**
Injectable contraceptives	8.45%	3.87%	11.28%	18.96%	20.95%	**12.15%**
Subdermal implants	0.08%	N/A	0.54%	0.04%	0.09%	**0.42%**
RH kits	10.26%	8.97%	16.33%	16.33%	17.32%	**15.38%**
Total	**5.88%**	**6.45%**	**5.36%**	**13.44%**	**8.23%**	**7.00%**

Similar to the current supply chain network design, the alternative supply chain network design would have the highest percentage of transportation cost per purchased value and highest transportation cost per order for the orders going to the Panama region due to the long distances from the suppliers to this region.

Inventory cost

The storage and handling of the goods at the UNHRDs would be free of charge according to the technical agreement that PSB has signed. There are currently four RH kits that contain items that need cold storage. The cold storage is also free of charge so this would not imply any extra costs. The keep-cool items would are assumed to be sent separately as in the current supply chain and therefore no kitting service would be needed. In total, the inventory cost would thereby be free of charge, regardless of the chosen inventory levels.

Inventory turnover ratio

The inventory turnover in the alternative supply chain network design was calculated to USD 26.6 million per year. See Appendix 7 for the turnover per category and year. It was assumed that the inventory turnover ratio would be kept at the same level for RH kits and contraceptives, i.e. six times per year for RH kits and three times per year for male condoms. The remaining contraceptives were assumed to have the same inventory turnover ratio as male condoms. This assumption was motivated by the equal or longer shelf-life of male condoms and the remaining contraceptives.

Inventory obsolescence

There would be a greater risk for obsolete products in the alternative supply chain network design due to that the inventory is spread out between five regional warehouses instead of gathered at the suppliers' premises. The risk is still considered to be low for contraceptives that have a shelf-life of five years or longer. 75% of the shelf-life has to remain at the point of transportation to the country (Nielsen, 2012) which implies that the contraceptives could be stored for a minimum of 1.25 years. The turnover ratio was assumed to remain the same

and therefore the risk of not getting the products out on time is considered low. The RH kits generally have lower shelf-lives, some as low as 12 months. These kits could only be stored for 2.4 months and with a turnover ratio of six times per year it would leave a margin of less than two weeks before these kits become obsolete.

Tied-up capital

Tied-up capital in inventory would be based upon the current target fill rates for male condoms and RH kits. In order for male condoms to reach their target fill rate, their tied-up capital would have to be increased to USD 3 million. However, the remaining contraceptives would also be held in storage. The assumption was made that the target fill rate should be the same for these categories as for male condoms; that the smallest 80 % of the orders should be filled from inventory. The inventory turnover ratio was also assumed to remain the same as for the current supply chain network design for male condoms and RH kits. The inventory turnover ratio for the remaining contraceptives was considered to be the same as for male condoms due to that they have the same shelf-life and demand situation. This would give a total amount of tied-up capital of USD 9.6 million. All contraceptives were considered to reach their target fill rate and RH kits were assumed to have the same target fill rate as for 2010.

Customer satisfaction

The customer satisfaction survey for 2010 showed that it was the timeliness of the deliveries that was lowering the average score of the overall customer satisfaction. By storing the products in regional warehouses, they would be closer to the customer and a shorter delivery time could therefore be possible to achieve which would increase the customer satisfaction.

On-time delivery

By storing the products in regional warehouses, they would be closer to the customer and a shorter delivery time from order placement to delivery should therefore be possible to achieve provided that PSB reach the target fill rates. Being closer to the customer would reduce the risk of delayed deliveries. Another reason why on-time deliveries could improve is because the uncertainty in time of customs clearance will be lowered because of the facilitated customs processes at the UNHRDs.

Target fill rate achievement

An assumption was made that the target fill rate of the smallest 80% of the orders would be suitable for the contraceptives that do not have storage today because they have the same shelf-life (or longer) and demand situation as male condoms. It was assumed that the same learning curve would apply to this supply chain network design as for the current one. All contraceptives should therefore be able to reach their targets. It could be difficult to reach the target fill rate of 100% for the RH kits due to the low inventory levels that would be required in the warehouses to minimize the number of obsolete products. A solution to this

could be to increase the inventory levels and budget for the cost of an increased number of obsolete products. Another way of increasing the target fill rate achievement would be to only utilize one or two of the regional warehouses. By doing so, higher inventory levels could be held at one warehouse and therefore it is more likely to reach the target fill rates. However, the savings in transportation cost would be reduced and the average delivery lead-times would increase due to the increased distances to some of the countries.

Freight performance

The freight performance in the alternative supply chain network design was determined to be the time to deliver the goods from the regional warehouse or from the suppliers to the customers. For the orders that would be fulfilled from the regional warehouses this would imply a shorter distance to the country of destination. All the UNHRDs are located close to airports and ports which would eliminate the in-land transport. See Table 6.8 for the estimated freight performance for contraceptives in the supply chain network design with regional warehouses. Contraceptives and RH kits are separated to be able to compare the freight performance for the current supply chain network design. In the current supply chain network design the freight performance is only measured for contraceptives. See Table 6.9 for the freight performance for RH kits.

Table 6.8. Freight performance for contraceptives in the alternative supply chain network design

Freight performance for contraceptives in the alternative supply chain network design (number of days)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total average**
Air	0.93	0.94	0.90	0.86	0.97	**0.91**
Ocean	5.72	1.56	8.57	8.02	3.97	**6.87**
Total average	**2.77**	**1.28**	**4.05**	**3.67**	**2.24**	**3.32**

Table 6.9. Freight performance for RH kits in alternative supply chain network design

Freight performance for RH kits in alternative supply chain network design (number of days)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total average**
Air	0.92	1.00	1.00	0.96	1.00	**0.96**
Ocean	1.93	N/A	4.21	N/A	4.71	**3.83**
Total average	**0.98**	**1.00**	**1.50**	**0.96**	**1.85**	**1.24**

The freight performance was calculated by dividing the actual freight performance for the current supply chain by the theoretical new freight performance. The theoretical freight performance was extracted from www.world-airport-codes.com and www.sea-distances.com. The fraction of the actual and theoretical freight performance was decided to represent the average delay of the actual transports that PSB ordered in 2010. The estimated new freight performance was calculated by multiplying the fraction with the theoretical freight performance for the supply chain with regional warehouses.

Share of transportation mode

The share of ocean and air transport was calculated with respect to the estimated distance traveled. In a supply chain with regional warehouses, the total share of air transport would be 11% and the share of ocean would consequently be 89%. See Table 6.10 for the share per region.

Table 6.10. Estimated share of air and ocean transportation for alternative supply chain network design

Estimated share of air and ocean transportation in alternative supply chain network design (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Average
Air	6%	7%	16%	7%	13%	**11%**
Ocean	94%	93%	84%	93%	87%	**89%**

Volume flexibility

The supplier base would not change due to a change towards regional warehouses and the volume flexibility would therefore remain the same as for the current supply chain.

Responsiveness to urgent deliveries

The UNHRDs are situated in strategic places that are close to disaster prone areas. Therefore, the responsiveness to urgent deliveries would increase as the lead-times to customers would be reduced.

Stock capacity

Due to the size of the UNHRDs, they were considered to have more or the same total capacity flexibility as a warehouse at the suppliers' premises. One factor affecting the stock capacity of the UNHRDs is that other organizations are storing products in the UNHRDs as well. However, it was assumed that the suppliers not only keep storage for PSB but also for themselves and perhaps for other organizations. Therefore, the stock capacity was considered to be equal between the UNHRDs and the suppliers.

Summary of performance

The performance of the supply chain with regional warehouses according to the developed performance measurement system is seen Table 6.11 below.

Table 6.11. Summary of performance for alternative supply chain network design

Summary of performance for alternative supply chain network design	
Performance measure	**Performance**
Transportation cost	$ 9 084 per order
Inventory cost	Free of charge
Inventory turnover ratio	6 times/year for RH kits and 3 times/year for contraceptives
Inventory obsolescence	Greater risk than in current supply chain
Tied-up capital	$ 9 600 000 in average
Customer satisfaction	Higher than in current supply chain
On-time delivery	Higher than in current supply chain
Target fill rate achievement	80% for male condoms and close to 100% for RH kits
Freight performance (for contraceptives)	0.9 days for air and 6.9 days for ocean
Share of transportation mode	11% air and 89% ocean
Volume flexibility	No issues
Responsiveness to urgent deliveries	Good, facilitated custom clearances
Stock capacity	No known restrictions

Several assumptions were made to determine the potential performance of the alternative supply chain network design. An average transportation cost per kg and 100 km had to be calculated to be able to determine the savings in transportation cost. Although the estimated cost differed by a factor of 2.5 from the actual cost, the transportation cost for the current and alternative supply chain network designs could be compared and relative savings could be calculated. Because the estimations were only compared to each other, the result of the analysis was considered to be reliable. The authors always tried to incorporate the risks of all assumptions and often leaving additional benefits out of the equation. These extra benefits, such as the possibility to consolidate transportations and gain further savings in transportation cost, provide a margin for the results from the analysis. Furthermore, an initial assumption was made that it would be possible to determine the suitability of keeping inventory in regional warehouses by analyzing data from 2010. There is a risk that future demand would change with respect to volumes and regions. Prices of products, warehousing and transportation could also be changing and this would affect the decision of utilizing regional warehouses. However, it is considered that these risks could be mitigated by continuously measuring the suitability of the chosen supply chain network design.

6.3. Comparison between supply chain network designs

The current and alternative supply chain network designs were compared with respect to the supply chain, supply chain strategy, supply chain network design and the performance according to the developed performance measurement system.

6.3.1. Supply chain

The current and alternative supply chain network designs were analyzed with respect to their material-, information- and financial flow.

6.3.1.1. Material flow

It was determined that the orders to the Brindisi region only represented 0.29% of the procured value for contraceptives and RH kits in 2010. Similarly, these orders only represented 2.37% of the total number of orders for contraceptives and RH kits. The material flow is therefore not large enough to justify having a warehouse in this region.

In the alternative supply chain network design, the products would be closer to the beneficiaries. The improved proximity implies that the responsiveness could be increased and the delivery-times could be shortened for the products that could be provided directly from the regional warehouses. In the alternative supply chain network design, there would also be an opportunity to reduce the transportation costs by sending full containers between the suppliers and the regional warehouses. There is however a greater risk of obsolete products in the alternative supply chain network design due to that the products would be divided among several different warehouses instead of among the suppliers that currently keep inventory. The risk of obsolete products would also increase because all contraceptives and not just male condoms could be stored. Another risk is that a product could be out of stock in one warehouse whereas it could be in danger of becoming obsolete in another.

6.3.1.2. Information flow

There would be one more organization to include in the information flow if PSB decides to utilize the UNHRDs as its regional warehouses. Compared to keeping the current supply chain network design, the information flow would be more complex in the alternative supply chain network design. However, this complexity would most likely be reduced after all agreements have been settled for instance regarding packaging requirements of the UNHRDs.

6.3.1.3. Financial flow

There would be an additional financial link in the alternative supply chain network design since not all the UNHRDs' services are provided free of charge, such as the arrangement of transportation. The additional work is however not assumed to take up a substantial amount of time since PSB would only need to purchase transportation services from the UNHRDs. Both supply chain network designs are therefore considered equally complex with respect to the financial flow. Furthermore, an opportunity exists for PSB to arrange more of the transportations instead of outsourcing it to the UNHRDs. If PSB would arrange the transportations, the workload would increase. However, there could be potential savings from investigating the different alternatives of the transportation market and avoiding the UNHRDs' 7% management fee. The management fee would have been USD 425 000 if PSB would have utilized the UNHRDs in 2010.

6.3.2. Supply chain strategy

The alternative supply chain network design is in line with PSB's supply chain strategy. In comparison to the current supply chain network design, the alternative supply chain network design could help reduce lead-times towards customers and increase the sales to third-party clients. The alternative supply chain network design is therefore considered to be more in line with PSB's current supply chain strategy.

6.3.3. Supply chain network design

Chopra and Meindl (2001) have determined the suitability of the two supply chain network designs for different product characteristics as seen in Table 6.12 below.

Table 6.12. Performance of the supply chain network designs for different product/customer characteristics (Chopra and Meindl, 2001)

Performance of the supply chain network designs for different product/customer characteristics		
Product/Customer characteristics	**Manufacturer storage with direct shipping (Current)**	**Distributor storage with package carrier delivery (Alternative)**
High demand product	-2	0
Medium demand product	-1	+1
Low demand product	+1	+1
Very low demand product	+2	0
Many product sources	-1	+2
High product value	+2	+1
Quick desired response	-2	-1
High product variety	+2	+1
Low customer effort	+1	+2
+2: Very suitable; +1 Somewhat suitable; 0: Neutral; -1: Somewhat unsuitable; -2: Very unsuitable		

Products that benefit most from the current, centralized inventory are usually characterized by high value as well as low and unpredictable demand. Response time can however be longer because the manufacturers are located further away from the customers which imply long shipping distances. Transportation costs should be lower for this supply chain network design compared to manufacturer storage since transportation can be consolidated and full truckloads can be used for the inbound logistics. The response time in this supply chain network design would also be shorter compared to the current supply chain network design since the warehouse on average would be closer to the customer than the manufacturer (Chopra and Meindl, 2001). The alternative supply chain network design was found to be more suitable for high- and medium demand products, products with many sources, products with quick desired response and when low customer effort is desired. The current supply chain network design is more suitable for products with very low demand, high

product value and high product variety. The two supply chain network designs were found to be equally suitable for products with low demand.

Both contraceptives and RH kits have been defined as products with unpredictable demand which would make them suitable for the current supply chain network design. Contraceptives are however more frequently requested and is considered to have a high demand whereas RH kits have a relatively low demand. Furthermore, contraceptives are considered to be low-value products whereas RH kits can be both high- and low-value products depending on the kit. Given these characteristics, the RH kits and contraceptives are only partly suitable for the current supply chain network design. Given that the RH kits also require a very high responsiveness since they are requested in emergency aid situations, it further reduces their suitability for this supply chain network design. Because contraceptives are high-demand products they could largely benefit from the consolidated transportations that could be possible with regional warehouses. RH kits have a relatively low demand and some of them have low shelf-lives which could be a risk in this supply chain network design. First, there is the risk of kits becoming obsolete in the warehouse. Second, it might not be possible to gain the savings from consolidation of transportation between the suppliers and the warehouses due to the low demand of the kits. However, RH kits would benefit from being closer to the beneficiaries since they are frequently transported by the expensive transportation mode air which this distance would be shorter with regional warehouses. Another aspect to consider is where the products are sourced from. PSB has several suppliers spread for most product categories. The alternative supply chain network design would be beneficial since products from several suppliers could be consolidated before being shipped to their country of destination.

Table 6.13 compares the two supply chain network designs with respect to their theoretical performance with 1 being the relatively best supply chain network design for the specific dimension. Response time, customer experience and transportation are indicators that PSB values. The alternative supply chain network design has a higher theoretical performance for all these indicators which further strengthens the advantages of this supply chain network design for PSB.

Table 6.13. Comparative performance of supply chain network designs (Chopra and Meindl, 2001)

	Manufacturer storage with direct shipping	Distributor storage with package carrier delivery
Response time	4	3
Product variety	1	2
Product availability	1	2
Customer experience	4	2
Order visibility	5	3
Returnability	5	4
Inventory	1	2
Transportation	4	2
Facility and handling	1	3
Information	4	3
1: relatively best supply chain network design for the dimension 6: relatively worst supply chain network design for the dimension		

6.3.4. Comparison of the performance of the current and alternative supply chain network designs

Transportation cost

The savings in transportation cost for the alternative supply chain network design compared to the current supply chain network design are displayed in Table 6.14 below. Two of the categories did not have any order lines for one of their regions. The savings for these categories and regions are displayed as N/A in the table. See Appendix 8 for the estimated savings in percent.

Table 6.14. Savings in transportation cost per category and region for the supply chain with regional warehouses

Savings in transportation cost per category and region for the supply chain with regional warehouses (USD)																
		Accra		Brindisi		Dubai		Panama		Subang		Total				
Combined low dose OC pills	$	2 938	$	-140	$	-2 551	$	-32 649	$	-20 673	$	**-53 074**				
Progestagen only pills	$	862	$	-20	$	729	$	N/A	$	-732	$	**839**				
Emergency contraceptives	$	-103	$	0	$	54	$	-1 383	$	28	$	**-1 404**				
Intra uterine device (IUD)	$	-6 153	$	-1 319	$	-1 097	$	-11 540	$	-185	$	**-20 294**				
Male condoms	$	9 522	$	2 727	$	51 963	$	10 858	$	-2 470	$	**72 600**				
Female condoms	$	-3 005	$	-170	$	-5 052	$	-10 581	$	65	$	**-18 742**				
Injectable contraceptives	$	-170 163	$	-551	$	-41 105	$	-250 426	$	-32 251	$	**-494 496**				
Subdermal implants	$	-2 878	$	N/A	$	-1 275	$	-205	$	-598	$	**-4 956**				
RH kits	$	-82 520	$	22	$	-57 086	$	-197 538	$	-22 872	$	**-359 993**				
Total	**$**	**-251 500**	**$**	**550**	**$**	**-55 419**	**$**	**-493 464**	**$**	**-79 688**	**$**	**-879 521**				

The alternative supply chain network design could generate 12% in savings for the transportation cost. 12% of the actual transportation cost for the current supply chain in 2010 is USD 879 521. There could also be additional savings from consolidating orders that are sent to the same country from different suppliers. In 2010, approximately 19% of the orders could have been consolidated from a regional warehouse. The only region that would not contribute with any savings is the Brindisi region. This further strengthens a recommendation of not including this warehouse in the new supply chain network design. The countries that have been assigned to the Brindisi warehouse for this thesis would have to be assigned to either the Accra or the Dubai region if the Brindisi region is not included in the alternative supply chain network design. The total potential savings in transportation cost from the warehouses to the countries of destination would be reduced due to the increased distance to the former Brindisi countries. However, only a very small share of all orders would be affected by this change and it is therefore considered to have a marginal effect on the total savings. Another risk factor that could reduce the potential savings in transportation cost is the risk of not reaching the target fill rate for the products. However, an increased inventory level has been recommended if PSB chooses the alternative supply chain network design. Therefore, the authors are confident that PSB would increase its target fill rate achievement and thereby maintain the potential savings in transportation cost.

Inventory cost

Both supply chain network designs would offer storage free of charge for PSB. However, it can be argued that PSB would have a better position to negotiate for lower prices with their

suppliers if this service was not provided to the same extent as it is today. There is a risk that either the suppliers or the UNHRDs would start charging PSB for keeping inventory. The risk is however assumed to be equal for both supply chain network designs and should therefore not affect PSB's decision of which supply chain network design to use. Another aspect to consider for the alternative supply chain network design is that it includes more handling of the products. The extra handling increases the risk of damaged products. The UNHRDs have specific packaging requirements and it is assumed that if suppliers follow these requirements the extra handling should not be a problem.

Inventory turnover ratio

The inventory turnover ratio is assumed to be the same in the alternative supply chain network design as for the current supply chain. Therefore, no decision can be made regarding the suitability of regional warehousing with respect to this measure. The inventory turnover ratio is however important to consider since the turnover ratio will affect other measures, such as the inventory obsolescence.

Inventory obsolescence

It was found that the risk of obsolete products would increase in the alternative supply chain network design. There would be a greater risk for obsolete products in the alternative supply chain network design due to that the inventory is spread out between five regional warehouses instead of gathered at the suppliers' premises. For contraceptives this risk was found to be low due to the long shelf-lives of these products. The risk of obsolete products for RH kits is higher due to their lower shelf-lives. Also, the high uncertainty in demand would require high inventory levels to reach the target fill rate. If the cost of obsolete products would equal the estimated savings in transportation it would allow 3.3% of the product value in inventory to become obsolete.

Tied-up capital

PSB would have more tied-up capital in inventory in the alternative supply chain network design because additional contraceptives would be stored. Also, in order for male condoms to reach the target fill rate of 80% the tied-up capital would need to be increased for this category as well. In total, there would be an increase from USD 3.3 million to USD 9.6 million which is equivalent to a 190% increase. An increase in tied-up capital is however something that PSB is willing to accept if other benefits such as reduced lead-times and increased customer satisfaction can be achieved (Sørensen, 2012b). The increase in tied-up capital is therefore not considered to be a great disadvantage for the alternative supply chain network design.

Customer satisfaction

The result of PSB's customer satisfaction survey from 2010 showed that PSB got a low score for on-time deliveries. By moving the goods closer to the customer as in the alternative supply chain network design, the lead-time to customer could be reduced and hence, the number of on-time deliveries could be assumed to increase. This would in turn give PSB a

higher ranking in the customer satisfaction survey. The responsiveness would also increase due to these factors which would further improve the overall customer satisfaction score.

On-time delivery
The lead-time to customer would be reduced by moving the goods closer to the customer in the alternative supply chain network design. The facilitated customer clearance at the UNHRDs will also increase the number of on-time deliveries.

Target fill rate achievement
An increase in tied-up capital for male condoms could help both supply chain network designs to achieve the target fill rate. However, because the inventory is further away from the manufacturer in the alternative supply chain network design, there is an increased risk that this alternative would not be able to reach the target fill rate. In the alternative supply chain network design the inventory levels for RH kits would be low for each warehouse. The low inventory level would make it difficult for PSB to reach the high target fill rate for RH kits. A centralized structure with only one warehouse reduces the uncertainty of demand by aggregating the uncertainties in one place. These factors favor the current supply chain network design.

Freight performance
It has been determined that the freight performance would be better for the alternative supply chain network design due to that the distance from the regional warehouse to the beneficiaries would be significantly shorter. See Table 6.15 for the estimated reduction of lead-times, port to port, when using regional warehouses.

Table 6.15. Comparison of freight lead-times between the current and alternative supply chain network designs

Comparison of freight lead-times between the current and alternative supply chain network designs (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Air	-75%	-92%	-89%	-86%	-80%	**-85%**
Ocean	-89%	-96%	-75%	-79%	-83%	**-83%**
Total	**-87%**	**-93%**	**-76%**	**-81%**	**-82%**	**-82%**

The alternative supply chain network design would reduce the freight lead-times and hence increase the freight performance. If PSB chose to not utilize the warehouse in Brindisi, these orders would have to be transported from a warehouse further away from the country of destination. The freight lead-times would increase, but due to the few orders to the Brindisi region the impact is considered to be marginal. The alternative supply chain network design would therefore be preferred from this perspective.

Share of transportation mode
The comparison between the share of air and ocean transport in the current and alternative supply chain network design is displayed in Table 6.16.

Table 6.16. Comparison between the current and alternative supply chain network design with respect to the share of air and ocean transport

Comparison between the current supply chain and the supply chain with regional warehouses with respect to the share of air and ocean transport (%)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Air	-89%	-88%	-51%	-88%	-79%	**-80%**
Ocean	+104%	+111%	+79%	+133%	+123%	**+102%**

The distance travelled by air transport could be significantly reduced by implementing the alternative supply chain network design. The ocean transport would increase but it has been determined that the overall transportation cost would be reduced in the alternative supply chain network design. The reduction in transportation cost is considered to be advantageous for the alternative supply chain network design. The increase in ocean transport originates from that all orders shipped to regional warehouses use this transportation mode. The transportation to the UNHRDs would not affect the delivery lead-times as it is part of the pre-positioning of the goods. The total distance transported could be further reduced if countries located close to suppliers receive their orders directly from the suppliers and not through the regional warehouses. The reduction in total distance from countries located close to suppliers has not been taken into consideration in the above calculations.

Volume flexibility

The supplier base would not change due to a change towards regional warehouses and the volume flexibility would therefore be the same in the current supply chain as for an alternative with regional warehouses.

Responsiveness to urgent deliveries

The UNHRDs are situated in strategic places that are close to disaster prone areas and have facilitated customs processes. Therefore, the responsiveness to urgent deliveries would be higher for the alternative supply chain network design and it is therefore preferred from this aspect.

Stock capacity

The stock capacity has been proven high for both the current and alternative supply chain network design. Therefore, the current and alternative supply chain network designs were considered to be equal for this measure.

Summary of performance comparison

The performance of the alternative supply chain network design is compared to the current supply chain network design in Table 6.17 below.

Table 6.17. Comparison of performance of the current and alternative supply chain network design

Performance measure	Current supply chain network design	Alternative supply chain network design
Transportation cost	$ 10 314 per order	$ 9 084 per order
Inventory cost	Free of charge	Free of charge
Inventory turnover ratio	6 times/year for RH kits and 3 times/year for male condoms	6 times/year for RH kits and 3 times/year for contraceptives
Inventory obsolescence	0%	Greater risk than in current supply chain
Tied-up capital	$ 3 300 000 in average	$ 9 600 000 in average
Customer satisfaction	4.24/5.00	Higher than in current supply chain
On-time delivery	40%	Higher than in current supply chain
Target fill rate achievement	60% for male condoms and 91% for RH kits	80% for male condoms and close to 100% for RH kits
Freight performance (For contraceptives)	6.0 days for air and 39.7 days for ocean	0.9 days for air and 6.9 days for ocean
Share of transportation mode	56% air and 44% ocean	11% air and 89% ocean
Volume flexibility	No issues	No issues
Responsiveness to urgent deliveries	Ok, but complex customs processes	Good, facilitated custom clearances
Stock capacity	No known restrictions	No known restrictions

According to the analysis, the alternative supply chain would better for the transportation cost, expected customer satisfaction, number of on-time deliveries, the target fill rate achievement, the freight performance and the responsiveness to urgent deliveries. The alternative supply chain would also use a larger share of ocean transport which would be both cheaper and more environmentally friendly. The alternative supply chain is therefore considered preferable from this aspect as well.

7. Conclusions

In this chapter, the research questions are answered and the recommendations for PSB are presented with respect to the organization's supply chain network design. A discussion of the reliability, validity and objectivity of the result and of interesting future research within this area is also presented.

The purpose of this thesis was to develop a new performance measurement system for PSB and use it to evaluate the current and alternative supply chain network designs. The results from the analysis and consequently the answer to the research questions are presented below.

1. ***What performance measures need to be considered when developing a new performance measurement system for PSB?***

The measures in Table 7.1 were chosen by considering the different aspects needed for a good performance measurement system while taking into account the purpose of using the system to evaluate the current and alternative supply chain network designs for PSB.

Table 7.1. Developed performance measurement system for evaluating PSB's current and alternative supply chain network designs

Developed performance measurement system for evaluating PSB's current and alternative supply chain network designs			
Performance measure	**Resources**	**Output**	**Flexibility**
Transportation cost (USD/order, transportation mode and region)	X		
Inventory cost (USD)	X		
Inventory turnover ratio (times/year)	X		
Inventory obsolescence (USD)	X		
Tied-up capital (USD)	X		
Customer Satisfaction (score out of maximum 5)		X	
On-time delivery (average lateness) (days)		X	
Target fill rate achievement		X	
Freight Performance (days)		X	
Share of transportation mode		X	
Volume flexibility			X
Responsiveness to urgent deliveries			X
Stock capacity			X

The performance measures were grouped with respect to the three categories resources, output and flexibility. Focus was on establishing a balance between the categories and to ensure that the total number of measures stayed below 20 to reduce the complexity and increase the user-friendliness. The performance measurement system was also evaluated with respect to its inclusiveness, universality, measurability and consistency before it was used as a tool for the analysis of the different supply chain network designs.

2. ***Should PSB keep its current supply chain network design or switch to a supply chain network design with regional warehouses in the UNHRDs?***

From the analysis it was concluded that the alternative supply chain network design would perform better in transportation cost, customer satisfaction, on-time delivery, freight performance, share of transportation mode and responsiveness to urgent deliveries. Especially the customer satisfaction, responsiveness and on-time deliveries were factors that PSB expressed as important to achieve and they are all in favor of the alternative supply chain network design and this supply chain network design was also found to be in line with PSB's supply chain strategy. The comparison of the two supply chain network designs is shown in Table 7.2 below.

Table 7.2. Comparison of the two supply chain network designs

Comparison of the alternative and current supply chain network designs	
Performance measure	**Relative performance of the alternative and current supply chain network designs**
Transportation cost	$1230 per order
Inventory cost	No difference
Inventory turnover ratio	No difference
Inventory obsolescence	Advantage for the current supply chain
Tied-up capital	In average $ 6 300 000 more in tied-up capital for the alternative supply chain
Customer Satisfaction	Advantage for the alternative supply chain
On-time delivery	Advantage for the alternative supply chain
Target fill rate achievement	Higher fill rate for alternative supply chain
Freight Performance	5.1 days shorter with air and 32.8 days shorter with ocean for the alternative supply chain
Share of transportation mode	45% more air transport and 45% less air transport with current supply chain
Volume flexibility	No difference
Responsiveness to urgent deliveries	Better for alternative supply chain due to facilitated customs process
Stock capacity	No difference

The total comparison is in favor of the alternative supply chain network design. Therefore, the authors recommend PSB to start using the UNHRDs as regional warehouses. However, it was found that the Brindisi warehouse would not be suitable for PSB due to the low material flow through this warehouse as well as the higher transportation costs. Therefore it is recommended that PSB uses the remaining four warehouses and allocate the countries that

should have been served from Brindisi to their closest UNHRD. For the majority of the countries, the closest UNHRD would be in Dubai.

All contraceptives were found suitable for regional warehousing and it is therefore recommended to store them in the different warehouses. The analysis showed that male condoms would be more expensive to transport compared to the current supply chain. However, the increased performance in on-time deliveries, customer satisfaction and freight performance are considered to outweigh the extra cost of transportation.

The analysis also showed that there would be a priority issue between inventory obsolescence and the ability to reach the target fill rate for RH kits in the alternative supply chain network design. There are two options if PSB decides that the target fill rate should be prioritized. Either the inventory levels could be increased in all four warehouses which would increase the risk of inventory obsolescence. The second option would be to consolidate the RH kits in two of the warehouses, for example Dubai and Panama, to mitigate the risk of obsolete products by gathering the uncertainties in demand. By only using two UNHRDs, the savings in transportation cost would be reduced because of the increased distances to the beneficiary countries. The increased distances would also increase the delivery lead-times. The authors will leave this decision of priority to PSB.

The same analysis that has been performed in this study can be conducted to determine the suitability to store medical equipment, office supplies and other products in PSB's portfolio in regional warehouses. This study was delimited not to include rules and regulations that could have an impact on which products that could be stored in a regional warehouse. A further investigation on which products that PSB is allowed to keep in regional warehouses is left for PSB to determine before making a final decision.

8. Future research

In this chapter, potential future research topics within this area are discussed. Some of them concern PSB specifically while others are of a more general character.

PSB's current performance measurement system does not measure all aspects of the organization. A performance measurement system was developed for the purpose of evaluating the alternative of regional warehousing. The system was adjusted to reflect aspects regarding regional warehousing. However, the performance measurement system could be modified as a future research project by applying the approach used to develop the performance measurement system in this study. A modified performance measurement system could for example be designed to measure PSB's continuous performance or to evaluate other alternatives for the supply chain network design. Furthermore, it was concluded that regional warehouses could reduce the lead-times towards the customers for PSB by bringing the products closer to the final destination. A good forecasting system could also be a way of reducing lead-times without having to tie up capital in inventory. Because many of the orders to PSB are for development aid they could possibly be predicted to a larger extent than what is being done today. The development of a forecasting system for PSB would also be interesting to see as a future research project. Another research possibility for PSB would be to investigate the advantages and disadvantages of only utilizing one or two of the UNHRDs as regional warehouses. In this study, the investigation focused on utilizing all the UNHRDs. Brindisi was not found to be suitable due to its low demand but there could be benefits of restricting the number of warehouses such as lower risk of obsolete products. It has been discussed in this thesis that the use of regional warehouses in the UNHRDs could open up increased opportunities for PSB with respect to consolidation of orders from different suppliers. What has not been discussed is the opportunity for PSB to consolidate the orders with other humanitarian organizations. Such collaboration could further reduce the transportation costs but further research is required to determine the potential savings and risks.

The conclusions presented in this thesis are a result of a study made specifically for PSB. Further research would therefore be needed in order to determine the applicability of the result on other organizations. However, the performance measurement system that was the foundation for the analysis was developed with measures found in literature. Due to their non-specificity, it is assumed that even though the result might not be applicable to all organizations, the performance measurement system could be used to measure the performance of other organizations as well.

Another aspect that was not included in the analysis for this thesis is the effect of environmental aspects such as regulations and increased fuel prices. A potential future research project could be to investigate current environmental trends with respect to transportation and what effects this would have on a recommendation to store goods in regional warehouses.

Finally, it would be interesting to see a benchmarking of performance measurement systems within different humanitarian organizations. Benchmarking could provide a platform for a discussion regarding what measures that should be included for different purposes and the possibility for the organizations to learn from each other.

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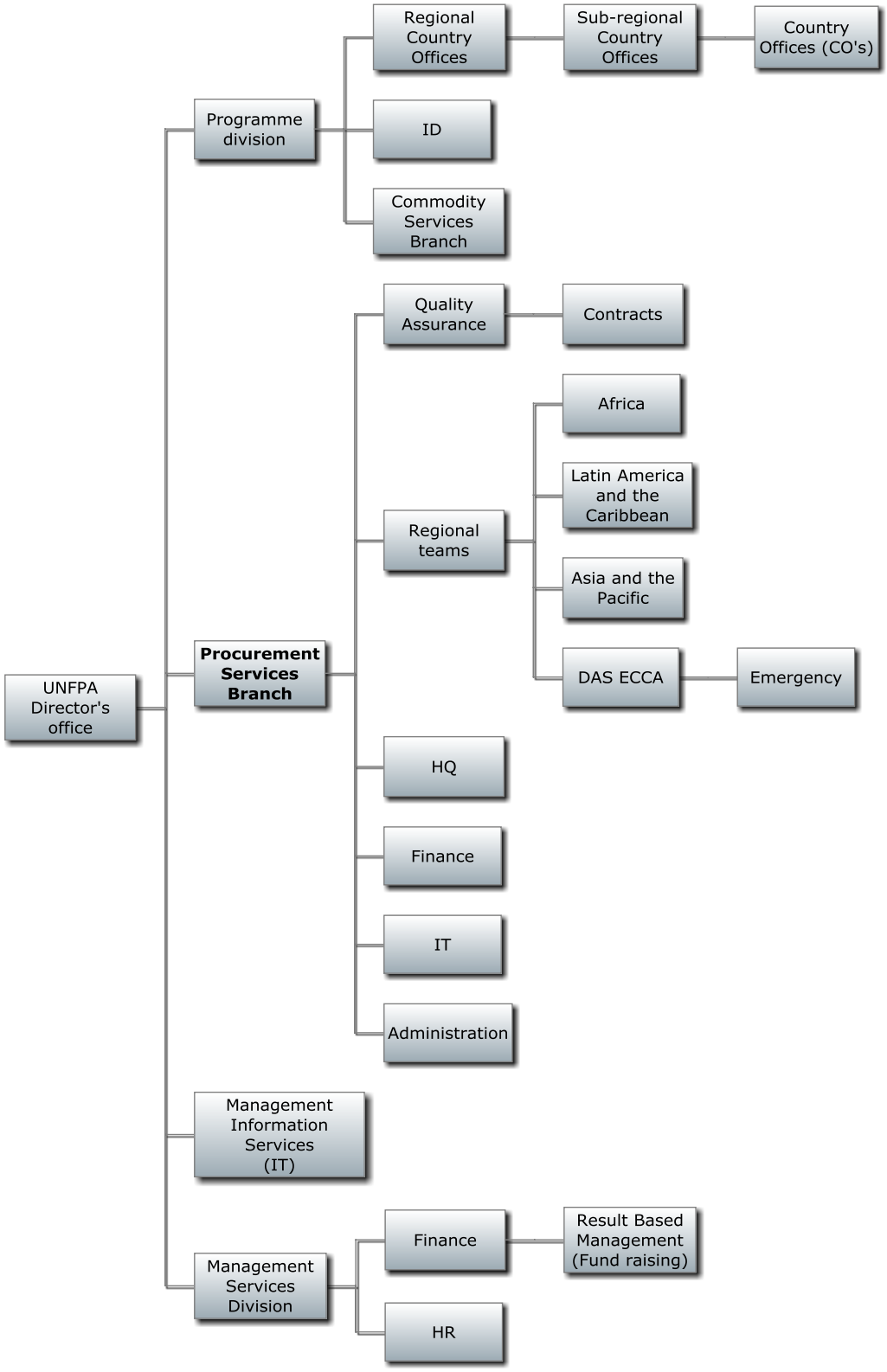
Appendix 1

Organizational chart of UNFPA



(Escriva, 2012)

Appendix 2

Exploratory interviews – semi-structured

Interviewee: Executive Chief of PSB
Years at PSB: 2
Date: February 9, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interviewee: Deputy Chief of PSB
Years at PSB: 7
Date: February 16, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide

- Ask interviewee to present the organization
- How is the supply chain structured?
- How has the supply chain changed over time?
- What has historically triggered change in the supply chain?
- What are the current issues in the supply chain?
- What are the alternatives regarding regional warehousing for PSB?
- What are the requests on the supply chain/products in the supply chain?
- What are the restrictions to changing the supply chain?
- Why didn't the recommendations from the previous reports result in implementations?

Interviewee: Access RH Demand Planner and Inventory Associate
Years at UNFPA: 2
Date: January 23, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interviewee: Emergency Procurement Assistant
Years at UNFPA: 2
Date: January 23, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interviewee: Procurement Specialist UNFPA
Years at UNFPA: 5
Date: January 24, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide

- What is your role within PSB?
- What products would you say represent the UNFPA product portfolio?
- What characteristics/special requirements do these products have?
- Are there any issues in the current supply chains for these products?
- What opportunities can you see regarding a change to regional warehouses?
- What factors need to be considered when evaluating the supply chain?
- Do you feel that the outsourcing of the materials handling and transportation has made PSB lose control of the supply chain?

Interviews regarding supply chain strategy and performance measurement system

Interviewees: Deputy Chief of PSB
Years at PSB: 7
Date: March 23, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interviewees: Procurement Specialist
Years at PSB: 12
Date: March 23, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide

Supply Chain Strategy

- What is PSB's supply chain strategy for contraceptives and emergency RH kits?
- How would you prioritize between cost and lead-time for each of the product categories?
- How would you characterize the demand situations for each of the product categories?
- Are PSB's mission and objectives central for the daily operations?

Supply Chain Mapping

- What are the characteristics of contraceptives and RH kits with respect to demand pattern, shelf life, value and volume ordered?
- What links and nodes exist in PSB's supply chain between supplier and end consumer for contraceptives and RH kits?
- How is the product flow handled?
- How is the information flow structured?
- How often does it happen that PSB orders the transportation?
- How is the financial flow handled?

- What are the main differences between the product categories in terms of their supply chains?
- How do the product-, information- and financial flow differ between emergency aid and development work situations?

Interviewee: Procurement Specialist
Years at UNFPA: 7
Date: March 20, 2012
Location: PSB Office, Copenhagen, Denmark
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide
Performance measurement system

- What does the current performance measurement system at PSB look like?
- What performance measures are included?
- What has changed historically?
- How is the current system being used?
- How has the current system been developed?
- Are there any performance measures that are desired but not included in the performance measurement system?
- If so, what is the reason why they are not included?

Interviews with other humanitarian organizations regarding regional warehousing

Interviewee: Davronbek Akhmadbekov, Procurement specialist at UNDP
Date: April 16, 2012
Years at UNDP: 6
Location: Phone interview
Interviewed by: Olof Petersson and Emilia Wiking

Interviewee: Gianluca Bruni, Chief of the IT Emergency preparedness and response branch at WFP
Date: April 18, 2012
Years at WFP: 9
Location: Phone interview
Interviewed by: Olof Petersson and Emilia Wiking

Interviewee: Jens Grimm, Emergency Logistics Specialist at UNICEF
Date: April 20, 2012
Years at UNICEF: 4
Location: Phone interview
Interviewed by: Olof Petersson and Emilia Wiking

Interviewees: Giuseppe Saba, Coordinator for UNHRD
Years within UNHRD: 12 years
Date: April 19, 2012
Location: Phone interview
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide

- What is your role within organization X?
- How many years have you worked there?
- What products does your organization handle?
- Could you briefly describe the supply chain for your organization?
- What is your organization's supply chain strategy? (Focus on cost versus lead-time)
- Are you currently pre-positioning goods in regional warehouses/a central warehouse?
- What kind of products do you store?
- What are the characteristics of these products?
- Do the products have any special requirements?
- If you are not utilizing regional warehouses, have you done it in the past?
- If you are not currently utilizing regional warehouses, why did you stop?
- For how long have you/did you utilize regional warehouses?
- What were the main objectives of starting to use regional warehouses?
- Where does/did your organization have regional warehouses? How were their locations decided?
- Do all warehouses supply all customers or are they divided by region?
- Are the pre-positioned goods mainly used for disaster relief or for development work?
- What effects have been seen on i.e. lead-times and costs since your organization started the pre-positioning?
- How do you measure the performance? (Lead-times, stock-outs, on-time deliveries, transportation cost etc.)
- What drawbacks have you experienced?
- What kind of adjustments did you have to do within the organization to make this work?
- Did you have to do any investments?
- How do/did you handle the new demand on the information infrastructure?
- How long did it take to set up the regional warehouses?
- Is your organization handling the storage or is someone else taking care of it? What does that cost?
- Has the purchasing process changed due to this?
- How has your organization's demand planning changed?
- Does your organization experience more waste now than before the regional warehouses?

- Is your organization collaborating with any other organizations in this initiative?
- Does your organization supply all clients with goods from the regional warehouses?
- Has the customs clearance become easier or more complex after the implementation of regional warehouses?

Interview regarding storage in UNHRDs

Interviewees: UNHRD responsible in Dubai
Years within UNHRD: N/A
Date: May 15, 2012
Location: Answers via e-mail
Interviewed by: Olof Petersson and Emilia Wiking

Interview guide

- How does it work with customs for the regional warehouses?
- How much do the UNHRDs charge for cold storage? And kitting?
- Do you believe that the UNHRDs would have the capacity to store goods for PSB at almost all times?

Appendix 3

Countries divided in the UNHRD regions

Accra		
Angola	Equatorial Guinea	Mauritania
Benin	Gabon	Namibia
Burkina Faso	Gambia	Niger
Cameroon	Ghana	Nigeria
Cape Verde	Guinea	Sao Tome and Principe
Congo	Guinea-Bissau	Senegal
Cote d' Ivoire	Liberia	Sierra Leone
Democratic Republic of Congo	Mali	Togo

Brindisi		
Albania	Bosnia and Herzegovina	Moldova
Algeria	Cyprus	Romania
Armenia	Egypt	Tunisia
Belarus	Kosovo	Turkey

Dubai		
Afghanistan	Lebanon	Sri Lanka
Botswana	Lesotho	Sudan
Burundi	Madagascar	Sudan (Juba)
Central African Republic	Malawi	Swaziland
Chad	Maldives	Syrian
Comoros	Mauritius	Tajikistan
Djibouti	Mongolia	Tanzania
Eritrea	Mozambique	Turkmenistan
Ethiopia	Nepal	Uganda
India Main	Oman	United Arab Emirates
Iran, Islamic Republic of	Pakistan	United Republic of Tanzania
Iraq	Palestine	Uzbekistan
Jordan	Rwanda	Yemen
Kazakhstan	Somalia	Zambia
Kenya	South Africa	Zimbabwe
Kyrgystan		

Panama		
Barbados	Ecuador	Panama
Belize	El Salvador	Paraguay
Bolivia	Guatemala	Peru
Brazil	Guyana	St. Lucia
Chile	Haiti	Surinam
Colombia	Honduras	Trinidad and Tobago

Costa Rica	Jamaica	Uruguay
Cuba	Mexico	Venezuela
Dominican Republic	Nicaragua	
	Subang	
Bangladesh	Fiji	Myanmar
Bhutan	Indonesia	Papua new Guinea
Cambodia	Japan	Philippines
China	Laos People's Democratic Republic	Thailand
Dem.Rep. of Korea	Malaysia	Vietnam
East Timor		

Appendix 4

Procurement statistics for contraceptives and RH kits, 2010

Percentage of purchased value for development work excluding transportation cost (%)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Contraceptives	24.41%	0.29%	52.25%	18.15%	4.87%	**99.97%**
RH kits	0.00%	0.00%	0.03%	0.00%	0.00%	**0.03%**
Total	**24.41%**	**0.29%**	**52.28%**	**18.15%**	**4.87%**	**100.00%**

Percentage of orders for development work excluding transportation cost (%)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Contraceptives	29.00%	2.06%	35.82%	18.07%	14.74%	**99.68%**
RH kits	0.16%	0.00%	0.16%	0.00%	0.00%	**0.32%**
Total	**29.16%**	**2.06%**	**35.97%**	**18.07%**	**14.74%**	**100.00%**

Percentage of purchased value for emergency aid excluding transportation cost (%)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Contraceptives	10.74%	0.00%	12.02%	0.07%	2.85%	**25.67%**
RH kits	13.05%	0.20%	34.46%	15.46%	11.15%	**74.33%**
Total	**23.79%**	**0.20%**	**46.48%**	**15.53%**	**13.99%**	**100.00%**

Percentage of orders for emergency aid excluding transportation cost (%)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
Contraceptives	8.06%	0.00%	13.71%	1.61%	2.42%	**25.81%**
RH kits	18.55%	4.03%	26.61%	15.32%	9.68%	**74.19%**
Total	**26.61%**	**4.03%**	**40.32%**	**16.94%**	**12.10%**	**100.00%**

Number of contraceptives purchased per product and region						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	10 223 419	185 000	15 521 109	9 441 767	2 144 100	**37 515 395**
Progestagen only pills	1 756 102	12 000	6 260 167	720 000	1 144 373	**9 892 642**
Emergency contraceptives	24 500	30 000	1 276 200	364 000	39 277	**1 733 977**
Intra uterine devices (IUD)	196 500	33 500	4 123 354	339 619	480 110	**5 173 083**
Male condoms*	1 224 961	54 660	4 826 207	2 757 325	492 429	**9 355 582**
Female condoms	2 337 000	4 000	5 710 000	222 000	1 318 000	**9 591 000**
Injectable contraceptives	23 066 000	50 000	26 702 050	12 284 230	4 062 000	**66 164 280**
Subdermal implants	287 500	0	795 884	31 608	24 800	**1 139 792**
Total	**39 115 982**	**369 160**	**65 214 971**	**26 160 549**	**9 705 089**	**140 565 751**
*Male condoms are measured in gross where 1 gross = 144 male condoms						

Number of RH kits purchased per product and region						
	Accra	Brindisi	Dubai	Panama	Subang	Total
RH kit 0	1	0	4	0	3	**8**
RH kit 1A	32	0	137	76	18	**263**
RH kit 1B	14	2	238	16	0	**270**
RH kit 2A	74	4	1 281	322	702	**2 383**
RH kit 2B	58	0	586	70	31	**745**
RH kit 3A	193	0	238	94	10	**535**
RH kit 3B	313	0	221	101	11	**646**
RH kit 4	15	0	69	133	16	**233**
RH kit 5	148	0	265	211	15	**639**
RH kit 6A and 6B	116	7	273	122	65	**583**
RH kit 7	16	0	119	40	20	**195**
RH kit 8	63	0	163	55	6	**287**
RH kit 9	121	0	95	29	15	**260**
RH kit 10	36	0	192	34	16	**278**
RH kit 11A	36	0	21	35	27	**119**
RH kit 11B	53	0	33	50	15	**151**
RHkit12	52	0	10	12	19	**93**
Total	**1 341**	**13**	**3 945**	**1 400**	**989**	**7 688**

Percentage of transportation cost for each RH kit and region in 2010 for the current supply chain network design (%)						
	Accra	**Brindisi**	**Dubai**	**Panama**	**Subang**	**Total**
RH kit 0	0.00%	0.00%	0.00%	0.00%	0.00%	**0.01%**
RH kit 1A	0.45%	0.00%	1.80%	1.58%	0.20%	**4.02%**
RH kit 1B	0.04%	0.00%	0.36%	0.06%	0.00%	**0.46%**
RH kit 2A	1.55%	0.02%	16.03%	8.91%	4.83%	**31.34%**
RH kit 2B	0.14%	0.00%	1.16%	0.25%	0.06%	**1.62%**
RH kit 3A	0.33%	0.00%	0.21%	0.20%	0.00%	**0.74%**
RH kit 3B	0.29%	0.00%	0.24%	0.22%	0.00%	**0.75%**
RH kit 4	0.06%	0.00%	0.10%	0.68%	0.10%	**0.94%**
RH kit 5	1.21%	0.00%	1.17%	2.11%	0.00%	**4.49%**
RH kit 6	3.29%	0.06%	6.83%	4.91%	2.02%	**17.12%**
RH kit 7	0.09%	0.00%	0.32%	0.23%	0.11%	**0.75%**
RH kit 8	0.61%	0.00%	1.07%	0.60%	0.07%	**2.35%**
RH kit 9	0.40%	0.00%	0.17%	0.13%	0.07%	**0.77%**
RH kit 10	0.05%	0.00%	0.22%	0.06%	0.03%	**0.36%**
RH kit 11A	0.16%	0.00%	0.06%	0.21%	0.15%	**0.57%**
RH kit 11B	7.49%	0.00%	6.24%	15.63%	3.88%	**33.23%**
RH kit 12	0.28%	0.00%	0.03%	0.06%	0.10%	**0.47%**
Total	**16.43%**	**0.09%**	**35.99%**	**35.85%**	**11.63%**	**100.00%**

Appendix 5

Calculation of transportation cost

An average transportation cost per kg and 100km for each transport mode was therefore calculated. These averages were calculated by using the transportation cost, distances and weights for 20 orders of each transportation mode from 2010.

$$Transportation\ cost\ for\ order\ \propto = C_t(w,d)\ * Max(dw(\propto), w(\propto)) * d(\propto)$$

where

$C_t(w,d)$ = average cost per kg and 100 km for transportation mode t (USD)

$d\,w(\propto)$ = dimensional weight for order $\propto$ (kg)

$w(\propto)$ = weight for order $\propto$ (kg)

$d(\propto)$ = distance travelled for order $\propto$ (100 km)

The averages were multiplied by the maximum number of the dimensional weight and actual weight, and by the distance of each order. The dimensional weight was calculated by dividing the volume (cm^3) of each product by 5000. This measure is used by several of the largest providers of logistics services such as DHL, FedEx and UPS (DHL, 2012; FedEx, 2012; UPS, 2012). The weight and the dimensional weight were compared and the heavier of the two was used as an input to calculate the transportation cost. The ocean distances were extracted from the distance calculator at www.sea-distances.com and the air distances were extracted from www.world-airport-codes.com.

Appendix 6

Performance for current supply chain – complementary tables

Estimated transportation cost for current supply chain network design (USD)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	$ 143 366	$ 1 445	$ 424 706	$ 205 457	$ 138 864	**$ 913 840**
Progestagen only pills	$ 23 856	$ 204	$ 121 282	N/A	$ 99 905	**$ 245 248**
Emergency contraceptives	$ 450	$ 922	$ 29 420	$ 20 647	$ 492	**$ 51 934**
Intra uterine devices (IUD)	$ 27 883	$ 5 275	$ 157 775	$ 58 021	$ 12 205	**$ 261 160**
Male condoms	$ 929 483	$ 30 251	$ 2 719 046	$ 2 783 102	$ 91 453	**$ 6 553 336**
Female condoms	$ 62 767	$ 557	$ 149 032	$ 42 557	$ 6 730	**$ 261 645**
Injectable contraceptives	$ 2 492 448	$ 3 627	$ 2 615 941	$ 2 953 462	$ 726 757	**$ 8 792 236**
Subdermal implants	$ 16 347	N/A	$ 219 387	$ 793	$ 2 889	**$ 239 418**
RH kits	$ 375 600	$ 2 085	$ 823 011	$ 819 747	$ 266 022	**$ 2 286 468**
Total	**$ 4 072 204**	**$ 44 368**	**$ 7 259 604**	**$ 6 883 789**	**$ 1 345 321**	**$ 19 605 288**

Response from PSB customer satisfaction survey 2010	
Comment	**Average grade out of maximum 5 points**
I am satisfied with PSB's response time to inquiries/requests made in 2010.	4.4
In 2010, when I contacted PSB for guidance and/or advice, I found their response helpful.	4.47
Shipment(s) scheduled to be delivered in 2010 arrived on time according to PSB's schedule.	3.92
If I experienced a problem with an order, PSB provided helpful solutions.	4.36
I am satisfied with the quality of products procured by PSB in 2010.	4.32
I am satisfied with the variety of products offered in the 2010 procurement catalogue.	4.08
I am satisfied with PSB's assistance on CRC submissions.	4.33
I feel PSB understands the realities of field operations when providing advice and services.	4.00
I am satisfied with the overall service provided by PSB.	4.44

Inventory turnover ratio for RH kits			
	Units sold (number of kits)	Reorder point (number of kits)	Turnover ratio (times per year)
RH kit 0	8	40	**0.20**
RH kit 1A	253	75	**3.37**
RH kit 1B	271	50	**5.42**
RH kit 2A	2370	200	**11.85**
RH kit 2B	740	150	**4.93**
RH kit 3A	525	100	**5.25**
RH kit 3B	496	100	**4.96**
RH kit 4	233	35	**6.66**
RH kit 5	624	50	**12.48**
RH kit 6A and 6B	573	150	**3.82**
RH kit 7	195	25	**7.80**
RH kit 8	287	100	**2.87**
RH kit 9	260	70	**3.71**
RH kit 10	280	100	**2.80**
RH kit 11A	116	15	**7.73**
RH kit 11B	148	15	**9.87**
RH kit 12	90	15	**6.00**

Appendix 7

Performance for alternative supply chain with regional warehouses – complementary tables

Estimated transportation cost for current supply chain network design (USD)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	$ 143 366	$ 1 445	$ 424 706	$ 205 457	$ 138 864	**$ 913 840**
Progestagen only pills	$ 23 856	$ 204	$ 121 282	N/A	$ 99 905	**$ 245 248**
Emergency contraceptives	$ 450	$ 922	$ 29 420	$ 20 647	$ 492	**$ 51 934**
Intra uterine devices (IUD)	$ 27 883	$ 5 275	$ 157 775	$ 58 021	$ 12 205	**$ 261 160**
Male condoms	$ 929 483	$ 30 251	$ 2 719 046	$ 2 783 102	$ 91 453	**$ 6 553 336**
Female condoms	$ 62 767	$ 557	$ 149 032	$ 42 557	$ 6 730	**$ 261 645**
Injectable contraceptives	$ 2 492 448	$ 3 627	$ 2 615 941	$ 2 953 462	$ 726 757	**$ 8 792 236**
Subdermal implants	$ 16 347	N/A	$ 219 387	$ 793	$ 2 889	**$ 239 418**
RH kits	$ 375 600	$ 2 085	$ 823 011	$ 819 747	$ 266 022	**$ 2 286 468**
Total	**$ 4 072 204**	**$ 44 368**	**$ 7 259 604**	**$ 6 883 789**	**$ 1 345 321**	**$ 19 605 288**

Estimated transportation cost for the alternative supply chain network design (USD)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	$ 151 178	$ 1 072	$ 417 925	$ 118 658	$ 83 904	**$ 772 739**
Progestagen only pills	$ 26 148	$ 151	$ 123 221	N/A	$ 97 958	**$ 247 479**
Emergency contraceptives	$ 177	$ 922	$ 29 564	$ 16 971	$ 567	**$ 48 201**
Intra uterine devices (IUD)	$ 11 524	$ 1 767	$ 154 859	$ 27 342	$ 11 712	**$ 207 206**
Male condoms	$ 954 797	$ 37 502	$ 2 857 193	$ 2 811 969	$ 84 886	**$ 6 746 349**
Female condoms	$ 54 778	$ 107	$ 135 602	$ 14 427	$ 6 903	**$ 211 818**
Injectable contraceptives	$ 2 040 058	$ 2 161	$ 2 506 661	$ 2 287 690	$ 641 016	**$ 7 477 589**
Subdermal implants	$ 8 696	N/A	$ 215 997	$ 247	$ 1 299	**$ 226 241**
RH kits	$ 156 215	$ 2 145	$ 671 246	$ 294 580	$ 205 216	**$ 1 329 403**
Total	**$ 3 403 575**	**$ 45 830**	**$ 7 112 271**	**$ 5 571 886**	**$ 1 133 466**	**$ 17 267 030**

Turnover per category and year (USD)						
	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined Low Dose OC Pills	$ 778 889	$ 28 305	$ 594 326	$ 584 761	$ 503 013	$ **2 489 295**
Progestagen only Pills	$ 386 727	$ 5 472	$ 219 305	$ N/A	$ 33 963	$ **645 467**
Emergency Contraceptive	$ 12 925	$ N/A	$ 21 500	$ 18 500	$ 9 450	$ **62 375**
Intra Uterine Device (IUD)	$ 58 125	$ 11 795	$ 87 534	$ 57 146	$ 16 579	$ **231 179**
Male condoms	$ 1 049 178	$ 181 618	$ 2 869 662	$ 2 614 346	$ 931 941	$ **7 646 745**
Female Condoms	$ 217 600	$ 2 400	$ 350 600	$ 133 200	$ 55 800	$ **759 600**
Injectable Contraceptives	$ 3 056 255	$ 21 000	$ 1 551 114	$ 1 627 941	$ 787 930	$ **7 044 240**
Subdermal Implants	$ 2 185 000	$ N/A	$ 1 796 838	$ 245 557	$ 249 500	$ **4 476 895**
Reproductive Health Kits	$ 572 918	$ 8 994	$ 1 579 673	$ 678 404	$ 445 561	$ **3 285 551**
Total	**$ 8 317 617**	**$ 259 585**	**$ 9 070 553**	**$ 5 959 854**	**$ 3 033 738**	**$ 26 641 347**

Appendix 8

Analysis of transportation costs

Estimated percentage of difference between the current transportation cost and the transportation cost for the alternative supply chain network design (%)

Product category	Accra	Brindisi	Dubai	Panama	Subang	Total
Combined low dose OC pills	5.45%	-25.78%	-1.60%	-42.25%	-39.58%	**-15.44%**
Progestagen only pills	9.61%	-25.78%	1.60%	N/A	-1.95%	**0.91%**
Emergency contraceptives	-60.66%	0.00%	0.49%	-17.81%	15.15%	**-7.19%**
Intra uterine devices	-58.67%	-66.50%	-1.85%	-52.88%	-4.03%	**-20.66%**
Male condoms	2.72%	23.97%	5.08%	1.04%	-7.18%	**2.95%**
Female condoms	-12.73%	-80.81%	-9.01%	-66.10%	2.58%	**-19.04%**
Injectable contraceptives	-18.15%	-40.40%	-4.18%	-22.54%	-11.80%	**-14.95%**
Subdermal implants	-46.80%	N/A	-1.55%	-68.78%	-55.02%	**-5.50%**
RH kits	-58.41%	2.84%	-18.44%	-64.06%	-22.86%	**-41.86%**
Total	**-16.42%**	**3.29%**	**-2.03%**	**-19.06%**	**-15.75%**	**-11.93%**