Hospital-based Health Technology Management: Analysing the Procurement Process from a Network Perspective

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Italian Version

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Executive Summary

Health technologies constitute the fundamental blocks at the base of modern health care. Therefore, Health Technology Management (HTM) and its activities have acquired more importance throughout the years. Nevertheless, both developed and underdeveloped countries are facing difficulties in managing health technologies and following the guidelines provided. This situation also applies to the UK which is the subject country of this dissertation. Among the various HTM activities, procurement will be the main focus for this thesis project since it represents a fundamental phase before the medical device effectively enters the hospital.

National and international organisations, as well as worldwide authors, have developed and proposed several guidelines and frameworks to help health care managers in conducting procurement practices and overcoming the current issues. Agency theory, integrated supply chain management, and networks and inter-organisational relationships, are the main concepts applied to procurement, mainly relying on economic aspects and focusing on the external relationships with suppliers and other outer parties. However, health care systems and their procurement practices are highly complex and present several values and stakeholders dominating both the internal and external environments. Therefore, the researcher decided to proceed in a novel way and to apply a new and different lens to analyse the procurement practices and their issues. In particular, this thesis project suggests looking at hospital-based procurement from an intra-organisational perspective stressing the importance of considering the internal network governing the various activities and interacting parties. Thus, the main objective of this dissertation is to understand to what extent hospital-based procurement can be classified as a network and how management in networks strategies could be applied and would be suitable to analyse and manage hospital-based procurement practices and complications.

The main information regarding health care procurement and policies in the UK has been collected through desk research. This study also collected data through interviews, which helped the researcher to get more details on the current procurement activities and the challenges encountered. Moreover, since the current literature does not describe hospital-based procurement in the UK in a satisfactory way, the author has developed four different BPMN diagrams delineating the four procurement cases identified. Once enough information and details have been collected, the author analysed these last ones according to networking theories.

The results obtained show several challenges both pointed out by respondents and identified by the researcher through data analysis. These challenges include lack of funding, lack of experts in the procurement department, poor involvement of clinical engineers, conflicts of interests between procurement members and clinicians, poor communication of guidelines, clinicians bypassing the ideal steps recommended, and excessive waste derived from the purchase of not needed or poor quality equipment. Additionally, this study shed light on how the centralised procurement system, represented by the NHS Supply Chain, is affecting the current UK hospital-based procurement. On the one hand, the centralised system allows hospitals to save time and be sure that all the tendering procedures have been respected. On the other hand, the prices obtained through centralised procurement are higher than the ones obtained through direct hospital-based negotiation, especially for big hospitals. Moreover, the devices' quality offered is quite low and because of the simplicity of ordering from the centralised system's catalogue, clinical engineers and procurement members find difficulties in controlling the whole system.

Analysing and trying to understand the data collected from the aforementioned networking perspective, this study identifies four 'grey areas' in which all the issues characterising networks and networking relationships are more evident as well as the lack of a unique and right final decision. These grey areas involve poor attention in day-to-day operational procurement activities, deciding when to go or not through centralised procurement, the development and communication of hospital-based procurement guidelines, and the involvement of clinical engineers. From a network perspective, it is evident that the actors involved in the procurement process are not aware of the presence and importance of an internal network characterising its various activities. Always following a 'management in networks' approach, health care managers should be able to perform suitable stakeholder analysis taking into account the values and interests of each actor. This means that each stakeholder has to recognise the presence of functional relationships and the importance of key stakeholders, such as clinical engineers, who constitute a strategic network and could help to improve outcomes. Health care workers need to be aware of the continuous negotiation phases characterising the procurement process, therefore, it is important to establish suitable agreements with all the parties involved and promote a strong organisational culture. The process of negotiation, which can be considered as the opposite of strict command and control, is also fundamental during the development of procurement guidelines to facilitate their understanding and encourage health care workers to follow them.

Health care system's activities are highly emotionally charged and their complexity is what differentiates health care from other domains. Therefore, it is worth stressing that, although this study focused on procurement, this new 'lens' could be applied and would be suitable to also analyse other HTM activities. This new approach would help researchers or health care managers understand the context-dependency characterising each health care process through the analysis of its internal network and phenomena.

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Terminology

Clinical Engineering Group: This refers to the hospital's group that deals with the maintenance, repair, training, and risk assessment of medical equipment. In some cases, they are include in the prioritisation process of medical replacement and in some phases of the procurement process. Other terms used to refer to this group are "biomedical engineering", "medical engineering" or "Electrical and Biomedical Engineering (EBME)".

Clinician: This term is used to define any healthcare professional, including doctors and nurses.

Medical Device or Equipment: This two terms are usually used interchangeably and refer to any product or technology designed and intended to be used in a healthcare context.

Inter-organisational: occurring between or involving two or more organisations during a specific process or activity.

Intra-organisational: occurring between or involving more actors belonging to the same organisation during a specific process or activity.

NHS Trust or simply "Trust": A Trust can be defined as a public sector bodies providing services on behalf of the NHS in England and NHS Wales. They may be composed of one or several hospitals, plus various peripheral sites not necessarily owned by the Trust, where clinics may be held and community health services, mental health services and ambulance services are provided, which are managed by their own boards of directors.

Procurement: This term refers to the process of managing activities with the aim to purchase goods and services required to operate the organisation. This term also refers to a department within an NHS Trust that administrates the purchasing of medical devices and their related services. However, in this last case it will be called 'Procurement Department or Group'.

Purchasing: This usually refers to process of buying and selling something. In this study, purchasing will indicate the final step at the end of the procurement process, when the hospital effectively decide what to buy.

Network: This term will indicate not only social networks or informal models of interaction, but it will be used to describe structures through which public goods and services (such as hospitals services and procurement activities) are planned, designed, produced and provided.

Abbreviations

AAMI Association for the Advancement of Medical Instrumentation

BPMN Business Model Process and Notation

CCGs Clinical Commissioning Groups

CTSPs Category Tower Specialist Providers

DRG Decision Resources Group

EBME Electrical and Biomedical Engineering

HB-HTA Hospital-based Health Technology Assessment

HB-Procurement Hospital-based Procurement

HB-HTM Hopsital-based Health Technology Management

HT Health Technology

HTA Health Technology Assessment

HTM Health Technology Management

MHRA Medicines and Healthcare products Regulatory Agency

NHS National Health Service

NPG New Public Governance

NPM New Public Management

SCCL Supply Chain Coordination Limited

UK United Kingdom

WHO World Health Organisation

Contents

Chapter 1

Introduction

1.1 Background

Health technologies (HT) are intended as technologies directly focused on health needs. According to the definition provided by the WHO (World Health Organisation) (2001), HT includes "devices, drugs, medical, and surgical procedures—and the knowledge associated with these used in the prevention, diagnosis, and treatment of disease as well as in rehabilitation, and the organizational and supportive systems in which care is provided" (World Health Organization. Regional Office for the Eastern Mediterranean, 2001). It is worth mentioning that health care systems in high-income countries are largely dependent on technology (Howitt et al., 2012), and considering that this dependence is set to grow, health technologies constitute the fundamental blocks at the base of modern health care. The main question is: "How to systematically manage these technologies?". The application and use of health technologies, as well as their systematic management, depends on what is called health technology management (HTM).

The WHO (2017) defines HTM as a combination of several activities and practices such as planning, selection, procurement, donations, inventory, installation and maintenance of medical equipment, training and finally decommissioning (World Health Organization, 2017). The management of health technologies serves to make sure that medical assets are available, accessible, affordable, appropriate, and used safely. Moreover, according to the WHO (2017), operational and appropriate management leads to improved health outcomes through optimal use of resources (World Health Organization, 2017). To facilitate the management of health technology and the consequent improvement of health outcomes, the WHO and many other authors suggest the implementation of HTM departments, at the national, regional, or local level (Vilcahuaman & Rivas, 2017) (World Health Organization, 2017)(McCarthy, Scott, Blackett, Amoore, & Hegarty, 2014)(Howitt et al., 2012)(Pallikarakis & Bliznakov, 2016)(World Health Organization. Regional Office for the Eastern Mediterranean, 2001). While promoting the implementation of HTM activities, those organisations and authors have developed guidelines showing how to correctly implement HTM systems and the various possible levels of implementation(Gentles, 2020). However, it is worth mentioning that, despite political and inter-organizational efforts, many countries are facing several challenges

in performing a proper management of health technology, and this directly affects their health systems performance and safety (World Health Organization. Regional Office for the Eastern Mediterranean, 2001).

Procurement represents one of the main activities of HTM and can be classified as one of the first phases characterising the whole medical device's operational life. Moreover, the procurement process itself can be divided into different phases such as identification of a need, specification of the device, selection of the supplier, and contractual/negotiation phase (Madhlambudzi & Papanagnou, 2019). The importance of performing proper procurement activities is recognised by several authors, therefore, as in the case of HTM, various guidelines and frameworks have been developed to indicate best practices to follow during the procurement process. However, very little attention is paid to the stakeholders involved in the procurement process, their interactions, and all the values involved during the different procurement phases.

The UK Case

Focusing on the UK, the NHS (National Health Service) is struggling to fund the replacement of health care technologies. This is an issue recognized by all NHS Acute Hospitals, which are 'making do' with old technology, and this affects patient care and increases costs (EBME, 2019). The main challenges that health care managers have to face are derived from severe pressure due to shortfalls in financial and personnel resources, in addition to a shortage of capable health care managers who understand how to design and implement new management systems and policies (EBME, 2017). Moreover, it should be mentioned that the health care system has been characterised by continuous policy changes, and this also applies to procurement activities. More specifically, the procurement process has been characterised by a continuous shift from centralisation to decentralisation and vice versa. Additionally, since the UK Government recognised the fundamental role of procurement and how good procurement practices could reduce the NHS non-expenditure, various attempts have been carried out to improve the UK health procurement. The most recent reform sees the introduction of the NHS Supply Chain, a centralised governmental body aiming to provide centralised procurement services and overcome the limitations characterising hospital-based procurement. Although centralised procurement covers only 40% of the whole national procurement, the final goal is to completely eliminate procurement at the hospital level. However, although there is evidence regarding the drawbacks related to hospital-based procurement, there are also substantial concerns about the NHS Supply Chain centralised system.

Health Care Context-dependency

One of the main takeaways from the literature is that almost all the frameworks and guidelines developed for the implementation, decision-making process, and ethical criteria regarding HTM rely on a project-based approach. Therefore, decision-making progresses in a number of logical phases following each other and in which planning is crucial. Indeed, a project-based approach is characterised by precision, unequivocality, focus, and sharpness (De Bruijn & ten Heuvelhof,

2018). The guidelines and decision-making frameworks provided by international and national organizations, mainly concentrate on the technical feasibility and safety of the technology, the impact this could have on patients, and the costs associated with the introduction and purchasing of a specific medical device. However, the evaluative process regarding health technologies, health outcomes, quality of care, etc., should be coherent with the specific necessities of the health care organization, taking into account its own geographic area, its own specific patients' epidemiology etc... (Palozzi, Falivena, & Chirico, 2019). Another aspect to consider is the complexity of the health care system as a whole, which differentiates decision-making in health care from other domains (Kuziemsky, 2016). Therefore, it would be meaningful to shift our analysis from HTM to hospital-based HTM, and in the particular case of this research project, the focus will be hospital-based procurement.

Management in Networks

The globalization of the economy means everything is connected to everything else (De Bruijn & ten Heuvelhof, 2018), and this also applies in the health care system. The chaos theory uses a well-known metaphor to clarify these processes in an interconnected world: the 'butterfly effect'. A butterfly in Brazil flaps its wings and causes a tornado in Texas months later. In the case of health care and the management of health technologies, just think, for example, about the Covid-19 pandemic, where its epidemiological and geographical origins are still unknown but have affected the entire world. This event has demonstrated that the vision of health care as a single unit within a bounded geographical area needs to be shifted to a more complex one, which sees health care as a network characterized by inter-connectivity, dynamism, and wicked problems (De Bruijn & ten Heuvelhof, 2018).

Focusing on the selection, procurement, deployment and disposal of particular health technologies, these activities can result in a wicked problem when different alternatives are available and several stakeholders and values are involved. In such cases, the aim is to find acceptable solutions, which are not necessarily optimum, and the negotiation/interaction process matters as much as the content of the decision (De Bruijn & ten Heuvelhof, 2018). According to de Bruijn and ten Heuvelhof (2018), when dealing with decisions that need to be taken in a network of actors and parties, it is important to shift from a project perspective to a process perspective. In the first case, the aim is the realization of the goal/solution after a problem has been identified, purely relying on costs/benefits analysis (CBA) and on the rules/laws that characterise the whole project. In the second case, in addition to the realisation of the goals, also the satisfaction of the parties involved, the fairness of the process, and lasting relationships for future cooperation are taken into account (De Bruijn & ten Heuvelhof, 2018). In their book "Management in Networks", the authors have developed a set of strategies for making decisions in a network and have indicated what are the main differences between a project-based and a process-based approach.

1.2 Research Problem and Research Objective

From a practical perspective, the UK, like so many other countries, is struggling to have a complete HTM implementation. The sources suggest that British health care managers face financial and personnel availability pressures, and this makes it difficult to follow the instructions provided by the various organizations for the implementation of HTM activities including procurement. It is worth mentioning that the guidelines and decision-making frameworks provided by national organizations and various authors, mainly follow a project-based approach, characterized by linear HTM implementation/decision-making, and usually focusing on purely technical and legislative aspects of HTM. However, the health care sector, as well as procurement of medical devices, is characterised by complexity, constitutes an interconnected network of actors, parties and policies, and it is mainly context-dependent. Therefore, in addition to technical and legislative advice, it would be sensible to train health care managers in recognising the presence of internal networking relationships, and how to negotiate with all the actors involved in the different procurement, or more in general HTM, activities.

From an academic perspective, almost all the articles analysing procurement aim to identify potential challenges, mainly related to financial and technical concerns, and subsequently provide decision-making frameworks to indicate the right path to follow when deciding which device to purchase. Very few articles perform a satisfactory analysis of the main actors involved during the procurement process and their responsibilities. Moreover, no attempts have been made to look at hospital-based procurement from a networking perspective and apply 'Management in Networks' theories and strategy to understand and improve it.

Considering the aforementioned practical and academic issues, this study wants to investigate how hospital-based procurement could be analysed under the network point of view. Therefore, this dissertation wants to propose a new way of looking at hospital-based procurement, taking into account the presence of potential internal networks and interactions proper of an interconnected world. More specifically, this thesis project aims to provide a satisfactory description of the main procurement activities performed within the hospital, inform about who are the actors involved, how they interact, how/if they follow specif guidelines, and the main challenges encountered. Once the author will arrive at a satisfactory description of hospital-based procurement, she will analyse this last one under the paradigms of an interconnected world, explaining how the various networking strategies and paradigms can be used to understand and analyse hospital-based procurement. Finally, this research will identify factors that could be addressed by health care decision-makers to manage technology successfully. In particular, this study intends to identify valuable strategies for technology management decision-making and activities, to detect which one should be addressed by hospitals, and to establish technology management system priorities for health care managers and clinical engineers.

The results of this thesis project are intended to strengthen the ability of hospitals to properly

manage health technologies. This is to be achieved by improved alignment of both managerial and decision-making strategies according to what is intended by management in a network. Definitions for the constructs of 'Hospital-based Health Technology Management' and 'Network' will be developed by means of document analysis and according to the author's assumptions. Subsequently, the thesis project will proceed with the development of a conceptual model that could be used and applied to the different 'areas for improvement' identified during hospital-based procurement. The strategies suggested will be informed by what has been described in the book 'Management in Networks' (De Bruijn & ten Heuvelhof, 2018), in addition to the views of health care experts and managers in the UK. More specifically, the conceptual model will be developed by using content/document analysis and will be applied according to the information gathered from explorative interviews. It is worth mentioning that the application of the conceptual model and the consequent strategies suggested, does not represent a substituting guideline to the ones developed by the UK Government. Thus, it doesn't want to validate which types of HTM activities should be performed within the hospitals and how, but it aims to assess how health care managers deal with and exploit technology management/decision-making strategies and practices.

Research Questions

Considering the main research problems detected and the aim of this research project, this study sought to answer to the following main research question:

"What are the most suitable organizational and decision-making strategies able to facilitate Hospital-based Health Technology Management?"

In addition to the main research question, a set of sub-questions have been developed to facilitate data collection. Since this study will only focus on one of the HTM activities, the sub-questions have been developed around the concept of procurement. It should be mentioned that, because of the qualitative nature of this study, all the sub-questions are explorative sub questions.

- **(1)**How are procurement activities conducted at the hospital-level in the UK?
- **(2)** What are the challenges affecting the current practice of hospital-based procurement in the UK?
- **(3)** How the current UK health care policies are affecting hospital-based procurement?
- **(4)** To what extent can the UK hospital-based procurement be categorised as a network?
- **(5)** What are the possible areas for improvement detected on the current UK hospital-based procurement?

Research Challenges

This research project can be divided into two main parts, an exploratory study on how hospital procurement works and the application of suitable 'Management in Networks' theories. However, the

largest part of the challenges has been encountered during the first phase of the research because of the complex nature of health care and its activities. The first challenge is represented by the wide terminology used in the health care sector and how the same concept is categorised using different labels across various geographical areas or even within the same country. This phenomenon has complicated both the collection of valuable papers during the literature review and the development of the various diagrams since, even across British hospitals, health care managers are used to their own hospital's terminology. Therefore, the whole research project has been characterised by continuous 'contrast and comparison' phases trying to reach a satisfactory level of validity. The second challenge regards the use of qualitative data to study health care phenomena which, differently from quantitative research, do not focus on biomedical matters but concentrate on social health research (Holloway, 2005). According to Holloway (2005), two main challenges while performing qualitative research in health care contexts are: gaining permission to conduct such research and ensuring that the research has been conducted ethically (ibid). During this research project, the permission of conducting the research was indirectly related to the willingness of individuals to participate in the interviews, and so the facility of data access. It is worth mentioning that, although the research will be characterised by complete anonymity in terms of individuals interviewed and NHS Trusts analysed, health care workers are reluctant in expressing their personal opinions especially if they cover 'prestigious' roles within the hospital's hierarchy. Khankeh et al. (2015) identified additional concerns characterising qualitative health research. These concerns include the identification of the research problem, formation of the research question/aim, and selection of an appropriate methodology and research design (Khankeh, Ranjbar, Khorasani-Zavareh, Zargham-Boroujeni, & Johansson, 2015). Moreover, in this particular case, to the aforementioned challenges, it should be added the general lack of medical expertise of the author and her unfamiliarity with the country chosen (UK) and its policies.

1.3 Thesis Structure

This thesis project is composed of eight main chapters, each of them presenting various sections and sub-sections, covering different topics and providing specific information. This part of the thesis will list the various chapters, their main contents, the methodology used to develop each of them, and which sub-questions they answer.

1. **Chapter 1**: Introduces the main thesis topics, providing useful background information. It also describes the research problems identified and the objective of the study, together with the challenges encountered and the relevance of the research.

2. **Chapter 2**: Presents the main findings of the literature review and the gaps detected. This chapter has been developed by means of document analysis.

3. **Chapter 3**: Describes the research methodologies followed and how the data have been collected and analysed. Additionally, it includes an overview of the whole research process.

4. **Chapter 4**: Represents the first part of the results obtained. It includes all the information relative to the UK. It indicates its main HTM challenges, health care policies, the application of network's theories, and the networking relationships detected within the UK health care. This chapter has been developed though document analysis and it will partially answer the sub-questions 1 and 2.

5. **Chapter 5**: Represents the second part of the results obtained and provides details on the current procurement practices in the UK, indicating the different procurement processes, the stakeholders involved, and their interactions. This chapter has been developed by means of both document analysis and interviews. It will provide a satisfactory answer to the sub-question 1.

6. **Chapter 6**: Represents the second part of the results describing the challenges characterising hospital-based procurement and the relative drawbacks of centralisation policies. This chapter has been developed through both document analysis and interviews. It will answer the sub-questions 2 and 3.

7. **Chapter 7**: Discusses the main findings and analyses the procurement processes described in Chapter 5 and 6 under the 'network' paradigms. It also identifies possible areas for improvement and applies suitable networking strategies suitable to the current situation. This chapter will answer the sub-questions 4 and 5.

8. **Chapter 8**: Provides a summary of the main key findings, answering the aforementioned research sub-questions and the main research question. It also describes the study's limitations and its contributions.

1.4 Societal and Managerial Relevance

The societal relevance of this research project is represented by the aim of the research itself: improving final health outcomes. Indeed, the improvement of procurement activities is strictly related to health systems performance. Firstly, conducting procurement activities in an acceptable or improved way will reduce financial waste which, especially in the case of public health care, are directly related to the well-being of the citizens. The money saved from procurement waste can be used in several different ways, both in the health care sector or other public sectors such as instruction. Secondly, considering that one of the main procurement activities is the selection of medical devices, purchasing adequate and reliable medical equipment will directly affect patient safety. In addition to the potential benefits deriving from correct procurement activities, the application of networking strategies proposed for procurement can also be transferred to other HTM activities. Indeed, from a managerial perspective, this thesis project has introduced a novel approach to the management of health technology. More specifically, the managerial relevance or contribution that could be addressed to this study, is to look at the problem from a different perspective. This last one is based on the awareness of the presence of an internal network and on the health care manager's duty of analysing this internal network and its peculiarities. It

should be mentioned that the author has not proposed a simple stakeholder analysis, but she suggested understanding the internal network according to the paradigms and assumption proper of an interconnected world. This new managerial approach to the health care sector can be considered the reverse of the static and linear procedure usually implemented to improve health outcomes and performance. Applying this managerial approach to the hospital-based procurement, or health care in general, indicates that, although all the health care workers involved in procurement activities should pursue the same final goal and the success of their working place, in practice each actor has his own perceptions and interests which could dominate during the decision-making process. Therefore, if all the actors become aware of the internal network dominating the various health care activities, the whole procurement process will be characterised by continuous negotiation phases arriving at acceptable decisions, or at least avoiding unilateral decisions.

Chapter 2

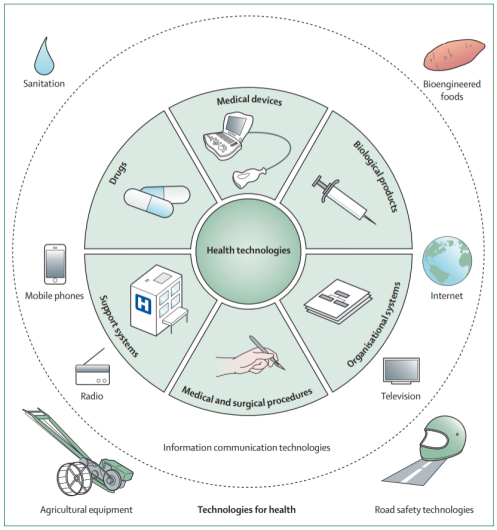
Literature Review

This chapter will provide the main insights gathered from a literature review analysing and collecting the information provided by scientific articles, books, and grey documents. The topics under investigation have been HTM, procurement activities, and management in notworks theories.

2.1 Health Technology Management

The WHO (2018) defines Health Technology or Health Care Technology as "the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of life" (World Health Organization, 2018). It is important to differentiate between technology for global health and health technologies. Indeed, while technologies for global health refers to a wide category of interventions aiming to reduce malnutrition, improve global sanitation, and increase citizens's safety on roads (Howitt et al., 2012), health technologies are directly focused on the population's health needs (ibid.) (Fig. 2.2). From Fig. 2.2 it is possible to notice that health technologies can be divided into six main categories: drugs, medical devices, biological products, organisational system, medical and surgical procedures, and support systems. This thesis project will only focus on one of these categories, medical devices. Often the literature stresses the slightly difference between a medical device and medical equipment. The first one is described as "an article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose" (World Health Organization, 2018). The second one, the medical equipment, is classified as "medical devices requiring calibration, maintenance, repair, user training and decommissioning – activities usually managed by clinical engineers. Medical equipment is used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury; it can be used either alone or in combination with any accessory, consumable or other pieces of medical equipment" (World Health Organization, 2018). Therefore, from the aforementioned definitions, it is possible to consider medical equipment as a sub-category of medical devices. In this thesis project, both the terms medical device and medical equipment will be used interchangeably.

Figure 2.1: Technologies for Global Health and Health Technologies. Retrieved from (Howitt et al., 2012)



Apart from the formal definition used to categorise medical devices, it is worth stressing that these last ones are important to provide health care and to improve population's health (World Health Organization, 2010). Moreover, thanks to the continuous improvement of health technologies, also accompanied by a continuous population increase, high and middle-income countries are largely dependent on health technologies, whose availability is inversely related to health needs (Howitt et al., 2012). Despite the importance related to health technologies, several problems can be related to medical devices. Indeed, choosing a medical device is a quite complicated process and requires transparency, public health needs assessment, and an efficient prioritisation process (World Health Organization, 2010). The challenges related to medical devices can be summarised into three main categories: choosing medical devices, using medical devices, and medical devices innovation (ibid). Focusing on the first category, the selection of medical device could involve barriers determined by lack of information, fascination with technology that can blind decision-makers, deference to personal preferences, both the known and hidden costs of medical devices, lack of a single nomenclature, collusion and corruption etc... (World Health Organization, 2010) Therefore, proper management of health technologies, starting from the selection phase, could result in being essential to provide valuable health outcomes.

Once it has been established the fundamental role occupied by health technologies within the health care system and how technological advancement has contributed to increasing the world's welfare, it would be sensible to optimise the management of health technologies. This last concept is commonly defined as Health Technology Management (HTM) which, according to the WHO (2017), ensures medical devices' availability, safety, affordability etc., and can be seen as a combination of several activities such as planning, needs assessment, selection, procurement, donations, inventory, installation of medical equipment, maintenance of medical equipment, training, and de-

commissioning (World Health Organization, 2017). Each of these domains is developed around two main principles, creating awareness and providing continuous health technology's monitoring and evaluation (Fig. 2.2). HTM can be considered as the last piece of a puzzle composed of health technology regulation and health technology assessment (Fig. 2.3). More specifically, once the technology's regulations have been established at the international, national, or local level, and the various medical devices have been assessed, then proper management of the technology needs to be carried out.

Figure 2.2: HTM Activities and Practice. Retrieved from (World Health Organization, 2017)

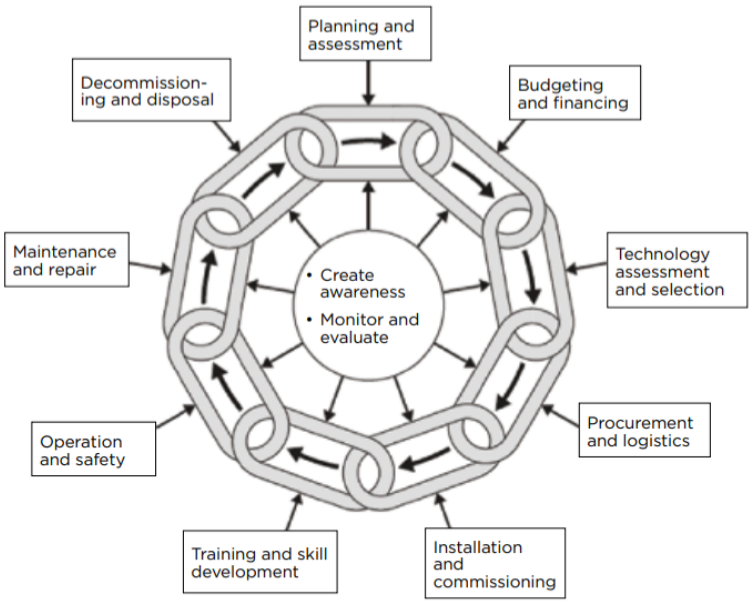


Figure 2.3: HT Regulations, HTA, and HTM. Retrieved from (World Health Organization, 2017)

Vilcahuaman and Rivas (2017) point out the extremely huge difference between conventional hospitals and hospitals with an HTM department (Vilcahuaman & Rivas, 2017). More specifically, an integrated HTM system presents well-defined inputs and outputs, such as high effectiveness in health services, high efficiency in the use of technological resources, maximum safety, and effective monitoring costs of technology (Vilcahuaman & Rivas, 2017). A proper implementation of HTM facilitates the success of health organisations, such as hospitals, thanks to its main key objectives: increasing the availability of technology though proper maintenance and good purchase practices; improving the patient care service by increasing patient safety and cost management through standardization; reducing unnecessary hospitalization; improving current and future cost management by reducing overall costs and carrying out a reliable equipment replacement forecast; financing and managing technology replacement and new technology additions (Vilcahuaman & Rivas, 2017). Indeed, HTM can be considered as "the point of convergence of science, technology, and the market" (Vilcahuaman & Rivas, 2017).

HTM and Clinical Engineering

HTM and its activities are usually related to clinical engineers. According to the WHO (2017), HTM activities should be performed by clinical engineers and HTM itself coincides with clinical engineering (World Health Organization, 2017). The literature stresses the importance of having clinical engineering departments within hospitals (Vilcahuaman & Rivas, 2017), pointing out that this would contribute to increasing final health outcomes. Moreover, David et al. point out that medical devices' management represents a fundamental part of the healthcare system, since it carries the best potential for clinical engineers (CEs) to demonstrate their expertise and leadership capabilities (David, Judd, & Zambuto, 2020). The role of clinical engineers coincides with all the activities included in the HTM domains since clinical engineers themselves are considered the most suitable experts to perform that kind of activities. According to David and Judd (2020), the transition into health programs concerning the increasingly fundamental role addressed to health technologies, requires the employment of trained competent clinical engineers professionals (David & Judd, 2020). In their article, the authors describe the extensive study of published data on the extraordinary contributions given by clinical engineers who, thanks to their abilities and expertise, have positively affected patient outcomes (ibid.). The results obtained by their study show that every region of the world, including middle and low-income regions, faces several challenges to improve the health services of their countries. These challenges also include varying levels of infrastructure and human resources capacity issues. In these circumstances, clinical engineers play essential roles during all stages of healthcare technology life-cycle management, from selection to disposal (David & Judd, 2020). Therefore, in each stage of the technology life-cycle, the requirement for well-trained clinical engineers makes a critical difference.

2.1.1 HTM Implementation

The WHO (2017) identifies different four main areas to describe HTM and to assess its implementation around the world. In particular, these areas include:

- Health technology management unit: a designated unit within the ministry of health at federal/national level that technically manages medical devices.
- Health technology incorporation:
  - Procurement: specific national guidelines or policies on the procurement of medical devices.
  - Donation: national policies or guidelines on donation of medical devices.
  - Technical Specification: any national recommended technical specifications for procurement or donations of medical devices.
- Health technology inventory management: available national inventories for medical equipment.
- Health technology maintenance: available management units with professionally trained biomedical/clinical engineers or technicians.

Because of the several advantages deriving from HTM activities, the WHO and many other authors suggest the implementation of HTM departments, at the national, regional, or local level, to improve the overall health care system (Vilcahuaman & Rivas, 2017) (World Health Organization, 2017)(McCarthy et al., 2014)(Howitt et al., 2012)(Pallikarakis & Bliznakov, 2016)(World Health Organization. Regional Office for the Eastern Mediterranean, 2001). Therefore, various guidelines showing how to correctly implement the aforementioned four areas and various possible levels of implementation have been developed by international and national organizations around the world (Gentles, 2020) with the support of experts in the health care sector. Among the various guidelines, it is possible to detect the ones developed by the WHO (World Health Organization, 2017) (World Health Organization, 2010) and the ones developed by the AAMI (Association for the Advancement of Medical Instrumentation). Focusing on the latter one, one of the most famous guidelines developed is titled 'AAMI HTM Levels Guide' (2016) which is part of an effort by AAMI to standardise and elevate the HTM field (AAMI, 2016). In particular, this guideline stresses the connection between HTM and clinical engineering, adopting HTM as the "new" name for clinical engineering departments in an apparent effort to raise their profiles, although, in most other countries, HTM is considered a subset of clinical engineering activities (Gentles, 2020). Another international guideline is the one developed by the Canadian Medical Biological Engineering Society, titled 'Clinical Engineering Standards of Practice for Canada'(CESOP, 2014), in which there is "an ongoing dialogue between the Society and Accreditation Canada to ensure that they understand the importance of the health technology management function in the Canadian healthcare system" (Gentles, 2020).

All the guidelines developed at the international, national, or hospital level, present a quite linear structure, describing HTM or the procurement process, as a succession of phases, each of them following its chronological orders. Because of the intrinsic connection between HTM's activities

and clinical engineering, all the guidelines indicate the huge importance of involving clinical engineers during the various HTM practices, including procurement. However, it is worth mentioning that, despite political and inter-organizational efforts, according to the results obtained from survey respondents not all the previously mentioned HTM areas and activities are present or equally implemented across and within countries (World Health Organization. Regional Office for the Eastern Mediterranean, 2001). Indeed, despite the improved health outcomes derived from HTM, implementing HTM departments and carrying out the activities they involve could result expensive, time consuming and requires experts.

2.1.2 From HTM to Hospital-based HTM

One of the main takeaways from the literature is that the frameworks and guidelines developed for the implementation, decision-making process, and ethical criteria regarding HTM usually rely on a project-based approach. Therefore, decision-making progresses in several logical phases following each other and in which planning is crucial. Indeed, a project-based approach relies on precision, sharpness, unequivocality, and focus (De Bruijn & ten Heuvelhof, 2018). The guidelines and decision-making frameworks provided by international and national organizations, mainly concentrate on the technical feasibility and safety of the technology, the impact this could have on patients, and the costs associated with the introduction and purchasing of a specific medical device. Without any doubt, these guidelines could be valid in indicating the right path to follow to ensure patient safety and cost-effectiveness. However, two further considerations should be made. Firstly, the evaluative process regarding health technologies, health outcomes, quality of care, etc., should be coherent with the specific necessities of the health care organization, since each of them is concerned with its own geographic area, its own specific patients' epidemiology, the social environment, and financial resources' availability (Palozzi et al., 2019). Moreover, from the analysis conducted by Hinrichs et al. (2013), the authors concluded that "each hospital is a unique entity with unique organizational and safety cultures requiring tailored solutions for overcoming its challenges" (Hinrichs, Dickerson, & Clarkson, 2013). This can be also deducted from the "dispersed use of any national guidance among the stakeholders" (Hinrichs et al., 2013), who were used to place heavier reliance on internal policies, measures, and human resources to control the management of devices (ibid.). Furthermore, focusing on medical device purchasing, it is possible to say that "because of its implications to patient safety on the one hand, and the uniqueness of the healthcare context, requires a unique approach" (Hinrichs, 2009). Secondly, it is fundamental to consider the complexity of the health care system as a whole. According to Kuziemsky (2016), health care includes various elements which constitute a series of interacting parts that work in non-linear and evolving ways (Kuziemsky, 2016). The complexity of health care delivery is what differentiates decision-making in health care from other domains (ibid). Kuziemsky also noticed that an additional challenge related to health care is that the decision-making concerning financial, human resource, or service delivery, is typically carried out separately from the context of how healthcare delivery should be provided (Kuziemsky, 2016). This suggests that although national guidelines could help health care managers in their decision-making process, each health care organisation is

heavily context-dependent and needs to develop its own strategies. Therefore, it would be meaningful to shift from a HTM to hospital-based HTM (HB-HTM) analysis. Therefore, this thesis project will focus on HB-HTM, intended as all the HTM activities performed at the hospital level. More specifically, this study will concentrate on one of the main activities of HB-HTM which will be defined as hospital-based procurement (HB-Procurement).

Taking into account that HTM can be considered as the last puzzle's piece concerning the health technologies domain (Fig. 2.3), it would be sensible to also make a parallel comparison between HB-HTM and the already developed concept of hospital-based Health Technology Assessment (HB-HTA). Preliminary evidence indicated that in the case of Health Technology Assessment (HTA), even if the HTA reports developed by national or regional HTA agencies are generally easily available, clinicians and hospital managers perceive them as connected only loosely to their daily clinical and management practices (Sampietro-Colom et al., 2015). Moreover, "preliminary evidence shows that HTA activities at the hospital level can improve efficiency in hospital budget management and also contribute in a real, positive way to decision-making" (ibid). Palozzi et al.(2019) point out that starting from health technology's introduction into a hospital context, the assessment process is closer to clinical practice and to the managerial strategies of the hospital (Palozzi et al., 2019). Therefore, "during the different stages of uptake of HTs in hospitals, there is a transition from HTA, conducted by national/regional agencies, to HB-HTA, performed "in" and "for" hospitals"(Palozzi et al., 2019). Accordingly, the main difference between HTA and HB-HTA is that the last one is "tailored to the hospital context and help in managerial decisions" (Palozzi et al., 2019).

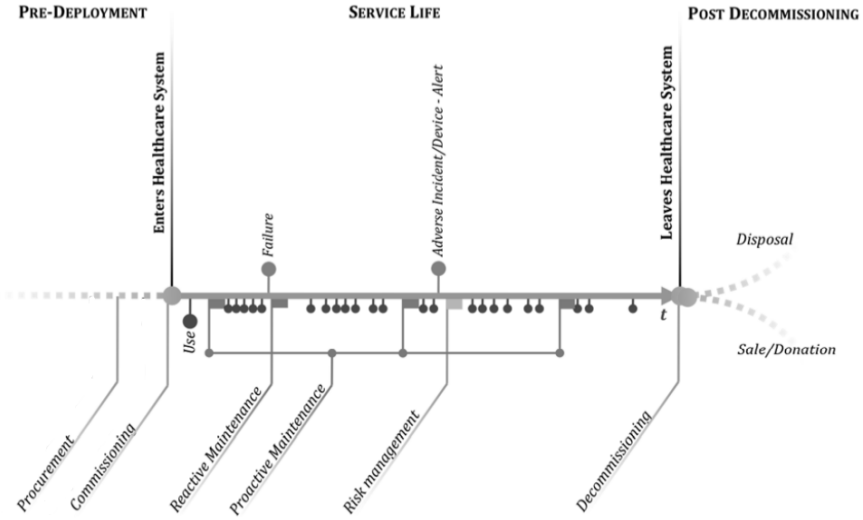
2.1.3 Why Focusing on Procurement

From medical devices' procurement to their disposal, HB-HTM activities accompany the entire health technology's operational life. Therefore, the management of medical equipment can be defined by events throughout the entire device's life. Moreover, this last one can be seen as a series of interactions among the device itself, users, patients, and its operational environment (Akinluyi et al., 2014). The medical devices' operational life can be divided into three main phases which, according to Akinluyi et al., can be classified as pre-deployment, service-life, and post decommissioning (Akinluyi et al., 2014). Each of these phases is dominated by different HTM activities and involves various stakeholders, both internal and external. The pre-deployment phase involves all the activities performed before the medical device effectively enters the hospital, mainly related to the procurement process and commissioning. The second phase, named service life, starts with the use of the medical device and continues with monitoring/checking practices, maintenance, and the decommissioning of the technology. Lastly, during the third phase, post-decommissioning, the medical device leaves the hospital structure and two directions can be undertaken: complete disposal of the device or transfer/sale of this last one to other structures or countries (Fig. 2.4).

This research project will mainly focus on the first phase of the device's operational life with particular attention to procurement, which is affected by both intra-organizational and extra-

organizational factors. 'Procurement' usually refers to the process of managing activities according to the organization's need of purchasing extra or new goods and services, with the scope of delivering their products and services or operating the organization (ICG, n.d.). Therefore, the term 'procurement' usually implies a broader sense of 'purchasing' and involves determining and selecting the best commodities or service, choosing the right suppliers, negotiating the best prices, and signing contracts to ensure that the correct amount of the product or service is received on time (Hinrichs, 2009). Thus, it is possible to assume that the procurement process dominates the entire pre-deployment phase, which consequently affects both the future use of the device and its future disposal. Moreover, as previously mentioned, one of the main problems characterising medical devices concerns their selection, which is considered as one the most important preliminary phases characterising the whole procurement process.

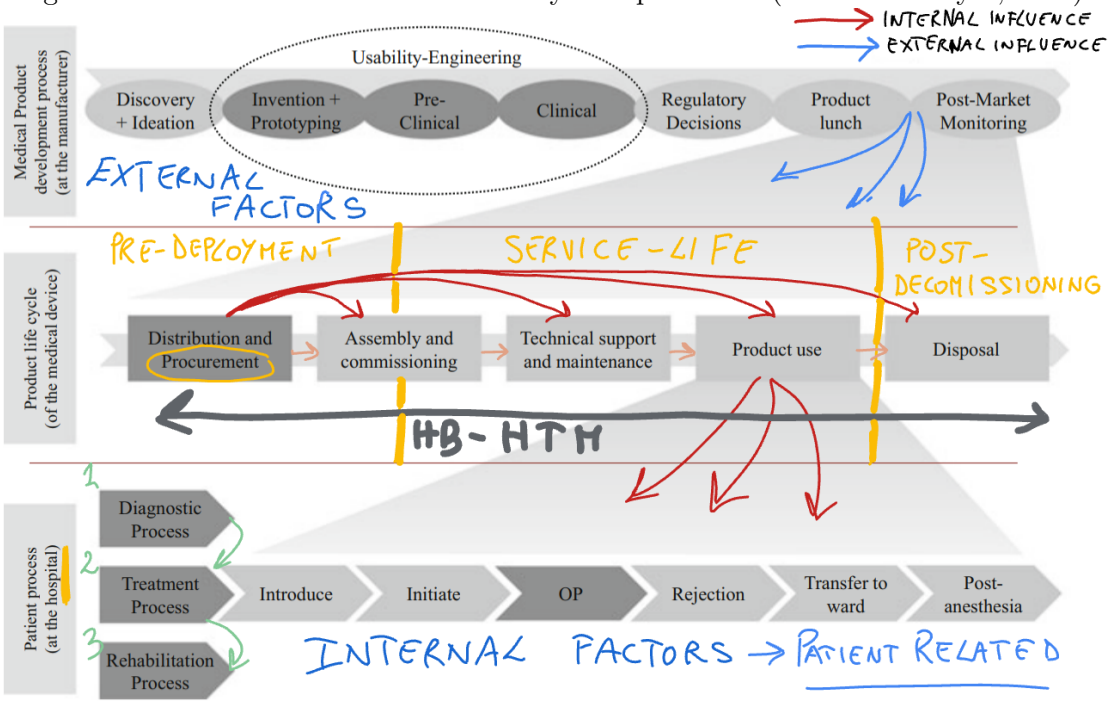
Figure 2.4: Medical Device's Operational Life. Adapted from (Akinluyi et al., 2014)



Usually, goods are always followed by a service component (Driedonks, Gevers, & van Weele, 2010), often supplied by the manufacturer with a service arrangement that covers installation, commissioning, training, maintenance, software, and spare parts (Madhlambudzi & Papanagnou, 2019). Both the choice of the supplier and the development of a suitable contractual agreement are fundamental factors characterizing the procurement activities. Therefore, the choice of focusing on procurement rather than other HB-HTM activities relies on the extreme importance of both the procurement process itself and the decision-making involved in it, which could potentially affect a large part of all the other HB-HTM activities during both the service-life and post-decommissioning phases. Evidence of this relies on the assumption that a proper selection of medical devices, having characteristics following the hospital's needs and being both cost-effective and reliable, will certainly facilitate their management during the subsequent stages of their life. Consequently, despite the linear conceptual model of Fig. 2.4, the three previously mentioned phases characterizing the device's operational life can be considered as interconnected with each in a non-linear and context-

dependent way Fig. 2.5. This last sentence is at the base of the main objective of this thesis project, as described in Section 1.2, and will be further stressed throughout the whole study through the results obtained and the author's discussions.

Figure 2.5: Procurement Inter-connectivity. Adapted from (Gurtner & Soyez, 2015)



2.2 Management in Networks

Management in Networks can be considered an alternative discipline that describes and supports the management of complex systems characterized by several stakeholders, different values and multiple interests. The literature on network management can be summarized around seven main points:

- Activation and coordination of network relationship (Lewis, Baeza, & Alexander, 2008), (De Bruijn et al., 2010)
- Skills and strategies of managers (De Bruijn & ten Heuvelhof, 2018), (McGuire, 2002), (O'Leary, Choi, & Gerard, 2012)
- How variability in managers' position, resources and skills affect network performance (Provan & Kenis, 2008), (McGuire, 2002), (Klijn & Koppenjan, 2012)
- Network governance (Ansell & Gash, 2008), (Klijn & Koppenjan, 2012), (De Bruijn & ten Heuvelhof, 2018), (Milward & Provan, 2003), (Osborne, 2006)

- Network characteristics and decision-making (De Bruijn & ten Heuvelhof, 2018), (De Bruijn et al., 2010)
- Management in network strategies (De Bruijn & ten Heuvelhof, 2018), (McGuire, 2002), (Milward & Provan, 2003), (De Bruijn et al., 2010)
- Network management roles (Bevir & Waring, 2020), (De Bruijn & ten Heuvelhof, 2018)

2.2.1 Networks' Characteristics

To better understand how managers should behave in a network and which strategies could be considered as valuable, it is important to first understand what are the main factors and phenomena characterizing a network. According to de Bruijn and ten Heuvelhof (2008), the governance of an interconnected world is characterized by three main factors which can be intended as the presence of interdependencies, unstructured or 'wicked' problems, and dynamism (De Bruijn & ten Heuvelhof, 2018). The first important characteristic, interdependencies, derives from the presence of a large number of parties or actors such as governments, companies, citizens, profit and non-profit organizations, etc. It is interesting to discover that each of these stakeholders has different interests and each of them is dependent on the other: nobody can achieve anything without the support of others. Therefore, these interdependencies result in a multitude of relationships giving origin to the so-called network. It is worth mentioning that the world as a whole has become a network, but nations, regions, and local communities can be equally considered as a network, which can be ideal-typed as the opposite of a hierarchy (De Bruijn & ten Heuvelhof, 2018). The second characteristic of an interconnected world concerns the types of problems that must be solved in such a world, which are often defined as 'unstructured' or 'wicked' (Rittel & Webber, 1973). The adjective 'unstructured' refers to ideal-typed problems as the opposite of the structured ones. More specifically, when the facts are ambiguous and the normative consideration is difficult to objectify, it is possible to detect an unstructured problem. Moreover, when these last ones have to be solved in a network involving many actors presenting different interests and values, there is a high probability that the actors will not agree about data, system boundaries, methods and the normative weight of different components (De Bruijn & ten Heuvelhof, 2018). The last characteristic, dynamism, can be considered as the opposite of what is intended with stability. It is possible to detect two types of dynamics. The first one depends on the behaviour of the actor in the network. The second represents the content of the problem. These two types of dynamism can reinforce each other. Therefore, when actors, enter or exit the scene, the problem's content will constantly shift, since they will have their own definitions of the problem.(De Bruijn & ten Heuvelhof, 2018).

2.2.2 Management in Networks Strategies

Various strategies have been developed to help managers of both public and private organisations to deal with all the issues that a network presents. This thesis project will rely on two main books and three main authors: 'Process Management: Why Project Management Fails in Complex Decision Making Processes' (De Bruijn et al., 2010), and 'Management in Networks' (De Bruijn &

ten Heuvelhof, 2018). These two books have been chosen because of their completeness in analysing the topic and because of the several concrete examples provided. The authors have analysed the problem of management in networks in a very satisfactory way, providing valid reasons supporting the use of a process-based approach as well as the challenges and limitations related to a project-based one. Further details on these two approached will be provided in the next paragraphs.

Process-based vs Project-based Approach

The so-called process-based approach is at the base of the entire discussion carried out in the two books. More specifically the two types of approaches (process and project-based) and their visions have been compared in relation to several factors such as problem formulation, goal determination, information gathering, decision-making, implementation, and evaluation (see Appendix C).

In a network, an actor who defines a problem must be aware that probably the problem does not exist, but there is 'only' problem perception, and the question is whether other actors have the same perception of the problem (De Bruijn & ten Heuvelhof, 2018) (Guba & Lincoln, 1989). In this case, a problem demarcation could be dysfunctional, since the more clear-cut the problem demarcation, the greater the chance that the other parties will not support the problem definition because of varying interests (De Bruijn & ten Heuvelhof, 2018). Therefore, in many cases, it is more sensible to formulate a problem in broad terms trying to include components that are attractive for many actors (ibid). Moreover, there is the possibility that the solution steers the problem when anyone who knows the problem of the other actor and who needs this other actor, can try to link his own solution to the other actor's problem (Fig. C.1). Regarding the formulation of the goals, clearly formulated goals are not sensible in networks (De Bruijn & ten Heuvelhof, 2018). Indeed, while a project-based approach has a fixed scope that must be monitored, in a network, specifying a scope is problematic since it implies that there is a party that can impose its scope on other parties (ibid) (Fig. C.1). Furthermore, in a network characterised by unstructured problems, the information that underpins the problem analysis is always debatable, and the problem analysis demands nominative choices which, however, are debatable (De Bruijn & ten Heuvelhof, 2018). Therefore, although information is necessary to reach a good or acceptable decision, the same information is often neither objective nor incontestable (ibid.). Hence, it is important to arrive at the so-called negotiated knowledge, indicating that in circumstances in which every party has an individual view of a specific problem and has relevant expertise, all the parties involved must, together, establish what is good information (De Bruijn & ten Heuvelhof, 2018). Regarding the application of a process-based approach to decision-making in a network, this can be defined as the result of a process in which the parties have negotiated on many issues, therefore, the result of the decision no longer comes as a surprise since they have already raised their issues during the consultation and negotiation phases (ibid).

An interesting approach that could be followed during the communication phase is a process-based activity backstage and a project-based communication front-stage (De Bruijn & ten Heuvelhof,

2018). The decision taken following a process-based procedure can also be communicated and justified using project-based procedures. In particular, because of the complexity characterising the various networking relationships and decision-making, the decision could also be communicated in project-based language, to facilitate understanding (ibid) (Fig. C.1, Appendix C). It is important to underline that in a network, the goal is not everything. More specifically, considering that different parties can have different goals and different opinions, parties can change their goals during the process, or parties can also participate in a decision-making process without having a particular goal (De Bruijn & ten Heuvelhof, 2018).

2.2.3 Making decisions in a Network

An important factor that differentiates a network from a hierarchy is its decision-making process. More specifically, the decision-making process in a network can be considered as unstructured and non-linear, where different actors are involved in the process and nobody can solve the problem alone. Moreover, the whole decisional process develops through irregular rounds, during which actors reach a decision or maybe do their utmost to prevent a decision from being reached (De Bruijn & ten Heuvelhof, 2018). Therefore, actors can and should act strategically, adapting their behaviour to reach a precise scope. The entire decision-making process evolves in multiple arenas and each stage does not have clear starting and finishing points. This is usually explained using the theory of the 'dancing table' which moves from one corner of the room to another according to actors' desires and perspectives. Thus, the content of the problem is continuously shifting and actors in a network will, at some point, make a strategic assessment regarding which problems have a chance of being solved and which don't. Always relying on the theory of the 'dancing table', although there is no apparent solution for the problem of the table, there might be a solution for another problem, such as the wall that needs painting. Hence, it would be sensible to concentrate on the problem in the room to be painted and, for the time being at least, to move the problem of the table in the corner to the bottom of the agenda (De Bruijn & ten Heuvelhof, 2018). One of the most interesting aspects characterizing successful decision-making in a network is the advantage of considering and defining a problem as unstructured. Indeed, in a network with many different stakeholders, there are significant incentives to define a problem as "wicked" since the minute a problem is unstructured, the players of the network have room to manoeuvre. They need not be as bound by the information because the information is ambiguous and the normative considerations will become open to discussion to reach a good decision (ibid.).

In order to properly manage a network and reach a final decision, it is fundamental to design the process through which a decision will be reached. The process design presents four core elements: openness, protection of core values, progress, and substance (De Bruijn et al., 2010). These design principles, described in Fig. 2.6, should be followed by the organisation's members to facilitate networking management. Each of these four elements follows each other and provide the base from which an acceptable decision can be reached even when the situation is characterised by wicked problems and excessive complexity (Fig. 2.7).

Figure 2.6: Design Principles. Retrieved from (De Bruijn et al., 2010)

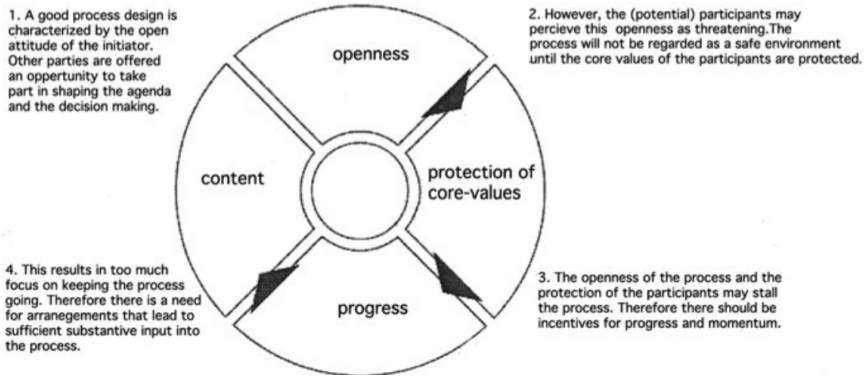
Openness
1. All relevant parties are involved in the decision-making process
2. Substantive choices are transformed into process-type agreements
3. Both process and process management are transparent

Protection of core values
4. The core values of parties are protected
5. Parties commit to the process rather than to the result
6. Parties may postpone their commitments
7. The process has exit rules

Progress
8. Stimulate 'early participation'
9. The process carries a prospect of gain
10. There are quick wins
11. The process is heavily staffed
12. Conflicts are addressed in the periphery of the process
13. Tolerance towards ambiguity
14. Command and control are used to maintain momentum

Substance
15. Substantive insights are used for facilitation. The roles of experts and stakeholders are both bundled and unbundled
16. The process proceeds from substantive variety to selection

Figure 2.7: The four elements of process design. Retrieved from (De Bruijn et al., 2010)



The first strategy involves actor analysis, since all actors in a network want to know which of the other actors they need to reach a decision (De Bruijn & ten Heuvelhof, 2018). During the actors' analysis, it is important to consider and understand which actors' support is necessary to reach a decision, what are their opinions, what are their interests, and which resources these actors have (ibid). While performing an actor analysis it is also valuable to consider the power and the influence each actor has in the network and the types of relationship among the various stakeholders. During an actors' analysis, it is possible to encounter various problems related to uncertainty or actors' reluctance in exposing their ideas and values. The 'Reputation Method' represents a possibility to overcome these challenges. More specifically, while using the reputation method the 'analyst' not only asks actors about their own opinions, interests and values, but he/she also makes them questions about their points of views regarding the opinions, interests and values of others actors in the network (De Bruijn & ten Heuvelhof, 2018). The second strategy refers to the maintenance of the relationships since they are considered as an important tool for actors, providing more

possibilities to acquire the support of other actors (De Bruijn & ten Heuvelhof, 2018). It should be mentioned that relationships have at least two functions. They are advantageous for actors when it comes to acquiring information and they can strengthen the actor's strategic positions within a network (ibid.). The last strategy involves process management. In particular, considering the various problems that need to be solved within a network of interdependencies and taking into account that they are unstructured and non-stable (De Bruijn & ten Heuvelhof, 2018), the decision making processes will follow the four paradigms of a process-based approach (openness, content, progress, and protection of core values). Decision-making will progress less erratically if it is based on these four principles since they can be translated into agreements reached by parties regarding the way in which the process will proceed (De Bruijn & ten Heuvelhof, 2018). These agreements want to specify entry and exit regulations, how the decision will be reached, how conflicts will be managed, how the decision-making will be organised, and lastly, how planning and budget allocation will proceed (ibid.).

Command and Control in a Network

According to the characteristics of a network and the main principles at the base of process management, often, using command and control is not the best way to reach a decision. Indeed, although command and control may seem decisive, it often lacks the knowledge and power to implement its own views, and will therefore be met with considerable resistance in the network (De Bruijn et al., 2010). This resistance could potentially obstruct, delay or change the project, in addition to destabilisation issues affecting the various networking relationships. Moreover, since a network can be considered as the opposite of a hierarchy, the application of hierarchical management may be highly counterproductive: while the manager may appear to be decisive, he only creates resistance (De Bruijn et al., 2010). Therefore, it is possible to assume that the resistance in the network is directly proportional to the level of hierarchy dominating the network itself. During these circumstances, goals will not be achieved and plans will not be realised (De Bruijn et al., 2010). Thus, once the manager becomes aware of having a function in a network, he/she cannot simply rely on hierarchical managing mechanisms, since he/she can not assume that other parties will automatically support him (ibid). Once the manager recognises the presence of a network and his/her role within the network, then he/she will not make unilateral decisions, but decides to follow a process of consultation and negotiation with other parties (De Bruijn et al., 2010). The processes of both negotiation and consultation can not be avoided in a network since they reflect the mutual dependencies of the network itself.

Although command and control do not represent the best option to reach a decision, there are a number of opportunities for using command and control within a network where an actor has the means available (De Bruijn & ten Heuvelhof, 2018) (Fig. 2.8). The most relevant cases of smart command and control are the following. It is possible to apply command and control by threatening command and control to influence other actors' perceptions of gain since decision-making in networks will probably succeed when there is a win-win situation (De Bruijn & ten Heuvelhof,

2018). Indeed, it is possible to talk about smart command and control when the actor is able to implement this threat with the aim of influencing actors' perceptions of their gain and loss (ibid). Furthermore, there is the possibility of using command and control when the process is not going to plan (De Bruijn & ten Heuvelhof, 2018), and in this case, it is possible to talk about 'passive threat'. Another way to apply smart command and control is to use them as an incentive for a process, or better, to get the process of consultation and negotiation started (De Bruijn & ten Heuvelhof, 2018). Moreover, command and control can be used smartly when a process of collaboration has failed and so when parties in a negotiation process are not able to reach a consensus, therefore, a unilateral, hierarchical intervention will take place (De Bruijn & ten Heuvelhof, 2018). Additionally, command and control could be used to impose a procedure on actors that needed to be followed in the decision-making process, without impacts on the contents of the decision to be made (De Bruijn & ten Heuvelhof, 2018).

Figure 2.8: Smart Command and Control. Retrieved from (De Bruijn & ten Heuvelhof, 2018)

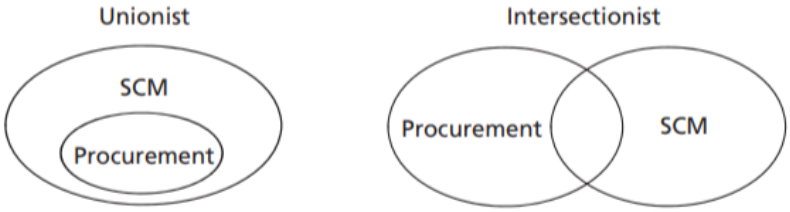
1	Threatening command and control in order to influence other actors' perception of gain – an active threat
2	The shadow of hierarchy: command and control may also be utilised when the process is not going to plan
3	Command and control as an incentive for a process
4	Command and control, when collaboration has failed
5	Command and control in terms of procedures
6	Regret minimisation: command and control but offering space at the same time
7	The good and bad guy with the command-and-control approach
8	Command and control when there is a critical mass of winners
9	Radiating success: command and control in public performance

2.3 Theories applied to Procurement

There are different theories, paradigms and ideas about procurement and supply chain management. It is worth mentioning that there are also different ideas and conceptual models explaining what is, if any, the difference between procurement and supply chain management. In our case, the procurement process is seen as one of the main phases characterising the medical device's operational life and consequently as one of the main activities determining Hospital-based Health Technology Management (HB-HTM). In particular, from the definition of HTM provided in Section 2.1, it is possible to assume that, in the case of health technologies adopted and used within the health care sector, the supply chain management of health technologies is part of or coincides with HB-HTM by definition. More specifically, considering the unionist and intersectionist perspectives of Procurement and Supply Chain Management (Fig. 2.9), both of them support the idea that Supply Chain Management involves the coordinated management of an organisation's upstream and downstream relationships (Sanderson et al., 2015). Consequently, in very broad terms, these theories suggest that Supply Chain Management encompasses several activities and functions including procurement. Therefore, shifting this concept to the health care sector and focusing on the

management of health technologies with the purpose to deliver health care services, it is possible to assume that Supply Chain Management coincides with what is intended with HB-HTM.

Figure 2.9: Unionist and Intersectionist vision of Procurement and Supply Chain Management. Retrieved from (Sanderson et al., 2015)



According to the review conducted by Sanderson et al. (2015), there are four main theories applied and used to study Procurement and Supply Chain Management:

- Organisational buying behaviour: The various paradigms and theories developed around the concept of organisational buying behaviour are based on the political aspects of the so-called organisational sociology. Therefore, it takes into account actors' bounded rationality and conflicts characterising the intra-organisational decision-making that can be solved by means of power and persuasion (Kohli, 1989) (Ryan & Holbrook, 1982). In their article, Johnston and Lewin (1996) reviewed some of the most relevant organisational buying literature of those years and identified four constructs that have often been used in previous organizational buying behaviour research: purchase characteristics, organizational characteristics, group characteristics, and participant(s) characteristics (Johnston & Lewin, 1996). From these considerations, the authors developed an integrated model of organizational buying behaviour which can be considered as the results of various models and frameworks indicating how to proceed with the decision-making process (Johnston & Lewin, 1996). It should be stressed that those previously developed models and frameworks stress the importance of looking at the organisational buying behaviour as the combination of several multicultural and multi-actor phases (Tanner Jr, 1999). Another concept related to the organisational behaviour theory is the risk associated with procurement decision-making (Sheth, 1973). Indeed, the particular decisional rules followed during the different procurement situations can be considered as strictly firm-specific (Johnston & Lewin, 1996) and risk-related.

- Economics of Contracting (Agency Theory and Transaction Cost Economics Theory (TCE)): On the one hand, agency theory mainly focuses on principal-agent relationships. In particular, it involves situations during which the principal influences how specific procurement activities are conducted to facilitate the realisation of his/her interests rather than those of another party, the so-called agent (Jensen & Meckling, 1976). Usually, the literature describing those theories aims to understand issues related to control, opportunistic behaviour, and ownership within business organisations (Jensen & Meckling, 1976) (Fama & Jensen, 1983). On the other hand, TCE is more focused on the issues related to buyer-supplier interactions. In particular,

it aims to identify the most efficient way to proceed with business transactions taking into account the bounded rationality characterising the actors involved (Baumol, 1986).

- Networks and inter-organisational relationships: This type of literature mainly focuses on inter-organisational relationships, with particular attention to how to manage supplier relationships, improve performance, and enhance innovation (Oliver, 1990). The networks and inter-organizational literature applied to procurement and supply chain can be divided into three main groups. The first one, supported by authors like Turnbull et al. (1996), sees the buyer-supplier relationship as the unit of analysis paying attention to both the economic and behavioural aspects related to such a relationship (Turnbull, Ford, & Cunningham, 1996). The second group focuses on the concepts of focal and strategic networks based on the idea of bounded rationality. Focal networks refer to the actors' perception of the network (Alajoutsijärvi, Möller, & Rosenbröijer, 1999), while strategic networks are intended as intentionally designed networks (Möller & Rajala, 2007). Moreover, the authors analysed different characteristics of various power structure and the presence of various power regimes involving one or more buyer-supplier interrelations (Emerson, 1962).

- Integrated supply chain management: This type of literature focuses on three main concepts: logistics processes/activities, operations management procedures, and management of materials and services. Like Macbeth and Ferguson (1994), some authors pay attention to the cooperation between buyer-supplier which could facilitate innovation and value gaining in the long term. Other authors addressing the theory of integrated supply chain management mainly focus on mathematical models or on the concepts of lean and agile supply chain (Christopher, 2000) (Womack & Jones, 1997).

Fig. 2.10 illustrates how among the four above-described theories, only one, organisational buying behaviour, identifies the buying centre (multi-actor) and the process steps/stages as the unit of analysis, while the others mainly focus on buyer–supplier transaction/relationship. Focusing on the application of networks theories to the procurement process, the authors have mainly used and developed these theories around the external network characterised by the buyer-supplier interdependence and little attention has been paid to intra-organisational relationships. Sanderson et al. (2015) indicated in which step of the device's operational life these theories are usually applied by dividing the operational life into different phases and sub-phases (Fig. 2.11), mostly in line with what is depicted in Fig. 2.4. Focusing on the network's theories, it is clear how these last ones are applied to the inter-organisational relationships and once the relationship with the supplier has been established (Fig. 2.11). Therefore, they are mainly put in application during the service-life and post decommissioning phases (Fig. 2.4). Moreover, although organisational buying behaviour theory considers the presence of internal conflicts of interests and pays attention to intra-organisational interactions, it does not consider fundamental paradigms at the base of the networking theories described in Section 2.2 and that will accompany the whole thesis project. In particular, the organisational buying behaviour theories developed and applied to procurement do not stress the importance of functional and non-functional relationships, overestimate the role of

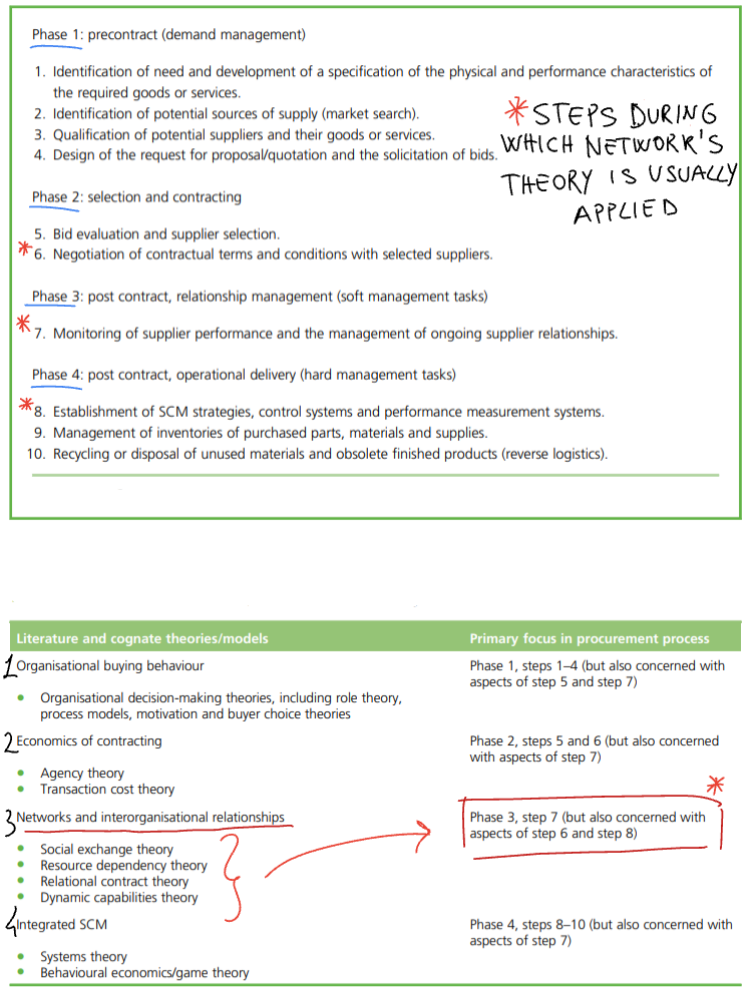
power and persuasion, do not mention the importance of negotiations and, lastly, do not address the four paradigms of openness, protection of core values, progress, and content at the base of process-management and management in networks.

It should be mentioned that in their literature review Sanderson et al. (2015) were mainly focused on the external relationship between buyer and supplier and no attention has been paid to the literature addressing the internal or hospital-based interactions. This phenomenon derives from the fact that the procurement literature itself is mainly, or purely, focused on the external buyer-supplier relationship, underestimating internal issues and interactions. Indeed, some of the critiques addressed to the organisational buying behaviour by other author are: little focus on the importance related to the buyer–supplier relationship, mediocre analysis of the benefits obtained from suppliers such as good delivery costs, and excessive focus on the buying organisation and its way of proceeding with the purchasing (Wilson, 1996).

Figure 2.10: The four theories summarised. Retrieved from (Sanderson et al., 2015)

Literature and cognate theories/models	Contextual assumptions	Key explanatory mechanisms	Intended outcomes
Organisational buying behaviour			
• Organisational decision-making theories, including role theory (who buys?), process models (what are the steps?), and motivation and buyer choice theories (what influences specific buying decisions?)	• Units of analysis are the buying centre (multiactor) and the process steps/stages • Actors have differing motivations and preferences • Actors have bounded rationality • Inevitable conflicts in decision-making are resolved either through persuasion or through power and politics	• Characteristics of the buying centre (size and complexity, experience and expertise of members) • Handling of conflict in buying centre • Nature of decision rules and information search • Purchase history (nature of buyer–supplier relations)	• Minimisation (mitigation) of purchase risk in supplier selection decision
Economics of contracting			
• Agency theory • TCE	• Unit of analysis is the buyer–supplier transaction • Buyers and suppliers have differing motivations and preferences – potential for opportunism • Buyers either have bounded rationality (TCE) or face information asymmetry (agency) • Buyers face different opportunism problems (adverse selection, moral hazard, hold-up)	• Contractual (agency) or governance (TCE) safeguards as a vehicle for monitoring and control of supplier behaviour	• Minimisation (mitigation) of supplier opportunism to achieve agency or transaction cost efficiency
Networks and interorganisational relationships			
• Social exchange theory • Resource dependency theory • Relational contract theory • Dynamic capabilities theory	• Units of analysis are the buyer–supplier relationship and its position in a wider network of relationships • Firms do not own all of the resources they need to succeed • Actors are self-interested and have bounded rationality	• Dynamic interactions between buyers and suppliers over time • Appropriate relationship and network design/development to control dependency on others • Emergence in some cases of collaborative, high-trust relations (social exchange) • Establishing and maintaining a favourable power position (resource dependency)	• Maximising value appropriation and, when possible, value creation through innovation
Integrated SCM			
• Systems theory • Behavioural economics/game theory	• Unit of analysis is the supply chain (extended enterprise) • Competition is between supply chains, not individual firms • Actors are rational, but may face information problems. They are self-interested, but will co-operate where greater net gains can be had from doing so (repeated interactions)	• Collaboration between buyers and suppliers across an extended chain to build trust and facilitate co-ordinated effort	• Maximising supply chain efficiency (leanness) or responsiveness (agility) as a basis for the firm to achieve competitiveness

Figure 2.11: Theories Applied to Procurement and Supply Chain Management. Adapted from (Sanderson et al., 2015)



Phase 1: precontract (demand management)

1. Identification of need and development of a specification of the physical and performance characteristics of the required goods or services.
2. Identification of potential sources of supply (market search).
3. Qualification of potential suppliers and their goods or services.
4. Design of the request for proposal/quotation and the solicitation of bids.

Phase 2: selection and contracting

5. Bid evaluation and supplier selection.
6. Negotiation of contractual terms and conditions with selected suppliers.

Phase 3: post contract, relationship management (soft management tasks)

7. Monitoring of supplier performance and the management of ongoing supplier relationships.

Phase 4: post contract, operational delivery (hard management tasks)

8. Establishment of SCM strategies, control systems and performance measurement systems.
9. Management of inventories of purchased parts, materials and supplies.
10. Recycling or disposal of unused materials and obsolete finished products (reverse logistics).

Literature and cognate theories/models	Primary focus in procurement process
1 Organisational buying behaviour • Organisational decision-making theories, including role theory, process models, motivation and buyer choice theories	Phase 1, steps 1–4 (but also concerned with aspects of step 5 and step 7)
2 Economics of contracting • Agency theory • Transaction cost theory	Phase 2, steps 5 and 6 (but also concerned with aspects of step 7)
3 Networks and interorganisational relationships • Social exchange theory • Resource dependency theory • Relational contract theory • Dynamic capabilities theory	Phase 3, step 7 (but also concerned with aspects of step 6 and step 8)
4 Integrated SCM • Systems theory • Behavioural economics/game theory	Phase 4, steps 8–10 (but also concerned with aspects of step 7)

2.4 Brief parenthesis on the UK

Since the country subject of this thesis project will be the UK, it is meaningful to provide some details on its HTM implementation, including challenges and guidelines provided. The few details provided in this section helped the researcher to develop the problem statement of Section 1.2. However, more information on HTM challenges in the UK, the current procurement policies, and how these last ones are affecting hospital-based procurement will be provided in Chapter 4, which represents the first part of the results obtained through desk research. From these premises, it should be mentioned that, in addition to what collected from the world wide literature, also in the UK the importance of properly managing health technologies is recognised. According to the EBME (Electronic and Biomedical Engineering) website (2019), adopting a professional approach to HTM meets the regulatory standards for medical devices management, guides best practices for medical devices management policy, and leads to improved practice through improved management

(EBME, 2019). Moreover, the same EMBE website (2019) stresses the considerable importance addressed to procurement among the various HTM activities, stating that refining procurement and its related activities would contribute to reducing both risks and costs (EBME, 2019). In particular, improving practice in procurement will assist in improving practice in the use and maintenance of equipment (ibid). Therefore, "good procurement reduces the variety of equipment types, enabling user training to be more effective, maintenance to be more effective and economies of scale to be achieved, thereby reducing costs" (EBME, 2019). Another added benefit is related to the potential risks associated with the use of equipment, indeed, good procurement practices and risk assessment could strongly contribute to making the patients' environment safer (ibid.).

As mentioned in Section 2.1.1, despite the aforementioned political and inter-organizational efforts, the implementation of the various HTM activities is still weak. In the UK, the NHS is struggling to fund the replacement of health care technologies. This is an issue recognized by all NHS Acute Hospitals, which are 'making do' with old technology, and this impacts patient care and increases costs (EBME, 2019). Moreover, there is increasing recognition of the serious issue of medical devices management, covering the areas of procurement, training, maintenance, and governance (ibid.) within the entire UK. According to the EBME website reports (2017), the main challenges that health care managers have to face to follow the MHRA (Medicines and Healthcare products Regulatory Agency) guidance on HTM implementation, are derived from severe pressure due to shortfalls in financial and personnel resources. More specifically, evidence shows that the UK is facing an increasing issue related to Healthcare Technology which can not be replaced because of lack of funding (EBME, 2019). Indeed, in 2017, "more than 40% of equipment is already past its recommended life" (EBME, 2019). According to the EMBE website (2019), a consistent amount of money savings may be achieved by the adoption of professional Healthcare Technology Management which, however, is not present in the UK (ibid). Moreover, another challenge faced by NHS Trusts is represented by a shortage of capable health care managers who understand how to design and implement new management systems and policies (EBME, 2017). Because of the aforementioned issues characterising the UK health care system, the Government decided to proceed with reforming the current procurement practices. The policies adopted aimed to reduce the NHS non-pay expenditure and have been developed to help hospitals during their procurement activities. In particular, the UK Government has introduced a new centralised system, known as NHS Supply Chain, through which health care managers can easily proceed with the purchasing of medical devices without carrying out all the various tendering procedures (Sanchez-Graells, 2018). Moreover, although currently the procurement activities conducted through the centralised system account the 40% of the whole procurement process, the aim is to arrive to a complete centralisation (Hall et al., 2020).

2.5 Reflections

The literature review stresses the importance of having proper health technology management to improve final health outcomes. Health Technology Management (HTM) involves several activities

that accompany the entire medical device's operational life. Among these activities, procurement and its practices will be the main focus of this research project. Because of the contribution that could be obtained by the various HTM activities, including procurement, its implementation has been promoted by international and national organisations, in addition to several authors describing the advantages obtained. However, despite the guidelines provided to facilitate HTM practices, countries are still facing difficulties in performing procurement activities and properly managing health technologies, and this phenomenon also applies in the UK. It should be mentioned that the guidelines provided, are based on a project-based approach, characterised by linearity and bureaucratic steps. This type of approach can be considered as the opposite of the so-called process-based approach which stressed the importance of stakeholder engagement, negotiation practices, and values accountability. Therefore, although the proposed guidelines and decision-making framework could be satisfactory under the technical and legislative points of view, they do not take into account the complex nature of health care systems and its internal interactions. This phenomenon can also be detected while analysing the theories applied to procurement which, also in the case of networking theories, mainly concentrate on the external networking relationship with the supplier and little attention has been paid to internal networks and conflicts of interests. The importance of considering the internal environment and its characteristics has been stressed in Section 2.1.2, where the author suggested focusing on HB-HTM because of the context-dependency of each hospital and its stakeholders. Indeed, with the term 'hospital-based', the author refers to the internal organisational factors affecting HTM and the same context-dependency can be also addressed to procurement. Moreover, as depicted in Fig. 2.5, the three phases characterising the device's operational life can be seen as interconnected with each other and procurement itself can be seen as the first phase affecting all the subsequent ones. These characteristics of non-linearity suggest looking at procurement from a different perspective, which takes into account the interconnections of the various procurement activities and their relative stakeholders. The approach of focusing and analysing the networking nature of HB-HTM, or more specifically hospital-based procurement, has not been addressed in the current literature and will represent one of the main contributions of this dissertation.

Chapter 3

Research Methods and Strategies

From the literature review carried out in Chapter 2 it is possible to develop three main statements summarising what was found and indicating possible areas for improvements. The sub-questions described in Section 1.2 will be addressed to each statement together with additional minor sub-questions to further investigate the topics under analysis. Sekaran and Bougie (2016) defined an exploratory study as a study presenting one or more of the following characteristics: not much is known about a particular phenomenon; existing research results are unclear or suffer from serious limitations; the topic is highly complex; there is not enough theory available to guide the development of a theoretical framework (Sekaran & Bougie, 2016). It is worth mentioning that, in a more or less pronounced way, all the aforementioned 'exploratory factors' apply to this study. Therefore, both the main research questions and the developed sub-questions present an exploratory nature.

- **Statement 1:** Conducting proper Health Technology Management is tough and this also applies to Procurement because of financial and personnel availability shortages, in addition to the hospitals' poor ability in performing all the procurement activities:
  - **(1)** How are procurement activities conducted at the hospital-level in the UK?
    - How many types of procurement processes can be detected?
    - Who are the stakeholders involved and what are their roles?
  - **(2)** What are the challenges affecting the current practice of hospital-based procurement in the UK?
    - Which factors influence the whole purchasing process and final decisions?
    - To what extent are clinical engineers involved in the current practice?
    - To what extent are the guidelines followed by health care workers?
- **Statement 2:** Improving procurement represents a valuable solution to reduce the non-pay NHS expenditure; the UK Government decided to do so by promoting centralised procurement activities, aiming to eliminate hospital-based procurement:
  - **(3)** How the current UK health care policies are affecting hospital-based procurement?
    - What are the advantages of going through centralised procurement?

    * What are the possible drawbacks related to centralisation?

- **Statement 3:** 'Management in Networks' theories and strategies are used in contexts that could be defined as complex and interconnected:
  - **(4)** To what extent can the UK hospital-based procurement be categorised as a network?
    * What are the dimensions, factors, and measures related to strategic management in networks?
    * How can the 'network paradigms' be applied to hospital-based procurement?
  - **(5)** What are the possible areas for improvement detected on the current UK hospital-based procurement?

The purpose of this chapter is to provide useful details on how the whole research has been conducted to answer the aforementioned research questions. Therefore, this chapter will focus on the research strategy, the data collection methods, and the possible limitations encountered. The research carried out in this thesis project can be classified as a qualitative type of research, in which network theory and grounded theory have been used to study the complexity of the procurement process at the hospital level, how it works, and how it can be classified. Indeed once the grounded theory has been used to study and depict how the hospital-based procurement works, the network theory, or better its paradigms, has been applied to understand to what extent the procurement at the hospital level can be considered as a network. Sub-sequentially, once the study has established that it is sensible to look at the hospital-based procurement from a network perspective, suitable strategies have been proposed to help health care managers to overcome the possible barriers identified.

3.1 Overview of Research Process

The research process followed during this thesis project mainly relies on the one described by Sim and Wright (2000) (Sim & Wright, 2000) (Fig. C.1), while the elements of the research design have been selected according to what reported in the book 'Research Methods for Business: a skill building approach' (Sekaran & Bougie, 2016), which has been read and studied by the researcher during the master's course Management of Technology. The first phase of a research process coincides with the research paradigm, defined as the researcher's worldview or theoretical perspective (Mackenzie & Knipe, 2006). Indeed, from this perspective, the researcher examines the methodological aspects of her research project and determines which research methods will be used and how the collected data will be analysed (Kivunja & Kuyini, 2017). More precisely, the starting point of this thesis project coincides with the selection of an interesting topic for the author, Health Technology Management (HTM). During the first phase of the literature review, the author understood the importance related to all the different HTM activities and the challenges faced by the various health care managers in conducting proper management of medical devices. Additionally, she also detected a lack of analysis concerning the application of networking strategies to health care activities, especially to the internal networks that can be identified across the various HTM

practices. Because of time and resource constraints, the author decided to purely focus on a particular aspect of HTM, and due to its importance, procurement has been selected as the main topic for this research. Procurement can be analysed under different perspectives but, since the author is particularly interested in stakeholders interactions and considering the main topics covered by the master's course Management of Technology, the thesis focuses on the actors carrying out procurement activities, their roles and responsibilities, the presence of possible conflicts of interests, and how the 'Management of Technology' theories and strategies could be applied to the health care sector. It should be mentioned that the author decided to focus on the UK for two main reasons. Firstly, several articles describe the UK health care policy, the HTM activities performed in the UK, and the relative challenges. Secondly, since one of the members of the thesis committee has already developed extensive research on the UK health care system, it would have been easier for the researcher to find relevant contacts and information to proceed with the data collection.

The development of the main research question and possible sub-questions indicates the presence of a literature gap and the necessity of further exploring particular aspects of the main research topic. Moreover, it is according to the research's paradigm that the researcher decides which methodology is more suitable to arrive at satisfactory and durable conclusions (Sim & Wright, 2000). Once the methodology and the research questions have been developed, the researcher can proceed with the selection of the most suitable research design. The research design includes several elements, such as research strategies, data collection methods, extent of researcher interference, sampling design, measurement, study setting, unit of analysis, and time horizon (Fig. 3.2).

Figure 3.1: Research Process. Adapted from (Sim & Wright, 2000)

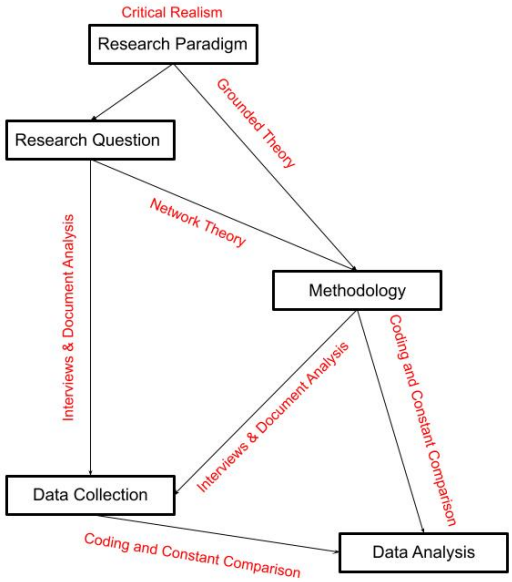
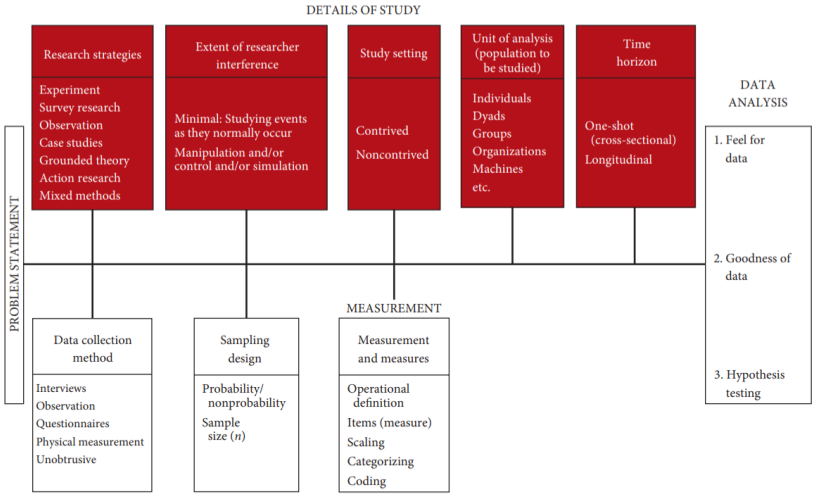


Figure 3.2: Research Design. Retrieved from ((Sekaran & Bougie, 2016); (pag. 96))



3.2 Research Approach

As previously anticipated, the research paradigm constitutes the theoretical principles and credence indicating the way through which a researcher sees the world, his/her interpretation of it, and how he/she acts within that world (Kivunja & Kuyini, 2017). Guba and Lincoln (1982), pointed out that a paradigm comprises four elements, which are epistemology, ontology, methodology and axiology (Guba & Lincoln, 1982).

The first element, epistemology, indicates how the researcher comes to know something. Epistemology is strictly related to the nature of the knowledge, therefore, according to Kivunja and Kuyini (2017), the researcher should ask herself questions like: What is the relationship between me, as the inquirer, and what is known?; how we know what we know?; is it something which has to be personally experienced? etc... To answer these questions the researcher has to consider and differentiate among four types of knowledge: intuitive knowledge, authoritative knowledge, logical knowledge, and empirical knowledge (Kivunja & Kuyini, 2017). In this study, two types of knowledge dominate, authoritative knowledge which relies on data gathered from scientific articles, people in the know, books, leaders in organisations etc., and empirical knowledge, especially used to develop informative and descriptive diagrams, draw conclusions, and articulate discussions.

The second element, ontology, "concerned with the assumptions we make in order to believe that something makes sense or is real, or the very nature or essence of the social phenomenon we are investigating" (Scotland, 2012). Ontology helps the researcher to conceptualise the form and nature of reality and what she believes can be known about that reality (Kivunja & Kuyini, 2017). Therefore, according to Kivunja and Kuyini (2017), the researcher should ask herself questions like: " Is there reality out there in the social world or is it a construction, created by one's own mind? What is the nature of reality? In other words, Is reality of an objective nature, or the result

of individual cognition? What is the nature of the situation being studied?" (Kivunja & Kuyini, 2017). From these basic questions, three main schools of thoughts or philosophical assumptions derive, realism (positivism), critical realism, and relativism (constructionism). The philosophical assumption at the base of this research project is critical realism. This last one acknowledges the existence of reality, whatever it is, but it simultaneously considers the extrinsic influences deriving from individuals' perceptions and cognitions (Bryman, n.d.). It is possible to say that critical realism is a combination of realism and relativism since it can be perceived as a combination of the belief in an external reality (an objective truth) with the rejection of the claim that this external reality can be objectively measured (Sekaran & Bougie, 2016). Therefore, observations, especially observations on phenomena that we cannot observe and measure directly, "will always be subject to interpretation" (Sekaran & Bougie, 2016).

The third element, methodology, articulates the logic and flow of the systematic processes followed in conducting a research project, to gain knowledge about a research problem (Kivunja & Kuyini, 2017). Therefore, it includes all the different elements of the research design. According to Kivunja and Kuyini (2017), the researcher should ask him/herself questions like: How shall I go about obtaining the desired data, knowledge and understandings that will enable me to answer my research question and thus make a contribution to knowledge? This qualitative study has been performed using both grounded theory and network theory methodologies, together with document analysis and interviews for data collection (Kivunja & Kuyini, 2017).

The fourth element, axiology, "refers to the ethical issues that need to be considered when planning a research proposal" (Kivunja & Kuyini, 2017) and it addresses the question: What is the nature of ethics or ethical behaviour? (ibid). To answer this question the researcher has to consider all the human values of individuals participating in the project. In this thesis project, the only value belonging to the various participants was privacy. This last one has been respected according to the procedure that will be further described in the next paragraphs.

3.3 Methodology Selected

The main difference between qualitative and quantitative study relies on the goal of the research. On the one hand, the goal of a qualitative study is to explain a phenomenon or a process also relying on the perception of a person's experience in that given situation (Stake, 2010). On the other hand, a researcher decides to proceed with a quantitative approach when he/she seeks to understand relationships between variables (Creswell & Creswell, 2003). Since the purposes of this study were to examine how the procurement at the hospital levels works, the main challenges detected, and to what extent it can be classified as a network, a qualitative approach was the most sensible choice. Moreover, considering the context of social science, qualitative research can be defined as any research that produces outcomes that cannot be not obtained using statistical procedures or other methods of quantification (Chigbu, 2019). During this study two main research methods have been used. Firstly, this study involves the application of networks theory to the

hospital-based procurement in UK. This has been done once the researcher obtained a satisfactory understanding of how the procurement process works, who are the main actors involved, and what are the main relationships dominating the various procurement activities. Secondly, grounded theory has been mainly used to develop the diagrams describing the activities performed during the procurement phases since, before arriving at the final diagrams, the author has performed a continuous comparison of the data collected.

3.3.1 Management in Networks Theory

Almost every organization, whatever its size is, works among a network of competing interests (De Bruijn & ten Heuvelhof, 2018). This also applies in the case of hospitals, where the environment is characterized by both the complexities related to the development and maintenance of a coherent health system able to provide optimal services and by the complexity of the current relationships between supplier organizations, service providers and products, payers/lenders/insurers, patients, the general public, regulators, researchers, and educators (Eisler, 2002). Therefore, compared to other industries, such as banking and transport, health care is seen not only as a more complex sector but also more emotionally charged (Geisler & Heller, 1996). Moreover, health care can be considered as a sector in continuous transition, characterized by changing economic conditions, changing technology, and changing population demographics which have caused changes in the structure, processes, funding, and management of hospitals (ibid.). These changing factors can be considered as inherent to an interconnected world and usually can only be recognized in hindsight rather than predicted in advance (De Bruijn & ten Heuvelhof, 2018). Without any doubt, the increasing complexity characterizing every sector has raised managers' and policy makers' awareness for a new type of governance and decision-making approach. This new type of approach is based on the characteristics of an interconnected world or more simply network.

Assumptions and Definitions

Once the main characteristics of a network have been illustrated (see Section 2.2.1), it would be meaningful to state the three main assumptions that will accompany the entire research project. Firstly, the term 'network' will be used to describe public decision making and administrative structures involving multiple nodes with multiple links (McGuire, 2002). More specifically, the term will indicate not only social networks or informal models of interaction, but it will be used to describe structures through which public goods and services (such as hospitals services and procurement activities) are planned, designed, produced and provided (ibid.). In this particular case, the network can be seen as a metaphor to describe situations in which one Trust's unit or actor depends on another to perform a task. Indeed, the main scope is not only to merely apply the network's concept to the health care sector but to provide useful insights showing how the UK public administration could be understood though networking theories and how health care managers could deal with and manage network-type contexts (McGuire, 2002). Secondly, the term 'network management' will be used to express the governing function of government or public institutions without relying on command and control processes within a bureaucracy. Practically,

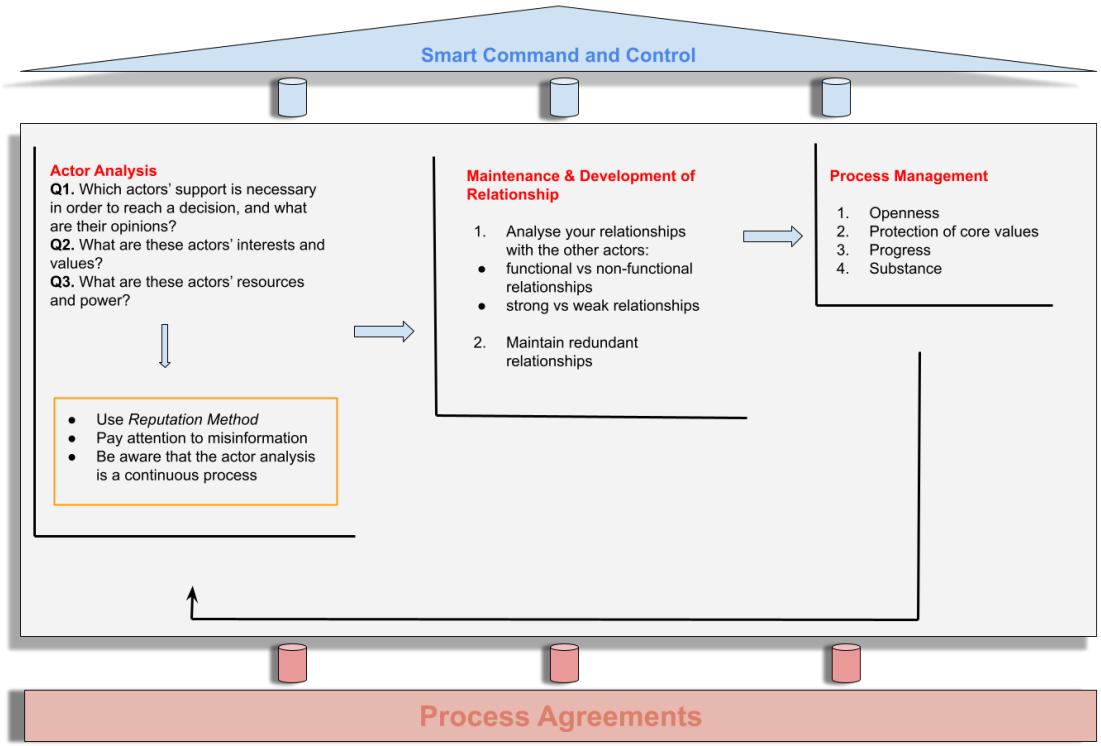
network management "can rely on various leaders at different times playing various roles, all of which may be necessary for the effectiveness of the network" (McGuire, 2002). Therefore, public managers cannot command action in networks directly, but they are still responsible for their results (ibid.). Thirdly, the goal is to analyze what managing the network as a network should involve in the case of hospitals and procurement activities.

Management in Networks Conceptual Framework

The conceptual framework depicted in Fig. 3.3 includes the main factors characterizing proper management in networks, according to the theories developed by de Bruijn, ten Heuvelhof, and in 't Veld (see Section 2.2). The framework does not present sequential phases to follow, since this would not be in line with what the process-based approach upholds. On the contrary, it can be considered cyclical and without a precise beginning or end. Moreover, each of the strategies suggested does not have to be followed sequentially or by a specific organisation's member. Indeed, according to the particular event and actor's position/role, the strategies would be applied differently. At the top of the framework, there is the concept of smart command and control which should be followed in circumstances in which procedures and rules need to be respected and are necessary for the organisation's safety. Putting this concept at the top of the framework indicates that, although the classical hierarchical control would not be effective in a network, it is important to be aware that in particular occasions, such as when cooperation fails, the smart use of control could facilitate the whole decision-making process. Process agreements based on the four main principles of process design (Fig. 2.7) represent the base of the whole conceptual framework. The idea is that decision-making will progress less erratically if it is based on these four principles (De Bruijn & ten Heuvelhof, 2018). The importance of establishing entry and exit barriers, planning and budget agreements etc., will facilitate each actor in the network to individuate the characteristics of the network itself and, consequently, to behave in a more coherent way. Between the smart command/control and process agreements, it is possible to individualise all the actions and strategies that each actor should pursue and follow respectively. One of the most important things is to be aware of the network in which the actor wants to make a decision or wants to obtain something. Therefore, a proper 'actor analysis' will provide fundamental information on how to manage the network. However, it is important to pay attention to misinformation that could provide a wrong picture of the network. Furthermore, the various information about the different actors' opinions and values can be also gathered by asking about the 'reputations' of the other actors. The whole decision-making process is characterised by networking relationships also defined as interdependencies. Thus, having well-organised relationship management represents a stronger information position for an actor. This indicates that when an actor recognises the importance of maintaining relationships, and which kind of relationships are worth cultivating, he/she will have the ability to move within the network in a more conscious way. Well-organised relationship management indicates that the actor is able to recognise between functional and non-functional relationships as well as where it is important to establish weak or strong ties. Finally, the last factors characterising the conceptual framework are the core values of a strong process management (Fig. 2.7). It should be mentioned that although

these core values are depicted as a separate entity in the right corner of the framework, they are intrinsically connected to all the other strategies and actions, and should accompany the whole decision-making process and problem-solving.

Figure 3.3: Conceptual Framework developed by the author from the theories and strategies collected from (De Bruijn & ten Heuvelhof, 2018) (De Bruijn et al., 2010)



3.3.2 Grounded Theory

A strategy can be defined as a plan to achieve a certain goal and answer the research questions of the study. Hence, choosing a particular research strategy will depend on several factors, such as the research's objectives, the research questions, the researcher's perspective on what makes good research, and on practical aspects of the research process, in particular data sources and time constraints (Sekaran & Bougie, 2016). Taking into account all the aforementioned variables, the author decided to proceed with grounded theory. This last one can be seen as a systematic set of procedures with the scope to develop a derived theory or conclusion from the collected data by means of induction (Corbin & Strauss, 1990). It should be mentioned that during this thesis project no theory has been developed. More specifically, the 'grounded approach' has been used to conduct an exploratory study on the current procurement practices and the results obtained have been shown as diagrams. Therefore, the results obtained can not be considered as pure and clear developed theories, but more as valid outcomes obtained though a 'grounded process' providing

additional and novel information on a specific topic.

According to Charmaz (2006), grounded theory involves both positivism and constructionism (Charmaz, 2006). More specifically, constructivist grounded theory relies on an interpretive tradition, while objectivist grounded theory has its roots positivism, from which the concepts of realism and objectivism derive (ibid). On the one hand, the constructionist approach prioritises the phenomenon of the study and perceives both the data collected and the data analysis as deriving from shared experiences and actors' relationships (Charmaz, 2006). On the other hand, the objectivist or realist grounded theory attends to data as real in and of themselves without attending the processing of their production. In this research project a combination of the two grounded theories has been used. This is because the whole project is based on the philosophical vision of critical realism and the data collected come from the combination of already existing sources with new data collected by the researcher. More specifically the conceptualisation of the procurement process has been developed starting from already existing data and refined thanks to the information collected through interviews, which mainly included the personal opinions and experiences of the respondents. Indeed, the diagrams describing the different types of procurement process describe both the 'optimal' process, defined as the one that should be performed by the hospital, and the 'actual' one, which can be defined by the process perceived by the respondents according to their personal experiences. The combination of both the two theories derives also from a practical reason since, because of time constraints, not all the data collected purely from the interviews were enough to proceed with the development of the diagrams. However, most of the information collected to conceptualise the procurement process rely on the constructivist grounded theory.

Important tools characterising grounded theory are theoretical sampling, coding, and constant comparison (Sekaran & Bougie, 2016). During this research project, the process of 'constant comparison' has been fundamental to arrive at substantial conclusions. During this comparison process, the researcher compares data, obtained from an interview for instance, to other data, obtained from other interviews or other sources, in our case scientific articles and grey literature. The process of comparison could be defined as a continuous process and its ending point is mainly determined by time constraints. Indeed, after a theory has emerged from the aforementioned comparison process, the researcher continues to compare new data with that theory (Sekaran & Bougie, 2016). It should be mentioned that in the case in which the theory (diagrams in our case) developed does not match with the new data collected, then the categories and theories have to be modified until your categories and your theory fit the data (ibid). This process has been at the base of the diagrams developed in this thesis project since each of the diagrams can be seen as a source of continuous data comparison until complete matching.

3.3.3 BPMN diagrams applied to Procurement

BPMN stands for 'Business Process Modeling Notation' and it is a flow chart method that models the steps of a planned business process from one extreme to another. BPMN diagrams have

been used to conceptualise the various procurement processes and activities. There are two main reasons behind the choice of using this type of diagrams. Firstly, the author had familiarity with the BPMN diagrams since she had already used them during her master's course. Secondly, according to the literature, BPMN models can be considered as simple and satisfactory tools to address the complexity in health care. More specifically, the explicit design suitable for non-technical users makes it a valid candidate for designing and modeling healthcare processes, where medical staff need to understand and discuss the process models (Müller & Rogge-Solti, 2011). Furthermore, according to Müller and Rogge-Solti (2011), BPMN diagrams are suitable to address the complexity of the health care characterised by many roles participating in one process, several specialists that work together on a shared task, a task that can be performed by several specialists, and a task that can potentially involve additional roles. It is worth stressing that all the aforementioned complexity can be ascribed to hospital-based procurement. More information on the BPMN diagrams can be found in Appendix D.

3.3.4 The Researcher

The researcher holds a Bachelor of Science in Mechatronics Engineering and she is enrolled in the second year of the master's course Management of Technology at TU Delft (The Netherlands). No participant had a direct or indirect relationship with the researcher that could represent a conflict of interest, such as contract relationship, personal relationship or any other type of relationship that may have caused biases in the research study. The researcher has successfully passed the course 'Research Methods' at TU Delft University, which trains master students in performing valid scientific research, from the methodology selection to the data analysis.

3.4 Data Collection

This study used two main types of data collection, document analysis (literature review) and interviews. Document analysis has been used to have a first and general vision of the main topics, to fill potential gaps deriving from the interviews, and to perform the desk research on the UK. Interviews have been used to develop all the BPMN diagrams, to further validate the diagrams, and to collect opinions on specific topics of interest for this research.

3.4.1 Document Analysis

The literature review can be considered as the initial stage of the whole research project since it provides the first details on a specific topic and allows the researcher to identify potential literature gaps. The strategies used to conduct the literature review are:

- *Database keyword search:* Searching process using different databases, such as ScienceDirect, TU Delft Library, Web of Science, and PubMed. Web of Science has been the most used database and the one from which the largest part of the articles and books have been collected. Fig. 5.1 shows some examples of the keywords used, how many results have been obtained, and the amount of articles that the researcher found interesting.

- *General Search Engine:* Google has been used to collect grey literature, including governmental and statistical reports, NHS reports, hospital guidelines and procedures etc.
- *Reference Chasing:* This kind of 'articles collection' technique has been very useful during this research project. It helps the research to collect some of the most interesting and used papers that have been used to develop the whole thesis project.

Figure 3.4: Literature Review searching details

Basic Search (period 1900-2021)

Research Tool	Keywords' number	Keywords	Amount of Sources	Type of research
Web of Science	#1	"Health technology management"	15	Title
Web of Science	#2	"Healthcare technology management"	18	Title
Web of Science	#3	"Healthcare technology management"	47	All fields
⋮			⋮	
Web of Science	#10	healthcare* network* manag*	73	Title
Web of Science	#11	health* professional* model* manag*	18	Title
Web of Science	#12	Hospital-based technology management	437	All fields
Web of Science	#13	health* technolog* manag* competenc*	1	Title
⋮			⋮	

Advanced Search (time period 1900-2021)

Combination	Amount of Sources
#8 AND #9	23
#9 AND #17	2
#15 AND #7	2
#13 AND #5	3
#7 AND #20	2
#21 AND #14	6
#8 AND #14	3
#18 AND #21	39
#17 AND #20	1
#8 AND #18	8
#12 AND #14	1
#14 AND #4 OR #3	51

3.4.2 Interviews

The interviewing method has been used throughout the whole thesis projects. Because of the Covid-19 pandemic and since the researcher does not live in the selected country (UK), all the interviews have been conducted via Zoom. Once obtained the respondent's approval, the interviews have been recorded. At the end of the interview both the recordings and the informed consent form signed by the respondents have been uploaded on SurfDrive, to ensure the safety of information collected and the privacy of the respondents. All the interviews have been conducted with the written and verbal informed consent of the participants and each of them has been interviewed in a single interview session. Each interview has been transcribed manually by the researcher who omitted

both the names of the respondents and of the Trust during the transcription process. The interviews conducted can be classified as semi-structured interviews, although during the interviewing process the researcher asked several open questions to better understand some new concepts introduced by the respondent. However, all the predefined questions have been asked during each interview.

Study Participants

The first step in qualitative sampling is to define the target population (Sekaran & Bougie, 2016). During this qualitative investigation, purposive sampling has been employed, in which subjects are selected according to their expertise in the main subject that is being investigated. In this thesis project two main subjects can be detected: procurement in the UK hospitals and management in networks strategies. Therefore, it is possible to distinguish between two groups of participants, health care professionals, including NHS suppliers, and networks' or procurement experts. In order to respect the privacy of the respondents, neither the names of the Trusts involved nor the ones of the respondents will be mentioned. More specifically, the two NHS Trusts taken as sample will be named 'TrustA' and 'TrustB', while the participants will be identified with general labels such as 'respondent', 'supplier' or 'expert'. The two Trusts considered in the study can be both classified as 'big' Trusts and are located in two different regions of the UK. Five employees working in these two Trusts have participated in the research. Fig. 3.5 shows how many participants from each Trust and their role in the health care sector.

The participants have been found in the following ways. The NHS supplier, Expert 1, and Expert 2 have been recruited through the researcher's existing professional networks. Respondent 1, Respondent 2, and Expert 3 have been recruited thanks to the professional network of one member of the thesis committee, while the other three have been engaged with the help and recommendation of Respondent 1 and Respondent 2. Each participant has been contacted via email by the researcher who used her institutional email (a sample email can be found in Appendix E). Although the research only involves nine participants, the researcher has sent several emails to various possible respondents according to their field of expertise and role within the health care sector. An informed consent form (Appendix F), was sent to participants via email before every interview and required for each participant prior to participating.

Procedures Followed

Approval from the Human Research Ethics Committee was sought from the TU Delft University. The committee also approved the informed consent form to send all the participants before each interview. The researcher contacted personally, using her institutional email, all the participants. In the first email the researcher described the main topic, the length of the interview, and the main objective of the study (a sample email can be found in Appendix E). Once the respondent accepted to participate, the researcher sent him/her a pdf file including the main questions that would have been asked during the interview and the informed consent form which invited the respondent to consent or not to the interview procedures (a sample of the informed consent form can be found in

Appendix F). At the beginning of each interview, the researcher asked for recording permission in order to facilitate her future data analysis.

Figure 3.5: Study Participants

Interviewees' Labels	Info and Details
Respondent 1	Director and Head of Clinical Engineering at Trust A
Respondent 2	Chief Biomedical Engineer & Head of Clinical Engineering at Trust B
Respondent 3	Medical Equipment Capital Portfolio Manager at Trust B
Respondent 4	Medical Equipment Planning Manager at Trust A
Respondent 5	Category Manager (Finance and Procurement Department) at Trust A
Supplier	Supplier of orthopedic medical devices to the UK and other European countries
Expert 1	Management in Networks Expert and Author
Expert 2	Procurement Expert and Author
Expert 3	Procurement and Supply Chain Expert

3.5 Data Analysis

Coding can be considered as one of the main factors characterising grounded theory (Sekaran & Bougie, 2016). Coding of transcripts was completed according to the order of the interviews conducted, allowing the researcher to reflect on the data collected and eventually edit the next interview's questions as interesting theories began to emerge from the data. However, some of the questions used to develop the BPMN diagrams were 'static' during the interviews to maintain consistency. One of the main advantages deriving from interviews' codification is understanding the perspectives of all the participants and analyzing their combined point of views and experiences, and finally building a new theory (new diagrams in our case). All the codes have been developed by the author during the research process, according to the data collected. Both interviews' transcripts and coding was conducted manually and once the transcription was complete, the researcher broke it down into meaningful and manageable chunks of data. This passage helped the researcher to detect the different topics encountered during the whole interview, also facilitating all the subsequent coding process. It should be mentioned that coding helps to prevent the author overemphasizing the importance of any one aspect early during the research project and it also facilitates a deeper and thorough analysis of the whole interview (Charmaz, 2006).

3.5.1 Open Coding

Open coding involves line-by-line coding and it is considered a critical part of grounded theory (Charmaz, 2006). Usually, open coding is carried out by using a few words to describe the data, as suggested by Charmaz (2006). In this research project the researcher has underlined with different colours, each sentence or word referring to different concepts. This method helped the researcher to have a more in-depth focus on every interview. However, this type of coding procedure gives origin to several codes, although many of them were common to various interviews.

3.5.2 Selective Coding

Once the open codes are terminated selective coding begins and involves the creation of categories/constructs. It should be mentioned that often the terms categories and constructs are used interchangeably across the grounded theory methods and articles (Urquhart, 2012). A selective code can be classified as a category and some selective codes may emerge more often than others. During the selective coding process, the researcher strives to find emerging categories and the aim is to have less selective coding than open coding (ibid.). The main idea behind both open and selective coding is that more open coding belong to a certain selective code. Also in this case colours have been used to help the researcher in individuate the various categories. Examples of categories selected are: capital procurement, revenue procurement, clinical engineers involvement, NHS Supply Chain, Challenges etc... In addition to the categories identifies for the development of the diagrams, other relevant categories created during the data analysis process are the ones related to the three characteristics of 'networks'. Indeed, these categories have been named interdependencies, wicked problems, and dynamics. The data included in each of this three categories has been used during the discussion phase to describe to what extent hospital-based procurement can be classified as a network. Furthermore, it should be mentioned that, sometimes, some open coding belonged to more than one category and that the selective coding process has been conducted following the instructions provided by Urquhart (2012) (Urquhart, 2012). The main technique used is to break the main research question into more specific sub-questions, as shown at the beginning of this chapter.

3.5.3 Theoretical Coding

Charmaz (2006) pointed out that the starting point of theoretical sampling or coding can be set once the categories emerge, therefore, once the processes of both open and selective coatings have been completed (Charmaz, 2006). However, there is the possibility of discovering and creating new categories during the theoretical sampling process. In particular, during this thesis project, because of time constraints and since the researcher was not sure about the amount of interviews she would have been carried out, each interview has been codified just after its completion. Urquhart (2013) asserted that theoretical coding occurs when the codes and categories emerged during open coding and selective coding are compared (Urquhart, 2012) and during this comparison procedure all the relevant relationships are found between the codes or categories (ibid.). It is worth mentioning

that the whole coding process can be classified as an iterative process, since new codes should be constantly compared to existing data. This interactive comparing process will allow the researcher to determine if new categories emerge, their relationship with the already existing categories and their relevance for the study. It should be stressed the huge importance that memos can occupy during the theoretical coding process, indeed creating memos will help the researcher to perform a more reliable and constant comparative analysis.

3.5.4 Building the BPMN diagrams

The development of the BPMN diagrams describing the various procurement cases has been characterised by a continuous data comparison. The researcher developed the first diagram according to the data collected by means of desk research. Subsequently, according to the data collected from the interviews, the author has provided further details on the current procurement practices. The whole process can be described as a continuous validation process, in which the researcher asked confirmation to the different respondents regarding the reliability of the diagrams developed. It should be mentioned that the last interviews both with Trust A and B have completely confirmed the ways in which the author has described the procurement activities and cases in their hospitals.

3.6 Trustworthiness and Validity

When interviews or observation are used as means for data collection, trustworthiness and validity of qualitative study are largely related to what the researcher saw and heard during the preliminary phases. One of the ways to increase the trustworthiness of the study is to include relevant participants in the sample and in this case participants with knowledge and background in procurement activities have been selected. A potential factor that could reduce the validity of the research concerns the researcher's biases. Biases can be found during the interviewing process, according to the questions asked and the way in which these are posed to respondents, but eventual biases can also be present during the interpretation of the data collected. Avoiding this last type of biases would increase the confirmability of the whole thesis project. Therefore, to reduce as much as possible eventual researcher bias, the interviews have been manually transcribed and codified to address transferability, and confirmability. It is worth stressing that the use of constant comparative analysis ensured a systematic comparison of the data collected, demonstrating the connection between the analysis performed by the author and the resulting conclusions developed (Charmaz, 2006). Although this study has only analysed one of the main activities of health technology management, the same type of research can be also carried out taking another HTM activity as main topic. Therefore, the results obtained, intended as the applicability of management in networks theory to the healthcare system, present a quite good level of transferability. Focusing on the generalisability of the study, because of the limited number of participants and Trusts involved, this research project has a quite low level of generalisability, especially regarding the specific types of strategies proposed and the areas for improvement detected.

Chapter 4

Result I: Desk Research on the UK

Since this thesis project focuses on the United Kingdom, once the general literature review on HTM, procurement, and management in networks theory has been conducted, the author performed a desk research on almost the same topics but focusing on the UK. In addition to the relative UK-HTM challenges, this chapter will also provide a general understandings of the UK health care structure, the main health care policies affecting procurement, and the current literature describing procurement practices. Moreover, it will also provide details on the networking relationships characterising the UK health system and to what extent network's theories have been applied to the procurement process.

4.1 HTM and Procurement: Challenges and Implementation

Because of the recognised importance addressed to HTM and its activities, in addition to the various international guidelines, the UK itself has developed some frameworks to improve the national HTM. In particular, The Medicines & Healthcare products Regulatory Agency (MHRA) has developed guidance to outline a systematic approach to the acquisition, deployment, maintenance and disposal of medical devices. This guidance mainly developed for health care workers and community-based organizations' employees (Medicines and Healthcare products Regulatory Agency (MHRA), 2021) and can be summarized into eight main areas, in which recommendations and guidelines are illustrated. The eight areas include systems of management, appropriate acquisition and selection of devices, receiving a new device, training, instructions for use, maintenance and repair, decontamination, and decommissioning and disposal (more details are provided in Appendix A) (Medicines and Healthcare products Regulatory Agency (MHRA), 2021). Considering the decision-making factors, to secure the best value healthcare and the greatest health benefit for their populations, twelve criteria grouped in four main categories have been developed by NHS for CPAG (Clinical Priorities Advisory Group) members (NHS, 2013a). Additionally, the NHS Commissioning Board has developed an ethical framework for priority setting and resource allocation whose scope is to provide a coherent framework for decision making, promote fairness and consistency in decision making, and ensure that the reasons behind decisions that have been taken are clear and comprehensive (NHS, 2013b). In addition to the general guidelines indicating the

best practices to follow in order to properly manage medical devices, considerable attention is paid to guidelines related to the procurement of medical devices. Indeed, while the HTM guidelines are usually developed only at the national level, the procurement guidelines are developed by both the NHS and the various hospitals of the UK. The guidelines developed by the various hospitals mainly refer to the structure of the hospital itself and indicate the main activities to perform before purchasing a medical device, in terms of approvals needed and responsibility. The national guidelines on procurement are more focused on the way this last one could be improved within the country and, usually, their aim is to save money. As an example, it is possible to look at the 'Procurement development programme for the NHS' published in 2013 (NHS, 2013), which aimed at saving £1.5 billion from 2015 to 2016 (ibid). The guideline focuses on three main points which are scope for improvement, delivering improvement, and contribution to economic growth, explaining how, with the cooperation of health care workers, they could reduce the national debt related to health care. It is worth stressing that, as explained in Section 2.1.2 and 2.5, also in the UK the guidelines provided are based on linearity, technical specifications, business advice, and bureaucracy. Therefore, also in the UK a project-based approach is observed.

In Section 2.4 the author described some issues characterising the procurement process in the UK which were referring to financial and personnel availability constraints. However, although the aforementioned issues surely inhibit a proper HTM, health care managers have expressed their challenges also in relation to the guidelines and decision-making frameworks provided. Stafinski et al. (2011) have performed a "comprehensive search for published, peer-reviewed and grey literature describing actual national, state/provincial and regional/institutional technology decision-making" (Stafinski, Menon, Philippon, & McCabe, 2011). In the sample, the authors included the "top 20 countries ranked according to GDP per capita by the World Bank and with populations over 1 million" (Stafinski, Menon, Philippon, & McCabe, 2011), which also include the UK. Their analysis shows that, "in general, all processes comprise four sequential components, which begin with specification of the decision problem and end with implementation of the decision" (Stafinski, Menon, Philippon, & McCabe, 2011). Moreover, with few exceptions, instead of precise decision rules, the decision-making process usually follows criteria comprising lists of factors to be taken into account (ibid.). This sort of established scoring process has also been described in the article written by Madhlambudzi and Papanagnou (2019) (Madhlambudzi & Papanagnou, 2019), whose analysis has been carried out in UK hospitals. The article indicates that following the factors included in this 'decision list' does not guarantee that "all aspects were thoroughly considered, such as patient safety, and manufacturer claims were never thoroughly evaluated" (Madhlambudzi & Papanagnou, 2019). Other limitations identified by various decision-makers are related to timeliness, methodological considerations, interpretations of 'value for money', explication of social values, stakeholder engagement, and 'accountability for reasonableness' (Stafinski, Menon, McCabe, & Philippon, 2011) proper of the proposed guidelines and frameworks. Madhlambudzi and Papanagnou (2019) also pointed out issues related to both stakeholder's engagement and identification, saying that throughout their research, "it was ascertained that NHS hospitals do not tend to apply stakeholder analysis as a part of their project planning process. This has in some cases

resulted in leaving out key stakeholders and thereby bringing about conflict and delays in the process" (Madhlambudzi & Papanagnou, 2019).Furthermore, Hinrichs et al. have also identified other main challenges faced by UK hospitals in purchasing medical devices. The first category of challenges is represented by the competencies of the stakeholders in the purchasing process (Hinrichs et al., 2013). In particular, " they operate within different directorates and, hence, had different knowledge and skills bases, as well as different management and clinical imperatives, to make these decisions" (ibid.). Another challenge is determined by the resources in the purchasing process, since "it was observed that the stakeholders from the respective financial, clinical, risk, and maintenance directorates display varying degrees of awareness and use of the external guidelines available to them to aid their purchasing decisions" (Hinrichs et al., 2013).

4.2 Overview of the UK Health Care System

The National Health Service (NHS) is one of the world's largest publicly funded health services and it provides its services to England and the rest of the UK (Venerable & Morales, 2020). The English NHS was created in 1948 and, since its creation, the health coverage in England has been universal. More specifically, under the 1946 National Health Service Act, "the Minister of Health had a duty to provide a comprehensive, free health service, replacing voluntary insurance and out-of-pocket payments" (Tikkanen et al., 2020). Regarding the role of the UK Government, responsibility for health legislation and general policy rests with Parliament, the Secretary of State for Health, and the Department of Health (Tikkanen et al., 2020). Indeed, NHS England can be considered as an arm's-length government-funded body and it is separate from the Department of Health. However, although the NHS presents various responsibilities, such as managing the NHS budget, setting the strategic direction of health information technology, etc., the Government owns the hospitals (Tikkanen et al., 2020).

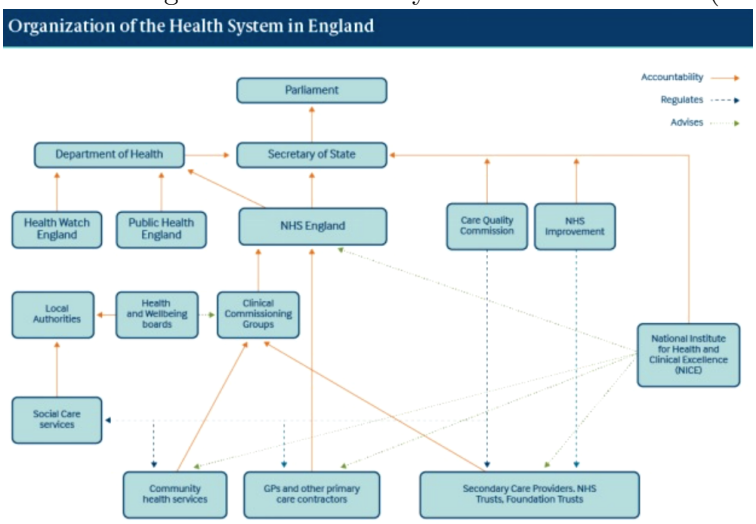
How the system is organized

The structure of NHS England is split into parts characterized by purchasers and providers (Venerable & Morales, 2020). On the one hand, the former ones, called Clinical Commissioning Groups (CCGs), are responsible for 60% of the NHS budget (BMA, 2018), which is mainly used for strategic healthcare planning and the purchasing of healthcare for a defined population from providers of healthcare services (ibid.). On the other hand, providers of care are run by NHS hospitals (Venerable & Morales, 2020). The creation of this internal market between suppliers and providers has been designed to allow competition among providers for commissioner funds (ibid.) and to enhance cooperation. More details on how England's delivery system is effectively organized are shown in Fig. 4.1 which also indicates the main relationships among the different parties.

Hospitals

Publicly owned hospitals in the UK are organized as Trust (NHS Confederation, 2017). Specifically, NHS Trusts are public sector bodies providing services on behalf of the NHS in England and NHS

Figure 4.1: Structure of the English Health Care System. Retrieved from (Tikkanen et al., 2020)



Wales (Farlex, 2012). They "may comprise one or several hospitals, plus various peripheral sites not necessarily owned by the Trust, where clinics may be held and community health services, mental health services and ambulance services are provided, which are managed by their own boards of directors" (Farlex, 2012). Therefore, the words hospital-based and trust-based will be used as synonyms in this paper. To provide their services, all public hospitals need to contract with local CCGs and they are reimbursed mainly at nationally determined diagnosis-related group (DRG) rates, which include medical staff costs (NHS Confederation, 2017). Furthermore, DRG payments account for about 60% of hospital income, while the remainder comes from activities not covered by DRGs, such as mental health, education, and research and training funds (Department of Health, 2017).

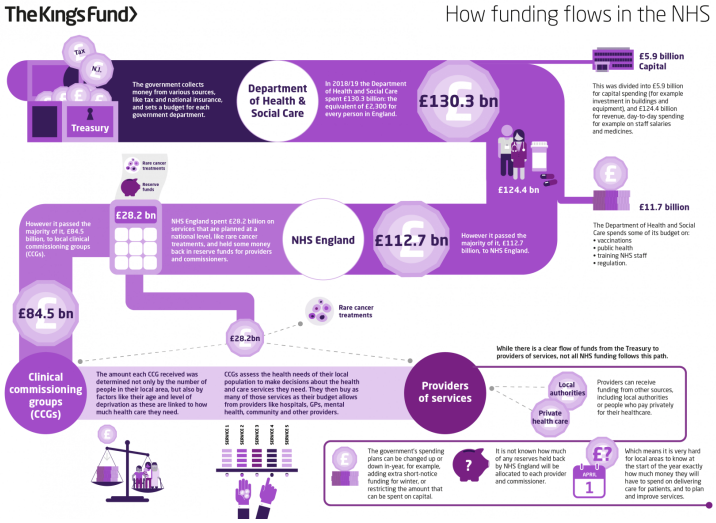
How the NHS is financed

The NHS funding comes from three main sources: general taxation, National insurance, and patient charges ("How the NHS is funded", 2021). The largest part of the funding comes from general taxation and a smaller proportion (20%) comes from national insurance (Tikkanen et al., 2020). Additionally, although the NHS is generally considered 'free', patients have been required to pay for the cost of some specific services, such as prescriptions and dental treatment, since 1951 (McKenna, Dunn, Northern, & Buckley, 2017). Regarding the role of private health insurance, in 2015, almost 10.5% of the UK population had private voluntary health insurance (LaingBuisson, 2015).

The central government establishes the level of NHS funding in a given year through the Spending Review process, which estimates how much the NHS will receive from the three different funding sources ("How the NHS is funded", 2021). However, in the case in which National Insurance or patient charges raise less funding than originally estimated, general taxation is increased in such a way to ensure the NHS receives the level of funding it was originally established for (ibid.). Fig.

4.2 shows how the funding flows from general taxation to health providers.

Figure 4.2: How Funding Flows in the NHS. Retrieved from (*How is the NHS structured?*, 2020)



4.3 Networking Relationships in the UK Health Care

Over the last twenty years, networks have become synonymous with public governance (Bevir & Waring, 2020). They are seen as a 'progressive' alternative to bureaucracy and markets, therefore, networks are usually associated with deliberative policy-making, collaboration, and resource exchange (Ansell & Gash, 2008) (Klijn & Koppenjan, 2012) (Milward & Provan, 2003) (Osborne, 2006). The literature upholds network management as distinct from traditional forms of public management and it is usually analysed as functioning within organizational hierarchies (Bevir & Waring, 2020). The network narrative has become a fundamental feature of contemporary public policy since it is commonly believed that the social, economic and political challenges faced by today's society require the diverse resources and capabilities of different specialists to participate in more inclusive ways and to implement more coordinated solutions (Bevir & Waring, 2020). Moreover, the importance of defining network characteristics and its strategic management has been pointed out by various relevant personalities such as Michael Howlett, Burnaby Mountain Chair, who commented the book 'Management in Network', written by de Bruijn and ten Heuvelhof, saying that "In an increasingly interactive world knowledge of how networks operate and evolve, and how they can be managed effectively, is increasingly important to students and practitioners of public administration, public management and public policy" "the authors developed the idea of "process management" – contrasting it with other forms of such as "project-based" management – highlighting the advantages of using a process lens as a guide to producing better public sector outcomes" (De Bruijn & ten Heuvelhof, 2018).

Traditional public administration was mainly characterized by both centralisation and adoption

of a top-down authority approach of the State. Thus, political decisions were implemented through bureaucratic planning and delegation (Bevir & Waring, 2020). The neoliberal reforms of the 1980s can be considered as the starting point from which more business-like theories, like the New Public Management (NPM), were applied. From that historical moment, several decentralised policy actors became responsible for making and implementing policy decisions, typically based on market-like relations (Bevir & Waring, 2020). The network narrative emerged as a response to the limits of both bureaucracy and markets, by promoting a model of public governance presenting multiple policy actors and shared resources, coming with more joined-up decisions, and establishing more coordinated services (Bevir & Waring, 2020). The new form of public governance, defined as New Public Governance (NPG), aimed to provide a more progressive and democratic approach, dominated by trust, mutuality, commitment, collaboration and co-design, rather than traditional contractual obligation or delegated rules (ibid.). It is possible to say that, "the general thrust of NPM (New Public Management) involved the professionalisation of the public space, performance measurement and output control, disaggregation, competition, privatisation and finally discipline and parsimony in resource allocation and use" (Shields, 2019).

Focusing on UK health care, the English health care system has often been one of the first countries facing transitions and trends in public policy and governance (Ferlie, Fitzgerald, McGivern, Dopson, & Bennett, 2013). In particular, as previously mentioned, the reforms of the 1980s and 1990s indicated the success and growth of the New Public Management theory (Shields, 2019). The New Public Management stressed the ideals of collaboration, networks, and partnerships which came to modify health policies and service organisations (Ferlie et al., 2013). The network narrative "has re-shaped almost all aspects of the health care system from high-level policy decision-making where government departments coordinate activities around policy problems, to regional care planning through networks of health and social care agencies, through to inter-professional networking in frontline service delivery" (Bevir & Waring, 2020) (NHS England, 2014).

According to Bevir and Waring (2020), various prominent initiatives in the UK give a clear idea of how the network narrative continues to guide and affect health and care reforms. One of these initiatives is the NHS Five Year Forward (2014), which emphasized regional strategic networks with the scope of planning and delivering more coordinated health care services (NHS England, 2014). More specifically, the NHS Five Years Forward View, published in October 2014, stressed the importance of better integration of General Practitioners, community health, mental health and hospital services, as well as more, cooperative working with home care and care homes (Powell, 2020). Moreover, it is possible to detect a continuous re-organisation of regional networking delivery service delivery (Fulop et al., 2015). Furthermore, the networking approach has been also used to fill the so-called 'translation gap' between the production of evidence-based innovations and the implementation and adoption of these breakthroughs in everyday care delivery (Bevir & Waring, 2020). In particular, policies have tried to solve this problem through supporting more collaborative partnerships and networks between research 'producers' and 'users', encouraging NHS care providers to work more collaboratively with university-based researchers and industries in the

form of research networks (ibid.).

Network Advantages and Challenges

In the field of public administration, networks constitute pragmatic collaborations to address 'wicked' problems (Bevir & Waring, 2020). There are two types of networks. On the one hand, we have networks created voluntarily, meaning that the actor or the organization freely decides to cooperate with another party, to exchange information or resources. On the other hand, focusing on the definition of an interconnected world, the network is intended as a creation employing superior and external economic, political and, demographic forces. This means that in the first case the actors take advantage of the networking relationships and their characteristics, while in the second case the actors are aware of the complexity in which they operate and tend to survive in the best possible way. However, what is interesting is that both the two types of network coexist in a more or less pronounced way. Indeed, even when the network is created voluntarily to gain something, valuable strategies and tactics need to be applied to maintain a strong and purposeful network relationship. Moreover, even when a network is established artificially, the actors should be aware of the presence of extra internal or external networks which could be considered as the results of the globalization phenomenon for example. Additionally, in the case of an interconnected world in which actors feel forced to cooperate, it would be sensible to take advantage of networking relationships. This double-network phenomenon can be detected in various sectors and industries, including the health care sector and its procurement practices.

In "Decentring Health and Care Networks: Reshaping the Organization and Delivery of Healthcare", Bevir and Waring (2020) described various networking purposes indicated and detected by various British health care managers. The main purpose of networking for almost all managers was to have the possibility of acquiring or sharing knowledge (Bevir & Waring, 2020), utilizing both active and passive networking for knowledge. In particular, in the second case, the managers referred to memberships, events, conferences etc... Networking for support represents the second main motive for forming and maintaining networks within the health care system (Bevir & Waring, 2020), mainly referring to emotional reassurance, personal validation, or consolation. Indeed, health care managers highlighted how difficult it would be to survive in a context dominated by extreme pressure and often emotionally challenging, without a strong support network (Bevir & Waring, 2020). Another purpose is represented by networking for career, referring to the need to be informed about new opportunities and openings, with the perceived importance of being known by key decision-makers (ibid.). Moreover, the deliberate use of networking could secure some influence over a decision or behaviour in another organisational location (Bevir & Waring, 2020). Finally, the authors pointed out that in practice managers' networking were driven by a combination of motives and each networking relationship has its own characteristics (ibid.).

In addition to the possible advantages deriving from being involved in a network, several issues were raised consistently as obstacles to forming effective networks. In particular, deadlines, competitive

tension, and intensive work demand represent the most considerable barriers faced by health care managers. Furthermore, in the case of formal networks, the effectiveness of the network itself could be undermined by the difficulty in maintaining active engagement levels (Bevir & Waring, 2020). Additionally, the involvement of several actors and parties, with different necessities and interests, affects the stability of the network's success and its effective management.

Types of Networking Relationship in the UK Health Care

Sheaf and Schofeld (2016) distinguish between six different types of networks: 'care networks' involved in the coordination of care services; 'professional networks' for the coordination and representation of occupational interests; 'project networks' that form around a specific initiative; 'programme networks' designed to implement a given policy or reform programme; 'experience networks' that bring together patients or the public with shared experiences and interests; and 'interest networks' that mobilise around particular agendas (Fulop et al., 2015) (Bevir & Waring, 2020). This indicates that networks in health care can vary according to purpose and intent, form and structure, and interest and ideology (Bevir & Waring, 2020). From this point of departure Bevir and Waring captured the varied and complex meanings of networking in order to highlight the presence of several relationships often overlooked by research, which simply seek to quantify them or measure their effectiveness (ibid.). It should be mentioned, that in addition to the relationships between the hospital and external organisation, Bevir and Waring (2020) have also pointed out the presence of internal relationships within the hospital itself. The types of networking relationship detected by the authors are shown in Fig. 4.3, together with their main characteristics.

Figure 4.3: Networking Relationships in the UK Health Care System. Retrieved from (Bevir & Waring, 2020)

Nature of network	Description
Academic/scientific	Links to universities, research or scientific bodies
Alumni	Connections made through participation in a specific training or educational programme which persist beyond end of programme
Peer/cohort	Relationships formed with others who joined this (or another) organisation at the same time
Commercial/3rd sector	Links to private sector organisations or charities
Elite	Connections to senior decision makers, within the trust/organisation or at a regional/national level
Functional specialist	Relationship or collectivities bound by a shared work specialism
Government	Relationships with individuals within regional or national government
Managerial	Relationships between groups of managers, including both occupational networks and more operational groups
Mentor	One-to-one relationships with a formal or informal mentor, typically but not necessarily outside the organisation
NHS	Connections to individuals in other NHS organisations, including Department of Health, SHAs/PCTs, GPs/CCGs, etc.
Operational/clinical	Day-to-day relationships typically formed through the day-to-day execution of responsibilities
Personal	Friendships, non-work relationships, family connections, etc.
Professional	Links with general or health-specific formal professional bodies, in accounting, HR, facilities, health and safety, etc.
Public sector	Non-governmental public connections, with for instance schools, legal bodies (e.g. coroners), prisons, armed forces, BBC
Political	Networks specifically cultivated to develop influence—typically diverse in composition, hence not captured by other categories

4.4 Procurement Theories applied to the UK NHS

In Section 2.11 the author described the four main theories applied to procurement: organisational buying behaviour, the economics of contracting (Agency Theory and Transaction Cost Economics Theory (TCE)), networks and inter-organisational relationships, and integrated supply chain management. It is worth mentioning that in addition to a general literature review regarding the development and application of theories to the procurement and supply chain, Sanderson et al. (2015) also provided a satisfactory investigation regarding the application of those theories to the UK NHS under both practical and political points of view. Naturally, the authors who have suggested procurement theories to the NHS, have expressed some relevant preferences among them. Therefore, from the articles analysing the application and validity of procurement theories to the NHS, it is possible to conclude that some of them have been more frequently used as a starting point for further development. To better understand to what extent and how these theories have been applied to the NHS, it is useful to distinguish four main contexts in which their application would have been sensible or helpful. Firstly, focusing on what needs to be ordered or purchased, authors like Cox et al. (2005) stress the importance of considering the political aspects of the procurement decision-making and how power can be used to solve potential conflicts of interests based on the various actors' preferences (Cox, Chicksand, & Ireland, 2005). Lian and Laing (2004) focus their attention on the application of organisational buying behaviour to the NHS. In particular, the authors focused to the expertise of each actor belonging to a specific decision-making unit. Moreover, although the data was not gathered from the NHS, they highlighted how the results obtained from their research and the lessons learned should be applied to the NHS (Lian & Laing, 2004). Secondly, focusing on the selection and contractual procedures of the NHS, the economics of contracting theories are the most used (Hughes, Allen, Doheny, Petsoulas, & Vincent-Jones, 2013). Conversely, poor attention is paid to the importance of establishing lasting relationships with suppliers. Thirdly, focusing on the management of NHS relationships, the networks and inter-organisational relationships literature is of clear relevance and utility in the NHS context (Sanderson et al., 2015). In particular, some authors, like Allen et al. (2009), see the NHS as a network composed of several supply chains, in which it is possible to detect a continuous cooperation between purchaser and provider (Allen, Wade, & Dickinson, 2009). Lastly, the operational delivery in the NHS is usually analysed according to the integrated supply chain management theories, since it mainly involves purely logistic aspects.

It is possible to conclude that economies of contracting paradigms and some aspects of the networks and inter-organisational relationships literature are the most frequently applied theories within the NHS. Whereas, the organisational buying behaviour theories have been applied less explicitly or in a heavily circumscribed way in the NHS context (Sanderson et al., 2015). Moreover, it is important to underline that, as already stressed in Section 2.11, the application of network theories is mainly related to the external environment characterising the procurement process and does not follow the paradigms and principles described in Section 2.2 that will be covered in this study. More specifically, the authors usually refer to the relationships between supplier and buyer, and in the

particular case of procurement in the UK NHS, they mainly refer to the relationships between Trust and medical devices' suppliers, or between hospitals and Clinical Commissioning Groups. Hence two main considerations arise. Firstly, although there is evidence about the presence of internal networking relationships within the UK health care sector, as mentioned in Section 4.3, the literature does not consider the presence of an internal network within the Trust. Indeed, the literature does not analyse intra-organisational relationships, does not apply networking strategies to internal health care networks, and does not consider the effect they could have on the whole procurement process. Thus, the literature does not take into account that in addition to the above-mentioned networking relationships identified between hospital and supplier, networks can also be detected within the Trust itself (this concept will be further discussed in Chapter 7). Hence, the networks theories are purely used to analyse the contractual aspects of the procurement process and the subsequent operational steps once the device enters the hospital, while the steps during the pre-deployment phase (identification of a need, specification/selection of the medical equipment, and selection of supplier) are not contemplated. Secondly, although the relationships with other public institutions (university, government, clinical commissioning groups etc.) are interesting and constitute determinant factors for the procurement process, this study will mainly concentrate on the internal networking relationships, since these are not yet addressed by the literature. It should be mentioned that the internal network within the Trust can be considered as a sub-network of the main external Trust-supplier network. Moreover, it is not the Trust as a whole having interaction with the supplier, but it is a single actor who directly interacts with him/her and who belongs to an internal hospital-based network. Therefore, it is fundamental to consider this internal hospital-based network and understand its composition to better acknowledge all the other external networking relationships.

4.5 The UK Policies affecting Procurement

As mentioned in Section 4.3, since the 1990s, the English health care system has been characterized by a series of decentralisation policies, mainly referring to the creation of decentralised networks and networking. In particular, from 1990, the NHS system has been characterised by a peculiar purchaser-provider structure (see Section 4.2) (Sanchez-Graells, 2018) in which part of the NHS acts as commissioners (Clinical Commissioning Groups) of healthcare services, while another is composed of providers of healthcare services and mainly compete with other private providers (Sanchez-Graells, 2018). It is worth stressing that those health care reforms "have sought to rely on market-based governance structures to unlock economic efficiency and high-powered incentives for the generation of ever-increasing savings in healthcare expenditure" (Sanchez-Graells, 2018). Another reason for developing the purchaser-provider split policy was to introduce a so-called 'NHS internal market'. This internal market should generate incentives to enhance cooperation to improve both service delivery and cost management (Sanchez-Graells, 2018). However, in March 2017, the 'Next Steps on the NHS Five Year Forward View' outlined several national service improvement priorities such as the acceleration of services' redesign and integration through the 'Sustainability and Transformation Partnerships' (Powell, 2020). These 'Partnerships' supported substantial

changes partially aiming to suppress the purchaser-provider split, together with its internal market. (Pollock & Roderick, 2018) .

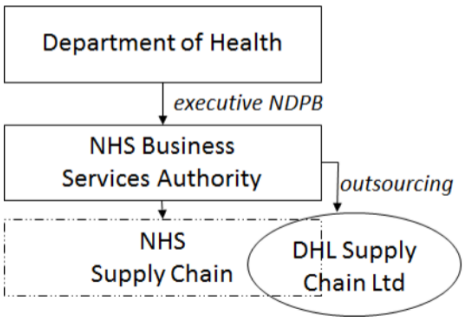
However, despite the presence or not of the NHS internal market, the provision of public healthcare services requires and will continue to require the acquisition of supplies and services from the external market (Sanchez-Graells, 2018) since NHS providers do not produce all equipment and consumables needed for providing adequate healthcare services. Thus, seeking savings in NHS procurement seems one sensible way of freeing up additional funds for the transformation of the NHS without significantly increasing overall healthcare expenditure (Sanchez-Graells, 2018). It should be stressed that despite the formation of various networking relationships within the UK health care system, the last periods have been characterised by continuous privatisation of the procurement activities, in addition to the desired centralisation of the procurement process by the Government. The years 2017-19 saw a steady push towards the complete break-up and outsourcing of NHS procurement and logistics services to elite management consultancy firms, like Ernst & Young or Deloitte (Hall et al., 2020). Following the recommendations of the Carter Review, the aim was to achieve annual savings of over £600m by doubling the centralized purchasing of the NHS products. However, while the Carter Review recommended sweeping changes, it did not recommend that the government should aim to centralise almost all the procurement activities for the whole of the NHS, nor that this procurement should be segmented and outsourced (Hall et al., 2020).

"The most recent wave of efficiency-seeking re-regulation of NHS procurement through the so-called 'Procurement Transformation Programme' (2016), and the resulting 'New Operating Model', pivots around the exercise of public buying power through the aggregation of demand and, in particular through the centralisation of procurement and the streamlining of supply chain management" (Sanchez-Graells, 2018). The main goal of the Procurement Transformation Programme was to deliver £700 million in savings from improving procurement by the end of the financial year 2020/21 (Sanchez-Graells, 2018)] and for the New Operating Model to result in end-state annual savings of £615 million in real terms from 2022/23 onward (NHS Procurement Transformation Programme, 2017). According to Sanchez-Graells (2019), "this is not a new goal, but rather a revamp of a strategy that already underpinned the creation in 2005 of the NHS Business Services Authority" (Sanchez-Graells, 2018). Indeed,"procurement services were identified as a matter for centralised policy in 2005 with the creation of the NHS Business Services Agency, which in 2006 outsourced NHS Logistics, and its responsibility for logistics and procurement to DHL and Novation under a contract that lasted [...] until 2019" (Hall et al., 2020). More specifically, until 2019, the NHS Supply Chain could be defined as a logistics management unit under the umbrella of the NHS Business Services Authority, operated by the private company DHL (DHL Supply Chain Limited) under a long-term outsourcing contract (Sanchez-Graells, 2018) as depicted in Fig. 4.4. However, in February 2019, Unipart Logistics took over responsibility for delivering the logistics service for NHS Supply Chain as NHS Supply Chain: Logistics, taking the role of the previously mentioned DHL. Additionally, in April 2019, the administration of the NHS Supply Chain was taken over by Supply Chain Coordination Ltd (SCCL), a company created by the Health Secretary, Matt

Hancock.

The Supply Chain Coordination Ltd was said to be 100% owned and controlled by the UK Government. However, according to Hall et al. (2020), the terms of reference of the Supply Chain Coordination Ltd, made it clear that the main goal was to outsource almost every aspect of NHS procurement and logistics services (Hall et al., 2020). Additionally, the authors sustain that "surprisingly SCCL had no intention to oversee and coordinate NHS procurement services through the development of in-house resources and staffing capacity" (Hall et al., 2020). Indeed, the Supply Chain Coordination Ltd divided responsibility for procurement into eleven different outsourced segments, known as "Category Towers" which has the role to procure different categories of products (Appendix B) (Hall et al., 2020).

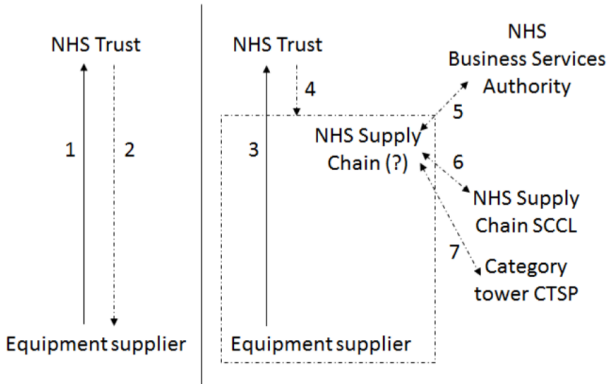
Figure 4.4: NHS Supply Chain and DHL Supply Chain Ltd relationship. Retrieved from (Sanchez-Graells, 2018)



With the birth of the Supply Chain Coordination Ltd, the procurement process became even more complicated. Sanchez (2018) developed a quite interesting scheme showing the main differences between hospital-based procurement and the procurement process carried out through the NHS Supply Chain (Fig. 4.5). According to Sanchez (2018), the direct purchasing of medical equipment for its use by an NHS Trust (depicted to the left of Figure 4.5) is quite direct, creating two relatively straightforward legal relationships between the NHS Trust and the Supplier. However, it is worth mentioning that the NHS Trust would have been obliged to comply with the applicable public procurement rules in the tendering of that contract (Sanchez-Graells, 2018). In particular, "the NHS Trust would have been constrained by the Public Contracts Regulations 2015 (the 'PCR2015') and its decisions would have been open to both the system of procurement-specific remedies and, potentially, to judicial review" (Sanchez-Graells, 2018). Conversely, the procurement process through the NHS Supply Chain (depicted to the right of Figure 4.5) creates some analytical and practical challenges since the whole procurement process is much more complex (ibid.). The Category Tower Specialist Providers run the procurement processes on behalf of the NHS and this represents a very different approach to the design and execution of procurement operations (Sanchez-Graells, 2018). Indeed, by tendering a framework agreement on behalf of the NHS, the Category Tower Specialist Providers (CTSPs) would not hold a straightforward direct procurement relationship with the equipment supplier (7 in Fig. 4.5). In particular, the tendering of the con-

tract would have been subject to the scrutiny and authorisation of the Supply Chain Coordination Ltd (6 in Fig. 4.5), while the contractual agreement would have been tendered on the specific behalf of NHS Supply Chain since it represents the relevant contracting authority. However, from the moment that the NHS Supply Chain has no separate legal personality, the standard approach under the current operation of the NHS Supply Chain has been for the latter to act as the agent of NHS Business Services Authority (5 in Fug. 4.5), which would be the entity ultimately (indirectly) holding the contract (Sanchez-Graells, 2018). "The setting up of a framework agreement under the NHS Supply Chain umbrella would then allow an individual NHS Trust to place a call-off for the required medical equipment without the need for any additional public tender" (Sanchez-Graells, 2018) (4 in Fig. 4.5).

Figure 4.5: New Procurement Structure. Retrieved from (Sanchez-Graells, 2018)

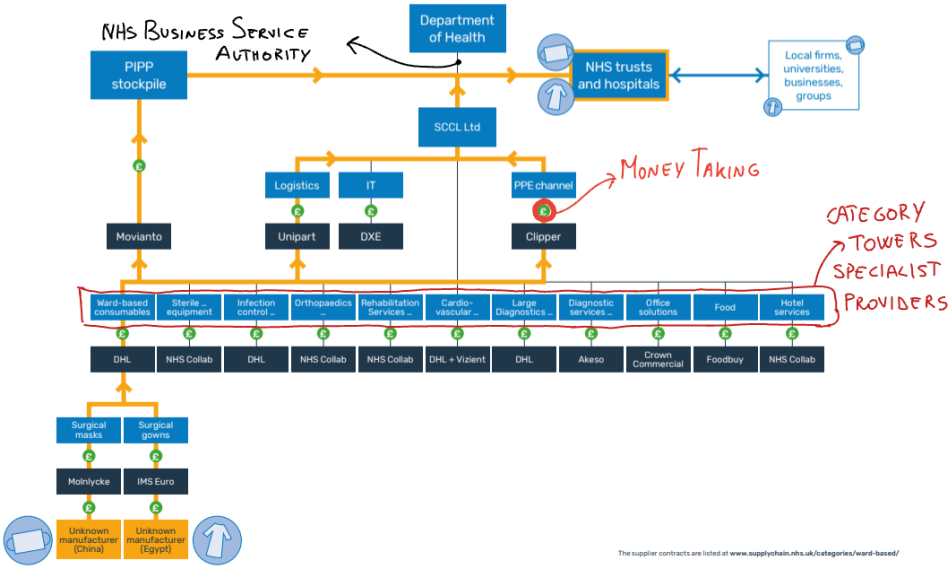


A zooming description of what involves the NHS Supply Chain procurement process has been described, and criticised, by Hall et al. (2020). According to the authors, the result of this centralised system is to create a complex set of companies increasing the distance between the NHS Trusts and the suppliers of the medical equipment. Indeed, it is possible to state that the actual manufacturers of medical equipment are "invisible and inaccessible to the NHS" (Hall et al., 2020) Trusts who are ordering and will use the products. According to the number of actors involved in the procurement process through the NHS Supply Chain, every piece of equipment passes through different levels of profit-taking before it arrives at the hospital. "The producers only deal with the wholesale suppliers, who in turn receive their contracts for the different categories through Category Tower Specialist Providers. The Category Tower Specialist Providers themselves are paid to find suppliers, and the equipment is delivered by another company with a logistics contract." (Hall et al., 2020). Additionally, the horizontal division into multiple Category Tower Specialist Providers contracts (Fig. **??**) complicates, even more, the whole procurement process and adds the additional difficulties of outsourcing some of the procurement activities to foreign private companies (ibid.).

It is worth mentioning that each of the Category Tower Specialist Providers has a contractual cost of £190 million and that none of this money buys any actual medical equipment, rather, it pays corporate middlemen to find equipment suppliers. Additionally, there are also two other large central contracts issued by NHS Supply Chain, which are 'Logistics' costing £730 million and IT

technology (Hall et al., 2020). Hall et al. (2020) have developed a very detailed scheme showing how the procurement progresses and who is involved. Therefore, an adapted version of the procurement networking relationship has been developed and shown in Fig. 4.6.

Figure 4.6: NHS Supply chain network. Adapted from (Hall et al., 2020)



4.6 Current Practice of UK Procurement

From the literature review it is not particularly clear how the procurement at the hospital level proceeds. This is due to the lack of information regarding which activities are effectively carried out and which actors are involved in them, in addition to a lack of standardization regarding those arguments. Van der Ham et al. (2019), sustain that "the international literature does not, by definition, reflect what really happens in hospitals. It could be the case that multiple agents in the hospital interact, negotiate or coordinate activities, but that this is not known publicly, perhaps for reasons of confidentiality" (van der Ham, Boersma, van Raak, Ruwaard, & van Merode, 2019). Moreover, the UK health care system has been characterized by several reforms during the last years. Therefore, it wouldn't be meaningful to rely on papers older than three years. In addition to this, not all governmental websites of the different NHS Trusts provide details on how hospitals carry out procurement activities in detail and, in many cases, the information is old or not particularly precise.

Because of the fundamental role occupied by procurement, most of the articles collected analyse the main challenges encountered during procurement activities usually from the perspective of health care workers, mainly decision-makers (Hinrichs et al., 2013) (Stafinski, Menon, McCabe, & Philippon, 2011) (Vilcahuaman & Rivas, 2017) (Akinluyi et al., 2014) (Stafinski, Menon, Philippon, & McCabe, 2011). Subsequently, once the challenges have been identified, the authors often

propose suitable decision making frameworks with the aim of helping decision-makers in performing procurement or HTM activities (Stafinski, Menon, McCabe, & Philippon, 2011) (Vilcahuaman & Rivas, 2017). As in the case of national or Trust-developed guidelines, the proposed frameworks mainly rely on how to perform the procurement activities rather than how to behave during the procurement process or which strategies should be used by health care managers. Furthermore, although some of the aforementioned articles indicate who are, or should be, the main actors involved and their responsibilities, they do not analyse how they interact with each other and they do not provide exceptional details on the various phases of the procurement process. Moreover, as previously mentioned, in the particular case of procurement in the UK, it is also important to consider the publication date of an article in addition to its content. Considering the various articles and books analysing the procurement at the hospital level and collected during the literature review, only one of them can be considered satisfactory in terms of details and information provided, and publication date. This article, written by Madhlambudzi and Papanagnou (Madhlambudzi & Papanagnou, 2019) (2019), provides a clear description of the procurement process at the hospital level in the UK. In addition to the main stakeholders identified, the authors also divided the procurement process in different phases and specified the main actors belonging to each of them. The aim was to see how stakeholders' salience is effectively used during the procurement process and what could be the consequences related to such phenomenon. However, three main limitations can be detected. Firstly, they described in a well detailed way the procurement of only a specific type of device, diagnostic medical equipment. Secondly, although they stress the importance of conducting stakeholder analysis to improve the procurement process, they do not specify how this stakeholder analysis should be performed. More specifically, considering the main idea of this thesis, which sees procurement as a complex and dynamic phenomenon, a simple and single stakeholder analysis is probably not enough to improve final health outcomes. Lastly, in their article they have not included the possibility of buying the device through centralised procurement, which constitutes a fundamental factor affecting hospital-based procurement in the UK.

4.7 Reflections

Although there is considerable research on the tasks and skills of network management and on how networks have become synonymous with public governance, relatively little attention is given to how and which network management strategies can and need to be applied to the public health sector, and to procurement practices in particular. Usually, the literature referring to the health care system as a network mainly focuses on decentralisation policies applied to the health sector and the consequent creation of relationships among different health care service providers. Other articles study how health care managers behave in a network and which types of relationships connect the different actors. Therefore, from the literature review about health care and network management various considerations arise. Although management in networks theories have been applied, even in very few and old papers, to the procurement process, the author mainly relied on and studied the external networking relationships between the hospital and the supplier. Indeed, there is no article found so far that describes and analyses the presence of an internal network

characterising hospital-based procurement in the UK. Moreover, it is possible to assume that the networking health care reforms developed and adopted at the macro-level have also influenced both the micro-level administration and management. In the particular case of health care, the micro-level refers to internal networks that can be detected within a hospital and even within its various departments. Thus, focusing on the micro-level network analysis, it would interesting to analyse what and how suitable networking strategies can facilitate HB-HTM and the interaction among actors within the hospital, taking procurement process as case study. Indeed, no attempt has been made to apply networking strategies to HB-HTM or at least suggesting their application to hospitals. In fact, the guidelines provided follow a project-based approach, without suggesting to health care managers how to deal with complicated and wicked situations.

Because of the continuous changes in the UK health care policy, the publication date of the articles describing UK procurement is fundamental. Additionally, although recent articles provide satisfactory details on the stakeholder involvement during the procurement process, they do not describe their main interactions, conflicts of interests, and values. Lastly, it is possible to detect a sort of paradox in the UK policies. More specifically, on the one hand, over the last years several reforms have promoted the creation of decentralised networks, as described in Section 4.3, while on the other hand, the UK Government is trying to centralise the whole NHS procurement (see Section 4.5). Furthermore, no recent article analysed how centralisation policies have affected and are affecting the current procurement practices. In particular, although the centralisation policies adopted by the UK and applied to the health procurement largely affects this last one, no articles shows how the hospital-based procurement practices have been changed since the implementation of the NHS Supply Chain nor how health care managers perceive these centralisation procedures. Therefore, before suggesting suitable decision-making strategies which take into account the network complexity of the procurement process, it is important to first understand how the hospital-based procurement works, to what extent it is worth having hospital-based procurement, and the possible challenges derived from centralisation policies. This analysis will be carried out in Chapter 5 and 6.

Chapter 5

Results II: Hospital-based Procurement in the UK

This chapter describes the main processes and scenarios characterizing the procurement process in UK hospitals. It should be mentioned that, since hospitals in the UK are grouped in Trusts, the term hospital-based procurement usually refers to the procurement carried out by Trusts according to the necessities of all the hospitals belonging to them. The whole analysis has been carried out through both interviews and literature review. This last one mainly refers to the article written by Madhlambudzi and Papanagnou (2019) (Madhlambudzi & Papanagnou, 2019) and to the procurement guidelines collected during the interviews.

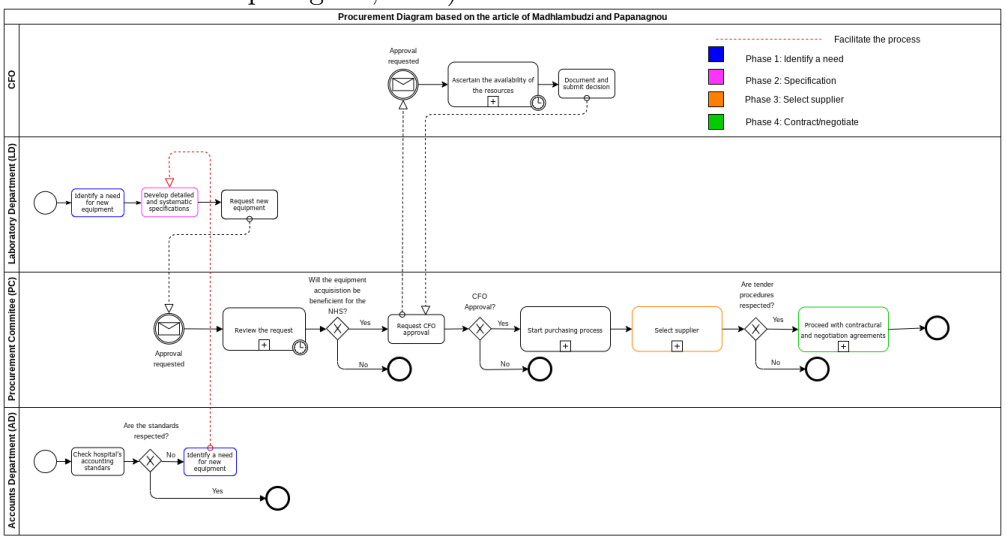
5.1 Starting Point

As mentioned in Section 4.6, the article written by Madhlambudzi and Papanagnou (2019) is quite satisfactory in terms of details provided, especially regarding the stakeholders involved and their roles and powers. Therefore, despite some limitations characterising this article, it has been used as the starting point from which the subsequent analysis of Section 5.2 has been developed. In particular, the first BPMN diagram has been created based on that article and subsequently adapted and modified according to the interviews' results. Indeed, as described in Section 3.5.4, the whole process has been characterised by a continuous contrast and comparison of the data collected. The first BPMN diagram depicted in Fig. 5.1 only presents three main actors and the analysis is based on the procurement of diagnostic medical devices according to what described by Madhlambudzi and Papanagnou (2019).

It is worth stressing that there is an evident difference between the diagram developed on the information collected during the literature review and the subsequent diagrams created adding the extra details gathered from the interviews (Section 5.2.3). The first difference is represented by the number of procurement processes identified, indeed, the literature did not differentiate among the possible procurement processes while, from the interviews, it was clear that evident differences

among the various procurement cases exist and need to be mentioned. Firstly, it is important to distinguish between capital procurement and revenue procurement, where the first one involves the purchasing of capital medical devices such as MRI scanners, while the second one refers to day-to-day operations. Secondly, it should be mentioned that the procurement process at the Trust level can follow two different paths: proceeding with a Trust-based tendering process or purchasing the device through the NHS Supply Chain. Another difference between the diagram of Fig. 5.1 and the future diagrams is the type of medical equipment considered. Initially, also the author of this dissertation decided to focus on diagnostic medical equipment, however, she found out that although each medical device is unique and used by different specialists, the process though which the object is purchased is almost the same. Therefore, the researcher preferred to provide a higher level of generalisation, since one of the study's goals is to analyse stakeholders' interactions and not the technical aspects of the procurement process. Moreover, because of practical reasons, not all the respondents were familiar with diagnostic medical equipment, since all of them belong to very high 'hierarchical' levels within the trust. Furthermore, the role of the CFO is not analysed in the diagrams of Section 5.2.3 since, according to the information collected during the interviews, the budget for each purchasing process is set in advance and does not involve a continuous negotiation with the trust's board or the CFO. Indeed, although the primary negotiation phase for budget allocation is an interesting aspect of the procurement process, this will not be analysed in this thesis project, because of data and time constraints.

Figure 5.1: BPMN diagram from the literature. Created on the information gathered from the article (Madhlambudzi & Papanagnou, 2019)



5.2 Analysis

Before the medical device effectively enters the hospital, various procurement activities take place. Thus, as suggested by Madhlambudzi and Papanagnou (2019), it is possible to summarise the procurement at the hospital level in four main stages: identification of a need (Why do we need

new devices?), specification/selection of the device (Which devices do we need?), selection of the supplier (Who can satisfy our requests?), and contractual/negotiation phase (What is the best possible way to proceed with the purchasing?) (Madhlambudzi & Papanagnou, 2019) (Fig. 5.2). All these stages evolve differently according to various types of procurement processes. Therefore, before analysing each of them it would be better to describe different situations in which a new medical device is purchased and how. The different types of procurement process have been discovered and selected through interviews. Firstly, *Respondents (1,2,3,4,5)* stressed the importance of making a distinction between capital procurement and revenue procurement. Capital procurement indicates the purchasing of medical equipment having a value above £5,000, the reverse applies for revenue procurement which focuses on day-to-day or operational medical equipment. Apart from the amount of money involved in each of these two types of procurement processes, another important difference is the level of bureaucracy applied to each of them. Therefore, it is important to understand what the 'approval levels' to follow during a purchasing process are. From the guidelines collected during the interviews, three main approvals have been detected: medical equipment approval, financial approval, and procurement approval. The medical equipment approval makes sure that all the medical standards regarding safety, training, decontamination etc. have been respected. The financial approval varies between capital and revenue procurement. In the first case, the financial approval is obtained by procurement department together with the capital equipment group, while in the second case the approval of the budget holder (Fig. 5.3) of a specific area is enough. Lastly, the procurement approval is directly obtained if the medical equipment is present in the NHS Supply Chain catalogue, otherwise, the requestor should ask for advice from the procurement group (Fig. 5.3). It is worth mentioning that the capital procurement itself can be of two types, replacement of existing equipment or new technologies requested by specific departments or professionals. The first scenario can be defined as a top-down situation in which the Trust decides and prioritises which types of medical equipment needs to be replaced and why. The second case, which is 'more' subject to all the aforementioned approvals, represents a bottom-up situation in which health care professionals of specific departments ask for new technologies, specifying why they need them and what the advantages of such purchase could be (Fig. 5.4).

Figure 5.2: Four phases of Procurement. Created by the author according to the information gathered from (Madhlambudzi & Papanagnou, 2019)

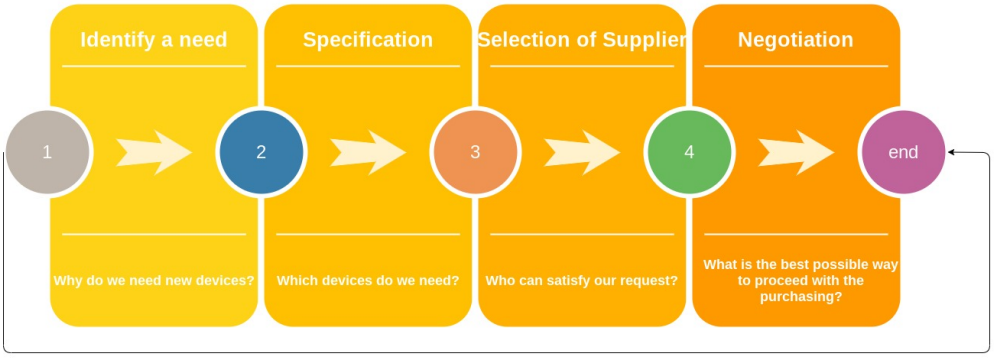


Figure 5.3: Approvals during the Procurement Process. Created by the author according to the information gathered from the guidelines collected during the interviews.

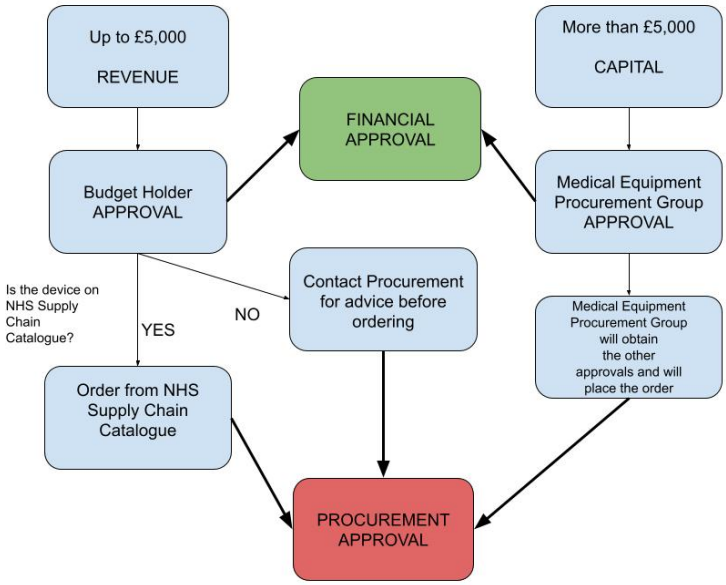
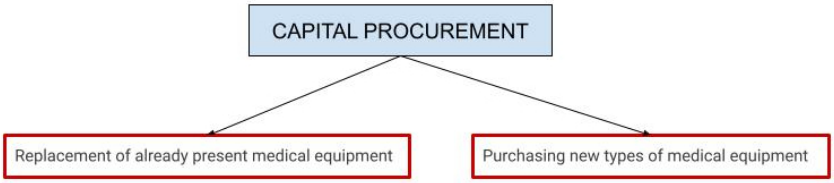


Figure 5.4: Two types of Capital Procurement. Created by the author according to the information gathered during the interviews.



5.2.1 Phase 1: Identification of a need

Procurement decision-making usually starts and evolves according to the identification of the need to purchase new equipment or adopt a different/more innovative health technology. However, depending on the amount of capital involved (capital or revenue procurement) or the type of expenditure (replacement of already existing equipment or new technologies), it is possible to detect four different cases. The first one refers to a revenue procurement process where the technology is present in the NHS Supply Chain catalogue. The second case refers to a revenue procurement process in which the technology is not present in the NHS Supply Chain catalogue. This could be a situation in which an innovative medical device used for operational activities has been developed and/or introduced in the market by a specific company that publicises it to doctors/health care managers. In this case, the expected procedure indicates that even if the expenditure is below £5,000, the one who wants to purchase that medical device needs to ask the procurement group for advice. The third case refers to a capital procurement process for replacement. This usually

refers to a situation in which the book value of the existing equipment has reached the end of its lifespan, hence there is no debate as to whether the acquisition should go-ahead to replace old equipment. The only question is what equipment to replace. The fourth case refers to a capital procurement process in which new technologies will be purchased. This case could be represented by the merging process of two hospitals, during which there could be the need to have a larger capacity to harmonize the systems and where the Trust administration had to be convinced of the benefits of acquiring new equipment. This could also refer to the need for new equipment due to the increased workload in the department or when existing machinery is experiencing frequent breakdowns, and downtime worsens the problem of failing to cope with the demand. Moreover, the purchasing of new equipment will also take advantage of innovations that are not included in the current system and sponsored by suppliers to various hospital's doctors. In any case, a decision-making process takes place in all the four procurement processes. Each stage of the whole procurement process is dominated by different stakeholders and the importance of their contributions varies according to the different situations. However, it is possible to identify a strong interconnection among actors and each of them can potentially influence the three different procurement stages.

5.2.2 Stakeholder Analysis

Before analyzing the remaining three stages (specification of the device, selection of the supplier, and contractual procedures) and the four different procurement processes, it is important to better understand who is effectively involved during the procurement decision-making, therefore, a stakeholder analysis needs to be performed. The analysis of the different stakeholders identified, who effectively are or could be involved in the procurement process, is based on both the article written by Madhlambudzi and Papanagnou (2019) in addition to information gathered from various governmental British websites (see Section 4) and interviews with health care professionals (Fig. 3.5) of the UK health care system. Six main stakeholders' groups have been recognized: Medical Physics Department, Capital Equipment Group (Medical Equipment Committee), Clinical Department, Budget holders, Procurement Group, and Clinical Engineering Group. Although the stakeholder analysis focuses on the procurement process, according to their characteristics and operational roles, the previously mentioned stakeholders are more or less involved in different HTM activities, as well as in the three different phases of the device's operational life. It is worth mentioning that to facilitate the development of a suitable model to describe hospital-based procurement, an approach which summarises all the main key findings, rather than presenting and discussing any similarities or differences between the two NHS Trusts considered, has been adopted.

Medical Physics Department

The Medical Physics Department, also called Medical Physics and Clinical Engineering Department or Medical Physics and Biomedical Engineering Department, is present in almost every Trust of the UK and involves several groups. Firstly, as the name suggests, it involves the clinical engineering group or department, together with other experts in the medical and technological fields. Additionally it can also include the capital equipment group. The main activity performed

by this department is approving medical equipment before their purchase. This department has a crucial role during capital procurement, especially during the purchasing of high risk devices. Therefore, when the capital equipment group is situated within this department, together with the other medical and technical experts, clinical engineers are involved in almost all the phases of the procurement process. However, the structure and composition of this department is not equal across Trusts and the same applies for its involvement during the procurement process.

Capital Equipment Group or Medical Equipment Committee

As suggested by its name, the Capital Equipment Group is involved during capital procurement processes, when the expenditure is above £5,000 and does not involved operational costs. One of the most important functions carried out by this group is to prioritise which medical equipment needs to be replaced first according to predefined algorithms or general books of values. The prioritisation process is necessary since, although a certain amount of medical equipment needs to be replaced, because of budget limitations the Trust can only afford a limited amount of replacements. Therefore, the capital equipment group can be defined as a decision-making group since it decides what the hospital can replace and how much money is allocated for each type of equipment. During the prioritisation process, the Capital Equipment Group works together with clinical teams and potentially with the clinical engineering department, which suggests what should be replaced more urgently, according to their knowledge and practice experience. The clinical director is one of the most influential personalities during the prioritisation process. However, the final decision of what needs to be replaced and how much money is allocated for that replacement relies upon the Capital Equipment Group. It is worth mentioning that within the Capital Equipment Group it is possible to distinguish between two "sub-divisions", the first one is focused on the replacement of capital equipment and the second one deals with the introduction of new technologies. In the second case, a different money allocation is established by the Capital Equipment Group and the procedure to purchase those medical devices is slightly different.

Clinical Department

Clinical teams are central to the hospital's operation and they are the ones who use the medical equipment (Madhlambudzi & Papanagnou, 2019). Because of their practical experience in using medical equipment, they are consulted during the prioritisation phase for the replacement of medical devices, where the clinical manager covers a fundamental role. Furthermore, clinical teams are the ones who request the procurement of new technologies, specifying the contribution these last ones could bring to the hospital. It is worth stressing that in the case of revenue procurement, clinical staff can directly order from the NHS Supply Chain catalogue or directly request the purchasing of technologies not present in the NHS catalogue to the procurement department. Clinical teams cooperate with: the procurement department and the clinical equipment group in the case of capital equipment; with the divisional leadership team in the case of revenue procurement for the budget approval; and with the clinical engineering group for general advice. It is worth mentioning that cooperating with the clinical engineering group is not mandatory, while relationships with both the

procurement and clinical equipment groups are required.

Budget Holder

The budget holder (also known as divisional financial manager) of a specific department belongs to what is commonly defined as a divisional leadership team. The budget holder is responsible for the financial approval of specific purchasing processes, usually below £5,000 or involving day-to-day expenditures (operational costs). There are different 'hierarchical levels' of budget holders who are responsible for different approvals depending on the type of revenue procurement process. The budget holder usually cooperates with the procurement department and clinical teams and this role is covered by nurses or other health care professionals who have received business training.

Procurement Group

Procurement group involvement in identifying the need for new equipment is not significant. However, the procurement group's members are accountable to ensure that both the rules on item specifications and supplier engagement are met. Thus, the procurement group is ultimately responsible for going through with the agreed transaction once all the previous steps have been completed. Indeed, health care workers within this group usually pay extreme attention to tender procedures which should be followed in identifying suppliers. They have a direct relationship with several actors participating in the procurement process such as the capital equipment group, clinical teams, clinical engineers, other experts, and suppliers. Therefore, it is possible to state that they occupy a central decisional role during the entire procurement process. Moreover, apart from the revenue procurement of medical devices present in the NHS Supply Chain catalogue, the procurement team should always be accountable for the purchasing of other medical devices. Furthermore, it should be mentioned that, usually, employees working in the procurement department are not technology or medical experts.

Biomedical/Clinical Engineering Department

Although biomedical/clinical engineers could be identified as key stakeholders, in practice, they are not always involved during the procurement entire process. From the analysis carried out by Madhlambudzi and Papanagnou (Madhlambudzi & Papanagnou, 2019), clinical engineers were completely left out of the procurement process. However, from the interviews, it was clear that in the case of big hospitals, or 'high profile' Trusts, they are involved in some phases of the procurement process although their involvement is not standardised but depends on the type of purchasing process and the Trust's organizational structure (*Respondent 1,2,3,4,5*). As an example, in some cases clinical engineers are part of the capital equipment group helping in the prioritisation process, in other cases, they are the ones who conduct a large part of the procurement process, such as device specification, supplier selection, and negotiation. However, usually, they are used more as experts able to *"put all the relevant information together"* (*Respondent 1*), which will be then used by the capital equipment group or the procurement department. It is worth stressing that it is possible to distinguish between two types of clinical engineers. On the one hand, clinical engineers

having purely technical expertise (technicians), therefore, their main task is to provide technical consultancy. On the other hand, especially in high profile Trusts, there are clinical engineers defined as 'scientists', since, in addition to technical knowledge, they also have business and managerial capabilities. The 'scientists' can be involved in different phases of the procurement process as previously mentioned.

5.2.3 Procurement Processes: BPMN diagrams

As already anticipated, it is possible to distinguish among four main types of procurement processes, each of them dominated by different actors and satisfying different purchasing needs. This part of the chapter will describe each of the four cases, accompanied by their respective BPMN diagrams to simplify understanding. The main advantage is that BPMN models visually depict a detailed sequence of business activities and information flow needed to complete a process. More information and details on the main characteristics of this model, together with the meaning of each symbol are provided in Appendix D and in Section 3.3.3.

Case 1: Revenue Procurement from NHS Supply Chain Catalogue

When a medical device is present in the NHS Supply Chain catalogue and the expenditure is below £5,000 (revenue procurement), the clinical teams can directly order from the NHS Supply Chain framework. According to established Trust's procedures, they need financial approval by the budget holder and they should require medical approval by the Medical Physics department. However, although the Trust's guidelines under analysis indicate the need for both budget holder and experts approvals before the device enters the hospital, from the interviews it was clear that often this does not happen (*Respondents 1,2,3,4,5*). Fig. 5.5 describes the main relationship between the three stakeholders previously mentioned. It is worth stressing that since the involvement of both budget holder and experts is 'optional', the relationship between the clinical teams and budget holder/medical physics department is coloured in red.

Case 2: Revenue Procurement of non-catalogue Medical Equipment

When clinical teams want to buy medical devices not present in the NHS Supply Chain catalogue, they can still proceed with the order by themselves but they should first ask the procurement department's advice and request the medical approval. More specifically, the procurement department has the role to test both the market and the specific supplier for the clinical teams. Also in this , the first approval that should be collected is the one of the medical physics department, which, however, as previously stated, is not always involved, or better, consulted by all clinicians. Fig. 5.6 shows the main relationships among the different actors and, in this case, the additional actor with respect to Case 1, is the procurement department. The red path indicates that usually the medical approval is not requested while the orange path indicates that there are few cases in which the procurement department is not involved at all.

Figure 5.5: Case 1: Revenue Procurement through NHS Supply Chain Catalogue

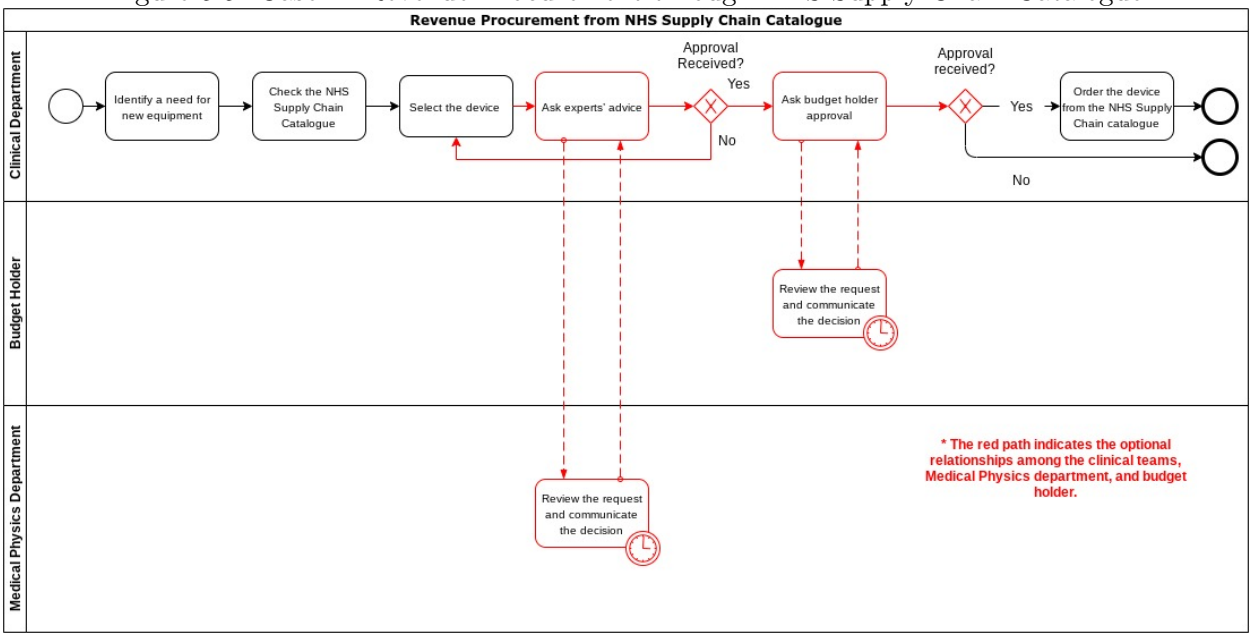
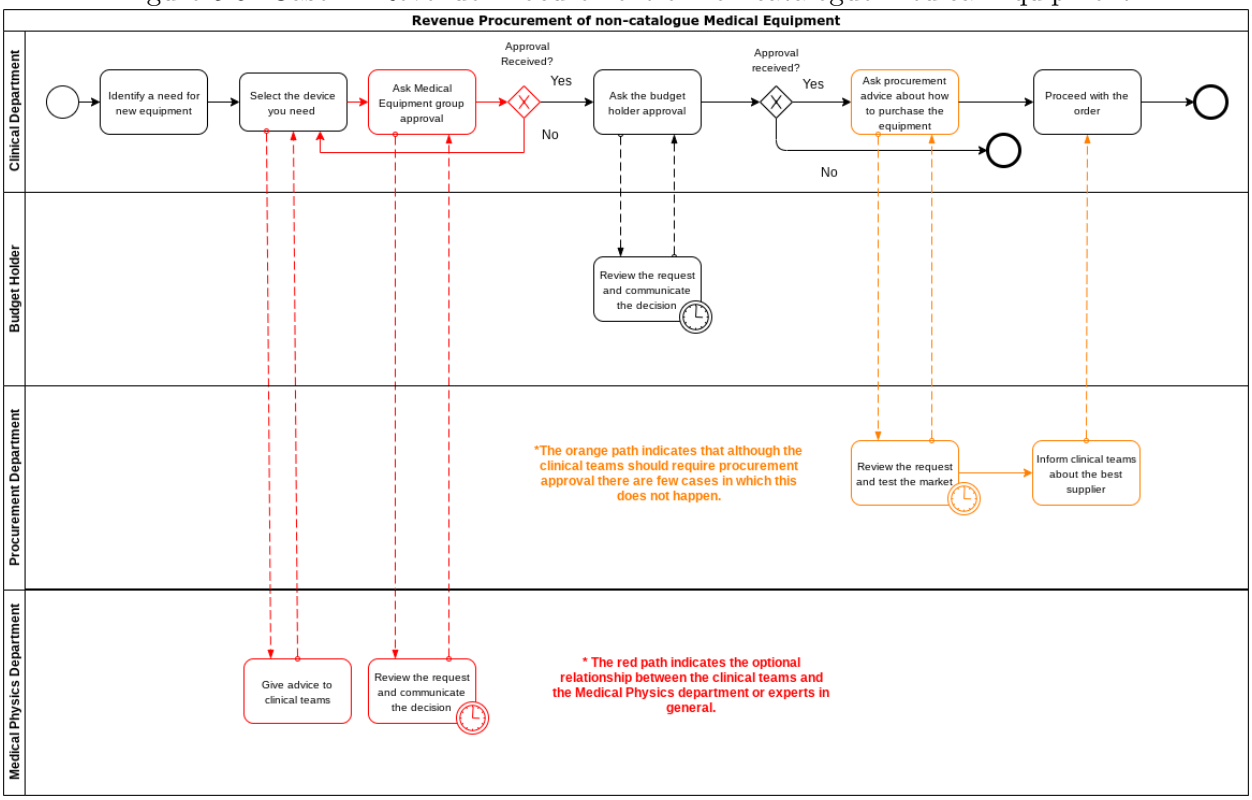


Figure 5.6: Case 2: Revenue Procurement of non-catalogue Medical Equipment



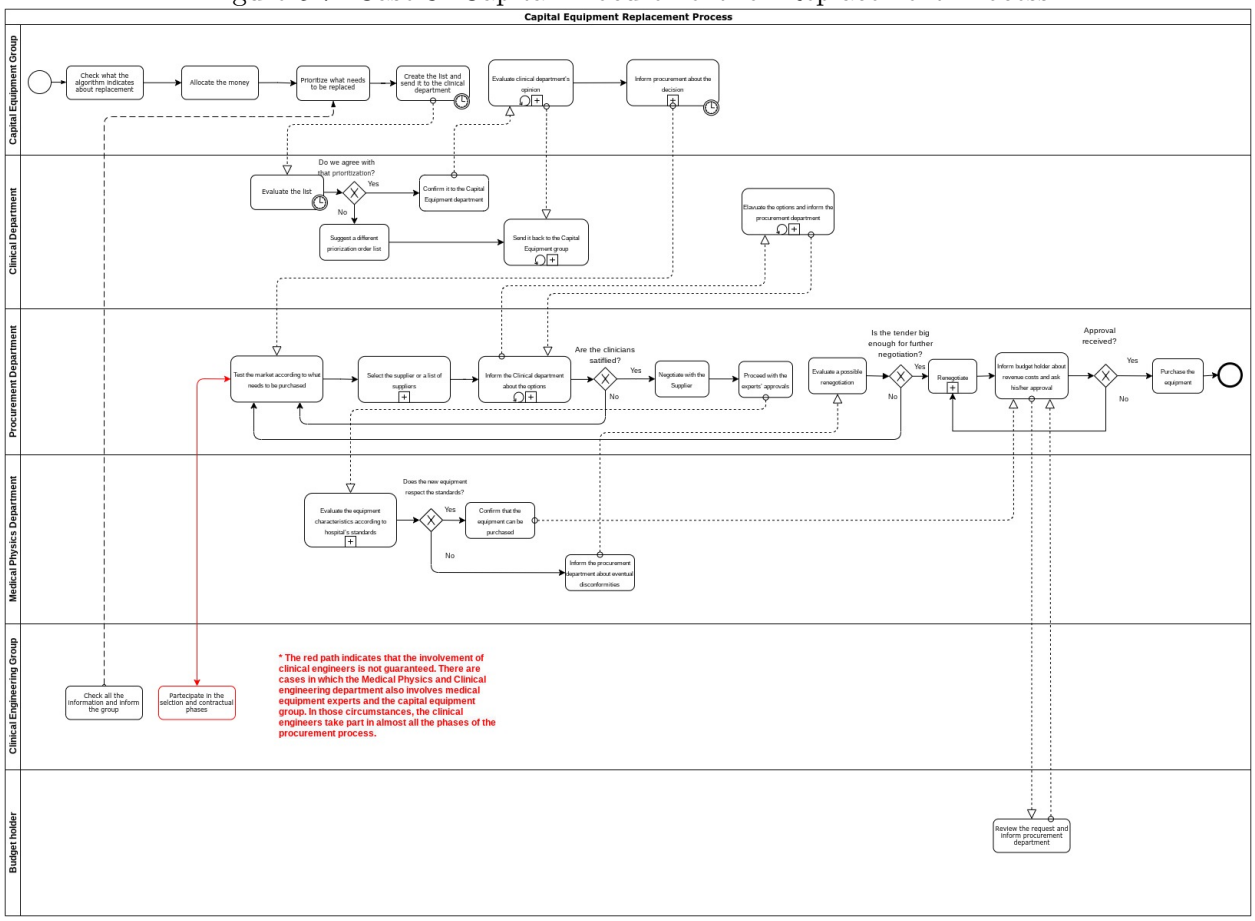
Case 3: Capital Procurement for Replacement Process

This type of procurement process is much more complicated than the revenue one. In particular, more actors are involved and the whole procedure takes more time. In the model depicted in Fig. 5.7, the starting point of the whole process coincides with what 'an algorithm' suggests to replace. This is one of the options described during the interviews, however, although every Trust has its algorithm and books of value indicating what needs to be replaced and when, not all the algorithms have the same level of sophistication and in some cases, human inputs such as the ones of clinical managers, are the main source of information regarding a replacement. Usually, the list of medical equipment that needs to be replaced contains more elements than what the Trust can afford to replace. Therefore, because of budget constraints, the clinical equipment group proceeds with a prioritisation process, establishing which equipment will be replaced first and how much money to allocate for different types of replacement. During this prioritisation process, the clinical equipment groups cooperate with the clinical teams. More specifically, the clinical equipment group creates a prioritisation list, usually according to the information obtained from clinical engineers, and asks clinical teams' opinion to check if they agree or not on what should be replaced. During this phase the role of clinical engineers differs among hospitals.

Once the clinical teams and the clinical equipment group arrive at a final decision on what will be replaced, the clinical equipment group informs the procurement department which will proceed with the purchasing process. One of the most important tasks performed by the procurement department is testing the market. However, *Respondent 1,2,5* stated that if something is available on the NHS Supply Chain catalogues, the procurement department prefers to buy it through centralisation. The procurement department cooperates with both clinical teams and various experts to check medical devices' specification and their suitability for the hospital. This phase is characterised by continuous trade-offs between clinical teams and procurement department, or between procurement department and suppliers, especially when they do not order from the NHS Supply Chain catalogue. More specifically, there are conflicts of interest regarding the price the hospital is willing to pay, the price the supplier is willing to offer, and the quality that the clinical teams would like to have. Once an agreement between the clinical teams and the procurement department is reached, and the experts confirm the suitability and safety of the medical equipment, the procurement department proceeds with the negotiation/contractual phase and then the order, which can be defined as the last phase of the procurement process. It is worth mentioning that the negotiation/contractual phase does not take place if the procurement group decides to go through the NHS Supply Chain. In the case in which the medical equipment does not receive the expert's approval, the procurement department can decide either to proceed with a new tendering or to renegotiate with the supplier. This choice depends on the type of problem the medical device presents and on the size of the order. More specifically, if the experts state that there are several risks, usually, the procurement department decides to retest the market, while if the problem is related to clinical staff training or IT maintenance and the tendering is big enough, then the procurement department decides to renegotiate with the supplier. As in the case of the prioritisation

procedure, also during the specification and negotiation phase the involvement of clinical engineers, both scientists or technicians, is not guaranteed. It is important to underline that all the services related to the purchasing of capital equipment, such as maintenance, IT services or training, belong to revenue budget. Therefore, the procurement group has to be sure that the budget holder of a certain department has approved all the services and costs related to that specific capital device purchase.

Figure 5.7: Case 3: Capital Procurement for Replacement Process

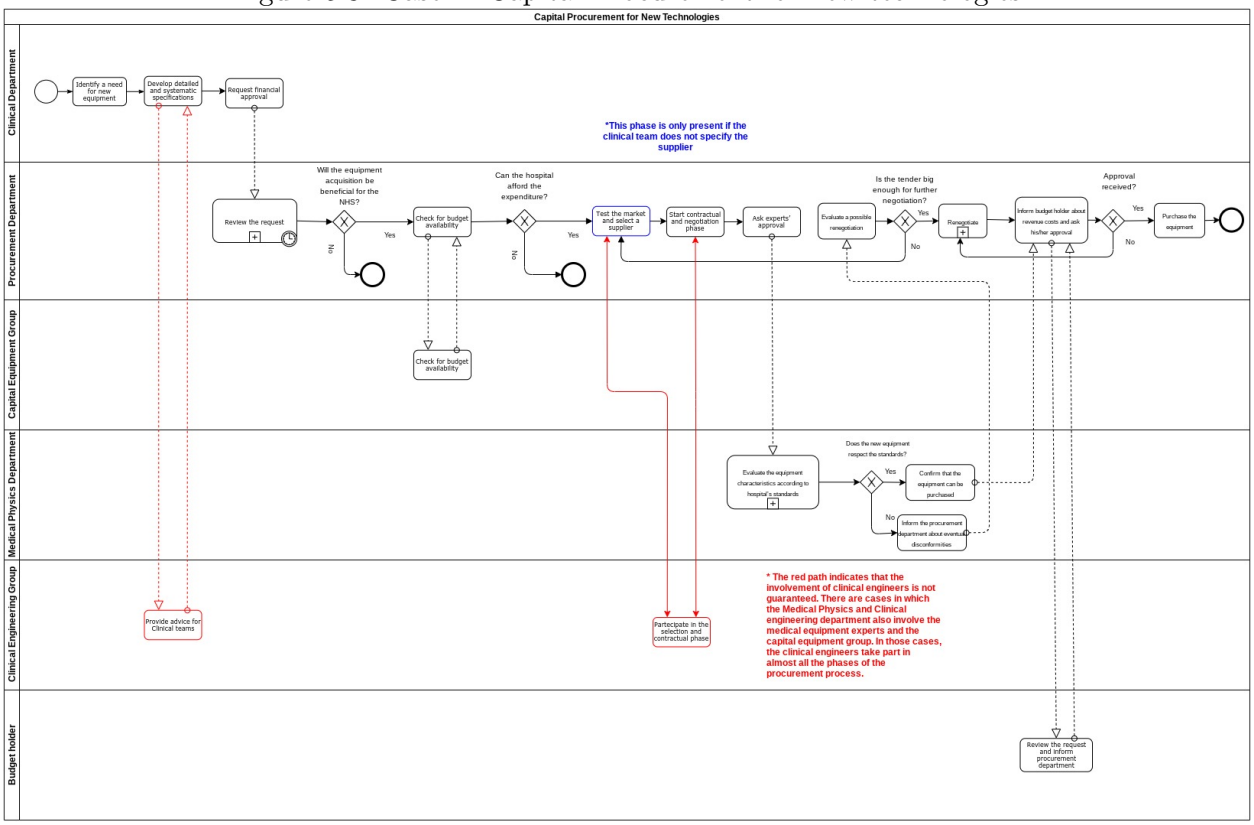


Case 4: Capital Procurement for new types of medical devices

This last process is quite similar to Case 3, however, here, the need for new equipment is requested directly by the clinical teams, and usually involves the introduction of new types of technology within the hospital (Fig. 5.8). During this bottom-up process, the clinical teams need to specify why they need the new medical device and the positive contribution this could bring to the hospital. The request is reviewed by the procurement department together with the capital equipment group, which decides, also according to budget constraints, if the Trust can afford the expenditure. Usually, when the clinical teams request new equipment they have already specified a supplier from which

that equipment can be purchased. If this is not the case, then the procurement group will test the market and select a supplier. Before proceeding with the real purchase, the procurement team asks for the experts' approval and, as in Case 3, they decide if to proceed with renegotiation, order or retest the market. It is worth stressing, that sometimes the clinical teams ask for clinical engineering advice before requesting new medical devices. However, this is not always the case.

Figure 5.8: Case 4: Capital Procurement for new technologies



5.2.4 Phase 2: Specification/selection of the device

The clinical department occupies a central role during the specification/selection phase. Indeed, clinical department's workers have a key interest in determining convenient specifications and selecting devices presenting such characteristics. Moreover, they can potentially play a pivotal role in identifying the need for new equipment for reasons such as increased workload or unreliable performance of their aged machines. Therefore, it is possible to assume that specification is mainly left to the clinical department employees, who can be considered as some of the main users of the medical equipment (Madhlambudzi & Papanagnou, 2019). However, because of budget constraints and a rooted culture of 'buying the cheapest', the procurement department has the power to reshape clinicians' specifications according to the amount of money the hospital is willing to spend for certain types of medical equipment. Indeed, in the case of capital equipment, the clinical teams

need to contact the procurement department for both financial and procurement approvals. Moreover, in the case of capital equipment replacement, the capital equipment group has huge decisional power in prioritising what will be replaced and when. As mentioned in Section 5.2.2, according to the study performed by Madhlambudzi and Papanagnou and with the information collected during the interviews, biomedical/clinical engineers, who are supposed to be properly skilled to verify the specifications determined by potential suppliers, are usually left out of the process. More specifically, the involvement of clinical engineers is mainly dependent on the size and profile of the hospitals. Furthermore, they are usually involved as consultants, without having the possibility to truly select devices or participate in the procurement process. In general, from the interviews it was clear that the selection and specification phase carried out at the hospital level is not always systematically performed and this can be summarised in a limited hospital-based health technology assessment (*Respondents 1,2,4*).

5.2.5 Phase 3: Selection of the supplier

The Procurement Committee is in charge of selecting the supplier according to organizational guidelines which impose that procurement is subject to tendering processes (Madhlambudzi & Papanagnou, 2019). The adjudication of tenders follows an established scoring process. However, this last one has been criticized by health care managers who retain that, although that scoring process has been designed to ensure fairness and competition among suppliers, it does not guarantee the best results (ibid.). This last claim wants to further validate the limitations that national and organizational guidelines/procedures could present in practice when the complexity of procurement decision-making requires a more strategic and flexible approach. The procurement department is mainly focused on the price suppliers are willing to offer for a specific type of device. On the one hand, this could seem like a valid procedure to reduce budget waste. On the other hand, since procurement employees do not have technical or medical expertise, it could be difficult for them to evaluate the cost-efficiency of a device. The selection of the supplier could also result contradictory. On the one side, the procurement process should follow tendering procedures and so, ideally, every time the Trust goes with public procurement it needs to test the market again and select the supplier offering the best price. On the other hand, hospitals prefer standardisation, which could not always be guaranteed if the procurement looks at the cheapest device or if they buy from the NHS Supply Chain. In addition to this, it is also important to differentiate between positive or negative standardisation. In the first case, the clinical teams together with the advice of clinical engineers have analysed and used the specific medical device, therefore, they are quite confident in their choice. In the second case, negative standardisation could be present if the clinical teams continue to use that medical device only because they are used to it or because it is present in the NHS Supply Chain catalogue. *"There is a little bit of tension between what's best for the organisation in terms of financial management and competition, in terms of not having too many different devices in hospitals. We don't want a particular supplier to have a monopoly and be able to take advantage financially but conversely, we don't want 100 different obs machines"* (*Respondent 1*).

5.2.6 Phase 4: Contractual/negotiation phase

The contractual/negotiation phase represents the point of juncture between the internal organizational network, as represented by the previously described BPMN diagrams, and the external network. Focusing again on the device's operational life depicted in Fig 2.4 and Fig. 2.5, it is possible to imagine the first phase (pre-deployment) and the last phase (post-decommissioning) as the head and tail of a snake respectively, which truly are in contact with the external environment. This phase is usually carried out by the procurement department although experts' knowledge is of fundamental importance. During this phase, big Trusts have a large contractual power. Indeed, when the tender is big enough suppliers are willing to offer very competitive prices. However, clinical engineers are not usually involved during this phase although, in addition to good prices, they could also give a huge contribution in terms of services offered, standardisation procedure, and maintenance provided.

5.3 Reflections

From the literature review it was not clear how the procurement process at the hospital-level is carried out and that different procurement cases can be identified. During the interviews it has been interesting to discover that it is important to distinguish between capital and revenue procurement and that the introduction of the NHS Supply Chain has reshaped and affected both the two main types of procurement processes. Additionally, although each Trust or single hospital has its own guidelines indicating the procedures to follow and the approvals to obtain during the various procurement steps, it is clear that not always the ideal path to stick to is followed in practice. This deviation from the predefined procedures has been indicated in red in the various BPMN diagrams and it is interesting to notice how each of the four developed diagrams presents the aforementioned 'red' paths. Moreover, although health care workers should follow standardised procedures there is no standardisation regarding the involvement of key actor such as clinical engineers. The next chapter will provide the current challenges and issues characterising hospital-based decentralised procurement and the procurement process carried out through the centralised NHS Supply Chain system. Furthermore, it will further investigate the current 'procedures deviations' that take place in the Trusts analysed.

Chapter 6

Results III: Centralised vs Decentralised Procurement

The problem of applying centralised or decentralised systems is present in almost every organisation. This is because each of the two 'approaches' presents both advantages and disadvantages. Therefore, during the last century, the idea of 'hybrid' systems has become popular. Currently, NHS procurement in the UK presents both the possibility of going through centralised or decentralised procurement processes, although the idea is to arrive at a complete procurement centralisation. It should be mentioned that the term hospital-based procurement has been used by the author to describe the procurement process carried out at the hospital level in general that, currently, can proceed through both Trust-based tendering procedure or NHS Supply Chain. However, in this Section the term hospital-based procurement will refer to 'decentralised' procurement process referring to situation in which the procurement activities have been conducted though hospital or Trust-based tendering procedure. The issues related to both hospital-based procurement (decentralised) and NHS Supply Chain procurement (centralised) have been collected by both performing desk research and conducting interviews. Before describing what could be and are the possible drawbacks related to these two approaches, it would be meaningful to truly understand what are the advantages and disadvantages of both centralisation and decentralisation as theories in general. Both the advantages and disadvantages that will be described in the next paragraphs have been collected by three sources: (Chan, 2021), (Kanepejs & Kirikova, n.d.), and (Contreras, 2016).

A centralised system can be defined as a system "in which all departments of a company make purchases through a common purchasing division" (Contreras, 2016). On the one hand, the main advantages can be summarised as follow: limited operational costs, easier to standardise, decisions made centrally, greater control and visibility on what the organisation is purchasing, and economies of scale ((Chan, 2021), (Kanepejs & Kirikova, n.d.), and (Contreras, 2016)). On the other hand, the main disadvantages deriving from the application of this approach could be the limited flexibility to move into new markets, limited disaster planning, maverick buying, possible delays, and difficulty of controlling processes remotely ((Chan, 2021), (Kanepejs & Kirikova, n.d.), and (Contreras,

2016)).

A decentralised system can be defined as a system that "allows each field site to have its own procurement centre. Typically, all personnel at a particular location report directly to their general manager for such needs" (Contreras, 2016). Moreover, "operations are spread out over a series of nodes in a network" (Chan, 2021). The main advantages deriving from the application of a decentralised system are increased flexibility, the potential for lower costs at the local level, better customer service, test new products at a smaller scale, employee turnover may decrease, overhead costs may be reduced, and reduced risks related to sudden supplier failure to supply ((Chan, 2021), (Kanepejs & Kirikova, n.d.), and (Contreras, 2016)). Focusing on the possible disadvantages, it could be possible to have: potentially less control, increased operational costs, managerial ability to ensure economies, and over/under-purchasing ((Chan, 2021) and (Contreras, 2016)).

6.1 Issues with decentralised hospital-based Procurement

As previously mentioned, from 2017 a series of policies have been applied with the scope to save money by improving the NHS procurement process. Therefore, the main question would be: "What were/are the main limitations and problems characterizing the procurement at the hospital level?". According to a report written in 2016 by Lord Carter of Coles, "NHS Trusts spend around £9bn on procurement of goods and services of which £6bn is spent by the acute sector. Around a third of this is spent on common goods and services, a third on medical consumables and a third on high-cost medical devices" (Lord Carter of Coles, 2016). The main issue encountered is represented by a considerable variation between Trusts on the value they extract from this non-pay spend, in addition to a relevant lack of understanding of the hidden costs. Furthermore, high levels of procurement inefficiency was and it still is caused by weak compliance to purchase-to-pay systems, under-investment in inventory control, and poor engagement with industry on cost containment (Lord Carter of Coles, 2016). According to Lord Carter of Coles, evidence showed that many Trusts do not know what they buy, how much they buy, and what they pay for goods and services (Lord Carter of Coles, 2016). Therefore, it is possible to assume that "very few Trusts can demonstrate even a basic level of control or visibility over total inventory or purchase order compliance that is common practice in other health systems and industrial sectors such as retail" (Lord Carter of Coles, 2016).

Because of the wide amount of variation in types of products used across the NHS, it is quite impossible to make meaningful comparisons. Lord Carter of Coles provides a quite satisfactory example to show this phenomenon. It was found that "a sample of 22 Trusts covering approximately 16% of NHS spending revealed that in one year they used 30,000 suppliers, 20,000 different product brands, more than 400,000 manufacturer product codes with more than 7,000 people are able to place orders" (Lord Carter of Coles, 2016). This huge product and supplier variety has caused a relevant disaggregation of the NHS, in addition to a continuous undermining of the NHS buying power with the inevitable results of variation and higher prices (ibid.). One of the causes related to

the high variation in both products and prices paid is represented by supplier catalogues changing at a rate of 30% per year, which consequently causes hospital supply chain waste, characterized by high inventories, expiration and obsolescence, and low-value orders and delivery charges (Lord Carter of Coles, 2016).

Apart from the drawbacks characterising hospital-based procurement detected by Lord Carter of Coles, all the challenges described in Section 2.4 and 4.1 have been confirmed during the interviews. In particular, both *Respondents 1 and 2* have mentioned the huge financial constraints affecting the NHS, and *Respondents 1,3,5* complained about personnel availability issues. This problem has also been stressed by *Expert 2* pointing out both the lack of people working in procurement and the difficulty of finding 'procurement experts'. In particular, according to *Expert 2* the NHS provides 'poor' working environment for procurement employees, with limited possibilities of careers, therefore, many possible candidates hesitate to work in the procurement department of a Trust, despite its size. However, the employee covering a specific role is of fundamental importance, especially at management levels such as the case of 'head of procurement'. Indeed, according to *Respondent 5*, the new head of procurement of his/her Trust has completely revolutionised the procurement process, hiring more people and promoting procurement activities across the hospitals.

In addition to confirming the findings of the literature review and the desk research of Chapter 4, further procurement limitations and challenges have been collected during interviews. Firstly, in few cases, the clinical department or whoever requests a new device does not make a complete health technology assessment (*Respondent 1*). Moreover, it is possible that *"they want a particular device [...] because the colleagues in another hospital have it, or they want a particular device because of a conference somewhere"* (*Respondent 1*), without effectively analysing if that device is truly beneficial for the hospital. This issue has also been mentioned in Section 2.1 in relation to the difficulties of selecting a health technology. This poor health technology assessment is also related to another limitation proper of hospital-based procurement, that is the lack of medical experts in the procurement department (*Respondents 1,2,3,4,5*). Indeed, it is worth mentioning that nobody working in the procurement department, who are the ones in charge of proceeding with the negotiation and purchasing processes, are physicians or clinical engineers. They are usually business and economics experts (*Respondent 1,2,3,4,5 and Supplier*). According to the opinions of both the *Supplier* and *Respondents 1,2,3,4,5*, the main problem characterising hospital-based procurement is the lack of medical and technical expertise within the procurement department members, which causes a poor health technology assessment. The lack of medical devices' experts belonging to the procurement department or working with it, has also been identified as a limitation by one of the *Suppliers of the NHS*, who stated that during the negotiation phase, often, the procurement department *"cannot understand what could be the best technology to buy both in terms of training/maintenance services and cost/effectiveness"*. Furthermore, although ideally, the procurement department should work in cooperation with the clinical engineering department, this event is quite rare, especially in small Trusts or in the case in which the doctors have the power to proceed directly with the purchasing process (revenue procurement) (*Respondent 1,2,4*). Indeed, *Respondent 2* deems that *"one of the*

main challenges is the capacity and willingness to engage clinical engineers". The technical and managerial competency of biomedical/clinical engineers could help both clinical teams in the specification/selection of valid medical devices and the procurement department in the selection of the best supplier. Additionally, *Respondent 1* believes that *"the more expensive equipment could be more cost-effective in the long run because it is cheapest to maintain, it can serve more patients, higher benefits [...]. All of that can be financial benefits as well as patient benefits. Sometimes buying the most expensive or more expensive equipment overall ends up costing less money. In the NHS we just want to buy the cheapest, the procurement department wants to buy the cheapest"*. The culture of 'buying the cheapest' has been defined as another main limitation at the base of hospital-based procurement. More specifically, according to *Respondent 1*, *"the biggest challenge we have is that we have developed a culture of finding the cheapest thing rather than the best we can afford. [...] The biggest influence in the organisation has been financing so the director of finance, the department of finance, carries more influence than anybody else, so the biggest challenge is that we focus on buying the most affordable product, not the best"*.

6.2 Possible drawbacks of procurement centralisation policies

In 2018, 40% of procurement was done through the NHS Supply Chain and the remaining 60% through local Trust negotiations (20%) and hubs (40%) (*Less waste, more health: Procurement 101*, 2018). In 2020, NHS Supply Chain managed more than 4.5m orders a year and it aimed (and still aims) to carry out 80% of all NHS purchases by volume by 2022 (Johnstone, 2019) (Fig. 6.1). This indicates that "such a significant increase in consolidated expenditure will in principle reduce the scope for both direct procurement by NHS Trusts and for collaborative procurement through NHS hubs" (Sanchez-Graells, 2018) (Fig. 6.2). Focusing on these last ones, given that the current level of hub-channelled procurement is 40% and supposing that the procurement managed by NHS Supply Chain is still 40% or a little more, achieving 80% of centralised procurement would be significantly different from the current structure (ibid.). More specifically, to some extent, it would seem that 80% of centralised procurement could result in rather small incremental changes not sufficient to unlock the reductions in costs currently expected. In addition, "there is a risk of parallel or competing procurement structures" (Sanchez-Graells, 2018) if there is insufficient coordination between centralised and hub-based procurement (ibid).

It is worth stressing that at the beginning of its development in 2016 the Procurement Transformation Programme, aiming to improve the whole NHS procurement, focused on three main components with the scope of solving the previously mentioned procurement issues at the hospital level. The three main components were the following: (1) 'NHS Catalogue', national catalogue of goods where Trusts can have confidence both in the range and price at which they are procuring; (2) 'Future Operating Model for procurement and supply chain in the NHS', focused on using the opportunity created by the end of the existing NHS Supply Chain contractual arrangements to restructure the procurement and supply chain delivery model, to rationalise the procurement landscape, to reduce spend, and consolidate purchasing power; (3) 'eProcurement', designed to drive

adoption of messaging standards throughout the healthcare sector and its supporting supply chains (Lord Carter of Coles, 2016). However, as described in Section 4.5, it is worth noticing that since establishing the Procurement Transformation Programme, the NHS procurement has been subject to progressive centralisation and privatisation, through excessive outsourcing. As previously mentioned, these centralisation policies could potentially save money. However, according to Hall et al. (2020), it is important to understand how those savings are sought. "First, by limiting the ability of local NHS Trusts and their staff to specify their needs in ordering supplies, since the CTSPs simplify the requirements for suppliers, who only have to provide for a single specification. Second, companies are induced to offer these standardised products at a lower price through the creation of an oligopoly, i.e. a limited competition pool, in which the commercial market is only made open to a restricted group of vendors. Some of the suppliers who receive these approvals are wholesalers who don't necessarily manufacture the products they supply"(Hall et al., 2020).

Figure 6.1: Procurement Centralisation Timeline

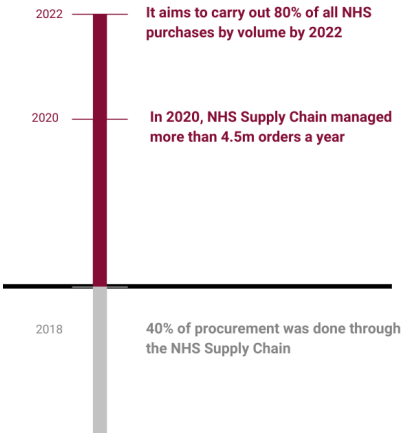
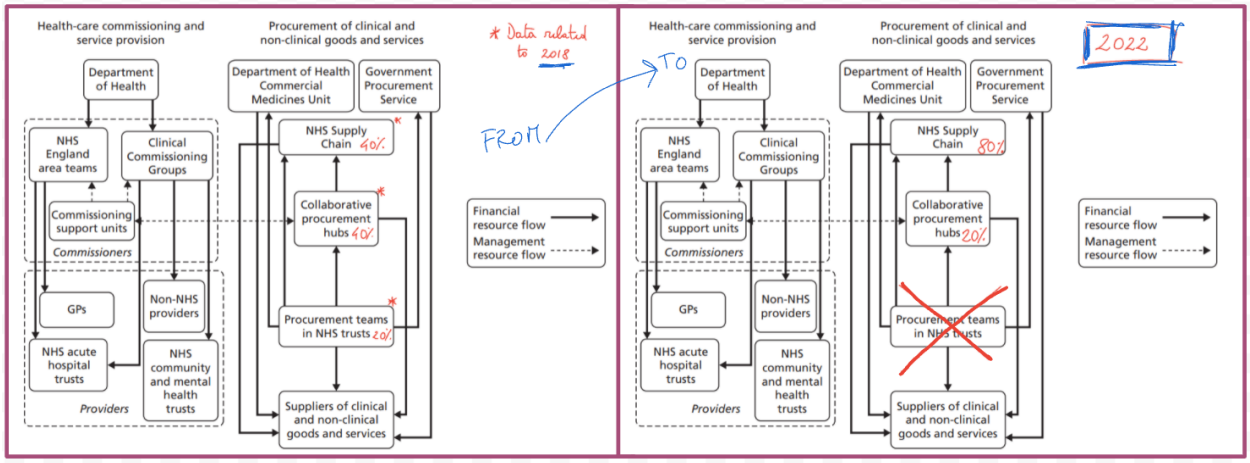


Figure 6.2: Progressive centralisation through NHS Supply Chain. Adapter from (Sanderson et al., 2015)



It is worth mentioning that the aforementioned drawbacks found during the author's desk research have also been confirmed during the various interviews. Moreover, further limitations have been detected. Firstly, the prices hospitals or Trusts can get from the NHS Supply Chain are not always lower than the ones they could obtain through direct negotiation with the supplier. Secondly, the limited health technology assessment is not only a problem concerning hospital-based procurement, *"but what hospitals and what the supply chain are not very good at doing is to perform a full assessment"* (*Respondent 1*). In addition to this, according to *Respondent 2*, another main problem of ordering directly from the NHS Supply Chain catalogue is that the *"NHS Supply Chain does not control the quality and it just makes things available, accessible and gets prices for them but they do not necessarily do the right thing"*. The main issue here is that the NHS Supply Chain does not have the right professionals for the selection of the devices they insert in their catalogue (*Respondents 2,3,4*) and so they *"do not allow new and good solutions to reach people's consciousness"* (*Respondent 2*). Therefore, it is possible to assume that a complete centralised procurement could inhibit innovation and consequentially medical advancement since, usually, a new and more efficient medical device is present in the NHS Supply Chain catalogue months after it has already been discovered and purchased through decentralised hospital-based procurement (*Respondent 2*).

Moreover, the simplicity of ordering through the NHS Supply Chain often represents a problem for the hospital. Firstly, physicians and other professionals buy from the NHS Supply Chain without even considering if they effectively need that device, contributing to increasing budget waste (*Respondents 1,2,4*). Secondly, since the NHS Supply Chain is particularly convenient in terms of time, clinical engineers are not motivated to search for more cost-efficient technologies, limiting the pro-activity of the entire clinical engineering team (*Respondent 2*). Thirdly, since consulting technology experts, such as clinical engineers, is more time consuming, doctors and other professionals prefer to buy devices from the NHS Supply Chain even if they are not fully satisfied with the medical devices' availability of the NHS Supply Chain catalogue (*Respondents 1,2,3,4,5*). Therefore, it is very difficult for the Trust to control the purchasing through NHS Supply Chain (*Respondent 2,4,5*) and according to one of the respondents, sometimes the Trusts themselves *"have to do some work to be able to mask the NHS supply chain catalogue, in order to stop people from ordering things just because they are in the catalogue [...] it is not a good decision"* (*Respondent 4*).

From the aforementioned drawbacks, it seems that one of the issues related to the NHS Supply Chain is represented by the potential and actual problems it causes to the current hospital-based procurement. Moreover, according to *Expert 2*, although one of the main problems affecting hospital-based procurement is the lack of standardisation during purchasing (as also stressed by the Lord Carter of Coles (Section 6.1)), the NHS Supply Chain catalogue presents several options among which clinicians can choose. Therefore, in addition to potential waste in terms of excessive orders made by clinicians, these last ones also have the possibility to choose among a long list of medical devices (*Respondents 1,2,3,4,5 and Expert 2*).

Overall, the multi-layered outsourcing procurement system previously described does not com-

pletely fulfil particular conditions and ideas that should be at the base of a public service procurement process. According to Hall et al. (2020), these ideals can be summarized as follows. Firstly, public interests should remain paramount. Secondly, procurement should take place via "transparent procedures of competitive tendering, published criteria, and diligent investigation of company records, thus minimising, corruption, cronyism, and cartels" (Hall et al., 2020). Thirdly, rigorous public scrutiny of contractor performance and payments of public money should be performed. Fourthly, "specification and supply of equipment should be based on the requirements of public services" (Hall et al., 2020). Lastly, ministers are effectively accountable for all the above points. It is worth stressing that, apart from predictable drawbacks depending on a layered structure and outsourcing policies, the current centralised NHS Supply Chain system has already shown some weaknesses. Hall et al. (2020), points out that it has already proven unwilling or unable to resist the intrusion of predatory cartels, referring to a parliamentary debate in 2019 when the Kier Group awarded the supplier status for floor coverings in NHS hospitals to three foreign firms – "who had been convicted just a few months earlier in France of operating a price-fixing cartel for 23 years" (Hall et al., 2020). Moreover, the Department of Health and Social Care declared that despite its holding responsibility for the management of the supply chain of the NHS, it was rather detached from operational decisions. This lets to a belief that probably the secretary of state quite literally does not know how the NHS supply chain is being operated, or that he does not know enough (Hall et al., 2020). Furthermore, expertise in procurement is about being aware of how the competitive market works and taking advantage of its structure in the interests of the purchaser. However, the privatisation of NHS procurement can be seen as characterized by mainly monopolistic and oligopolistic arrangements, where the needs of NHS could be easily subordinated to the contractual rigidities of the suppliers (ibid.).

The problems related to procurement centralisation, or better to excessive procurement centralisation, have also been stressed by *Expert 3* who stated that the UK Government has tried for years and years to centralise procurement and that *" it's been driven by obviously the desire to reduce costs, reduce prices"* (*Expert 3*). However, he/she also believes that the centralisation approach *"is overestimated in terms of its potential value and impact, especially now that we're more concerned with the innovation and sustainability agenda that pushes you in a different direction."* (*Expert 3*). Additionally, he/she stated that *"it's important to distinguish between the centralisation of contracts versus maybe better coordination of market intelligence, better coordination of data, there's a lot that can be done to work collaboratively beyond bundling your purchases into bigger and bigger contracts"* (*Expert 3*). Indeed, involving the centralisation of contracts, *"it's overvalued, and works contrary to other interests that you might have. So I think there's a huge need for central coordination, central facilitation, and lots of things can be done with central support. That's not the same as bundling contracts"* (*Expert 3*). Moreover, he/she said that decentralise procurement does not mean doing everything on your own or having completely freedom of choice. Moreover, although *"you buy into a centralized arrangement, and it serves you well for a time, that doesn't mean it will serve you well necessarily in the long term. So there's something about not looking for a solution because the whole system is highly dynamic and things will come back and forth and so*

on. I'm skeptical about centralization." (*Expert 3*).

An example showing the drawbacks of centralised procurement process which have affected final health outcomes and the safety of health care workers is described in Appendix F and concerns the case of Personal Protective Equipment during the Cvoid-19 crisis.

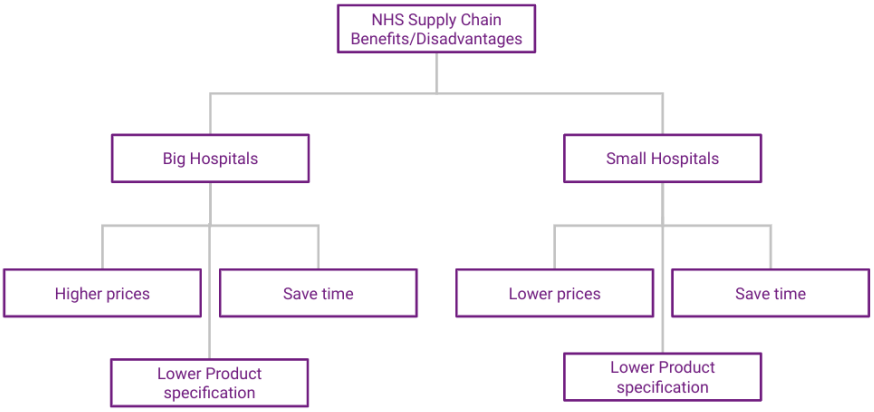
When the NHS Supply Chain does and does not work

In addition to the possible limitations of centralised procurement or the drawbacks characterizing hospital-based procurement, it is important to understand when and in which circumstances it is worth it for the hospital to go through the NHS Supply Chain procurement process. The results obtained from the interviews indicated two discriminant factors that have to be considered, the size of the hospital and the type of expenditure. Focusing on the first one, to the question "What are the possible advantages deriving from procurement through NHS Supply Chain?", *Respondent 1* replied that, in terms of money savings, *"I think it is very much depending on the size of the hospitals, small hospitals benefit from the supply chain, large not so"*. Indeed, as mentioned in Section 6.2, although the centralisation of procurement aims to save money letting hospitals pay optimal prices for medical devices, not always the prices offered by the NHS Supply Chain catalogue are lower than the ones obtained by the single hospital during the negotiation phase. Therefore, *Respondents 1,2,3,4,5* pointed out that when the expenditure is quite big they prefer to directly contact the supplier and do their own decentralised tendering procedures. More specifically, when the size of the trust/hospital is big enough, this last one has a high purchasing power since the suppliers *"are willing to offer them a much better price in order to win the trade"* (*Respondent 1,2,3,4,5*). This has also been confirmed during the interview with a medical devices' *Supplier*, who stated that the contractual power of the trust/hospital increases proportionally with its size, and often the price they can reach during the negotiation phase can be lower than the ones offered by other suppliers belonging to the NHS Supply Chain Framework (*Supplier*).

Moreover, it is worth mentioning that in addition to the hospital contractual ability with suppliers, the hospital does not have to afford the fixed costs proper of the structure of the NHS Supply Chain, deriving from excessive outsourcing of its main activities (see Section 4.5). Thus, "What are the advantages to go through the NHS Supply Chain?". As previously mentioned, another discriminant factor to consider is the type of expenditure. In particular, *Respondents 1,2,3,4,5* stressed the importance of making a distinction between capital procurement and revenue procurement. In the UK, capital procurement indicates the purchasing of medical equipment having a value above £5,000, the reverse applies for revenue procurement where a single doctor of a specific department has the power to purchase certain types of day-to-day equipment without going through all the several hospital approvals. Therefore, especially in the case of revenue procurement, *Respondents (1,2,5)* retained that, because of the simplicity of purchasing medical devices through the NHS Supply Chain, physicians or clinical directors prefer to order directly from the NHS Supply Chain framework without consulting the clinical engineering department or

other technology experts, if any. It is worth stressing that this 'procedure' is also suggested by one of the guidelines on procurement collected during the interviews, which indicates no need to get the procurement approval in the case in which the device is available from the NHS Supply Chain framework. The document also specifies that *"Supply Chain may not always be the cheapest way for [...] to buy, but it is compliant and the process is simple and efficient"*. Hence, they decide to *" buy from the supply chain cause it is easier, it just saves time so they might be prepared to pay a little bit more for the product"* (*Respondent 1*) since *"if we buy a recommended product from the supply chain we don't have to go through all the processes"* (*Respondent 1*). However, *"for big procurement exercises we will go directly to the manufacturers, we know we can get a better price"* (*Respondent 1*). Therefore, it is possible to assume that, according to the results obtained from the interviews, the main reason for big Trusts to proceed with centralised procurement instead of decentralised hospital-based procurement is to save time and to comply with all the legislative aspects (*Respondents 1,2,3,4,5*) (Fig. 6.3).

Figure 6.3: Advantages and Disadvantages of centralised procurement



The data collected from the report "NHS foundation Trusts: consolidated accounts 2016/17" (NHS Improvement, 2017), indicates that in the UK (2016/2017) there are 157 Trusts. More specifically, there are: 6 Community, 5 Ambulance, 17 Specialist, 44 Mental Health, and 85 Acute (Fig. 6.4). Since acute Trusts represent the majority in terms of quantity, income, and expenditure, it would be sensible to concentrate on that type of Trusts. The same report differentiates between large, medium, and small acute Trusts, indicating for each of the three categories interesting financial data. Fig. 6.5 shows that although big Trusts account for only 31,5% of the UK Trusts, their income represents the 54,2% of the total Trusts' income, while their expenditure the 53,85% (these values are calculated from the data reported in Fig. 6.5). Furthermore, from the report "Consolidated NHS provider accounts 2019/20" (NHS Improvement, 2020) the largest individual deficits were at big or medium Trusts (King's College Hospital NHS Foundation Trust (£111.8 million) (big trust);

London North West University Healthcare NHS Trust (£93.4 million) (big trust); Worcestershire Acute Hospitals NHS Trust (£81.0 million) (medium trust); University Hospitals of Leicester NHS Trust (£79.9 million) (medium trust); Barts Health NHS Trust (£74.5 million) (big trust). Therefore, it could be questionable how centralisation would help these types of hospitals to improve their savings.

Figure 6.4: Types of Trusts. Retrieved from (NHS Improvement, 2017)

Analysis by type of trust

2016/17 excluding charities	**Community £m**	**Ambulance £m**	**Specialist £m**	**Mental Health £m**	**Acute £m**	**Total £m**
Income	1,151	985	3,382	9,605	36,854	**51,977**
Expenditure before depreciation and impairments	(1,102)	(940)	(3,122)	(9,072)	(35,366)	**(49,602)**
Depreciation and amortisation	(21)	(40)	(118)	(199)	(969)	**(1,347)**
Net finance costs	(9)	(8)	(59)	(184)	(742)	**(1,002)**
Other	-	1	31	15	62	**109**
Surplus/(deficit) before I&T	**19**	**(2)**	**114**	**165**	**(161)**	**135**
Impairments (net of reversals)	(8)	(31)	(61)	(200)	(641)	**(941)**
Transfers by absorption	-	-	(1)	9	1	**9**
Surplus / (deficit) for the year [1]	**11**	**(33)**	**52**	**(26)**	**(801)**	**(797)**
Number of trusts at end of the year [2]	*6*	*5*	*17*	*44*	*85*	***157***

Figure 6.5: Small, Medium, and Big Foundation Trusts. Retrieved from (NHS Improvement, 2017)

2016/17: acute sector (excluding charities)	**Large Teaching £m**	**Large Other £m**	**Medium £m**	**Small £m**	**Total acutes £m**
Income	15,529	4,444	12,847	4,034	**36,854**
Expenditure before depreciation and impairments	(14,795)	(4,252)	(12,363)	(3,956)	**(35,366)**
Depreciation and amortisation	(411)	(110)	(339)	(109)	**(969)**
Net finance costs	(366)	(85)	(238)	(53)	**(742)**
Other	40	5	4	13	**62**
Surplus/(deficit) before I&T	**(3)**	**2**	**(89)**	**(71)**	**(161)**
Impairments (net of reversals)	(316)	(122)	(158)	(45)	**(641)**
Gains from transfers by absorption	1	-	-	-	**1**
(Deficit) for the year [1]	**(318)**	**(120)**	**(247)**	**(116)**	**(801)**
Number of trusts at end of the year [2]	*20*	*7*	*38*	*20*	***85***

6.3 The case of Revenue Procurement

"NHS bodies do not capitalise any purchases of assets for less than £5,000 in accordance with the requirements of the GAM (Group Accounting Manual). The exception to this is where a collection of assets that are part of a single collective asset – in this case, they are capitalised as a grouped asset. To be capitalised as a group, each of the items in the group must meet all of these criteria:

- the total cost of the grouped asset is greater than £5,000
- functional interdependence – so they can only be used together
- acquisition at about the same date and planned disposal at about the same date

- under single managerial control, and each individual asset has a value of over £250" (HFMA, 2019)

Fig. 6.6 demonstrate that much medical equipment costs relatively small sums, like infusion pumps, vital sign monitors etc., and accounts 93% of the organisations' medical equipment assets and 30% of the cost base (Hegarty et al., 2017), in 2017. However, considering that the revenue budget covers all the day-to-day running costs of the NHS, the whole budget allocated for revenue is much higher that the one for capital. In particular, for 2018/19, the revenue budget was £123.3bn and the capital budget was £5.9bn (Kraindler, Gershlick, & Charlesworth, 2019). Additionally, it should be mentioned that the revenue budget has increased during the last few years. In particular, according to (Kraindler et al., 2019), since 2010/11, capital spending by the Department of Health and Social Care has declined from £5.8bn (2010/11) to £5.3bn in 2017/18 (minus 7%) (ibid.). The capital budget in 2017/18 was 4.2% of total NHS spending while in 2010/2011 it was 5% and fall is mostly explained by transfers from the capital to the revenue budget (ibid). Moreover, "although sales of capital are meant to be re-invested, this has not been the case, with significant amounts of money from sales of land being used for the revenue budget, which covers the day-to-day costs of delivering care" (Kraindler et al., 2019).

Despite this increase in revenue budget and consequent revenue procurement, this last one allows more freedom of choice and individual power during the purchasing process. Indeed, from the interviews it was clear that only if the procurement process involves an expenditure far above £5,000, more rigid procedures are applied and it is more common to have the involvement of experts during the procurement process (*Respondents 2,3,4,5*). Moreover, *Respondent 5* said that although the 'official' budget threshold to differentiate between revenue and capital is £5,000, the budget holders can approve orders much more expensive than that value if the order represents operational costs. In particular, only when the expenditure reach 'non-conventional' costs involving substantial amounts of money, the finance/procurement department stops the order and performs a deeper investigation on it (*Respondents 2,5*). However, such a large number of relatively low-cost medical equipment is vital for the delivery of efficient and safe health care to patients and needs to be effectively managed (Hegarty et al., 2017). Moreover, whereas the Finance Department may in some circumstances be purely concerned with capital equipment (ibid), the clinical engineers recognise the importance of all medical equipment, and this was also clear during the interviews (*Respondents 2,4,5).* Furthermore, clinical engineers also expressed their concern regarding the way in which revenue procurement is carried out (*Respondent 2*). The possibility to order directly from the NHS Supply Chain does not guarantee the best purchase, both in terms of quality and price (*Respondent 2,4*). Moreover, *Respondent 4* stated that *"when orders go through the NHS Supply chain"*, many times they *"are aware of the purchase once it gets here (at the hospital) and no training etc is provided"*. In the case of revenue procurement clinicians are often free to order from the NHS Supply Chain catalogue even without the approval of their budget holders (*Respondent 4*). In particular, often, the budget holder has already given pre-authorisation to clinical teams to directly order from the supply chain catalogue through a sort of delegation.

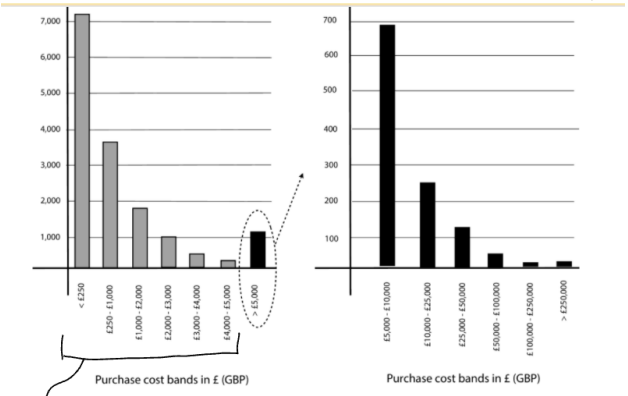
From the interviews, it is possible to say that *"it is not a great system for that aspect, it really does not offer a lot of assurance, the only real control is that they do not have access to everything in the supply chain catalogue, because procurement masks a lot of the catalogue and only allows ordering unmasked products"* (*Respondent 4*). The practice of 'masking' some of the NHS Supply Chain catalogue's products by procurement or clinical engineers is common to both the two Trusts interviewed. Therefore, it seems that Trusts want to protect themselves from the supply chain catalogue. *Respondent 4* said *"It just makes me uncomfortable how easily people can order things from the NHS Supply Chain catalogue"*, since *"with the supply chain catalogues, nobody has to press the bottom and give the approval"* and *"there is not so much control on it"*. It is also important to underline that each department or specific area can overspend, therefore, it could result in an alarming situation.

Respondents 1,2,3,4,5 believe that one of the biggest challenges is controlling the process, controlling choices, and controlling the placement of orders without approvals. According to their opinions, this 'lack of control' mainly characterises revenue procurement since capital procurement follows fairer procedures and there are just the occasional things that 'bypass the system' (*Respondents 2,3,4,5*). It is the revenue process that is more worrying (*Respondents 2,4,5*). Moreover, although budget holders themselves authorise the purchasing, frequently they are not completely aware of what is going to be bought by clinicians, since they do not conduct a proper budget evaluation (*Respondents 1,2,3,4*). One of the causes of this phenomenon could derive from bad training provided to health care workers. In particular, *Respondent 4* stated that *"we don't train people enough, we should make junior clinical staff more aware of this things"*. In addition to the excessive amount of products purchased even without real necessity, it is also sensible to look at their quality since *"some of the things in the NHS supply chain catalogue are really for infrequent lay use and sometimes people just look at the price"* (*Respondent 4*), *"Personally, I don't like that they can order without the medical device approval"* (*Respondent 4*). Moreover, it is worth stressing that even when the device is not present in the NHS Supply Chain, the involvement of clinical engineers or Medical Physics department is not mandatory for the purchasing of day-to-day medical equipment. According to *Respondents 1,2,3,4*, these phenomena inhibit innovation and increase waste.

6.4 (Un)Following Procurement Guidelines

Although every Trust has its own guidelines, in addition to the ones provided by national and international organisations, not all health care workers follow or are even aware of them. Focusing on the national guidelines, *Respondents 1,2,4,5* said that even when they are aware of those guidelines their Trusts do no rely on them, confirming what was found by Hinrichs et al. in Section 4.1. More specifically, they consider only the 'legislative' aspects of those guidelines to be aware of necessary and new procedures to be followed according to the English law (*Respondent 2*). However, in the case of Trust-developed guidelines (as the ones described in Section 5.2) it is not guaranteed that

Figure 6.6: Revenue Procurement Expenditure. Adapted from (Hegarty et al., 2017)



93% of organization's medical equipment assets AND 30% of the cost base in 2018

93%

30%

REVENUE

CAPITAL

Medical Equipment Assets Data				
Cost Bands	Number of Items	% of Items	Total Cost in Band	% of Total Cost
Up to £250	7,147	46.6	£893,375	2.5
£250 to £1,000	3,540	23.1	£2,212,500	6.1
£1,000 to £2,000	1,795	11.7	£2,692,500	7.4
£2,000 to £3,000	1,004	6.6	£2,510,000	6.9
£3,000 to £4,000	471	3.1	£1,648,500	4.5
£4,000 to £5,000	238	1.6	£1,071,000	2.9
£5,000 to £10,000	690	4.5	£5,175,000	14.2
£10,000 to £25,000	250	1.6	£4,375,000	12.0
£25,000 to £50,000	130	0.85	4,875,000	13.5
£50,000 to £100,000	39	0.25	£2,925,000	8.0
£100,000 and £250,000	12	0.08	£2,100,000	5.8
Greater than £250,000	14	0.09	£5,880,000	16.2
Totals	15,330	100	£36,357,875	100

these last ones will be followed by health care workers, or that hospital's employees are aware of their presence (*Respondents 4,5*). *Respondent 5* pointed out that the only ones who follow procurement guidelines are the ones who have developed them. In particular, *"Everyone in the trust very rarely follows the guidelines for procurement and financial instructions, so we do have a lot of challenges and discussions with that stakeholders, procurement hasn't been presented enough by the trust"* (*Respondent 5*).

One of the most relevant cases where the system is bypassed is represented by situations in which the budget holder gives pre-authorisation to clinicians to order medical equipment, or inversely when clinicians purchase medical devices without having received a 'direct' budget holder approval for that precise order. This situation occurs for two main reasons. Firstly, budget holders usually present excessive workload (*Respondent 3,4*), therefore, in some circumstances they prefer to bypass the system to save time. Secondly, the same applies to the procurement department. Because of excessive workload, the procurement department has shifted a large part of its responsibility to budget holders, who, in some cases, are also able to approve orders above the threshold established by the Trust. This lack of procurement personnel has been stressed by the literature review (see Section 2.4), during the desk research (see Section 4.1), and by *Expert 2* who said that because of poor career's opportunities, few people are willing to work in the procurement depart-

ment of an NHS Trust (see Section 6.1). Excessive workload and lack of personnel also increase the phenomenon of deviation from guidelines since, often, these last ones have not been properly communicated by the procurement group. Poor communication between budget holders and the procurement department, deriving from excessive workload, has been stressed by *Respondent 4* who said that budget holders *"have a lack of time to sit with you and talk about procurement"*.

Clinical Engineers Involvement

Both national and Trust-developed guidelines suggest the involvement of clinical engineers during the different phases of the procurement process (see Section 2.1). However, from the procurement cases described in Section 5.2.3, it is clear that not always the involvement of clinical engineers is guaranteed (see also Sections 5.2.4,5.2.5, and 5.2.6). The poor involvement of clinical engineers or other experts has been amplified from the moment in which clinical teams or the procurement department can order directly from the NHS Supply Chain Catalogue. Indeed, as already mentioned, the simplicity of ordering directly from a catalogue pushes clinical teams to 'bypass' the clinical engineering department. This leads to poor standardisation within the hospital. Furthermore, according to *Respondents 1,2,4* clinicians tend to order devices from the NHS Supply Chain catalogue even when they are not truly useful or needed by the hospital or the specific clinical department. This could potentially amplify the risk of buying equipment that does not have the capabilities specified by suppliers (Madhlambudzi & Papanagnou, 2019) or that do not conform with the business strategy of the Trust.

6.5 Reflections

From the literature and according to what previously described in Section 6.1, it is clear that hospital-based procurement in the UK presents some challenges and the UK Government would like to solve these issues by centralising 80% of the whole national procurement of medical devices, with the consequent elimination of hospital-based procurement. Therefore, since the main objective of this thesis project is to provide useful insights on how to improve hospital-based procurement, it is necessary to understand what are some of the limitations of centralisation policies, what some of the consequences for the whole sanitary system could be, and why it would not be optimal to completely eliminate decentralised hospital-based procurement. Moreover, since the objective is to put an end to decentralised hospital-based procurement, it would not be meaningful to proceed with the idea of improving it without explaining what the current advantages of having it are, or what the disadvantages of its complete cancellation could be.

From the previous analysis (see Section 6.2) it is clear that some of the main limitations deriving from excessive centralisation and privatisation can be summarised with the creation of oligopoly and low product quality. On the one hand, this structure could potentially save money and reduce the amount of non-pay NHS expenditure. On the other hand, this type of inflexible structure can inhibit and limit innovation in the long run, since the culture of 'buying the cheapest' is even more

rooted when the purchasing process is centralised and the device's specification by the hospital is limited. It is worth mentioning that, because of budget constraints, also at the Trust level, the procurement department tends to buy the cheapest and usually it does so without performing a proper health technology assessment. However, this phenomenon has increased with the introduction of the NHS Supply Chain framework and the possibility of buying directly from its catalogue instead of consulting the various Trust's specialists and technology consultants. After all, if the NHS Supply Chain has already tested the market, selected suppliers offering the best prices, and created its catalogue, why should health care workers go through hospital-based procurement? From the interviews, it is clear that, in many cases, one of the main advantages of having decentralised hospital-based procurement is the possibility to test the market according to the specific hospital's necessities and enhance innovation (*Respondents 1,2,3,4 and Expert 3*). Indeed, innovative and more efficient medical technologies are usually discovered and adopted several months in advance by Trusts through hospital-based procurement, before they are included in the NHS Supply Chain catalogue (*Respondent 2*). In particular, when the clinical engineering department is consulted and when physicians specify their needs for a particular medical device, a more cost-effective purchasing process is carried out (*Respondents 1,2,3,4,5*).

In addition to this, when the procurement progresses at the hospital level, it is possible to buy medical devices perfectly in line with the strategy of the hospitals. Moreover, *Expert 3* said that *"the logic, the rationale of getting people on site, especially when you're talking about innovation, is trying to help with healthcare transformation, trying to integrate new technologies, there's no way you're going to succeed without doing that. If you don't pay attention to stakeholders, if you don't see it much more as a negotiated way forward.[...] if you're looking at something that goes across commercial, across the boundaries of the healthcare provider to the commercial side, you want all to work in a very collaborative way, especially where we're talking about healthcare transformation, and so on"* (*Expert 3*). Therefore, it would be sensible to consider to what extent could the complete elimination of hospital-based procurement be beneficial for the UK health care system, especially in terms of health care performance and patient-centredness. In addition to this, as previously mentioned, at least in the case of big Trusts, the prices offered by the NHS Supply Chain are not always cheaper than the one obtained through direct negotiation with suppliers (*Respondents 1,2,3,4,5*), and the main advantages are that the 'supply chain way' is compliant, simple, and efficient. Hence, the main doubt is how coherent is it to maintain or enlarge the whole complex NHS Supply Chain structure, together with its outsourcing costs, only to potentially offer better prices for small hospitals and to save time for big ones. Moreover, what will be the role of clinical engineers, procurement department employees, and other technicians in the hospitals if the job has already been done by the private companies constituting the national supply chain? Without any doubt, the contribution of these professionals would still be valid during other phases of the medical device's operational life, however, their potential contribution in improving hospital performance would be limited.

As already mentioned several times, the idea of eliminating hospital-based procurement derives

from the objective to save money and reduce the NHS debt. Furthermore, there is also the desire to reduce the so-called 'internal market' established in 1990. However, adopting a complete procurement centralisation policy could potentially destroy the competition among Trusts in the UK, with a consequent possible decline of health care quality. More clearly, if all the Trusts or single hospitals are forced to purchase medical devices already selected by an external organization, they will have limited choices based on what the centralised catalogue offers them. Therefore, none of the hospitals are spurred on being excellent in a particular field, or better, none will have the possibility to excel in something since everyone will be limited in the use of similar specific devices without the possibility of testing innovations or even decide what, according to their own research, is the most cost-efficient device.

Furthermore, this centralisation structure could also cause a negative dynamic effects on the market in the medium-long run. These negative outcomes could mainly affect small and medium enterprises, which, in the absence of adequate tender design, could be excluded from very large contracts (Sanchez-Graells, 2020b). The potential exclusion of small-medium companies from the NHS market, does not only bring a potential anti-competitive situation, but it also affects the types of product that can be used by hospitals. More specifically, the exclusion of a certain company from the market does not only limit its economy but it also inhibits the presence of its product on the market. This could potentially damage innovation which is largely dependent on both product diversification and free market competition, which pushes competitors to innovate and excel in various medical and non-medical fields. This situation would proportionally degenerate with centralisation, higher levels of centralisation would contribute to higher difficulty for small-medium enterprises to trade their products and survive in the market. With a complete procurement centralisation through NHS Supply Chain and their catalogue, the future of small enterprises or start-ups can only follow two directions, being incorporated by bigger companies or failure. Indeed, if small companies will no longer have the possibility of showing their products to clinicians, or better clinicians will no longer have the possibility of buying niche products produced by small companies not included in the Supply Chain catalogue, the only way to survive for the small enterprise is to merge with bigger ones, always assuming that there would be the possibility of doing so.

In addition to adequate tender design, also the price offered could affect the small-medium enterprise economy. Usually, the price offered by small companies are higher than the ones offered by huge corporations, which perform a mass-production able to amortise the various expenditures. However, it should be mentioned that the final price is not only determined by the amount of devices produced and so by economies of scale, but it also depends on the quality of the final product. Therefore, if the culture of buying the cheapest will dominate within the NHS Supply Chain catalogue, the cost-efficiency of the purchased product can not be guaranteed. According to Sanchez-Graells, "The emerging evidence of the failure of the UK's centralised healthcare procurement system to react to the COVID-19 pandemic is the canary in the coalmine" (Sanchez-Graells, 2020b). More precisely, "The excessive concentration on single suppliers and service providers justified on the grounds of 'listed price' savings and streamlined contractual administration, at the

expense of a wider choice of (more expensive) suppliers, creates very significant operational and governance issues—including exploitative capture (through excessive pricing), insufficient supply and inflexibility to scale up operations when required, as well as too many 'single points of failure' along supply chains that can be put under extreme pressure—in particular, but not only, concerning medical equipment and consumables" (Sanchez-Graells, 2020b).

Another point to discuss is the importance of considering the context-dependence of the various HTM activities as discussed in Section 2.1.2. The idea behind the development of HB-HTA relies on each hospital's single and peculiar necessities during the assessment of the various medical devices. This is because each hospital can be considered as a single and different entity. Its singular characteristics are determined by the context in which the hospital is situated, the patients it serves, and the health care employees working there. From these considerations, it is paradoxical how national and international studies promote and recognise the importance and efficiency of hospital-based health technology assessment, while the UK Government simultaneously implements and promotes centralised health technology management activities such as procurement. If the assessment of health technology would be improved if performed at the hospital level, why would it not be the same for the selection of health technologies, the negotiations of prices with the supplier, and the contractual agreements related to maintenance, training etc... It should be mentioned that from a practical point of view, the activities conducted during the procurement process can be considered even more dependent on the hospital in which those activities will be performed. This is because, in addition to the high level of 'objectivity' and 'technicality' characterising the assessment of a medical device, the procurement of this last one is also subject to the single necessities of the health care workers using it and checking for its safety and maintenance.

Chapter 7

Discussion: Apply Networking Strategies to HB-HTM

This chapter will discuss the main results obtained under the three paradigms characterising an interconnected world or network. Moreover, it will provide evidence of how networking theories can be used to explain and understand hospital-based procurement and how the relative networking strategies can be applied.

7.1 Legitimacy to Apply Networking strategies to HB-Procurement

The analysis carried out in Section 5.2 shows the different types of procurement processes and the relative stakeholders involved. Moreover, the diagrams depicted in Section 5.2.3 revel a series of interconnections among the various actors according to the different types of procurement activities during each procurement process. In addition to this, both Chapter 6 and Chapter 5 have provided several examples of the possible 'unstructured' issues and drawbacks characterising the whole procurement process conducted at the hospital level. Therefore, from these premises, it is important to understand to what extent hospital-based procurement can be classified as a network. To do so, the three main network's characteristics (interdependencies, wicked problems, and dynamics) developed by de Bruijn and ten Heuvelhof (see Section 2.2.1) will be used and applied to the hospital-based procurement cases described in Section 5.2.3.

7.1.1 First characteristic: Interdependencies

The first important feature of an interconnected world is that it is characterised by a large number of parties or actors, each of them with differing interests and dependent on each other. Moreover, even the organisations that form the actors in a network are often networks themselves (De Bruijn & ten Heuvelhof, 2018). It is worth stressing that according to de Bruijn and ten Heuvelhof an organisation, such as a hospital or an engineering consultancy, comprises highly trained professionals, with very different specialisms, who are dependent on each other. Moreover, it should be mentioned that even if the professionals are dependent on the management, the management is

equally dependent on the professionals who possess the expertise and knowledge the managers do not have (De Bruijn & ten Heuvelhof, 2018). Reading Section 2.2.1 it possible to understand that a network can be considered as the opposite of a hierarchy. Therefore, instead of purely vertical relationships, in a network there are many players and the relationships are horizontal.

The presence of networking relationships within the UK health care system has been already identified during the desk research in Section 4.3. However, there is no analysis on the interconnections characterising HB-Procurement. It should be pointed out that there are different types of interdependencies characterising the HB-procurement. The most frequent types of interdependencies are bilateral or multilateral interdependencies. More specifically, according to the descriptions provided in Section 2.2.1, the following applies. In 'case 1' (see Section 5.2.3), when the clinical teams can directly order from the supply chain catalogue, it is possible to detect one bilateral interdependence between the clinical team and the budget holder manager. In 'case 2' (see Section 5.2.3), when the medical equipment still belong to day-to-day expenditure but its not present in the NHS Supply Chain catalogue, a multilateral interdependence takes place between the clinical team, the budget holder, and the procurement department. In the case of capital procurement (case 3 and 4 described in Section 5.2.3) it is possible to detect several multilateral interdependencies. In the case of capital procurement replacement, the two strongest interdependencies are, the multilateral interdependence among the capital equipment group, the procurement department, and the clinical teams, while the other is the multilateral interdependence between the procurement department, the various experts, and the supplier. When the capital procurement involves the purchasing of a new medical device not for replacement reasons (case 4, Section 5.2.3), the first type of multilateral interdependence (capital equipment group, procurement, and clinicians) is stronger since the clinicians need to specify why they want that type of new medical equipment before receiving the procurement's and clinical equipment group's approvals. Moreover, it is possible to say that all the interdependencies can be classified as multidimensional interdependencies, since all of them involve two different dimensions: money (procurement department) and product's quality/efficiency (clinical teams and medical physics department).

It is also important to distinguish between synchronous versus asynchronous dependencies. Synchronous dependencies take place when actors can at one point in time all be mutually dependent on each other, while asynchronous dependencies are usually spread out over time (De Bruijn & ten Heuvelhof, 2018). During hospital-based procurement, particularly referring to capital procurement, the presence of synchronous or asynchronous dependencies partially 'hangs' on the involvement of clinical engineers during the different phases of the procurement process. More specifically, if clinical engineers are involved during the specification, selection and negotiation phase, then the interdependence among the procurement department, clinical teams, and clinical engineers is synchronous, otherwise, it is possible to identify various asynchronous dependencies along with all the phases of the procurement process. Another aspect to consider is the dynamics affecting the various dependencies. Taking the capital equipment group as an example, when some equipment needs to be replaced, they occupy a fundamental role during the prioritisation process, however, their role

becomes weaker during the selection of the supplier or during the negotiation phase. Almost the same applies to clinical teams or to the procurement department during revenue procurement of medical devices present in NHS Supply Chain catalogue.

Another important observation is that the interdependencies are different per topic and this also applies in the case of hospital-based procurement. Focusing on the different types of procurement processes, the interdependence between the supplier and the procurement department, or even between the procurement department and the clinical teams varies according to the type of procurement process. Indeed, the procurement department has a direct relationship with the supplier in the case in which a tendering process needs to be carried out, however, this direct relationship does not exist if they decide to order from the NHS Supply Chain catalogue. Additionally, focusing on the procurement department-clinical teams relationship, in the case of revenue procurement, the clinical teams need to contact the procurement department only if the medical equipment they would like to purchase is not present in the NHS Supply Chain catalogue, otherwise, clinicians can 'skip' this procedure.

7.1.2 Second characteristic: Unstructured, wicked problems

Unstructured problems can be classified as the opposite of structured problems, which are problems for which there is only one right solution (De Bruijn & ten Heuvelhof, 2018). In particular, when the facts are ambiguous or impossible to objectify, the result is an unstructured problem and in that case many parties will have a tendency to make choices according to their own interests or preferences (De Bruijn & ten Heuvelhof, 2018). During hospital-based procurement, various wicked problems can be identified. One of them is described in 'case 2' of Section 5.2.3, where the capital equipment group needs to decide which equipment to replace first. Because of budget constraints, not all the medical equipment that should be replaced can be effectively replaced by the hospital. Therefore, the capital equipment group needs to prioritise. The prioritisation process takes into account two main variables, the opinions of the various clinical departments, and the budget allocated for each capital replacement. On the one hand, all the various clinical teams usually require new medical equipment, as they can argue that the one they have does not work properly or the workload has been increased (see Section 5.2.1). On the other hand, the capital equipment group has to decide what to replace first also according to financial restrictions. The financial restrictions have also been detected during the literature review performed in chapter 2, where in Section 2.4 the author mentioned the various challenges characterising HTM and procurement. This decision involves several determinant factors, such as replacing the cheapest equipment, replacing the one used at most, replacing the oldest one etc.. Moreover, once a final decision on which type of equipment will be replaced has been agreed on, a new decision arises: "How much money is the Trust willing to spend? Should the trust replace the old equipment with a new one but of the same 'type', or should they completely re-test the market and select a new supplier proposing more advanced equipment?" (see Section 5.2.4 and 5.2.5) . The trade-off is more or less the same, money versus performance/quality. Here another actor takes part in the discussion, the procurement

department, which ultimately selects the supplier. Furthermore, the procurement department, after consulting clinical teams and experts, can purchase the medical equipment from the NHS Supply Chain catalogue or test the market by themselves. On the one hand, as mentioned in Section 6.2, choosing the first alternative could save time and the procurement department would be sure that all the tendering procedures have been conducted correctly. On the other hand, experts like clinical engineers would always prefer to test the market by themselves, to select the best supplier, to enhance innovation and try to get better prices and services during the negotiation phase. In addition, when the clinical teams decide to buy any medical equipment for day-to-day operations, they can go directly through the NHS Supply Chain or ask advice from experts like clinical engineers 6.3. The procedure proposed by the NHS Supply Chain is quick and easier to follow for clinicians. However, the advice provided by various experts could guarantee more cost-efficient medical devices. Moreover, clinical teams know that the clinical engineering department would always prefer to test the market instead of ordering among the devices offered by the NHS Supply Chain catalogue, and this would elongate the time needed to receive the device. In this case, the trade-off would be between time and quality.

7.1.3 Third characteristics: Dynamics

Dynamic represents the opposite of static or stable(De Bruijn & ten Heuvelhof, 2018). More specifically dynamic is intended when actors, each with their own definition of the problem, enter or exit the scene, causing a the constant shifting of problem's content (De Bruijn & ten Heuvelhof, 2018). This phenomenon continuously characterises the whole hospital-based procurement process. Indeed, the problem concerning the decision of which medical device to purchase could present three different perspectives: the clinical department would like to buy the cheapest, the clinical teams usually prefer to have the one with the best technical specifications, while the clinical engineers often look at the most cost-efficient or innovative technology.

7.1.4 Hospital-based Procurement as a Network

As mentioned in Section 1.2, this study wanted to investigate how hospital-based procurement could be analysed according to network's perspectives, identifying and taking into consideration the presence of an internal interconnected world characterising and affecting the various procurement activities. Therefore, the first step was to understand to what extent the various hospital-based procurement cases can be considered as unstructured, or simply as networks. This first step also coincides with answering the sub-question 4 (see Section 1.2). The terminology 'to what extent' has been chosen by the author for a precise reason: it is not possible to assert if or if not a certain process or organisation is a network or how many 'networking' relationships are necessary to be defined as a network, it is only possible to estimate it. This is because, during this 'estimation' process, which coincides with the analysis conducted in Sections 7.1.1, 7.1.2, and 7.1.3, there is not a measuring scale or instrument indicating various possible levels of 'networking' proper of a process. However, it is possible to state that hospital-based procurement in the UK presents networking characteristics and it is dominated by the presence of internal networks and their continuous interactions. More

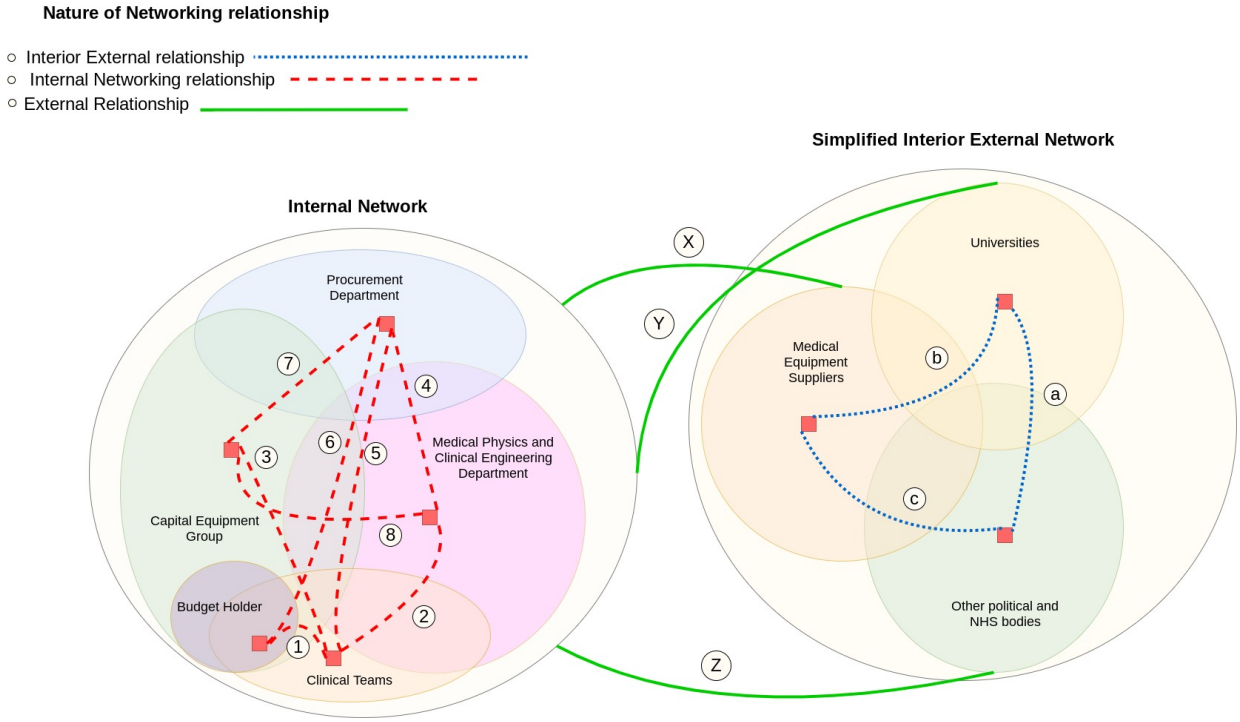
specifically, what has been shown in this study is that the literature suggested that the health care system in the UK could present various networking relationships (Section 4.3) and that from the analysis performed and the data collected, it is clear that hospital-based procurement in the NHS Trusts is dominated by various actors and interests, in addition to issues without a single or right solution. This suggested that it would be sensible to investigate and examine hospital-based procurement from the network perspective and to apply the strategies proposed by de Bruijn, ten Heuvelhof, and in 't Veld to the current hospital-based procurement in the UK.

7.2 How to deal with the complexity of HB-Procurement

From the previous analysis it has been concluded that hospital-based procurement is characterised by networking relationships and complex phenomena. In particular, its complexity derives from a multitude of interacting actors, wicked problems dominating the stage, and different values belonging to the various stakeholders. Therefore, it is important to be aware of the internal networking relationships dominating all the different procurement activities, the several actors' positions within the network, and their interactions. Fig. 7.1 shows the internal network that can be detected within the hospital during the procurement process and its relationships with the external environment. It is worth noticing that in Fig. 7.1, even the external environment has been depicted as a series of actors or parties interacting with each other. Therefore, the external environment itself is dominated by internal networks which the researcher decided to label with the term 'interior external network'. The difference between the internal hospital network and the interior network determined in the external environment is represented by the nature of the parties involved. In the first case, all the actors belong to the same organisation (hospital), while in the second case all the parties represent different organisations. It should be mentioned that the relationships between the internal hospital network and each of the parties belonging to the interior external network are defined as external relationships. The relationships detected within the internal hospital network, within the interior external network, and between the internal and interior networks are labelled according to the descriptions provided by Bevir and Waring (2020) and depicted in Fig. 4.3. Focusing on Fig. 7.1, all the relationships coloured in red (1,2,3,4,5,6,7,8) represent internal networking relationships during hospital-based procurement. All of them can be classified as 'peer' relationships but it is possible to detect some differences among them. Firstly, it is possible to identify some internal elite relationships (3,5,6,7 of Fig. 7.1) among decision-makers such as procurement department, clinical equipment group, budget holders, and clinical teams. Additionally, relationships 7 and 4 also present a managerial nature since both of them involve a relationship with a group of managers. Furthermore, relationships 2,4,5,8 can be classified as professional relationships and it is important to notice how the presence of clinical engineers is dominant since they also cover a functional/specialist role. Lastly, the relationship between budget holders and clinical teams can be defined as an operational/clinical relationship since it involves day-to-day executions and responsibilities. Moving our attention to the interior external relationships coloured in blue in Fig. 7.1, it is possible to notice how all of them present a managerial nature. However, also within the interior external network, it is possible to detect some peculiarities. Some examples

include relationship 'a' also presenting a professional and public sector nature, relationship 'b' also having a commercial scope, and relationship 'c' which is characterised by political, commercial, and professional objectives. Finally, always relying on Fig. 7.1, it is possible to detect three external relationships coloured in green and indicated with letters X, Y, Z. All of them present a managerial nature, however, relationship X is mainly commercial, relationship Y is largely professional, and relationship Z presents a quite political nature and NHS origins.

Figure 7.1: Internal and External Networks



As the previous analysis suggests, hospital-based procurement can be effectively considered as a network. Therefore, it would be meaningful to propose 'Management in Networks' strategies, that could be suitable and effective for hospital's procurement ability. Before doing so, it would be sensible to detect the possible 'grey areas' within the process itself. The term 'grey area' will be used to indicate situations in which all the issues characterising networks and networking relationships are more evident. More specifically, within these 'grey areas,' the presence of interdependencies, dynamism, and wicked problems is amplified, as well as the lack of a unique and correct final decision. Focusing on hospital-based procurement, 'grey areas' can be detected across the different procurement cases, capital procurement for replacement, capital procurement of new types of medical devices, revenue procurement of catalogue's medical equipment, and revenue procurement of non-catalogue medical equipment. From the analysis carried out in Chapters 4, 5, and 6, grey areas within hospital-based procurement are usually represented by situations in which Trust's procedures are not respected, excessive tensions among stakeholders is present, relevant conflicts of interests dominate the stage, there is a lack of awareness of actors belonging to the network and

their relative importance, power, and contribution etc... Each of these situations is more or less present across the different procurement cases according to the number of stakeholders involved and their values. However, as in the case of HTM, each procurement case is also largely dependent on the context in which it is carried out (see Section 2.1.2). Therefore, the grey areas indicated in this thesis project are mainly related to the Trusts that have been included in the sample and so, their generalisability is limited. Nevertheless, how the problems are detected and analysed would constitute the basis from which further networking issues could be properly managed. Thus, the main networking issues detected among the four different procurement cases can be considered as a case study which will be analysed according to the 'Management in Networks' theories. More specifically, the conceptual framework developed in Section 3.3.1 (Fig. 3.3), will be used as a guideline to look at the procurement issues from the network perspective, trying to solve them accordingly. It is worth stressing that, although the strategies indicated in the framework have not been used in practice by any Trust, the conceptual framework developed and the idea behind it have been described to *Expert 1* during the interview. *Expert 1* agreed with the strategies included in the framework and with the feasibility of its application to the procurement process conducted at the hospital level. Moreover, his main comment was *"I'm impressed. I'm impressed by the way you interpret our book".*

7.2.1 Grey Area I: Revenue Procurement

The importance of revenue procurement is often under-estimated at both national and local level. This is due to the amount of money involved in the procurement process itself and the final scope for which this money will be used, day-to-day operations. Underestimating revenue procurement could affect both the performance and economy of the Trust. In the first case, buying non-compliant medical equipment could represent a danger for both health care workers and patients. From literature review in Section 2.1, it is possible to understand the fundamental role occupied by health technologies and how a proper selection of the latter could highly improve health care outcomes. In the second case, although revenue procurement is usually described as operational costs below £5,000 by the various national and Trust's procurement guidelines, budget holders and clinicians can approve and purchase, respectively, catalogue medical equipment even far above £5,000 (eg. £15,000), if these are considered operational costs (see Section 6.3). Moreover, from the guidelines, until a certain Trust-established threshold, clinical teams can order from the supply chain catalogue only with their budget holder's approval. However, the budget holder's approval relies on both the medical and business administration competence of the budget holder him/herself, who sometimes is not well-trained according to two of the respondents (*Respondents 4 and 5*) and usually gives pre-authorisation to clinicians to buy some products (Respondent 4) (see Section 6.3). This can be considered as an example showing how employees, especially at lower levels, can possibly not be aware or do not follow all the guidelines provided (*Respondents 1, 2, 5, 6*). Looking at this situation from a hierarchical perspective, the one who holds the main responsibility is the budget holder, and he/she is also the one who has allowed the clinician to bypass the system and his/her authority. Under the project-based point of view, the budget holder has not respected his/her duties and so, the

potential drawbacks deriving from this situation, can be considered as his/her fault. Although this vision works from a legal point of view, the aim is to improve the whole process and not to address responsibilities. Therefore, from a network perspective, both the clinician and the budget holder should be considered responsible for this 'system bypassing'. This can be considered a 'network' responsibility since, both of them, could have put in danger the performance of the department. Indeed, behaving as a network means that the core values of the process itself should be placed first.

During this type of procurement process, although the presence of experts like clinical engineers is not required, these experts indirectly affect the procurement. More specifically, Section 6.3 described how common it is to mask some of the medical equipment from the online catalogue to which clinicians can have access. However, because of its vastness, the Trust can control the NHS Supply Chain catalogue only to some extent. Therefore, although there is some medical equipment that can not be ordered by the clinicians, there still is a lot of waste among the revenue procurement orders (*Respondent 1, 2, 3, 4, 5*). During this type of procurement process, the involvement of the procurement department is limited voluntarily by the procurement department itself, to reduce its level of responsibility, by making the budget holders ultimately responsible for what should and shouldn't enter the hospital (*Respondent 6*). This phenomenon is characterised by personnel availability issues, excessive workload, and poor working environment, as described in Section 6.1 and 6.4. In this situation, it is possible to notice a shift of responsibility from the Trust to the hospital level, or better to the department level, since each budget holder is responsible for a specific area/department. However, the waste that characterises a certain hospital's area will directly affect the whole Trust's budget. Thus, improving the revenue procurement in a single department would surely contribute to the whole Trust's financial performance, and the 'grey area' here is that the Trust is only partially aware of that.

In this particular procurement case, the evidence of 'grey areas' is represented by:

- People within the network are not aware of all the other actors and their importance/contribution. Clinicians are not aware of how clinical engineering could help during procurement, and how it could be useful to consult them during the selection of the best device even within the supply chain catalogue. The same applies to budget holders.

- People within the network are not aware of or do not respect the procurement guidelines provided. Budget holders usually do not perform a proper analysis and the procurement/finance department stops revenue orders only when the amount of money is suspect.

- Health care workers are not aware of the interdependencies among each other. Although the budget holder is ultimately responsible for this type of revenue procurement, the procurement and finance department are not aware of how the budget holder's decisions and capability affect the whole Trust.

7.2.2 Apply Management in Networks strategies (I)

In this section, the aforementioned grey area will be analysed from the point of view of the Trust and its main actors (procurement/finance department, medical physics and clinical engineering department, trust's board). Their aim is to optimise the expenditures at the department level during the purchasing of operational medical equipment by clinicians. Starting from actors' analysis, it is important to be aware that the main actors are the clinicians and the budget holders of the various areas/departments, while both the procurement/finance department and the clinical engineering group have a contingent role during this type of procurement process. The only clear interest here is the clinicians', who want specific medical equipment. The budget holder has the power to approve or reject the order, therefore, in this situation, he/she has both production and blockage power. The clinician who asks for the product has production power, while the procurement department has blockage powers since it can block an order even if it has received the budget holder's approval. However, checking for each of the approved orders would not be meaningful and counterproductive, therefore, the best way to improve this type of procurement is to act at the area level. Since budget holders of the different clinical areas are established at the Trust level, it would be sensible to adopt a proper selection for them. Indeed, apart from their seniority within the hospital and the business training followed, it is important to also use the so-called reputation method during the selection process (see Section 2.2.3). The 'reputation method' can be applied also to other HTM activities or sectors since the importance of peers' opinions affect all the working environments. In our specific case, since budget holders are people who already work within the Trust, it would be useful to ask other area/department workers about their reputation. This does not indicate that the opinions of some clinicians in the department will completely affect the promotion of someone to becoming a budget holder, but their opinions will let the Trust have a clearer idea of budget holder candidates and how their relationship with their peers is. It should be mentioned that the way clinicians perceive their budget holders affects their relationship with these last ones and so the whole procurement process.

Both in the case in which the budget holders are already operating within the department or new budget holders will cover that role soon, it is important to establish all the process agreements necessary. Firstly, all the actors should be aware of where and when their responsibility starts and ends, as well as their duties and rights. This last concept should be valid in every sector and organisation, apart from its nature. Therefore, in our case, the budget holders have to be aware of the huge contribution they can give while performing a proper budget analysis, but also the possible damage they could cause with their superficiality and carelessness. Secondly, both the clinicians and the budget holders should know how the budget is allocated and which procedures should be followed to proceed with the purchasing. This last agreement is established at the procurement level, together with the guidelines that should be respected. Therefore, the procurement/finance department should improve its way of communicating guidelines and the organisation's core values by performing good process management. This means that, instead of imposing strict rules and procedures or creating guidelines without even checking if they are truly considered by other Trust's

workers, the Trust should create guidelines and communicate their content following the four principles of openness, protection of core values, progress, and substance. It should be mentioned, that process agreements and negotiations do not apply only in the specific cases analysed, but they are factors that should be followed during every guideline development, despite the specific activities involved. From these premises, the guidelines should be precise in terms of actors involved and transparent in terms of budget allocation and distribution of power and legitimacy. In general, it should be stressed that the guidelines provided do not only have to provide sterile and linear procedures to follow, but they should promote and include the organisational culture of the Trust. In our particular case, while reading the proposed guidelines both the budget holders and the clinicians should feel comfortable with what their roles and responsibility are, what is expected from their side, and how their core values are protected by the Trust.

Another important factor is to make clear that there is an exit rule, this means that the budget holder will feel free to inform higher levels about his/her difficulties and will have the opportunity to exit from certain types of processes or to ask for help without feeling pressured. This will avoid situations in which the budget holder will feel forced to approve an order because of his/her personal relationship with the clinicians, or on the contrary, to reject an order just because of money constraints, even if that order could be beneficial for the department. The last point that should be covered is the roles and participation of experts. More specifically, the decision of purchasing or not a certain device should meet certain substantive quality standards. Although clinicians are medical experts, their opinions can be biased and in the specific case of the supply chain catalogue, the product included in the catalogue may be not the best according to the Trust's standards (see Section 6.2). Therefore, both clinicians and budget holders should be aware of the presence of clinical engineers and their role within the hospitals. This means that the Trust should promote a so-called cross-cultural behaviour, stressing the importance of including all the actors that could give a contribution in the final decisions. This last concept does not only apply to the procurement process or health care sector in the UK, indeed, a strong cross-culturalism should be at the base of every private or public successful organisation.

As already mentioned in Section 6.2, the involvement of clinical engineers is indirect since they are used as consultants to remove specific devices from the online catalogue. Moreover, the extent to which clinicians are aware of the masking process is not clear, what is evident is that they underevaluate the contribution clinical engineers could give during the selection of the device. Although including a mandatory 'passage' through the clinical engineering group before every purchase could result in being exaggerated, it is important to make health care workers aware of the presence of clinical engineers and of the fact that they work to support that type of medical equipment choices. This last point can be easily connected to the maintenance of relationships and the ability to recognise functional and non-functional relationships, whose importance is valid in every context and circumstances. The various advantages related to the UK networking relationships have been also described in general terms in Section 4.3. In the case of HB-Procurement, the Trust should make clinicians aware that their potential relationship with the clinical engineering team can be consid-

ered as a functional relationship. Furthermore, they also have to clarify the importance of having strong ties between budget holders and clinicians during the 'catalogue' revenue procurement.

An additional aspect of this first 'grey area' is how to manage situations in which the system is bypassed by clinicians who orders without receiving a 'real' budget holder approval. In the previous section, it has been mentioned that from a network perspective and looking beyond what the hierarchical structure indicates, both the two parties can be considered accountable in case of potential drawbacks. The question is, would an increase in command and control by the trust improve the situation? From a process-based perspective, command and control is not the best solution to apply, at least during a first approach. Moreover, from the interviews, *Expert 1* said that *"applying hierarchical power is dangerous and risky"*. It is not possible to completely avoid deviation, but it is possible to negotiate on that deviation. *Expert 1* also said that *"people deviate every day. But it's possible to strive, to prescribe the way you should do so, for instance, it's allowed to deviate on the condition that you inform us"*. Therefore, in every sector and complex organisation, a possible way to improve process deviation is to make people aware of what could be the potential effect of bypassing the system. In our particular case, the effects could be excessive overspending or wrong device selection. However, since it is not always possible to rely on people's consciousness, in certain circumstances there is space for applying smart command and control. In this specific situation, smart command and control can be applied both at the department level, by the budget holder, and at the Trust level. A possible way of using smart command and control is to influence the perceptions of the gain of others actors. In the first case, the Trust should make budget holders aware of their importance within the trust. Trusts should inform about the potential financial problems caused by bad budget management, and how paying attention and spending time (core values for budget holders) on checking the various orders could improve the non-pay expenditure situation characterising the department. Regarding the command and control that budget holders can apply to clinicians, the situation is similar. Therefore, the budget holder can inform the clinician about the importance of checking the budget and experts' approval before placing the order. Additionally, they can agree on some circumstances in which the clinician can, for example, place the order and then inform the budget holder to avoid wasting time. However, in this case, the budget holder will be aware of the order placed and will have the possibility to stop it if necessary.

7.2.3 Grey Area II: NHS Supply Chain or Not in Capital Procurement

One of the main tensions detected and analysed in this thesis project is the one between centralised (NHS Supply Chain) and decentralised hospital-based procurement (tendering procedures carried out by the Trust). As described in Chapter 6, in addition to the various issues determined by the literature, practical problems have also been collected during the interviews. The NHS Supply Chain catalogue represents the introduction of a new factor in the network and, although the aim was to improve the whole NHS procurement, to some extent the possibility of directly ordering from the NHS Supply Chain catalogue has increased the procurement complexity. Supposing that

the level of centralisation will not reach the desired 80% by the Government, it would be sensible to understand when and why it is worth going through the NHS Supply Chain or not. Going beyond the personal idea regarding the feasibility and utility of centralised or hospital-based procurement, what is important to understand is that at the state of the art both hospital-based (intended as the process of proceeding with 'private and trust-based' tendering instead of ordering from the NHS Supply Chain catalogue) and centralised procurement can be carried out. Therefore, because of practical reasons, it is important to take advantage of both of them when possible, trying to manage the situation in the more convenient and acceptable way.

Respondents 1,2,3,4,5 has expressed their concerns regarding centralised procurement, both in terms of products' quality and waste (see Section 6.2). These opinions were more common across clinical engineers or medical physics workers, while the procurement department was more focused on the prices offered by the supply chain catalogue, not the best, and on the time savings deriving from its use. From the BPMN diagrams of Section 5.2.3 developed through interviews, it was quite clear that the presence of the NHS Supply Chain catalogue affects both revenue and capital procurement. In the first case, the situation is more or less the one described in Section 7.2.1 and can be improved with the aforementioned strategies. In the second case, when a capital purchasing is involved, the choice of ordering from the NHS Supply Chain catalogue can be suggested by the clinical teams which require specific products present in the catalogue, but it is ultimately confirmed by the procurement department which often prefers to go through the NHS Supply Chain to save time. Therefore, the procurement department has both blockage and production power. The same applies to the capital equipment group which is the one that ultimately sets the budget and allocates the money for capital expenditure replacement or for purchasing new technologies. Hence, during replacement, the capital group sets the budget and decides what needs to be replaced, while the procurement team establishes how to proceed with the purchase, NHS Supply Chain catalogue or testing the market by themselves. The involvement of clinical engineers, especially regarding the purchase of new technologies, could redirect that choice. Hence, clinical engineers have a contingent power, whose strength depends on the structure of the Trust and it is not standardised.

As described in Section 6.4, involving clinical engineers, or better when to involve clinical engineers, is a touchy point with procurement, both at the national and trust level. Moreover, although the literature stresses the importance of including clinical engineers in all the different HTM activities, their involvement by Trusts is still limited, especially according to the opinions of medical physics and clinical engineering department's workers. The main tension is determined between experts (medical physics and clinical engineering department) and the procurement department. The main source of conflict is quality versus costs. However, what is important to understand is that, usually, involving clinical engineers will not let the Trust buying the product presenting the best quality, but the one presenting the highest level of cost-efficiency and cost-effectiveness also according to the peculiar Trust's structure and strategies.

7.2.4 Apply Management in Networks strategies (II)

This section will apply the main management in network strategies to two different cases, capital procurement replacement and capital procurement of new technologies, which correspond to 'case 3' and 'case 4' of Section 5.2.3 respectively. This difference is fundamental to make a proper actor analysis since the power among the various stakeholders differ according to the situation. Moreover, the analysis will be conducted assuming that clinical engineers are not involved in the clinical equipment group, therefore, they are not involved in the budget allocation and prioritisation phase of the procurement process. Hence, their involvement is not ensured.

Capital Procurement Replacement

The first type of decision characterising capital procurement replacement regards what will be replaced. Therefore, the first set of strategies will be applied considering the point of view of the capital equipment group. Because of budget constraints, a process of prioritisation takes place. During the actors' analysis, the capital equipment group should be aware that although clinical teams are the main users of capital equipment, usually, the maintenance and monitoring of the device rely on the hands of the medical physics and clinical engineering group. Indeed, they are usually involved during prioritisation. Moreover, while clinical teams could have additional interests in replacing a specific device, reducing their objectivity in the selection phase, clinical engineers' opinions could result to be more reliable. Therefore, during this phase the capital equipment group should pay attention to the misinformation that could be provided by the various clinical teams.

It should be mentioned that although clinical engineers are usually consulted during the first phase of the prioritisation process by capital equipment group, there is no direct cooperation between clinical engineers and clinical teams when clinical engineers do not belong to the capital equipment group. However, the relationship between clinical engineers and clinical teams can be functional for both the clinical teams themselves and the capital equipment group. This is because, as mentioned in Section 2.1, the 'introduction' of clinical engineers in hospitals has been a choice characterised by the desire of improving strategic management of health technology. Indeed, clinical engineers can help clinicians to be aware of what should be replaced and how, and this indirectly affects the information that capital equipment groups gather from the clinical teams. Regarding the process agreements, the capital equipment group should be transparent in terms of budget allocation and purchasing procedure. In general, transparency could improve every type of organisational relationship especially when there are several conflict of interest and it is important to establish trust-based cooperation. In our particular case, capital equipment group's transparency will contribute to improving its relationship with clinicians. The whole process must be characterised by openness, meaning that the capital equipment group will not be able to take a unilateral decision and is aware of the importance of not doing so. More specifically, while creating its prioritisation list, the capital equipment group has to be aware that each clinical team has its own core values and, therefore, the help of 'external' actors, such as clinical engineers, could be beneficial for the final choice. It should be mentioned that a continuous analysis of the values and interests of the

different clinicians could inhibit the production of a clear result. However, because of the urgency characterising capital procurement, the clinical equipment group has to properly balance time and values' inclusion. To simplify the whole decision, it is important to include 'substantive' elements, thus, the capital equipment group, with the help of clinical engineers, should set clear standards, in terms of both price and quality.

Once the decision on which type of equipment will be replaced has been agreed on, the procurement department dominates the stage. Firstly, the procurement group needs to consider both budget and technical specifications provided by the various stakeholders. These considerations should be at the base of the purchasing process. Indeed, the capital equipment group needs to be clear about what needs to be bought. At this point, the procurement can decide to go through the NHS Supply Chain or testing the market and perform all the various tendering procedures. Although it could be quite inviting to save time and directly order from the supply chain catalogue, the procurement department needs to consider the 'openness' (Fig. 2.6) of the process and the impossibility to proceed with a unilateral decision. The procurement department needs to consider all the various core values dominating the stage and avoid following the so-called culture of 'buying the cheapest' (see Section 6.1). To proper balance values such as quality, time, and money, the procurement department could involve clinical engineering in the supplier selection process. However, from the side of clinical engineers, it is important to avoid biased behaviours, rejecting the supply chain framework regardless. Indeed, while the procurement department should take into account the openness of the process and the importance of protecting core values, clinical engineers should consider the time and personnel restrictions of the procurement department. Thus, also clinical engineers should balance the cost-efficiency of the product and the time that would be spent by avoiding the supply chain framework. During the negotiation phase with the supplier, the procurement team should recognise the functional relationship that they could have with both clinicians and clinical engineers, trying to strengthen the ties with both of them.

Capital Procurement for new types of medical devices

When the clinical teams identify the need for new equipment, usually they also specify which equipment they would like to have. Identifying the need for new equipment and deciding which equipment to request involves a decision. Supposing that the clinician does not have any personal interest in requiring a specific technology and that he/she truly believes that the purchasing of that new medical equipment could be beneficial for the hospital, the clinician still has to follow management in network strategies. Before placing and requesting any order, the clinician should be aware of the actors present in the system and what would be their concern. As an example, the procurement department would have financial concern because of the excessive price of the medical device, or clinical engineers could have a concern about the type of maintenance/training offered or standardisation issues. From these perspectives, the clinicians can apply management in networks strategies for two different scopes: negotiate in the best possible way and obtain the medical device, or negotiate with the main 'resource' actors to understand if buying that device

is the best choice. In the first case, the clinician is behaving purely according to his own opinions which, however, could also be the best for the hospital. In the second case, the clinician is aware of the capabilities and importance of the other actors in selecting the best for the hospital. In both two cases, if all the other parties involved will apply a suitable decision-making strategy, an acceptable solution for the hospital could be reached. In all situations, the involvement of clinical engineers is not standardised. As in the previous case, the involvement of clinical engineers should be promoted by both the Trust and the clinical engineering department itself. This is an issues that could be only solved by promoting a stronger organisational culture.

7.2.5 Grey Area III: Guidelines

From the interviews, *Respondents 1,2,3,4,5* revealed that the guidelines, especially the ones at the national level, are not always followed. In particular, only the 'legislative' and 'legal' aspects are considered, while the 'strategic approach' is usually developed by the single Trust (see Section 6.4). However, also in the case in which the Trust sets specific rules and guidelines to follow, the health care workers not always rely on those guidelines. From a network perspective, *Expert 1* said that *"there is always room for deviation from the guidelines"*. However, he/she also said that it is important to agree upon 'grey area' in established procedures could not be followed. There could be several reasons explaining why people deviate from prescribed guidelines. In the case of nationally developed guidelines, health care workers may ignore them when those guidelines are not following their organisation's strategies. In the case of Trust-developed guidelines, hospital's employees deviate to simplify the process, to pursue their own interests, or because they are not even aware of the guidelines. Although there is room for deviation, the establishment of guidelines will help the whole decision-making process, supposing that the guidelines have been developed properly.

7.2.6 Apply Management in Networks strategies (III)

Two approaches can be followed to increase the visibility of Trust's guidelines and the willingness to follow them. Firstly, as suggested by *Expert 1*, *"you should negotiate these guidelines, with the main actors involved. So invite them and start a meeting and discuss the rules and fringe, you can start with an evaluation of the latest process. What was good, what was wrong in that process? And how can we improve the way we negotiate and communicate, please give me your input. And let's try to write a new arrangement. So yeah, it's, it's also negotiating is also about this arrangement"*. Therefore, while developing the main guidelines the procurement department should perform a proper actor analysis, not only by indicating which actors are involved in the process, but they should also consider their core values, their functional and nonfunctional relationships. This is a procedure that could help various managers during both the communication and development of their guidelines, apart from its applicability to the UK health care context. In our specific situation, who develops the guidelines should be aware that the procurement process is not linear but is characterised by continuous negotiations. Additionally, from the interviews, it was clear that the guidelines are mainly followed at the 'high level', or better by the ones who develop

them (*Respondent 6*) (see Section 6.4). This could be explained in three different ways: the guidelines are not well communicated to the lower levels, or the guidelines do not conform to departments' necessities and strategies, or, lastly, there is complete anarchy within the Trust. The last case is quite improbable while the second one could be solved by increasing the involvement of lower level workers during the development of guidelines or paying more attention to what are the practical problems at the base of this non-respect of guidelines. It should be mentioned that in addition to the specific hospital procurement context, the involvement of lower level workers and considering practical organisational problems, should always be driving factors accompanying guidelines' development in every sector and organisation. Communication issues depend on the relationship established between the Trust and its departments. One of the strategies that could be applied in these circumstances is to establish a trust-based relationship between the procurement (the one who develops procurement guidelines) and the one who should follow developed guidelines (doctors, budget holders etc.). This trust-based relationship will make people aware that the guidelines are not only developed because of legal or budget constraints, but they have been written for the safety of the hospital as well as its staff.

7.2.7 Grey Area IV: Clinical Engineering Involvement

From Section 2.1 and the results described in Section 6, it is clear that the role of clinical engineers is strictly related to all the various HTM activities and that their involvement could provide a huge contribution to improving final health outcomes. However, from the literature ((Madhlambudzi & Papanagnou, 2019)) and from the interviews, it is quite clear that health care workers do not exploit the presence of clinical engineers enough (see Section 6.4). This phenomenon, which affects both the UK and other countries, has also been detected as a factor contributing to the creation of the aforementioned 'grey areas'. Indeed, the poor collaboration with clinical engineers causes various networking issues, which are mainly characterised by unilateral decisions and weak health technology assessment. Therefore, clinical engineers' involvement has already been suggested as a partial solution to improving the current procurement challenges. The next paragraph will provide major details on how to look at the presence of clinical engineering departments from a network perspective.

7.2.8 Apply Management in Networks strategies (IV)

In Section 6.1, one of the issues recognised by all the health care respondents (*Respondents 1,2,3,4,5 and Supplier*) is the lack of medical experts within the procurement department. According to their opinions, procurement committee members have poor abilities in purchasing medical devices because they do not know enough about health technologies and health in general. The question is: would having medical experts in procurement departments facilitate or improve the procurement process? According to the network' theories, as in the case of command and control or project management, management by expertise does not guarantee the best solution. Indeed, having only a singular type of expert involved during the decision-making process could hide potential valid solutions and could be purely focused on specific aspects of the decisional process. Therefore, the

real problem is not the lack of medical expertise within the procurement committee but the lack of cooperation among the various stakeholders involved during the whole procurement process. This problem could be easily improved by exploiting the presence of clinical engineers which constitute a sort of bridge between the medical and cost-efficiency fields.

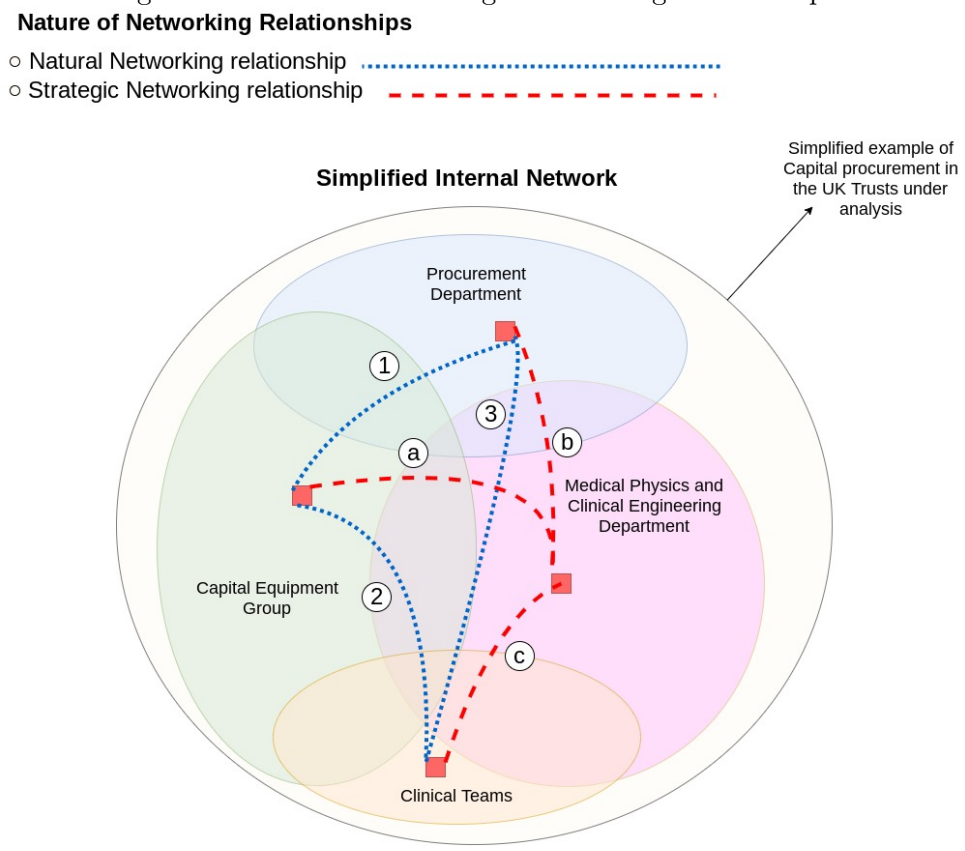
As already anticipated in Section 4.3 it is possible to distinguish between two different types of networks. Naturally created networks determined by the structure of the organisation and the necessity of different professionals and expertise, and strategic networks, which can be intentionally designed. In particular, these last ones are created to facilitate organisational procedures, enhance innovation, and improve performance. The types of networking relationships mentioned in Section 4.3, mainly refer to strategic networks, since it is stressed the importance of creating and promoting networking relationships. However, in the case of hospital-based procurement both the two types of networks can be identified. One the one hand, naturally created networks are determined by professionals having expertise in one particular field, such as procurement department (economic and financial expertise), clinical teams (medical expertise), IT department and other experts (technical expertise). Each of these actors is, in some way, forced to collaborate with others because of the structure of the hospital itself, in addition to the specific legislative responsibilities and duties that each actor holds. On the other hand, the introduction of clinical engineers, or clinical engineering departments within the hospital, can be seen as the intent to create a strategic network.

Fig. 7.2 shows an example of internal network. In particular it depicts the internal network that can be detected during the capital procurement process and it is possible to notice how the relationships 1,2, and 3 (coloured in blue) are determined by the 'basic' structure of the hospital itself since each of the three actors presents specific and singular expertise. Indeed, in Section 5.2.3, the BPMN diagrams show how the connection among those three actors is present both in the real and ideal processes, indicating that those interdependencies can not be avoided. Reversely, the relationships 'a', 'b', and 'c' of Fig. 7.2 (coloured in red), represent strategic and non-mandatory relationships between each the three specific three professionals and clinical engineers. The fact that the relationships 'a', 'b', and 'c' are not mandatory has already been anticipated in Section 5.2.3 in which those relationships have been usually indicated with different colours in the various BPMN diagrams and represent common deviations from the ideal procurement process proposed in the guidelines (see Section 6.4). However, the fact that health care workers deviate from the ideal process does not mean that they could not gain advantages from those non-mandatory and strategic relationships. Indeed, it should be mentioned that clinical engineers do constitute a strategic network, also thanks to their wide and multi-faced expertise (see Section 2.1). In particular, they should be able to evaluate the cost-efficiency of different medical devices and to communicate in a professional way with all the different experts involved during the procurement process or other HTM activities.

The role of clinical engineers working within a hospital and collaborating with other hospital's professionals is a new concept and it is strictly related to all the HTM activities (see Section 2.1).

Clinical engineers have been introduced in hospitals to improve health care outcomes. Thanks to their expertise, clinical engineers combine the perspectives of both economic and medical experts, arriving at an acceptable compromise. This concept has also been stressed by *Respondents 2,3,4* during the interviews who defined the role of the clinical engineers as being able to optimise the cost-efficiency of the whole procurement process. Moreover, *Respondent 5* said that *"I believe that the presence of clinical engineering is fundamental, without them the Trust would be at high risk"*. This concept of strategic network needs to be stressed and transmitted to the various health care workers. The presence of clinical engineering departments has to be perceived as a strategic resource for the hospital organisation and its workers. Only in this way health care workers will be willing to truly cooperate with other professionals present within the same internal network. The involvement of clinical engineers is helpful for all the different HTM activities (see Section 2.1). Therefore, the presence of clinical engineers can be considered as a strategic network during each of the different HTM stages.

Figure 7.2: Natural vs Strategic networking relationships



7.3 Reflections

This chapter has described the main networking characteristics that can be addressed to hospital-based procurement. In particular the author identified the presence of interdependencies, wicked problems, and dynamism distinguishing the various procurement cases described in Section 5.2.3. This suggested to look at and analyse hospital-based procurement from a different perspective, the network perspective. This new perspective involves identifying internal networks characterising hospital-based activities, their interactions, and the combination of values that accompany the various decision-making processes. Additionally, this chapter has also provided some examples of the so-called 'grey areas' identified during the data analysis of Chapters 4, 5 and 6. The 'grey areas' analysed represent situations in which the actors are not aware of being part of a network, do not recognise the contribution that is given or that could be provided by other actors, do not follow or do not know specific guidelines, and are not willing to involve relevant stakeholders such as clinical engineers. The analysis of the aforementioned 'grey areas' has been conducted under the networking point of view. Therefore, the author did not propose practical strategies of guidelines to follow, but she suggested to look at the decisional problem under this new perspective and to adopt behaviours and attitudes suitable to the current procurement practices. One of the problems stressed is the lack of a proper organisational culture within the hospital, which should promote the importance of conducting procurement activities following a cross-cultural and process-based approach.

Chapter 8

Conclusion and Recommendations

This research aimed to identify suitable organisational and decision-making strategies for hospitals to improve their procurement ability. The main research question was the following: "What are the most suitable organizational and decision-making strategies able to facilitate Hospital-based Health Technology Management?" Based on qualitative analysis, the author suggested to look at the procurement process through a new lens, taking into account the internal networking nature characterising health care activities. Indeed, from the literature review it was clear that the health care system in the UK could present various networking relationships and that, according to the additional data collected through interviews, the hospital-based procurement in the NHS Trusts is dominated by several actors and interests, in addition to issues without a single or right solution. Therefore, the results indicated that a proper analysis of the internal networks characterising hospital-based procurement, in addition to valuable negotiation and networking strategies, could be suitable to help health care managers during the procurement process. Hence, from the analysis conducted it is possible to say that 'management in networks strategies' is the answer to the main research question of this dissertation.

To arrive at this main conclusion various steps have been followed. During the literature review, the author detected some limitations proper of the health care guidelines provided which, although could be satisfactory under the technical and legislative points of view, are mainly project-based without addressing the context-dependency and complexity characterising health care. Once the researcher decided to focus on the UK and performed desk research on its health care procurement, she discovered the 'duality' characterising the current procurement of the UK hospitals: centralised procurement through NHS Supply Chain and the so-defined 'hospital-based' tendering procedures. The researcher performed a deeper analysis on the 'historical' political process affecting health care procurement and the future intentions of the UK Government regarding centralisation. The author became aware that the main objective is to eliminate hospital-based (decentralised) procurement, or vice versa adopt a complete centralisation. Therefore, she retained that it would have been meaningful to provide major details on the possible effects of this complete centralisation and the current advantages of hospital-based (decentralised) procurement.

From the desk research performed, the limitations of both hospital-based procurement and centralisation policies were quite satisfactory, however, there was not enough information on the current procurement practices in the UK hospitals and how the centralisation policy is affecting hospital-based procurement. Therefore, before listing the possible challenges and drawbacks, the researcher had firstly obtained a satisfactory description of the current procurement process. According to both data, time, and travel restrictions, the author decided to do so by conducting interviews, analysing, combining, and comparing the data collected while creating suitable BPMN diagrams to facilitate both analysis and reader's understanding. Once the researcher obtained a satisfactory description of the main procurement processes, she analysed the diagrams developed from the 'network' perspective, trying to understand to what extent the main characteristics proper of an unstructured world applied to the procurement process.

It is worth mentioning that, although the development and application of centralised procurement policies present a key role within the UK health care system, this research found that apart from the possible drawbacks related to oligopoly creation, the literature did not address the effect the NHS Supply Chain is having on the current procurement practices. From the interviews and according to the diagrams developed, this study shows how the possibility of ordering from a centralised catalogue presents both advantages and disadvantages. It should be mentioned that the analysis of the possible and current drawbacks addressed to centralised procurement did not want to suggest the elimination of this centralised system but it only provided the starting point to further investigate how valuable it could be to completely centralised the procurement process. Indeed, the main reflections provided in Section 6.5 wanted to describe the current advantages deriving from hospital-based procurement and the possible results of a complete centralisation, without taking a clear position on what could be the best solution. However, despite the limitations of this study in terms of participants involved, it is quite evident that according to the results obtained and the main considerations provided, the author does not 'promote' a complete centralisation. This main idea of non-complete centralisation is also at the base of the objective of this study: improve hospital-based procurement intended as the involvement of all the relevant stakeholders who co-operate together to arrive at acceptable procurement decisions for the specific Trust within which they operate.

8.1 Key Findings

This section will provide a general summary of the main findings according to the all the various sub-questions developed in Section 1.2 and further investigated at the beginning of Chapter 3.

- **Statement 1:** Conducting proper Health Technology Management is tough and this also applies to Procurement because of financial and personnel availability shortages, in addition to the hospitals' poor ability in performing all the procurement activities:
  - It is possible to differentiate among four main procurement cases in the UK: revenue procurement from the NHS Supply Chain catalogue; revenue procurement of non-catalogue

medical equipment; capital procurement for the replacement process; capital procurement for new types of medical devices (see Section 5.2.2).

- Without considering the hospital's board which is indirectly involved in the current procurement practices, it is possible to detect six main stakeholders: capital equipment group, procurement department, medical physics department, clinical engineering group, clinical teams, and budget holders (see Section 5.2). Each of them is more or less involved during each of the four procurement cases.

- The main factors influencing the different procurement processes are: budget available to purchase medical equipment, the needs of clinical teams, involvement of clinical engineers, the possibility of buying from the centralised catalogue, time constraints of health care workers, willingness to follow or awareness of procurement guidelines, and possible conflicts of interests (see Section 5.2 and Chapter 6).

- Despite both the literature review and the developed guidelines suggest the involvement of clinical engineers, this is not always true (see Section 6.4). Their involvement depends on the structure of the hospital, the willingness of clinical teams, the type of procurement process, and the positions that clinical engineers occupy in the Trust.

- The guidelines provided at the national level are usually not followed by the various NHS Trusts which purely take into account the legislative aspects of those guidelines and prefer to develop their own (see Sections 6.1 and 6.4). However, even in the case of Trust-developed guidelines, usually, only their developers follow them and often health care workers bypass prescribed procedures or do not even know about these last ones (see Section 6.4).

- From the literature review the main issues addressed to hospital-based procurement were financial constraints, lack of standardisation among the products purchased, excessive prices paid, and poor health care managers' procurement ability (see Sections 2.1.1 and 4.1). From the interviews, additional challenges, mainly related to the current procurement practices, have been found: poor health technology assessment, poor involvement of clinical engineers, lack of medical experts in the procurement committee, conflict of interests between clinicians and procurement department, excessive waste and poor control of revenue procurement, unfollowed guidelines or guideline deviation, and need to mask some of the catalogue's products (see Chapter 6).

- **Statement 2**: Improving procurement represents a valuable solution to reduce the non-pay NHS expenditure; the Government decided to do so by promoting centralised procurement activities, aiming to eliminate hospital-based procurement:

  - According to both the literature review and interviews the main drawbacks addressed to centralised procurement are: the simplicity of ordering from the catalogue is poten-

tially increasing the waste deriving from procurement activities since clinicians order products even when they do not need them; the poor quality of the products offered by the catalogue; creation of oligopoly; innovation inhibition; not considering the context-dependency of each hospital; higher prices than the ones obtained through direct negotiation (especially for big Trusts); potential market exclusion of small-medium enterprises (see Section 6.2).

- The main advantages of going through the NHS Supply Chain are: time savings and being sure that all the tendering procedures have been followed correctly (see Section 6.2).

- The main advantages of proceeding with decentralised hospital-based procurement are: better prices (especially in the case of bug Trusts); enhancing innovation; buying medical equipment perfectly in line with the hospitals' needs; having more possibility of involving hospital experts (see Section 6.5).

- **Statement 3:** 'Management in Networks' theories and strategies are used in contexts that could be defined as complex and interconnected:

  - Management in Networks is based on a process-based approach, assuming that there are no right solutions to problems within an unstructured world that is characterised by interdependencies, wicked problems, and dynamics (see Section 2.2).

  - From the data analysis conducted and the BPMN diagrams developed, it is possible to state that hospital-based procurement is continuously characterised by wicked problems and decision-making, such as what equipment to replace (see Section 7.1.2). Moreover, it is clear that all the actors involved in the various procurement activities are connected with each other and several interdependencies can be detected (see Section 7.1.1). Furthermore, the whole procurement process can be considered as dynamic, in which the content of the problem shifts according to the different actors' perspectives (see Section 7.1.3).

  - In addition to various challenges and drawbacks related to hospital-based procurement, this thesis project also detected four main specific 'grey areas' according to the network perspective (see Section 7.2). These areas include: challenges characterising the roles and responsibilities during revenue procurement; excessive waste derived from poor cooperation; uncertainty of proceeding with hospital-based tendering procedures or deciding to go through the NHS Supply Chain; blind guidelines' development and poor communication strategies; lack of valid negotiation procedures; challenges in identifying the strategic network represented by clinical engineering departments.

8.2 Future Recommendations

This thesis project underlined the importance of considering and analysing the peculiar characteristics of the internal network present within hospital-based procurement. Indeed, although the guidelines provided can be satisfactory under the technical and legislative points of view, health care managers must look beyond those guidelines and analyse the context in which they operate, considering both the stakeholders and the values involved. Health care managers should be aware of the complexity of health care which affects all its activities, including procurement, and that the whole process is characterised by continuous negotiation phases, without the presence of a final right solution. Moreover, although the hospital environment presents different units which seem to work lonely, actually it is dominated by a continuous interaction among them, therefore, it is important to promote an organisational culture, making people aware of the main and common goals of the organisation. Furthermore, health care managers and clinicians should be aware of the presence of the strategic network represented by the introduction of clinical engineers in the hospital. Their expertise represents a source of help for both procurement and clinical teams, and constitutes a point of juncture between financial objectives and quality assurance, facilitating the cost-efficiency of the whole procurement process. Finally, the development of procurement guidelines can not be carried out without the involvement of all the relevant health care workers and without several phases of negotiation. In particular, since deviation from guidelines is natural and difficult to be completely avoided, it is important to establish agreements on the possible levels of deviations also indicating the related consequences.

8.3 Limitations of the Study

The analysis regarding the trustworthiness and validity of this study have been described in Section 3.6. The main limitations characterising this project are related to the number of participants interviewed, the time available to analyse the data, and the interpretation of the researcher. Indeed, although this project has followed precise phases of data analysis and BPMN diagrams development, it is impossible to completely exclude the biases deriving from the researcher herself. Additionally, as Hinrichs (2009) mentions in her dissertation, it also must be taken into account that, because of the iterative and dynamic nature of the project, it would be quite impossible to exactly repeat this study (Hinrichs, 2009). Moreover, the reader should be aware that the findings of this study are based on the empirical evidence detected within the current political climate in the healthcare system in the particular Trusts examined at the time and in that specific country (Hinrichs, 2009).

8.4 Academic Relevance

Because of the qualitative nature of this study, it is more sensible to talk about 'transferability' of results instead of 'generalisability'. Indeed, as already anticipated in Section 3.6, the results obtained in terms of challenges detected and types of procurement process identified can not be highly generalized to other UK Trusts or foreign hospitals. This is because of their intrinsic descrip-

tive nature and the limited amount of participants involved in this research. However, this study presents a high level of transferability. First of all, as described in Chapter 2, context-dependency and complexity can be considered as phenomena affecting the whole health care system. Therefore, it is possible to say that it would be sensible to 'transfer' the 'networking lens' used to understand the UK hospital-based procurement to look at other health care activities. Moreover, it is worth stressing that in Chapter 2, the analysis about the complexity and networking nature of the health care sector was general and did not refer to any specific context or country. Therefore, understanding and analysing health care activities, such as procurement, from a network perspective, can be considered a 'practice' or an 'approach' suitable and applicable to worldwide health care contexts. Secondly, the use of BPMN diagrams can be considered as a valid alley during the analysis of any complex process or system, such as the ones related to the health care sector. Therefore, this type of schematism can be transferred to also understand and analyse other HTM activities and processes. Indeed, these diagrams present a standard and adaptable structure since, simply changing the actors' names and their interconnections, a BPMN diagram can depict a completely new process. The adaptability of these diagrams allows the researcher to easily describe and compare different processes even when these are carried out within different organisations or by various actors. Moreover, apart from the simple use of BMPN models, it is interesting to adopt different colours to individuate the possible deviations between the actual and ideal process. This comparison of real/ideal can be applied to every sector and, since researchers are able to decide the level of complexity to include in their diagram, it is possible to communicate the findings also to non-expert people. Lastly, some of the strategies proposed for the particular procurement cases detected could be transferable also to other similar and interconnected environments. In particular, in Section 7.2, the author has indicated when some of the strategies and approaches proposed would be applicable to also other HTM activities or different contexts. This is because, some of the strategies proposed do not provide specific behavioural procedures or actions related to HB-procurement, but they put some of the challenges under a new and different light suggesting practical and quite universal networking approaches.

Future Work

From the aforementioned considerations, it is possible to derive some ideas of possible future work. Firstly, it would be interesting to also conduct the same kind of analysis for other HTM activities and look at the presence of internal networks characterising their processes. Secondly, the use of BPMN diagrams to describe hospital-based procurement has been limited to only the two Trusts considered, thus, the same methodology could be extended to other hospitals or HTM activities in order to perform deeper comparisons and increase the validity of the results. Thirdly, although the research project has introduced the new idea of HB-HTM (hospital-based Health Technology Management), there is still a lot of space to further elaborate on this new concept. Fourthly, it would be interesting to validate how the application of the suggested strategies, or management in networks strategy in general, could affect the current procurement practices in their real contexts. This would also suggest how sensible it would be to transfer the use of this 'new lens' to other

sectors. Finally, it is worth mentioning that although it is not possible to completely generalise some of the challenges detected by this study, they still represent the starting point for further analysis and investigation of those sensible topics. This especially applies to the introduction of the centralised system and the effects that it is currently having on UK hospital-based procurement.

8.5 Summary of Contributions

This study contributes in the following ways:

- **Proposing a new lens to understand and analyse hospital-based procurement:** Chapters 2 and 4 provide details on the complex nature and context-dependency of HTM and its activities. Nevertheless, the author found that often this complexity is not taken into account while analysing the procurement process and that its internal networking relationships have not been addressed by the literature (Chapter 4). By means of BPMN diagrams, the author also discovered and showed how these internal stakeholders' interconnections are extremely evident if looking at the current procurement practices in the UK (Chapter 5). Indeed, analysing the results of Chapters 4, 5, and 6 from a networking perspective (Section 2.2), in Chapter 7 the researcher detected the presence of interdependencies, dynamics, and wicked problems characterising hospital-based procurement in the UK. Additionally, in Section 7.2, the researcher identified possible 'grey areas' where the interconnected nature of hospital-based procurement is particularly evident. She also found suitable 'Management in Networks' practices that could improve the current situation (Section 7.2). Therefore, it is possible to conclude that although various studies have been conducted on health care and procurement, there was no previous research analysing the internal network characterising hospital-based procurement and suggesting how suitable negotiation and networking strategies could be applied. Indeed, this study has introduced a new managerial approach to understand and analyse hospital-based procurement, involving the application of networks paradigms and theories.

- **Shedding light on the current procurement practices in the UK:** in Chapter 5 the author discovered that it is possible to identify different procurement cases and provided details on them by describing the various actors involved and their interactions. Moreover, with the help of BPMN diagrams the author found how the current procurement process differentiates from the ideal one suggested by the NHS guidelines.

- **Highlighting and detecting challenges faced by health care managers during hospital-based procurement:** in Chapter 6 the author discovered that in addition to the challenges described in the literature, it is possible to detect further challenges that health care managers face during the procurement process and that are strictly related to the interconnected nature of hospital-based procurement. Moreover, in Section 6.2, the researcher found that the implementation of the centralised system (NHS Supply Chain) is largely affecting the actual hospital-based procurement activities.

- **Identifying the presence of a strategic network within the NHS Trusts:** in Chapter 5 and 6 the author discovered that, although the involvement of clinical engineers is heavily recommended, it is actually quite limited and depends on several factors. Subsequently, through the application of the new proposed lens, the researcher concluded that the presence of clinical engineers within the hospital can be considered a strategic network able to facilitate cooperation among stakeholders and improve final health outcomes (Section 7.2.8).

- **Minor contributions:** This dissertation has also provided additional novel contributions. Firstly, although BPMN diagrams have been used to describe health care processes, they have never been used to describe the current procurement practices and the different procurement processes in the UK. Therefore, this study showed the suitability of these diagrams to depict complex and multi-actor situations. Secondly, the author has introduced a new concept in current literature: hospital-based Health Technology Management (HB-HTB). From this new concept, the researcher has suggested the importance of considering the context-dependency of HTM activities and she developed her idea of studying and improving hospital-based procurement, taking into account the so-defined internal network that has been usually excluded by the literature.

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Appendix A

MHRA Recommendations for HTM Implementation

The following recommendations are taken from the MHRA guidance (Medicines and Healthcare products Regulatory Agency (MHRA), 2021). Recommendations for an effective management system:

- a comprehensive, organisation-wide policy on the management of medical devices and a system in place, which ensure that all risks associated with the acquisition, deployment, use, monitoring, record integrity, reprocessing, maintenance, record generation and storage, decommissioning and disposal of medical devices are minimised. Board-level responsibility for medical devices management is clearly defined and there are clear lines of accountability throughout the organisation, leading to the board
- a medical devices group with representation from a wide range of staff
- a comprehensive organisation-wide policy on the management of medical devices including: acquisition, deployment, use, monitoring, maintenance, decontamination and disposal
- a record of the current whereabouts / location of medical devices to facilitate a systematic approach to medical devices management and to help establish the relevance of any particular Medical Device Alert (or other MHRA advice) or manufacturer's Field Safety Notice to the organisation. Records of the action taken as a result should be maintained mechanisms to distribute manufacturer's Field Safety Notices, MHRA Medical Device Alerts, other MHRA safety guidance to the appropriate people in the organisation and to report incidents
- robust procedures to deal with all medical devices loaned within the organisation or to individual users. Independent contractors using medical devices have appropriate risk management systems in place and are aware of the overall policy and systems for medical device management within the healthcare organisation
- connectivity between the healthcare organisation's strategic plan and the 'on the ground' equipment lifecycle management activities

- an evidence-based and methodical decision making framework to optimise decisions taken within each stage of the equipment lifecycle
- risk management as inherent in the management of medical devices.

Recommendations for acquiring equipment:

- Local acquisition policies and processes to be established with the involvement of the medical devices group within the organisation.
- The relevant advisory groups to be established and consulted.
- Safety, quality and performance considerations to be included in all acquisition decisions.
- The recommendations of the MHRA and other appropriate bodies to be considered for selection and acquisition.
- Ensure all acquisitions meet local and European regulations.
- All developments, modifications and trials of devices to be carried out in accordance with the relevant legislation, guidance and risk management policy. Model ranges to be rationalised, where possible.
- Technical support, maintenance and repair systems, timescales and details of the lifetime of the device to be included.
- User experience to be fed back into the policy, process, future acquisitions and advisory groups.
- Organisations should identify how they can achieve savings through smarter procurement. Examples include: identifying opportunities to aggregate spend, utilising national and/or local framework agreements and equipment standardisation.

Recommendations for receiving a new device

- Check that the device matches the acquisition specification, is undamaged, is accompanied by all the necessary information and documentation
- Make sure that the appropriate acceptance checks and tests have been carried out in accordance with risk assessment and legal requirements.
- Where required, medical devices have been appropriately installed.
- Details of the device and the manufacturer's instructions have been entered into the appropriate device monitoring and tracking systems.
- Training needs have been identified and acted on.
- For reusable devices, maintenance has been scheduled.

Recommendations for training

- • There is an organisation-wide policy on training regarding the safe use of medical devices.
- End users, carers, professional users or other staff are supported in attending training.
- End users, carers, professional users or other staff are made aware of and, where necessary, trained in adverse incident reporting requirements for medical devices.
- All professional users and contractors are trained in the safe operation of medical devices.
- All end users are given appropriate training in the safe and effective use of medical devices.
- Staff and contractors involved in providing maintenance, repairs and decontamination are adequately trained and appropriately qualified.
- Independent contractors using medical devices have appropriate risk management systems in place.

Recommendations for instructions

- All users and prescribers should have access to the manufacturer's instructions.
- Records should be kept of who has received written device instructions.
- There must be a process for recording, tracking and updating the manufacturer's instructions.
- Any updates must be distributed to all relevant users of the device.
- Any manufacturer's instructions considered to be inadequate or ineffective should be reported to the MHRA

Recommendations on maintenance and repair

- All medical devices and items of medical equipment are to be maintained and serviced in line with the manufacturer's service manual and advice from external agencies e.g. Medical Device Alerts.
- Maintenance and repair providers preferably have a certified quality management system.
- Audit and user feedback systems are in place to frequently review the processes, policies and contracts.
- All staff involved in maintenance and / or repair are appropriately trained and qualified.
- Spare parts are of the correct specification and their quality and compatibility match those supplied by the original equipment manufacturer (OEM).
- Maintenance procedures are in line with manufacturer's maintenance instructions and timescales.

- All medical devices returned for servicing and repair are properly decontaminated.
- Where appropriate, ensure handover procedure completed.
- Organisations carrying out repairs and maintenance have adequate indemnity insurance.

Recommendations on decontamination

- A local policy sets out the management and transport of medical devices from the point of use to the decontamination facility.
- All items subject to inspection, service, repair, or disposal should be decontaminated beforehand, following validated methods and procedures.
- Decontamination has been carried out in line with the manufacturer's instructions.
- All relevant members of staff have been fully trained in decontamination protocols
- It is illegal to send contaminated items through the normal post.
- Ensure that single use items are disposed of and not reused even if decontamination has been attempted.

Recommendations for removal from service

- Medical devices and items of medical equipment are replaced, decommissioned and disposed of in line with an agreed policy.
- Before the sale or donation of medical equipment for reuse, the potential for future liability against the healthcare organisation should be considered.
- Disposal of waste should meet the applicable requirements for UK legislation.

Appendix B

Category Towers Specialist Providers (CTSPs) Contractors

"Currently, among the eleven CTSP contracts:

- Five of them have been awarded to UK public sector bodies
- Two have been awarded to private UK-based firms – one to the large catering multinational Compass, one to the small consultancy Akeso.
- Four have been awarded to DHL – one of which is shared with a USA company – which is owned by the German post office, Deutsche Post, which is itself 20% owned by the German state.

These CTSP contracts in total cost £190 million. None of this money buys any actual medical equipment, rather, it pays corporate middlemen to find equipment suppliers. Paying the middleman is wasteful at the best of times, and all the more so when corporate middlemen in the NHS are proving spectacularly unreliable, e.g. in allowing millions of items of PPE equipment to be exported by British factories to Europe " (Hall et al., 2020).

Fig. B.1 (see next page) shows the main contractors for each of the respective categories, together with the parent countries, the value of the contract and its duration. It is worth mentioning that Fig. B.1 pays particular attention to the contracts related to the Personal Protective Equipment (PPE), since the main study carried out by Hall et al. (2020) were focusing on the procurement outsourcing problems characterizing the Covid-19 pandemic in the UK.

Figure B.1: Category Towers Contractors (Hall et al., 2020)

CTSP				
Categories	**Contractors**	**Parent country**	**Value £M**	**Years**
Ward based consumables	DHL	Germany	22.5	3-5
Sterile Interventions Equipment	Collaborative Procurement Partnership LLP	UK	18.0	3-5
Infection control and wound care	DHL	Germany	18.0	3-5
Orthopaedics, Trauma and Spine, and Ophthalmology	Collaborative Procurement Partnership LLP	UK	18.0	3-5
Rehabilitation Disabled Services, Women's Health	Collaborative Procurement Partnership LLP	UK	18.0	3-5
Cardio-vascular, Radiology, Endoscopy, Audiology and Pain Management	HST = DHL + Vizient	Germany + USA	18.0	3-5
Large Diagnostic Capital Equipment	DHL	Germany	30.0	3-5
Diagnostic, Pathology and Therapy Technologies and Services	Akeso and company	UK	22.5	3-5
Office solutions	Crown Commercial Services	UK		3-5
Food	Foodbuy (Compass Group)	UK	12.5	3-5
Hotel services	Collaborative Procurement Partnership LLP	UK	12.5	3-5
PPE Monopoly Suppliers				
Surgical gowns (standard)	IMS Euro	UK (sourced Egypt)		
Surgical masks	Mölnlycke	Sweden (sourced China)		
Logistics and IT				
Logistics	Unipart	UK	£730	5
Logistics sub-contract	Movianto	USA		
Supporting technology	DXC Technology	USA		4-6
Other Central Contracts				
Pandemic Influenza Preparedness Programme (PIPP)	Movianto	USA	£55	5.5
Develop new procurement model	Deloitte	UK/global	£0.4	
	Clipper Logistics	UK	n/a	
Testing facilities management	Deloitte	UK/global	n/a	
Nightingale hospitals	KPMG	UK/global	n/a	

Appendix C

Project-based VS Process-based

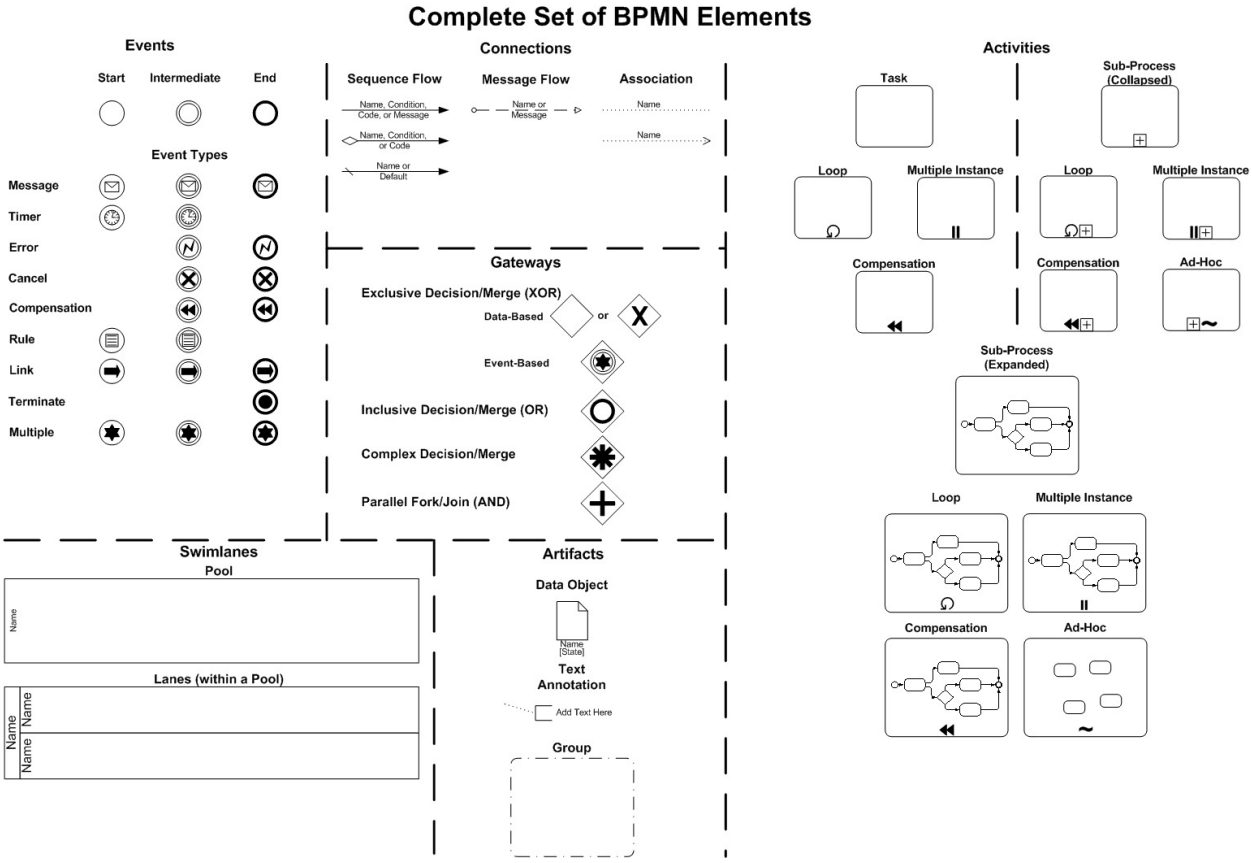
Figure C.1: Project versus Process. Adapted from (De Bruijn & ten Heuvelhof, 2018)

Project	versus	Process
Problem Formulation		
There is a problem, so a content analysis is required.		There is a perception of a problem, so the perceptions of others should be influenced.
The problem is clearly demarcated.		The problem is formulated in broad terms.
The problem steers the solution.		The solution steers the problem.
A problem is solved when it arises.		The moment at which a problem is formulated is a strategic choice. The *window of opportunity* must be open.
Goals Formulation		
Unambiguous and clearly formulated goals that give direction to the decision-making.		Broad or even vague goals. Clear-cut goals obstruct learning and are strategically unadvisable.
Goals are formulated in advance.		Goals arise during a process.
Well-defined scope		*Flexible scope*
Information		
Objectify information as far as possible		Create negotiated knowledge
Clear-cut distinction between information gathering and decision-making		Information gathering and decision-making run into each other
The right information leads to the right decision		The right process leads to the right decision
The leading principle for gathering information: need to know		The leading principle for information gathering: nice to know
Decision-making		
The decision follows on from problem, goal, information		After the decision there is a following round, so new opportunities exist
Making the decision explicit gives direction		Making the decision explicit makes it vulnerable – it generates incentives for resistance
Phased planning		Tempo changes
Project management techniques (tight planning, deadlines)		Project management techniques are dysfunctional
Project-based activity and communication		Process-based activity and project-based communication
Implementation		
Implementation follows the decision.		The decision follows the already undertaken actions, or decision-making is circumvented.
Decision-making gives compulsory direction to the implementation.		Partial-result decision-making but also new rounds and new opportunities
Implementation is an operational activity.		Implementation requires strategic choices.
Evaluation		
Have goals formulated in advance been achieved?		Are parties satisfied? Have problems been solved? Have parties learned? Have trusted relations for the future been created? Has the process been fair?
Evaluation is a post-project activity.		Evaluation is a continuous, process-monitoring activity.

Appendix D

BPMN Guidelines

Figure D.1: Complete set of BPMN Elements. From (OMG, n.d.)



Appendix E

Sample Email sent to Respondents

Figure E.1: Sample Email for interviews

From: Federica Fecondo <F.Fecondo@student.tudelft.nl>
Sent: woensdag 26 mei 2021 12:23
To:
Subject: Interview on Procurement TU Delft student

Dear Professor ,

Thank you in advance for reading this email.

My name is Federica Fecondo and I am a second-year student of the Management of Technology master course at the TU Delft University.

I'm conducting my thesis project with the supervision of Dr Saba Hinrichs-Krapels and the main topic is Health Technology Management (HTM). I would like to investigate the concept of hospital-based HTM, with particular attention to the Procurement process at the hospital level. More specifically, I hypothesize that the strategies applied for 'management in networks' in other private or public sectors and organizations can be applied and could be beneficial to health care, in particular to hospitals, to improve their HB-Procurement ability.

Because of your wide experience and deep knowledge in supply chain management and procurement, it would be an honour to have the possibility to interview you. This would be very helpful and significant for my thesis project.

If you agree to proceed with the interview, please suggest me a suitable time to speak (30 minutes should be enough).

I'm looking forward to receiving your kind reply.

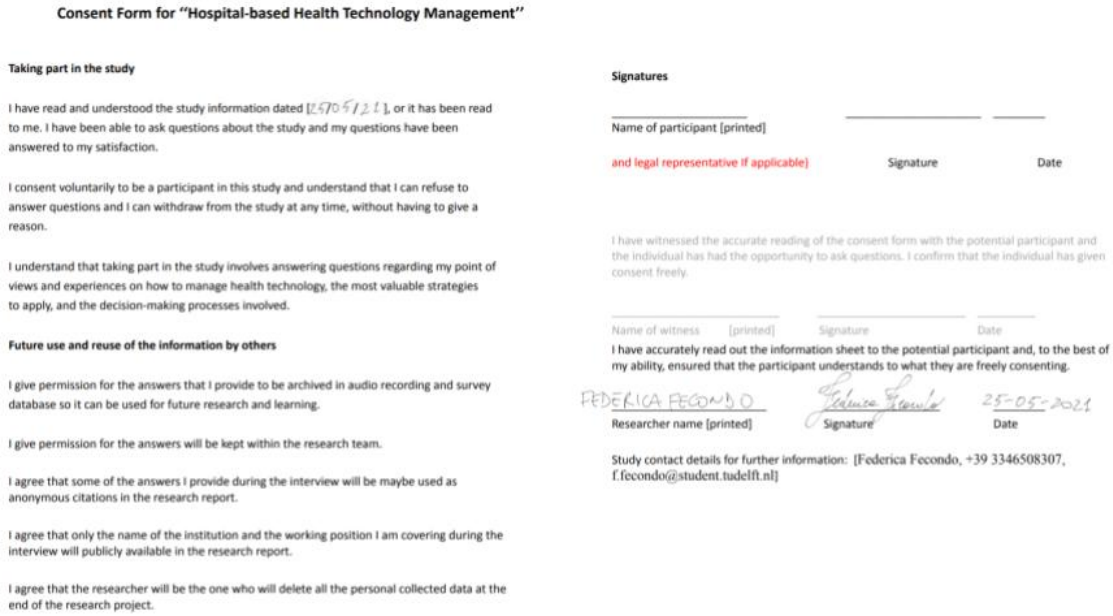
Thank you in advance!

Sincerely,
Federica Fecondo

Appendix F

Informed Consent Form

Figure F.1: Informed Consent Form sent to Participants



Consent Form for "Hospital-based Health Technology Management"

Taking part in the study

I have read and understood the study information dated [25/05/2021], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

I understand that taking part in the study involves answering questions regarding my point of views and experiences on how to manage health technology, the most valuable strategies to apply, and the decision-making processes involved.

Future use and reuse of the information by others

I give permission for the answers that I provide to be archived in audio recording and survey database so it can be used for future research and learning.

I give permission for the answers will be kept within the research team.

I agree that some of the answers I provide during the interview will be maybe used as anonymous citations in the research report.

I agree that only the name of the institution and the working position I am covering during the interview will publicly available in the research report.

I agree that the researcher will be the one who will delete all the personal collected data at the end of the research project.

Signatures

Name of participant [printed] and legal representative if applicable) Signature Date

I have witnessed the accurate reading of the consent form with the potential participant and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Name of witness [printed] Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

FEDERICA FECONDO — Researcher name [printed]; Signature; 25-05-2021 — Date

Study contact details for further information: [Federica Fecondo, +39 3346508307, f.fecondo@student.tudelft.nl]

Appendix G

The case of Personal Protective Equipment

The article written by Hall et al.(2020), who criticized the excessive privatisation and centralisation of the procurement process in the UK, was based on the drawbacks encountered by the UK health care system during the Covid-19 pandemic, in particular referring to the shortage of Personal Protective Equipment (PPE). Indeed, in addition to general considerations regarding both actual and possible issues derived from procurement centralisation/privatisation, the authors also described various events and circumstances in which that kind of procurement structure hasn't worked properly. The problems related to the shortage of Personal Protective Equipment in the UK can be seen as the consequence of two main factors. On the one hand, that shortage was due to a global surge in demand for Personal Protective Equipment because of Covid-19. On the other hand, the privatisation of NHS procurement generated perverse incentives that encourage rationing of the demand for Personal Protective Equipment, rather than a boosting of supply (Hall et al., 2020). More specifically, on the 11th of February 2020, the Department of Health and Social Care raised the official Covid-19 risk to the UK from low to moderate, therefore, the suppliers kept their equipment stockpiles unchanged. The Department of Health and Social Care also stressed the importance for suppliers of monitoring orders carefully and considering demand management plans in the event of excessive or unusual ordering patterns. The consequences of this, together with the centralisation/privatisation of procurement through the NHS Supply Chain, are the following. Firstly, the companies holding the procurement contracts "for various NHS supplies – e.g. DHL, for masks – were using automated processes to determine what counted as an "excessive" PPE request, and withholding supplies from NHS Trusts accordingly"(Hall et al., 2020). Therefore, instead of boosting supplies, the NHS Supply Chain was rationing demand. Secondly, active steps have been taken to prevent NHS Trusts from finding their own solutions. In particular, it is worth mentioning that until recently NHS Trusts could still directly buy their PPE and with the formation of "collaborative procurement partnerships," the process resulted to be more efficient, increasing their combined purchasing power. This enabled them to bypass the failings of the centralised NHS Supply Chain system by buying Personal Protective Equipment materials directly

(Hall et al., 2020). However, on the 3rd of May 2020, the Government told Trusts to stop buying their own protective equipment stressing that Supply Chain Coordination Ltd was the one responsible for the management of any new deals being negotiated between Trusts and suppliers (ibid.). However, the "NHS Supply Chain then issued suspension notices for 13 non-invasive ventilator masks and 57 tracheostomy tubes, tracheostomy kits and vascular catheters, meaning they can no longer be ordered from its online catalogue as normal for hospital Trusts. This move would "protect stockholding" and "push out volumes in line with the NHS England and NHS Improvement consumption model". The details of this model are not known. The NHS Supply chain customer notice says "Orders which have been placed on 5 May 2020 will be cancelled." We can only assume that these orders to ration equipment are advised by NHS Supply Chain's Category Tower Service Providers (CTSPs), given that they are responsible for procuring these items. They are protecting their own contracts with other private companies, and literally managing demand to fit the supply, rather than responding to demands from the NHS for resources" (Hall et al., 2020). "The PPE scandal not only shows that the deactivation of procurement rules and their checks and balances was exploited in dubious ways (and chumocracy is perhaps the kindest label this can be given), but also that the institutional arrangements for centralised commercial procurement for the NHS failed in the face of the challenge" (Sanchez-Graells, 2020a).