Systems and Methods for Resource Allocation in Late-Stage Drug Development

A Case Study of Decision Support in the Pharmaceutical Industry

Bachelor's Thesis in Industrial Engineering and Management

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System och Metoder för Resursallokering i Sena Faser av Läkemedelsutveckling

En Fallstudie av Beslutsstöd inom Läkemedelsindustrin

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Systems and Methods for Resource Allocation in Late-Stage Drug Development

A Single Case Study of How Uncertainty, Constraints, Managerial Judgment, and Organisational Structures Influence Resource Allocation at AstraZeneca

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ABSTRACT

Problem: The pharmaceutical industry is characterised by high uncertainty, resource scarcities and strict time and quality constraints, making resource allocation in multi-project environments particularly complex. This is distinctly critical in late-stage drug development, where heightened regulatory requirements and unpredictable results intensify coordination challenges.

Aim: This study aims to investigate how effective resource allocation is conducted under the constraints of late-stage drug development in the pharmaceutical industry and how its effectiveness can be improved.

Theoretical Framework: A theoretical framework was established for the study and was based on previous literature related to the characteristics of late-stage drug development, decision levels, governance, organisational alignment, and allocation methods.

Method: A qualitative single-case study was applied to the thesis, consisting of a literature study and an interview study. This was done in order to examine how theoretical approaches are applied in practice and which decision parameters shape allocation behaviour within AstraZeneca, a global pharmaceutical company. The literature study was conducted to establish a theoretical base for the analysis of resource allocation in late-stage drug development. The interview study provided empirical data from employees at AstraZeneca working in various roles related to the focus area of the study.

Results and Implications: The findings confirm that resource allocation in multi-project environments and late-stage development are shaped by high uncertainty, structural constraints, and reliance on managerial judgement. Uncertainty limits optimisation at operational and tactical levels, causing decision-making to rely on heuristic and experience-based judgement under time constraints and incomplete information. Consequently, resource allocation becomes reactive and requires continuous re-prioritisation across projects. The study also identifies a gap between formal systems and enacted practices, where informal coordination compensates for limited local

flexibility and fragmented decision-support systems. This suggests that, rather than attempting to eliminate uncertainty and reactivity, organisations within late-stage drug development should enable more integrated decision-making tools, implement information-sharing structures for managerial knowledge, and balance governance structures with local flexibility.

Keywords: resource allocation, late-stage drug development, multi-project environments, bounded rationality, decision-making, enacted processes, heuristic decision-making, organisational governance

SAMMANFATTNING

Problem: Läkemedelsindustrin karaktäriseras av hög osäkerhet, brist på resurser, strikta tidsramar och höga krav på kvalitet. Dessa förutsättningar bidrar i sin tur till att resursallokering inom multiprojektmiljöer blir särskilt komplex. Problematiken blir tydlig inom sena faser av läkemedelsutveckling, där ökade regulatoriska krav och oförutsägbara utfall försvårar koordinering mellan projekt och funktioner.

Syfte: Denna studie syftar till att undersöka hur resursallokering hanteras under de begränsningar som präglar sena faser av läkemedelsutveckling inom läkemedelsindustrin, samt hur resursallokeringens effektivitet kan förbättras.

Teoretiskt Ramverk: Ett teoretiskt ramverk sammanställdes för studien och baserades på tidigare litteratur relaterad till karaktäristik av sena faser av läkemedelsutveckling, beslutsnivåer, styrning, organisatorisk samordning, samt allokeringsmetoder.

Metod: En kvalitativ enfallsstudie bestående av en litteraturstudie och en intervjustudie genomfördes. Syftet var att skapa underlag för att dra slutsatser om hur teoretiska förhållningssätt tillämpas i praktiken samt vilka beslutsparametrar som formar allokeringsbeteende inom det globala läkemedelsföretaget AstraZeneca. Litteraturstudien genomfördes för att etablera en teoretisk grund för vidare analys av resursallokering inom sena faser av läkemedelsutveckling. Intervjustudien bidrog med empiriska data från anställda på AstraZeneca verksamma inom olika roller relaterade till studiens fokusområde.

Resultat och Implikationer: Resultaten bekräftar att resursallokering i multiprojektmiljöer och sena utvecklingsfaser präglas av osäkerhet, strukturella begräsningar samt ett beroende av ledningsmässiga bedömningar. Osäkerhet begränsar möjligheten till optimering på operativ och taktisk nivå, vilket leder till att beslutsfattandet i stället baseras på heuristiska och erfarenhetsbaserade bedömningar under tidspress med ofullständig information. Till följd av detta blir resursallokeringen reaktiv och kräver kontinuerlig omprioritering mellan projekt. Studien belyser även ett gap mellan formella system och faktiskt tillämpade arbetssätt, där informell koordinering kompenserar för begränsad lokal flexibilitet och fragmenterade beslutsstödssystemsystem. Detta tyder på att organisationer inom sena faser av läkemedelsutveckling, snarare än att försöka eliminera osäkerhet och reaktivitet, bör utveckla mer integrerade beslutsstödsverktyg, etablera strukturer för delning av erfarenhetsbaserad kunskap samt balansera styrningsstrukturer med ökad lokal flexibilitet.

Nyckelord: resursallokering, läkemedelsutveckling, multiprojektmiljöer, begränsad rationalitet, beslutsfattande, praktiserande processer, heuristiskt beslutsfattande, organisationsstyrning

Notera: Rapporten är skriven på engelska

Table of Contents

1 Introduction

Resource allocation plays a critical role in effectively managing complex pharmaceutical projects in an environment of high uncertainty, long project timelines, and expensive development processes (Laslo & Goldberg, 2008). Meanwhile, companies face pressure to improve efficiency, manage costs, and generate profits (AstraZeneca, 2026). Therefore, effective resource allocation is critical for pharmaceutical companies. However, despite its importance, resource allocation in the pharmaceutical industry is made difficult due to the characteristics of the environment, including high uncertainty and resource constraints (Hampson et al., 2021). To better understand these challenges, the following section provides a background on resource allocation in the pharmaceutical industry. The subchapters will also present the purpose and scope of this study.

1.1 Background

This chapter provides an overview of the pharmaceutical industry and its characteristics. It also explains the process of drug development and its inherent complexity.

1.1.1 The Pharmaceutical Industry

The pharmaceutical industry operates at the intersection of scientific, regulatory, and commercial activities (Laínez et al., 2012). It exists within a resource-intensive environment, where coordination across numerous specialised functions is required. Concurrently, it is vital to manage competing priorities across multiple development programs simultaneously (Laínez et al., 2012). Furthermore, the industry is characterised by strong competitive pressure and substantial reliance on returns from intellectual property protections, such as patents. As a result, the pharmaceutical industry invests heavily in research and development (Park, 2024).

Drug development within the pharmaceutical sector is further characterised by a long and complex process, associated with significant risks and long timelines (Park, 2024). This, in combination with its nature of high uncertainty and resource-intensity, explains why only a small fraction of developed drugs reach the market successfully. Late-stage development is particularly crucial due to its high investment costs and that decisions in this stage carry substantial financial and strategic implications (Hwang et al., 2016).

In addition, the industry must adhere to regulatory compliance, which consists of strict standards to guarantee patient safety and product quality (Parapalli, 2026). While these policies are non-negotiable, their specific requirements vary across nations. However, if not followed properly, this can carry out devastating consequences such as adverse patient outcomes, legal consequences, market withdrawals, and damage to public trust (Parapalli, 2026). These requirements thereby increase the complexity of decision-making within the pharmaceutical industry.

AstraZeneca is a global company, which operates in the pharmaceutical industry. It is a complex and resource-intensive organisation, comprising six strategic research and development (R&D) centres, ten global hubs, and 31 operations sites in 15 countries worldwide (AstraZeneca, 2026, p. 27). According to AstraZeneca's strategic targets, the company strives to launch a minimum of 20 new medicines and generate a total revenue of $80 billion by 2030 (AstraZeneca, 2026, p. 10). The company has significantly increased its investments in R&D over recent years to reach these goals, amounting to approximately $14.2 billion in 2025 (AstraZeneca, 2026, p. 30). These investments are meant to enable drug development to generate and launch more effectively (AstraZeneca, 2026). However, increasing costs puts pressure on pharmaceutical companies to provide R&D performance, which increases the importance of effective resource allocation (Schuhmacher et al., 2025).

1.1.2 Drug Development and its Complexity

The process of drug development is complex and prolonged, involving several regulatory and scientific steps from initial discovery to clinical use (Darji et al., 2024).This process, also known as the drug development lifecycle, can take up to 15 years and demand an extensive use of resources. A central aspect, as mentioned previously, is that only a tiny proportion of all researched substances eventually reaches the market (Darji et al., 2024), reflecting the complexity created by the regulatory demands.

The process begins by identifying and validating a biological goal with the purpose of determining a potential therapeutic approach to a disease. This stage is followed by experimental validation to ensure that the approach has a desired impact on said disease (Darji et al., 2024). Thereafter, an identification of active substances takes place. These then go through an optimisation process meant to improve attributes such as potency and safety (Darji et al., 2024). When the desired properties are achieved, the process enters the preclinical phase, where effects and safety are further evaluated. The results from these studies then lay the foundation for the decision to initiate human clinical trials (Darji et al., 2024).

The clinical development is divided into multiple phases where the drug is tested on humans at different scales (Darji et al., 2024). In Phase I, dosage and safety of the drug is examined in a small group of individuals, while Phase II focuses on the same safety evaluation on a moderately larger scale. Phase III then involves studies on a much larger scale to confirm effectiveness and identify uncommon side effects. After regulatory approval, Phase IV trials are conducted, which involves post-marketing surveillance and monitoring of a drug's safety and performance after being made available to the public. The final steps of Phase II, together with Phase III, are defined as the late stage of drug development and this is where uncertainty and decision-making complexity become increasingly significant (Hampson et al., 2021).

1.2 Purpose

The purpose of this thesis is to investigate how effective resource allocation is conducted under the constraints of late-stage drug development, and how the environment shapes the applicability of different allocation approaches. The aim is to understand how resources are matched to project needs in practice, and why allocation processes take the form that they do.

The focus lies on identifying key decision parameters, understanding how uncertainty and constraints influence allocation behaviour, and examining the gap between formal planning logic and operational reality. This provides a basis for discussing potential areas for improving resource allocation effectiveness.

1.3 Problem Definition and Research Questions

The topic is relevant from a societal perspective because decision-making in pharmaceutical development impacts healthcare priorities and patient welfare (Van Campen et al., 2021). Additionally, effective resource allocation improves lead times, delivery reliability, and cost efficiency (Pinto, 2020). Although resource constraints have always been present, the problem has become more complex because of tighter regulatory expectations, more demanding clinical trial requirements, and expanded monitoring after market launch (Schuhmacher et al., 2025). Academically, it is an interesting problem at the intersection of project portfolio management, capacity planning, and decision-making under uncertainty. It connects to broader discussions on how knowledge-intensive organisations can coordinate complex portfolios under tight resource constraints. This study is guided by the following research questions:

Main research question:

- What are the key challenges of resource allocation in multi-project environments in practice and how can they be addressed?

Sub-questions:

- How does uncertainty affect resource allocation decisions?
- How do organisational constraints affect resource allocation?
- How does managerial judgement affect resource allocation decisions?
- How are tools and systems used to support resource allocation in practice?

1.4 Delimitations

The following thesis concerns itself exclusively with projects that are already underway and will therefore not address the criteria by which new projects are initiated or acquired. From a practical standpoint, limiting the scope in this way makes the study more manageable and allows for greater depth of analysis in the defined domain. Had the thesis attempted to cover the full life cycle of projects, from acquisition to delivery, the breadth of the subject matter would risk creating

conclusions which are too general to give any meaningful impact. By focusing on active projects, the thesis can engage more closely with the operational and organisational dynamics at play during execution, where resource allocation decisions are more consequential and time sensitive. This also reflects the reality that managing an ongoing project portfolio presents its own distinct set of challenges, separate from those involved in project selection. These challenges warrant dedicated attention rather than being treated as a subset of a broader strategic discussion.

Further, the results of the study will only include findings from AstraZeneca. This follows from the method of empirical study being interviews exclusively with representatives from AstraZeneca. However, due to the size and global influence of AstraZeneca this was considered sufficient in order to give conclusions about what problems and constraints are generally experienced in the industry.

2 Theoretical Framework

This chapter presents foundational theory for the analysis of resource allocation in late-stage drug development. This environment is shaped by multiple projects, budget constraints, and high complexity, which shape resource allocation (Hampson et al., 2021; Hwang et al., 2016). In such multi-project environments, resource allocation requires coordination across decision levels, which may create challenges with differing incentives, information, and constraints (Hendriks & Kroep, 1999). In order to analyse decision-making in resource allocation and where challenges may appear, this framework employs previous literature that are related to the characteristics of late-stage drug development, decision levels, organisational factors, and allocation methods.

2.1 Characteristics of Late-Stage Drug Development

The core of late-stage drug development is the confirmatory part, which is a sequence of clinical trials designed to confirm the safety and efficacy of a new drug before regulatory approval (Hampson et al., 2021; Darji et al., 2024). The late-stage trials therefore play a critical role in establishing whether earlier findings remain consistent under stricter conditions. However, despite the trials' critical role, many drugs fail during late-stage development due to inadequate effects or safety concerns (Hwang et al., 2016). Furthermore, the late-stage development is regulatory constrained and involve critical decision-making. In addition, the trials are resource intensive and normally involve large scale studies, which naturally increases the magnitude of consequences of an incorrect decision (Hwang et al., 2016).

A central characteristic of late-stage drug development is that uncertainty changes in nature. In earlier phases, the uncertainty is closely linked to fundamental biological or clinical questions. At the late stage, it is instead tied to whether existing evidence is sufficient to support future confirmatory trials (Hampson et al., 2021), which indicates that uncertainty arises from how well earlier data translates into the later stage. This includes uncertainty related to aspects such as study design, patient populations, and endpoint performance in confirmatory trials (Hampson et al., 2021). The high failure rates in late-stage development demonstrate that these uncertainties remain substantial, especially with respect to efficacy and safety outcomes (Hwang et al., 2016).

Flexibility becomes more limited in late-stage development because of the confirmatory and regulatory constraints (Hwang et al., 2016). The scale and complexity of the trials, paired with their importance in generating decisive evidence, limit the feasibility of making substantial changes during execution (Hwang et al., 2016). Furthermore, the use of quantitative frameworks reflects the need to commit to development decisions based on available data prior to initiating the late-stage trials. This leads to the flexibility being reduced (Hampson et al., 2021). However, flexibility does not disappear entirely, but it rather shifts to portfolio level. While the late-stage studies themselves are mostly fixed and not easily altered, firms still retain the ability to reallocate resources across their different projects (Jiang et al., 2025). This supports the idea that late-stage

drug development is characterised by low flexibility at trial level, while still maintaining strategic flexibility at the portfolio level.

Decision models in late-stage drug development need to reflect its structural characteristics: high costs, irreversible investments, constrained study designs, operational bottlenecks, and a multidimensional probability of success (Jiang et al., 2025). Consequently, late-stage decision making requires integration of clinical and commercial factors rather than reliance on a single metric. Moreover, Hampson et al. (2021) show that probability of success is not directly observable but must be estimated using models that integrate the clinical data, prior trial results, and expert judgement. These estimates often start from historical success rates and are adjusted based on the current information. However, such approaches may lack transparency and fail to fully utilise available data if not properly structured (Hampson et al., 2021). Furthermore, Parasrampuria et al. (2018) demonstrate that late-stage failures can result both from scientific uncertainty and from issues such as suboptimal study design or execution. Empirical evidence supports this, showing that many drugs entering late-stage trials still fail despite earlier promising results (Hwang et al., 2016). Therefore, useful models should capture both quantifiable risks and uncertainty. In contrast, models become dysfunctional and risk misrepresenting the likelihood of success when they rely on unjustified assumptions (Parasrampuria et al., 2018).

2.2 Decision Levels

The decisions of an organisation can generally be categorised by their time horizon and strategic weight. Anthony (1965) offers a broad distinction between two types: planning, concerned with determining what should be done, and control, which looks back to assess what was done and whether it was achieved on time.

The framework proposed by Anthony (1965) divides planning and control planning into three hierarchical categories with different time horizons: strategic planning, management control, and operational control. The theory also identifies two functions: information handling and financial accounting. These are vital for the communication within and outside of the organisation. In this framework, the decisions made in levels above need to trickle down and are used as input for the levels below. Anthony's (1965) framework is further elaborated upon in relation to resource allocation by Hendriks & Kroep (1999), who identify five different elements which are vital to an efficient resource allocation strategy. These elements are described in a similar fashion to those identified by Anthony (1965) and include long-term-, medium-term-, and short-term resource allocation, links, and feedback.

2.2.1 Long-Term Planning

The decision level with the longest planning horizon is strategic planning (Anthony, 1965). Strategic planning involves decisions that impact the organisation's long-term objectives. This plan also needs to include the resources necessary to reach the objectives and policies regarding how

these resources are to be acquired, disposed, and handled by the organisation. Similarly, Hendriks & Kroep (1999) describe long-term resource allocation in which resources needed for the long-term objectives of the organisation are defined and planned for. This plan should be based on the business plan and should give information of what is needed for each discipline within the organisation for at least a year. In accordance with Anthony (1965), Hendriks & Kroep (1999) argue that the plan at this level needs to be indicative of the organisation's efforts going forward. Because the plan covers the coming year, it can be directly translated into budgets for the organisation's divisions and projects. Given that these decisions carry long-lasting consequences and broadly define how the organisation will operate going forward, both Hendriks & Kroep (1999) and Anthony (1965) agree that direct involvement from upper management is required.

2.2.2 Medium-Term Plan and Control

Sitting below strategic planning in Anthony's (1965) hierarchy is management control, a level often referred to in the literature as tactical planning (Swamidass, 2000). This level involves managers making sure that resources are obtained in accordance with the strategic planning and that they are used effectively and efficiently in accomplishing the organisation's objectives. The level is therefore a blend between planning and control where strategic alignment is controlled, and plans are made for how available resources will be used going forward. Hendriks & Kroep (1999) call this level medium-term resource allocation. Hendriks & Kroep (1999) describe this as a periodic review of the project portfolio's resource needs, which they argue is necessary given that an organisation's portfolio is likely to shift considerably over the course of a year. This medium-term allocation should draw on the long-term resource plan as its primary input while itself feeding into short-term allocation decisions. It should also address project prioritisation, establishing which projects take precedence when resources are insufficient to meet all demands simultaneously. As this is clearly defined, project managers can take this into account and calculate possible delays because of resource deficiency which can be communicated back to upper management. When the project portfolio and project priority has been determined, a rough-cut-capacity-plan can be created as an agreement between project leaders and resource leaders.

2.2.3 Short-Term Plan and Control

The lowest level in the planning and control hierarchy is operational control (Anthony, 1965). This level involves ensuring that specific tasks are carried out in an efficient and effective manner, in line with the previous levels. In contrast to management control, where control is concerned with individuals and control activities are not specified, operational control is only concerned with controlling already specified tasks. Hendriks' & Kroep's (1999) short-term resource-allocation plan involves both short-term planning and control. The planning part takes the rough-cut-capacity-plan and the priority rules, established in the medium-term plan, as its main inputs and creates a day-to-day plan for how resources should be assigned. The control part involves

observing deviations from the day-to-day plan and adjusting it according to needs, the rough-cut-capacity-plan, and priority rules.

2.2.4 Information and Links

Both Anthony (1965) and Hendriks & Kroep (1999) identify that the different levels cannot exist on their own and therefore need something which makes it possible for them to communicate. Anthony (1965) identifies information handling as a critical function outside of the three levels. Information handling dictates how objectives are shared between levels and how their activities comply with objectives.

Hendriks & Kroep (1999) identify links and feedback to communicate between levels. Without clear communication in place, different resource-allocation levels may have different goals which can interfere with each other. Therefore, the organisation must have links between levels to clearly communicate different levels' goals and how they are linked to the organisation. Feedback is communicated along the links to give information regarding the adherence to goals and objectives.

2.3 Governance and Organisational Alignment

Governance provides a framework for decision-making in organisations, to enable regulating of roles, accountabilities, and managerial action (Ahola et al., 2014; Too & Weaver, 2014).In complex organisational environments, it is typical for the involved actors to have unequal access to information vital for organising the transaction at hand, and their goals may conflict with each other (Ahola et al., 2014). Furthermore, failing to align the project portfolio risks preventing the project from serving as tools that execute the strategic objective of the organisation. This often occurs when actors prioritise their own interest rather than unifying toward a shared goal. To mitigate these conflicts and align the interests of multiple organisational actors toward a shared strategic goal, organisations must implement tailored governance structures (Ahola et al., 2014).

The following subchapters rely on Ahola et al. (2014) to explain how governance structures are established in multi-project environments. Particular focus is directed towards Project Portfolio Management (PPM) and Project Management Office (PMO), further supported by the reflections of Too & Weaver (2014). In addition, structural tensions are discussed by Ahola et al. (2014) and related literature. Finally, the principles of lean management are presented based on multiple sources.

2.3.1 Governance in Multi-Project Environments

According to Ahola et al. (2014), organisations that operate several projects simultaneously face significant portfolio-level challenges, particularly regarding the allocation and prioritisation of the resources. In such multi-project environments, governance structures are established to ensure that individual project managers do not act against the interests of the parent project-based firm. Project

governance serves as a central tool for controlling the risk exposure of individual projects and for proper risk allocation among engaged actors in complex projects (Ahola et al., 2014). To remain effective, these governance structures must be aligned with organisational competencies and regulatory practices. They may reduce the risk that project participants distort or misreport progress information for their own benefit, thereby strengthening reliable monitor and control of the project execution (Ahola et al., 2014).

The relationships between the business managers and the project managers can be explained through agency theory, which highlights the separation of ownership and control (Ahola et al., 2014). Within this structure, business managers act as principals who delegate mandates to project managers, who in act as agents controlling the actual execution of the projects. Agency theory highlights how information asymmetries and misaligned incentives between principals and agents may lead to opportunistic behaviour and inefficient resource allocation (Ahola et al., 2014).

2.3.2 Project Portfolio Management

Project portfolio management (PPM) is defined as the management of a collection of projects to help an organisation achieve its strategic objectives, which involves identifying, evaluating, and prioritising various portfolio components, in addition to managing risks and changes (Flores & Portillo, 2025). This ensures that the organisation's resources are focused on the right initiatives, prioritising the projects that add maximum value to the business. Furthermore, it supports the general governance processes by balancing workload against an organisation's capability and capacity to undertake the work (Too & Weaver, 2014). PPM consists of information gathering, applying organisational policies, procedures, methods, and criteria to make and implement effective decisions. Alongside continuous review and learning, this reflects the philosophy of continuous improvement in the portfolio domain (Too & Weaver, 2014).

Despite the intended benefits of PPM, several challenges may arise. One recurring issue is the occurrence of overlapping projects within portfolios, which can lead to coordination problems and resource conflicts (Too & Weaver, 2014). In order to achieve the most effective overall project-outcome, the organisation must maintain control over a wide variety of specialist projects, balance often competing priorities with finite resources, and coordinate the project portfolio (Too & Weaver, 2014). Additionally, the outcomes of different projects are not always combined effectively, which limits the integration of project results across the portfolio (Too & Weaver, 2014). Problems in decision-making may also arise when resource availability, project priorities, or the need to terminate underperforming projects are not appropriately considered, particularly when new initiatives are continuously introduced into the portfolio (Too & Weaver, 2014).

Another challenge that may arise in PPM is that the roles and responsibilities of decision-makers are often unclear or insufficiently defined (Too & Weaver, 2014). In addition, feedback from portfolio level to the project leaders is frequently minimal or missing, possibly leading to insufficient governance structures (Too & Weaver, 2014). Finally, organisations often show

unwillingness to stop projects even when doing so would be beneficial, indicating limitations within portfolio governance (Too & Weaver, 2014).

2.3.3 Project Management Office

A Project Management Office (PMO) is another important mechanism in project governance, providing centralised support and oversight of projects (Too & Weaver, 2014). Its responsibilities range from offering project management support to taking direct responsibility over the execution of a project (Too & Weaver, 2014). The PMO, that is acting on a strategic level, focuses on developing a structure that balances competing needs within the governance framework. Its governance support role is dependent on the availability of accurate information to support portfolio decision-making (Too & Weaver, 2014). A successful PMO includes an established discipline and rigor in its processes to achieve a high accuracy of reporting and generates effective support in development and innovation that allows organisations to achieve their objectives (Too & Weaver, 2014).

2.3.4 Structural Tensions that Disturb Organisational Alignment

When governance structures fail to coordinate between actors involved in a project, structural tensions emerge that disturb organisational alignment (Ahola et al., 2014). This occurs when parties to transactions, have unequal access to vital information and pursue conflicting goals, which creates an environment susceptible to adverse selection, moral hazard, and opportunistic behaviour (Ahola et al., 2014). Such tensions commonly appear in complex multi-project environments, where coordination depends on shared information and aligned priorities across functions and decision levels (Laslo & Goldberg, 2008).

As previously described, an agency problem occurs when a project manager prioritises their own interests or the specific interests of the project over the broader strategic objectives of the organisation (Ahola et al., 2014). This misalignment makes it difficult to align projects with the short-term and long-term goals of the organisation. Consequently, this creates a tension between different time horizons where the project manager prioritises the interest of the project at the expense of the strategic objectives of the firm (Ahola et al., 2014). This becomes particularly challenging in resource allocation contexts, where decisions must be coordinated across multiple actors and organisational levels (Samuel & Guikema, 2012).

Managing large projects without implementing a specific governance structure that is adapted to the characteristics and context of the projects significantly increases the probability of encountering severe problems (Miller & Hobbs, 2005). This includes difficulties in managing projects that are exposed to high levels of risk and uncertainty, as well as challenges in coordinating multiple stakeholders with conflicting interests. A lack of strategic flexibility may also reduce the organisation’s ability to adapt to changing project conditions, which ultimately increases the risk of project failure (Miller & Hobbs, 2005).

2.3.5 Lean Management

Lean management, often known as just lean, is an organisational philosophy consisting of methods and measures, which aims to enhance a company's competitiveness (Nenni et al., 2014). The core of the philosophy is to maximise customer value while eliminating non-value adding activities, often called waste (Rotter et al., 2019). This is done with standardised processes, an optimised flow, and involvement of employees (Rotter et al., 2019). Lean strives to deliver the right quality at the right time and in the right quantity, which in the long run leads to increased efficiency and reduced costs (Mahmoud et al., 2021). Originally developed within the industrial sector, the concept of lean management is now widespread over different sectors, with healthcare and drug development among them, where efficiency and quality are prominent (Rotter et al., 2019). Lean functions through a step-by-step process where value adding activities towards the end customer are identified, then a value stream analysis is done to showcase the waste in the system (Rotter et al., 2019). A central method is to implement a pull-based system, meaning that the production is controlled by demand rather than forecasts (Nenni et al., 2014). Studies show that lean often leads to standardisation of work and a collective problem solving (Mahmoud et al., 2021).

The pharmaceutical industry faces pressure related to expiring patents, high R&D costs, and strong competition, creating an increasing need for resource efficiency (Nenni et al., 2014). In this context, lean management can be proposed as an approach to shorten lead times to market launch and reduce waste in production (Nenni et al., 2014). A unique challenge for the industry is the harmonisation between lean-principles and the strict legal demands that exist (Nenni et al., 2014). Since lean originates from the manufacturing industry, its application to regulated environments like healthcare and drug development becomes complex (Nenni et al., 2014). This is because the standardisation must be balanced against high safety and quality assurances.

To manage flows, showcase deviations, and create a structured way of communication across an organisation, tiered huddles can be used as a level-based management system (Merchant et al., 2023). Tiered huddles, labelled as tier system later in the thesis, consist of short meetings involving multiple levels of staff throughout the organisation, where elements such as operational concerns, staffing issues and resource allocation are discussed (Merchant et al., 2023). The purpose of this system is not to report previous data, but to identify deviations from the standard and quickly elevate problems that cannot be solved at the current level (Mahmoud et al., 2021). The system can be divided into several tiers, with the tiers rising in the organisation the higher the problem is escalated, until it eventually reaches strategic decision levels (Merchant et al., 2023). According to (Merchant et al., 2023), tiered huddles allow companies to move from a reactive to a more proactive working philosophy by creating a transparent method for sharing information and resolving issues across functions. Consequently, these huddles ensure that data is constantly available, which shortens the decision time and allows the decision makers to focus on problem solving rather than chasing after information (Nenni et al., 2014).

2.4 Allocation Methods & Logic

For analytical purposes, this study divides resource allocation into three logics: optimisation logic, heuristic & rule-based logic, and enacted process logic. This is because resource allocation is a complex field that spans over technical optimisation, human interactions, and organisational factors. The logic is applied in their respective frameworks to construct methods aimed to optimise resource allocation in an effective manner.

2.4.1 Optimisation Logic

This study defines optimisation logic as the process of mathematically determining the optimal outcome through a framework consisting of a value function, restrictions, and inputs. From a resource allocation perspective this translates to optimising the value function through determining the best distribution of resources across competing areas, while also considering the constraints that resources and areas are subject to. This definition is heavily based on Hillier's & Lieberman's (2001) work in Introduction to Operations Research, where they formulate a general expression of a mathematical model expressing optimisation in operations environments.

The core of optimisation logic-based modelling is the objective function, which is dependent on structural assumptions regarding the environment that is being modelled (Hillier & Lieberman, 2001). The function works by predefining quantifiable inputs and constraints that are deemed relevant to the objective (Hillier & Lieberman, 2001). These inputs are then transformed to an aggregated quantifiable value, enabling ranking between different combinations of inputs (Hillier & Lieberman, 2001).

Optimisation logic-based models are constructed within a framework consisting of assumptions of real-life mechanisms (Hillier & Lieberman, 2001). A crucial assumption necessary for applying optimisation-based logic is that there exists an organisational objective (Hillier & Lieberman, 2001). For this to be true, objectives must be clearly defined and reasonably consistent with overall organisational goals, enabling coordination at a system-wide level. Another assumption is that inputs, outputs, and constraints are quantifiable (Hillier & Lieberman, 2001). Variables that are unable to be expressed numerically are therefore not compatible within the optimisation logic framework, as they hinder the construction of a value function. As a corollary, there is an assumption that organisational goals and resource scarcity can be represented through numerical variables and constraints (Hillier & Lieberman, 2001).

Since the applicability of optimisation logic is dependent on structural assumptions, the conditions should reasonably satisfy them to ensure quality in models constructed from this framework (Hillier & Lieberman, 2001). This requirement affects the ability to implement and therefore the usability of the logic, as different goals, environments, and approaches involve different real-life mechanisms that are being modelled. Additionally, to ensure the objective function correctly reflects organisational goals, the data on which models are based should be reliable and uncertainty

sufficiently limited (Hillier & Lieberman, 2001). Decision variables must be measurable and quantifiable to be compatible with the framework (Hillier & Lieberman, 2001).

The objective functions adaptability to real-life dynamic environment must also be acknowledged, as changing conditions and organisational strategy affect the functions transformation of different inputs (Hillier & Lieberman, 2001). Complexity is another factor that characterises models based on optimisation logic when not approximating parameters, possibly limiting the ability to implement the model (Hillier & Lieberman, 2001). Optimisation logic relies on numerical and precise quantifications (Hillier & Lieberman, 2001). Because of this, scenarios where resource scarcity is quantifiable, clear, and binding are well suited for the logic framework. Trade-offs being explicitly managed is also a characteristic that may be favoured in decision making, a characteristic that optimisation logic provides (Hillier & Lieberman, 2001).

Within optimisation logic, several methods aim to model real-world system dynamics. One of the most fundamental is linear programming, which is restricted to linear relationships (Hillier & Lieberman, 2001). As a result, complex mechanisms may be simplified when modelled using this approach. Linear programming also assumes additivity, meaning that interactions between variables are not directly represented, limiting its ability to capture synergetic effects (Hillier & Lieberman, 2001). Furthermore, the assumption of divisibility allows decision variables to take fractional values, which may be inappropriate when modelling discrete resources (Hillier & Lieberman, 2001). Finally, linear programming assumes certainty, meaning that all model parameters are known and constant (Hillier & Lieberman, 2001). A standard form of a linear programming model is given by Hillier & Lieberman (2001, p. 32) that maps out how inputs, constraints, and value functions is mathematically structured:

$$Maximise: Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

where Z is output value, c_i are coefficients, x_i are decision variables with a quantifiable output

Subject to the restrictions

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &\leq b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &\leq b_2 \\ &\vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &\leq b_m \end{aligned}$$

where a_{ij} is a coefficient to constraint b_i and decision variable x_j

To combat the limits of linear programming in modelling real-world relationships, other more sophisticated methods have been developed. Stochastic programming attempts to more accurately model dynamics by accounting for the uncertainty that real life dynamics inhibits (Powell, 2007). However, by embedding uncertainty into the model, exact solutions may become computationally impractical (Powell, 2007). It should also be noted that incorporating uncertainty into model spawns another problem, which is acquiring information about the system that is modelled, while simultaneously making optimal decisions (Powell, 2007). Dynamic programming is a method for optimising complex problems by breaking them into smaller, more manageable subproblems and

solving them recursively (Powell, 2007). By optimising these subproblems, the solution to the larger problem is also optimised (Powell, 2007). Many problems that involve making decisions over time naturally exhibit this subproblem structure, making them suitable for dynamic programming (Powell, 2007). However, in practice dynamic programming becomes computationally infeasible, therefore approximative dynamic programming is preferred as it offers tractable solutions, while sacrificing exact optimality (Powell, 2007).

In conclusion, optimisation logic assumes that resources and constraints can be expressed numerically, with respect to clearly defined organisational objectives that are reasonably consistent with overall organisational goals. The effectiveness of optimisation models is influenced by the extent to which uncertainty and complexity can be appropriately represented, rather than requiring a perfectly precise environment. Although such models produce clear and precise outputs, their usefulness depends on how well their underlying assumptions reflect the real-world system. Therefore, when assessing the suitability of optimisation logic in a given environment, it is important to consider the extent to which these assumptions are violated, as well as the purpose of the model.

2.4.2 Heuristic- and Rule-Based Logic

In complex, organisational environments of limited information and time constraints, human decision-making is often characterised by bounded rationality, which is the idea that people choose satisfactory options, instead of finding the optimal solution (Simon, 1979). In these cases, heuristic- and rule-based methods are often used to simplify complex scheduling and allocation problems (Kolisch & Hartmann, 1999). Such methods use simplified decision rules in order to guide resource allocation decisions in complex multi-project environments.

Optimising resource allocation and scheduling across multiple projects where resources are constrained is considered by previous research to be an NP-hard optimisation problem (Kolisch & Hartmann, 1999). This means that finding an optimal allocation solution for multiple resource-constrained projects simultaneously is considered computationally extremely difficult (Kolisch & Hartmann, 1999). Heuristic- and rule-based methods are widely used for finding a feasible solution for computationally difficult problems using reasonable computational effort (Kolisch & Hartmann, 1999). Although computational methods can be used to find more accurate solutions, those methods are complex and difficult to implement in large and dynamic organisations (Browning & Yassine, 2010). Since the landscape of multi-project organisations is dynamic, the data and information that are vital for advanced computational methods can rapidly change (Browning & Yassine, 2010). As a result, heuristic- and rule-based methods may provide more practical decision support in multi-project environments (Browning & Yassine, 2010).

A common heuristic- and rule-based approach often employed in multi-project organisations is priority rules (Kolisch & Hartmann, 1999). By ranking projects or tasks according to priority based on a predefined set of criteria, this kind of logic allows complex allocation problems to be solved

using relatively simple computation and relatively minimal input information requirements (Kolisch & Hartmann, 1999). Another type of heuristic- and rule-based methods is the use of simple problem-structuring, such as decomposition. This technique breaks down a complex scheduling problem into small, manageable parts that can be solved separately before being integrated back into the whole schedule (Brucker et al., 1999). Through this kind of simplification, heuristic- and rule-based methods are able to solve complex problems in a realistic way. Furthermore, heuristic- and rule-based methods can support faster decision-making (Browning & Yassine, 2010), which may increase adaptability and flexibility in a complex and dynamic environment.

Heuristic- and rule-based methods also have important limitations to consider. Due to their reliance on simplified rules rather than global optimisation procedures, results are typically approximate and suboptimal (Kolisch & Hartmann, 1999). Additionally, the resulting plan may depend heavily on how prioritisation rules and decision criteria are defined (Kolisch & Hartmann, 1999). Consequently, allocation decisions may potentially be sensitive to subjectivity or bias. In multi-level organisations, priorities and incentives may vary across different levels, and they may contradict each other (Engwall & Jerbrant, 2003). If different levels interpret or apply such criteria differently, it will create tensions between levels.

2.4.3 Enacted Processes

Organisational structure and governance define decision rights and aim to coordinate resource allocation across various levels (Too & Weaver, 2014). However, prior research has shown that formal structures and procedures do not completely define how work unfolds, and that actual procedures may deviate from the defined structure (Feldman & Pentland, 2003).

Organisational processes consist of both an ostensive part and a performative part (Feldman & Pentland, 2003). The ostensive dimension is described as the intended structure of activities and may be represented by formal processes, rules, and shared understanding. How these activities are actually enacted represents the performative dimension (Feldman & Pentland, 2003). This reflects how actors interpret the organisational routines and formal processes, and how actors adapt and execute them in specific situations. However, since it is not possible to clearly state all actions in advance in uncertain and complex environments, formal processes may often leave room for interpretation in practice (Feldman & Pentland, 2003). A ramification of this is that deviations from the plans are made in practice and effective coordination is needed.

The ostensive dimension both enables and constraints the performative dimension, while the performative creates, maintains and modifies the ostensive (Feldman & Pentland, 2003). Some mechanisms are suggested for how the ostensive and performative dimension may interact with one another: guiding, accounting, referring, creation, maintenance, and modification (Feldman & Pentland, 2003). First of all, Feldman & Pentland (2003) suggest that the ostensive dimension can serve as a guiding template for how actions should be enacted in practice, which allows

adaptability to specific situations. However, it also requires self-monitoring, which may introduce agency as actors interpret situations and make decisions (Feldman & Pentland, 2003). Secondly, accounting allows actors to use the ostensive aspect to justify and explain their actions, by relating their actions to defined procedures (Feldman & Pentland, 2003). Thirdly, the ostensive dimension may act as an encyclopaedia of recurring processes, and can simplify communication and information-sharing (Feldman & Pentland, 2003). Furthermore, organisational routines are often created when a pattern of actions persists (Feldman & Pentland, 2003). Through the performance of these actions, the routines are maintained and improved. When actors choose to deviate from the routine and find variations or developments in practice, the routines may be modified (Feldman & Pentland, 2003).

Allocation processes are further complicated by the nature of multi-project environments, where interdependencies between projects are high and resources are limited (Engwall & Jerbrant, 2003). In these environments, coordination does not just rely on formal procedures, but also on informal ones such as interaction, negotiation, and mutual compromise between actors (Okhuysen & Bechky, 2009). This interdependence can be contextualised in a hierarchical, multi-level organisation, where actors work with different information, and operational decisions are constrained by tactical decisions that in turn are constrained by strategic decisions (Anthony, 1965).

Informal dynamics may disturb the intended formal procedures (Okhuysen & Bechky, 2009). When that is the case, work must be done to reestablish vital conditions for coordination to function, such as establishing clear responsibilities and transparent workflows (Okhuysen & Bechky, 2009). Coordination works in practice when three conditions are achieved: accountability, predictability, and common understanding (Okhuysen & Bechky, 2009). Coordination may break down when these conditions are not met, which results in inefficiencies and misalignment (Okhuysen & Bechky, 2009). These conditions are, however, quite difficult to maintain in multi-project environments where decision rights are spread, and interdependencies are high.

2.4.4 Synthesis of Allocation Logic

The allocation logics that have been reviewed in this framework are fundamentally different from each other. Optimisation logic is complex, precise, and demands an organisational environment of clarity and certainty (Hillier & Lieberman, 2001). In contrast, heuristic- and rule-based logic considers conditions of limited information and a need for simple-decision making (Kolisch & Hartmann, 1999). Furthermore, enacted processes reflect the reality of organisations, where decisions are shaped by multiple actors, their interactions, and their agency (Feldman & Pentland, 2003).

Due to the differences between the different allocation logics, the handling of coordination across decision levels also differs. Optimisation logic assumes one single organisational goal, expressed and formulated by the objective function (Hillier & Lieberman, 2001). This implies that

optimisation logic assumes that there is an optimal combination of allocated resources for the organisation. Heuristic- and rule-based logics have a certain degree of flexibility, which may improve coordination between levels (Browning & Yassine, 2010). However, they also leave room for interpretation, which may cause misalignment between various levels (Kolisch & Hartmann, 1999). Therefore, the effectiveness of such methods depends on the definition of criteria and rules. In comparison, enacted processes handle inter-level tensions through governance mechanisms and informal interactions (Feldman & Pentland, 2003).

The comparison suggests that resource allocation cannot be solved solely as a technical optimisation problem. It also needs to consider the coordination within the organisation. How effective a resource allocation method is in reality will depend on factors such as uncertainty, complexity, and intra-organisational alignment.

3 Methodology

This chapter presents and evaluates the methods used in the thesis. It describes how data was collected and analysed, as well as providing a critical reflection on the chosen methods, including suggestions of improvement in future research. The purpose of the selected methods was to enable a scientifically grounded approach to answering the research question. Furthermore, they provided a strong base for the overall analysis, thereby enabling proper well-founded conclusions. To achieve the given purpose, a qualitative approach was utilised in the thesis. A single-case study was conducted to gain an in-depth understanding of resource allocation in a real-world context. Due to the complexity of resource allocation and its dependency on context, a single case allows for a deep exploration of decision-making and processes.

3.1 Data Collection

Data for this study was collected through two methods: a literature study and an interview study. The literature study was conducted to establish a theoretical base, while the interview study provided empirical data from employees within the pharmaceutical industry. Each method is described in the following sections.

3.1.1 Literature Study

The purpose of the literature study was to review existing theoretical research on resource allocation methods. This was done to identify research gaps, inconsistencies, and key debates, as well as to map the field. Furthermore, the literature study provided a robust base for the theoretical framework and the succeeding discussion.

To ensure scientific validity, sources for the literature study were found on the scientific databases Scopus and Web of Science. These databases consist of numerous peer-reviewed journals and books, which was considered pertinent for the study. Relevant sources were identified through a systematic screening process based on relevance and critical appraisal. Searches for documents were done within ‘Articles title, Abstract, Keywords’ using combinations of predefined keywords such as ‘(Resource Allocation) AND (Late-Stage Development)’, as well as other relevant terms related to the study. Relevance was assessed by sorting documents by keywords and year of publication. Most of the sources used in the study are peer-reviewed.

The study primarily focused on publications after 2021 to reflect recent developments in the field. However, the research area addressed in this thesis is built upon confirmed theoretical concepts. Consequently, older, peer-reviewed, and highly cited sources also constituted a significant part of the thesis. This is since they were considered essential for capturing core concepts and theories. By combining recent research with established literature, both theoretical depth and relevance was ensured.

All the selected sources were reviewed and prioritised collectively based on relevance for the research question of the thesis. This was done to minimise biases within the group. In cases where different opinions regarding relevance occurred, decisions were made based on consensus and by considering multiple perspectives.

Critical appraisal was conducted by evaluating scientific quality and credibility of the sources. This included assessing whether publications were peer-reviewed, which was ensured by database filtering. Additionally, citation counts were considered as an indicator of academic impact of each document.

All selected sources for the thesis were either downloaded as PDF files or imported manually into the reference management software Mendeley. This tool was used to systematically organise and manage the literature. A private group was created within the software, enabling all group members to access the collected sources. The platform's PDF annotation features were also utilised, allowing important information to be highlighted and shared. This approach was considered efficient, as it facilitated easy access to the material and improved collaboration among the group members.

3.1.2 Interview Study

The interview study was the main part of the empirical data collection. Interviews were conducted with employees from three occupational groups, all working within late-stage drug development. With the support of a contact person at AstraZeneca, these groups were identified as relevant to the study, since they represented different roles, responsibilities, and hierarchical positions, as well as different degrees of proximity to operational work and decision-making.

Group 1 included respondents with broader strategic responsibility at a higher organisational position, Group 2 included respondents with coordinating roles related to planning and resource allocation, and Group 3 included respondents in managerial roles closer to day-to-day operations, with responsibility for team-level prioritisation and staffing. Involving respondents across different levels made it possible to develop a more complete picture of how resource allocation is understood and handled across organisational levels in late-stage drug development. To preserve anonymity, the occupational roles are referred to throughout the study as Group 1, Group 2, and Group 3.

The contact person also enabled access to potential respondents within each group, making it possible to arrange digital interviews with employees located in different parts of the world. In total, five interviews were conducted: two with respondents from Group 1, one with a respondent from Group 2, and two with respondents from Group 3. This number was considered sufficient to capture perspectives from each identified occupational group and to enable comparisons both within and across groups. Recurring themes and patterns emerged across respondents, suggesting that the interviews provided depth to address the research question within the defined delimitations.

All respondents were informed, prior to the interviews, that their participation would remain anonymous in order to encourage open responses about their roles, responsibilities, and experiences. The interview questions were shared with the respondents prior to the interviews to allow time for preparation and reflection. To further preserve anonymity, respondents are labelled A-E. An overview of each respondent, including their group affiliation and area of responsibility, is presented in Table 1 below.

Respondent	**Group (*Area of responsibility)***
A	Group 2 (*Planning and coordination*)
B	Group 3 (*Operational*)
C	Group 1 (*Strategic*)
D	Group 3 (*Operational*)
E	Group 1 (*Strategic*)

Table 1: Interview respondents and their respective group and responsibilities

The interviews were conducted using a semi-structured format, meaning that each interview was based on a set of predetermined questions while also allowing for follow up questions when further clarification was needed (Bryman, 2012). The interviews lasted between 35 and 50 minutes. Each interview was attended by 3 of the authors, with designated roles: one was responsible for taking notes, one led the interview by asking the predetermined questions, and one focused on asking follow-up questions when further clarification was needed. An interview guide (see Appendix) was created prior to the interviews to maintain a structure across all interviews and reflect the aim of the study. While the core questions of the interview guide remained the same for all roles, a few varying questions were developed for each group to reflect their respective areas of responsibility. The question guide was discussed among the authors prior to the interviews to ensure relevance and clarity. This format was considered appropriate for the study, as it enabled a balance between consistency and flexibility. The predetermined questions ensured that central themes related to resource allocation, identified in the literature review, were addressed in all interviews, thereby enabling comparison across respondents and occupational groups. At the same time, the semi-structured format made it possible to adapt the interviews to the respondents' different roles and experiences, and to explore emerging issues in greater depth when relevant.

All interviews were held over AstraZeneca's Microsoft Teams platform, which was also used to automatically record and transcribe the interviews, with the consent of the interviewees. The transcripts were subsequently reviewed by the authors in relation to the audio recordings, and any discrepancies were corrected accordingly.

3.2 Data Analysis

The analysis of the interviews was conducted with thematic analysis based on the six-step process presented by Braun & Clarke (2006), including familiarisation, coding, theme development,

review, definition and reporting. The analysis was inductive and data-driven; themes were created based on patterns in the dataset and not on predefined categories.

Firstly, familiarisation of the data was completed through repeated reading and listening of the interviews. Secondly, coding of relevant phrases and sentences was performed. This step was done within an internal document and codes were marked using comments. The different transcripts were divided among group members to code, with 2-3 persons performing coding together on each transcript. The criterion for inclusion was alignment to the research question of this paper. Specifically, relevant data extracts were defined as segments that gave insights into how resource allocation works in practice and what problems that often arise. Then, codes were structured in a spreadsheet with the name of the code, a description of the code, and a quote that represented the code. To reduce individual bias, coding and theme development was done collaboratively and discussed within the group. Once each transcript had been coded, coordination between group members was done during meetings, conflicts between codes were handled, and codes were then edited to ensure consistency across all transcripts.

Thirdly, theme development was done in a separate spreadsheet where codes were categorised into broader themes. This categorisation was done by grouping codes that together showed recurring patterns across the dataset of how resource allocation is conducted in practice, including both challenges and enabling factors. In the review step, these themes were repeatedly checked against the data and refined before being finalised. This was done in order to ensure that themes were coherent, distinct from each other, and accurately captured the underlying dataset. Finally, themes were defined and named to properly reflect the underlying patterns in the data. The sixth step, reporting, involved presenting and explaining the identified themes in the results chapter.

3.3 Method Critique

This part aims to evaluate the research techniques used in this study in a systemic and balanced manner to correctly assess its strengths, weaknesses, and thereby the total validity of the study.

3.3.1 Literature Critique

Since the majority of sources used in the study are from peer-reviewed journals, it increases the risk of publication-bias, which may impact the articles available for the study (Moher et al., 2009). Furthermore, preferring higher citations increases the risk of filtering for old sources and undervaluing newer ones. Anthony (1965) provides an important structural foundation for this study. Although its age may raise concerns about it being outdated, it remains relevant because it introduced a framework that has been adopted and built upon by more recent sources.

Because the interview questions were partly based on the literature study, the subjectivity in source selection also affects the formulation of the interview guide. A repeated literature search might therefore lead to slightly different interview questions. However, since the search strategy relied

on recurring themes, citation patterns, and established theoretical concepts, it is unlikely that the overall direction or essence of the interview questions would change significantly.

The shared library and annotation features of Mendeley contributed to consistency in interpretation and reduced the risk of individual bias dominating the selection process. Despite this, the literature study remains partly dependent on subjective assessments of relevance and quality, and the limitations related to publication bias, citation-based selection, and restricted database coverage should be considered when interpreting the findings.

3.3.2 Interview Critique

Semi-structured interviews create a unique aspect of every interview that builds upon the uniform core questions, something that introduces a risk of limiting comparability between the different interviews. Furthermore, a few questions were tailored with the role of the interviewee in mind, which means different roles got different questions, limiting comparability between them.

There is also an aspect of interpretation which needs to be considered. Each interviewee may interpret the same question differently and therefore provide unintended answers. This issue is also difficult to notice for the interviewers as both parties: the interviewee and interviewer, naturally assume that the question was interpreted correctly. However, this risk is not limited to semi-structured interviews but is a general characteristic of interviews and questionnaires. In conjunction, these factors may have affected the overall quality of the answers provided by the interviewees and thereby the validity of the results.

Although the respondents represented three different occupational groups with varying proximity to operational and strategic decision-making, they all operated within the same organisational environment. Limiting the study to 5 interviews from a similar environment increases the risk of selection bias and limited generalisability. Therefore, the findings reflect experiences within AstraZeneca rather than the overall pharmaceutical industry, which may restrict transferability. However, by analysing resource allocation practices within AstraZeneca, the study captures how certain approaches function in a real-world drug development environment. This provides context-specific insights that may still have broader applicability even though organisational differences between companies should be considered when interpreting the results.

Due to limited availability and the need to identify respondents with relevant experience and roles, five interviews were conducted. After completing these interviews, the need for additional data collection was discussed. The conclusion was that the interviews provided a higher-than-expected level of information quality and density, allowing for an extensive and thorough analysis in line with the study's objectives. This reduced the perceived need for additional interviews. Nevertheless, the limited sample size still increases the risk that individual perspectives influence the findings.

Another limitation relates to the recruitment process of interviewees. While the contact person made it possible to reach individuals with relevant experience, it may have also introduced selection bias. The selected respondents may share similar perspectives or work within similar parts of the organisation, which could have reduced variation in responses and limit the range of viewpoints captured.

While the volume and diversity of information were considered sufficient with perspectives from five individuals representing different proximities to operations, the risk of selection bias and limited generalisability remains. The relatively homogeneous organisational context may have reduced the variation in responses, making it more difficult to identify contrasting viewpoints. This may have led to an overly narrow understanding of resource allocation practices, where the findings primarily reflect specific experiences rather than a broader range of perspectives.

These limitations are expected from a single-case study. However, the single-case study was deemed the best alternative due to it enabling a deeper understanding of the problems and constraints experienced by the company which would not have been possible, given the time-constraints, would a multi-case study have been chosen.

3.3.3 Analysis Critique

A key limitation of the thematic analysis lies in its interpretive nature. While conducting the thematic analysis, themes were identified and analysed by the authors, which may have led to different interpretations playing a role in the analysis. This subjectivity could have led to varying results, where different authors may have identified different themes in the same dataset. To lower this risk, the coding of data was conducted in groups of at least two authors. However, the risk of subjectivity may still come into play as different groups still may interpret data differently from each other. But since codes were discussed between all group members, the group could reach a consensus between the different interpretations, therefore finding which themes most accurately reflect the data. This increased the replicability and credibility of the findings.

Another risk that may impact the result is that of themes being under- or overvalued based on how much they are mentioned in the data. When conducting the thematic analysis, the theme's importance to the analysis was partly based upon how often it is mentioned in the data. This may lead to certain themes being under- or overvalued since the number of times it is mentioned does not reflect its actual importance to the topic. For example, an issue which is easily explained and therefore is mentioned only briefly, can be of high importance to the issue at hand. Overrepresentation could also arise from the similarity across some interview questions, which can lead to similar responses and consequently lead certain answers getting overrepresented in relation to other topics.

3.4 Ethical Aspects

This thesis examines societal and ethical aspects of resource allocation in late-stage pharmaceutical development. Improved allocation of scarce specialist resources can reduce delays and support faster access to medicines, which is societally relevant. Ethically, the work relates to fairness and transparency in prioritisation, but it does not involve patient data or clinical decision-making. Therefore, ethical risks are limited and addressed at an organisational level.

The most prominent ethical aspect associated with the project was that of organisational secrecy at AstraZeneca. Since AstraZeneca competes on a highly competitive market, leaked information about projects or other sensitive information could be detrimental to the company. No questions were asked about current projects or things that could be regarded as sensitive in the interviews. To further guarantee that no sensitive information was leaked, the contact person at AstraZeneca was informed about how information discussed in interviews and shared to us in other forums would be used, and that the thesis would be publicly available once completed. In conjunction with this, the interviewees were all informed of the use of the interview material. Hence, all people involved had a clear understanding of how the information would be used and the implications of their participance.

Another ethical issue associated with the project is that of the handling of personal data and risks associated with non-adequate anonymisation. Firstly, all personal data was handled in accordance with GDPR. Secondly, our contact at AstraZeneca, as well as the interviewees, were all anonymised. However, there is a risk that the interviews may be de-anonymised by people in AstraZeneca or other people with knowledge about the organisation. To minimise this possibility, the people being interviewed were, as previously mentioned, made aware of this possibility and they also had the ultimate authority in what could not be included in the thesis.

The use of AI is also a subject which needs to be addressed, particularly when it comes to what is shared with AI-tools. AI-tools were used in a supporting role for literature review and sifting through large amounts of material. It is important that no sensitive information is shared to the AI-models as this data will be stored in the models' databases. Therefore, only publicly available information was shared with AI-tools while interview transcriptions and recordings, which may have included sensitive information or personal data, were only reviewed by the authors of the thesis.

4 Results

This chapter presents the findings from thematic analysis. The findings are divided into four main themes that represent recurring patterns from the interview data. The themes display how allocation decisions are shaped by context, how they are affected by alignment and local flexibility, how they are made difficult by limited information, and how they are affected by limitations in the currently applied tools and methods.

4.1 Reactive Resource Allocation Under Constraints and Uncertainty

This theme shows that the uncertain, constrained, and dynamic environment of late-stage drug development causes allocation decisions to be made in reaction to changes in priorities, resource demand, and resource supply. Rather than following a predefined plan or forecast, allocation is described as a continuous process of adjustments. Multiple respondents emphasised the difficulty of making decisions when uncertainty is high, and resources are constrained.

A central issue in this theme is that there is high uncertainty by nature. When asked about resource supply and demand changes, Respondent A said: ‘You'll know when some leave is scheduled, other leave just kind of shows up.’ This high uncertainty complicates decision-making and planning because long-term planning becomes very unreliable, and decisions need to adapt when the environment changes.

4.1.1 Constraints Shape Allocation Decisions

A pattern is clear across the interviews which shows that resource allocation in the studied organisation is constrained in multiple ways. First of all, respondents highlighted resource constraints, including the limited availability of personnel, particularly with specialist knowledge roles. Respondent C explained the systematic nature of these resource constraints:

> The way we are set up and I think pretty much every successful company is set up this way, is that you have less resources than you need. That's how you maximise profit basically. So, it's intentional that we should have a stretch of roughly 10% always. So, if we know we need 200 people, we will not have 200 people, we will have 180 people to deliver that and then be flexible and agile and all that. (Respondent C)

This suggests that understaffing the organisation to a certain level in order to lower costs is described as an intentional, strategic decision. It is then the job of resource allocation functions to efficiently place these resources to projects. However, a difficulty in this is allocating specialist roles. Several respondents explained this when asked what types of resources are most difficult to allocate properly:

> Specialist roles are always the most difficult ones. It's a very science driven business we're in. It's a very expertise driven business that we're in. So, for every project there is sort of routine work where if you look at let's say that I have 160 people, the majority of them could do probably 70% of the work. But

> the remaining 30% of the work is quite specialised and we can't hire that many specialists, so they need to move around quite much in between projects. There are many people who are supporting. (Respondent C)

This means that allocation is not only constrained by the number of accessible resources, but also by the limited availability of specialist resources. To build on that, Respondent E explains that the budgeting is updated quarterly: 'We get the forecasts from the projects, which are shared with us on a quarterly basis. So, we have something called RBU. It is a rolling budget update which is done quarterly.' This constant update cycle suggests that resource constraints are not static but regularly redefined, creating a dynamic baseline for allocation decisions. Furthermore, time and quality constraints are described as characteristic for the pharmaceutical industry.

> So we can never compromise with quality with anything that goes to a patient. … Time is also very difficult to compromise with because we are committing to certain milestones. … So, the difficult answer is we don't compromise with any of these, which is the impossible equation, right? Because you need to compromise with one of these, but we're saying, well, we're not compromising with cost, but we're working smarter with cost. (Respondent C)

These constraints further limit allocation decisions, as timelines cannot be adjusted, and time spent on many activities cannot be reduced since it may undermine the quality of the product. As a workaround, respondents highlighted the need to instead improve efficiency.

4.1.2 Shifting Priorities Over Time

Several respondents emphasised how priorities between projects shift constantly and how resource allocation needs to adapt to those shifts.

The difficulty of choosing where to place resources when a new high-priority project arrives is pointed out by several respondents.

> So, if a new project comes in that's higher priority, we would get a high-level understanding of what that prior new high priority project is, what its timelines are, and what resources and skill types it would need. And we give them options of which projects we could take from. So basically, because we don't want them to stop a project that doesn't free up enough resources and or the right resources. (Respondent A)

This shows how allocation decisions need to be revisited to account for changing priorities. In practice, those decisions involve reallocation of people to supply a project's needs:

> So, we just have to use a prioritisation process that we work on those closest to the market and those with the larger volumes that would benefit most. … We want to get to the market as quickly as possible. So, we're taking three months on this part, four months on that part. Yes, and we can deliver it, but it needs more people. Where do we take the people from? What's the impact on those projects where we're, you know, removing people? (Respondent E)

The resource needs and ongoing work of one project is therefore sacrificed when reallocating resources to a higher priority project. This illustrates that reallocation has an impact on other projects, which is also considered and further complicates reallocation decisions. Another aspect of such a decision is focused on the individual staff and their productivity:

> I think it's a lot about personality. And I think I've been a team manager for a very long time and for example, in my team, I know that some people are at their best when they are doing several projects in parallel. That's the best working situation for them. And then I have some individuals also who struggle a lot with that and feel that they don't get it, yeah, it's not effective, etc. But also, if you are in a lot of, in several projects at the same time, obviously it's not possible to get a good understanding of the project as such. (Respondent D)

This further complicates allocation decisions since constant reallocation between projects may affect individual productivity. Overall, these findings highlight that shifting priorities require resource allocation decisions to be made and revisited constantly, where each decision includes trade-offs between projects, individual performance and resource availability. There is also a clear desire for the organisation to have agility and flexibility in order to be able to react quickly to dynamic changes in the environment, such as changing market priorities, with one respondent noting that ‘we are trying to … become more agile and to use the resources we have’ (Respondent A).

4.2 Organisational Alignment and Local Flexibility Trade-offs

This theme represents how organisational alignment is needed in order to make effective decisions across the entire organisation, but limitations in the structure can create challenges in responsiveness and flexibility. Furthermore, alignment may in some cases mean centralised decision-making, which there is a desire to move away from, as described by several respondents.

4.2.1 Alignment Across Decision-Levels

All respondents highlighted the studied organisation’s current tier system in a positive light. As one respondent explained:

> So, the tier process is that each team have their own meeting on a weekly basis looking at how we're doing. Do we need more resources somewhere? Do we have to manage resources somewhere and can share somewhere else? And then the conclusion from that meeting is escalated to the next tier level. So, this is the lean concept, right? And that would be then to the section heads. So, then they will run it through as well and see if we have problems that we can fix within this team or not. And if not, it's going to be escalated to my level. And then I sit in a meeting together with my section leads and look where do we have the gaps currently and how do we fix that? And if I cannot fix that, or if we cannot fix that together with my leadership team, that's escalated up to my boss and her leadership team where I sit. So that's how we try to share resources across first teams, then functions, and then units. (Respondent C)

Decisions are taken within a clear structure. Issues that are difficult to make and need a broader point of view are escalated so that those decisions are made at a higher level. As issues are escalated to higher decision-levels, decisions involve a broader set of actors who together contribute to shared priorities across the organisation. This ensures consistency in decision-making across the organisation. However, respondents also pointed out downsides to this system:

> But it's a slow process and we are trying to get more effective, but we always want to deliver everything… Sometimes we are stuck. It can take weeks, I would say, if there is a very extreme situation, for example, that we have several escalations at the same time for high priority projects. And for example, key personnel or key staff are on sick leave or whatever. So, in those situations, we see them as well. Obviously, we try to solve the issues as soon as we can. (Respondent D)

Decision-making and escalation in this structure can therefore be slow at times. In those cases, it leads to diminished ability to react quickly to dynamic changes in the environment, particularly in cases that require an immediate reallocation of resources. Furthermore, several respondents highlighted the challenges of alignment, communication, and coordination in the global organisation. When asked about the challenges of information flow, one respondent explained:

> So, we're actually, I'm looking to do it differently because it hasn't been working because we are a new global organisation and we are so large. I've never worked with a group this large before and we are in three different time zones. It's been quite a challenge. (Respondent A)

Coordination is difficult when the organisation is split across different locations all over the globe. One respondent further elaborated on this:

> But what we're also seeing and what I actually would like to see more of is that we actually have a lot of local perspectives. I mean obviously it doesn't make sense if we make the tablets here in Gothenburg, why would we ever ship them to Macclesfield in the UK to test them there? That takes a lot of time. However, we still maybe not seeing fully like that, but almost. So, to me there's a local factor that's still important, but it's challenging to work with. (Respondent B)

Coordination is not only difficult across the global organisation, but also takes up a lot of time. The quote also highlights how geographical proximity influences how work is more efficiently organised. At the same time, alignment is described as necessary in order to be able to make decisions that affect projects within the organisation:

> But if there would be an impact on milestones, I would not make that decision on my own. I would have to align with quite many different people. So, if I would, let's say it this way, I would align with the project leads and then the project leads need to make sure that there's alignment with other functions such as clinical for instance. There is quite much alignment required if you want to miss a milestone. (Respondent C)

Consequently, alignment is necessary for coordination mechanisms to work and for the organisation to move in the same direction. However, the process may at times come at the cost of

reduced agility. This tension between alignment and responsiveness is further reflected by the respondents' views on decision-making authority.

4.2.2. Desire for Increased Local Flexibility

While the tier process moves decisions up decision-levels, there is a desire from several respondents to be able to make decisions at lower levels as often as possible. As one respondent described:

> I would think if we want to be effective and quicker, we need to have people like me or others more close to the projects and the people to take more decisions. Then again, I don't get to see all the priority calls or the…, you know other some information are classified for certain reasons as well, giving that it can be hard for me to understand why we wouldn't resource allocate a certain project where it looks like we really need to because maybe someone has the information that this is going to be paused to terminate this project in a couple of months' time for instance. But I think that's what I would like to see. (Respondent B)

This suggests that allowing decisions to be made at lower levels may increase agility and flexibility in the dynamic environment. However, local decision-making is also closely linked to information accessibility across the organisation. Without clear information sharing, decisions risk being made without considering all relevant factors, which can hinder coordination in the organisation.

4.3 Available but Imperfect Information Shapes Decision-Making

This theme represents how information is central to resource allocation decisions, but also shows limitations in how information is used in practice.

4.3.1 Visibility of Demand and Capacity

Several respondents highlighted that current systems allow for clear and structured visibility of resource demand and availability. As these respondents explained:

> We've come a long way from even just a few years ago. We're actually able to pull out the demand and I can put information in about the capacity and I can sort it by. I can see things ahead of time. I can sort it by skill type, I can sort it by projects. So, there we can create pivot tables to understand what it looks like and show the differences over time. (Respondent A)

> But to handle that in a more easy going way, because you know these resource requests don't say anything about the people that we have to support, so therefore we have an Excel spreadsheet. … And then we have the projects in the horizontal file and the vertical file we have all the people. (Respondent B)

The information is structured and visualised for managers, allowing analysis of the data using various methods. However, respondents described that this alone was not sufficient for decision-making in the complex environment of resource allocation.

4.3.2 Information Requires Interpretation

While much information is available, it does not provide a precise basis for decision-making and instead requires interpretation from managers.

> Then of course, we also do a lot of judgement as team managers, where I say, well this gap here is 0.8 full time equivalents, that's all right. I know the project and they will manage. They requested a bit more than they really needed. And then we can sort of still, even if it was amber or red, we can still mark it green to say it's all right. (Respondent B)

This suggests that information is not treated as a definitive basis for decision-making, but decisions are made by interpreting the information available and making a decision based on experience and knowledge about projects. Consequently, resource allocation is not purely data-driven but depends on both structured information and managerial judgement.

4.4 Insufficient Tools and Methods for Resource Allocation

This theme captures how the current tools and methods for resource allocation used within the studied organisation are generally described as simple and somewhat manual. While some respondents consider them fit-to-purpose, others see them as insufficient for the complexity of the organisational context.

> So right now, the tools are that we don't have a good simulation, so we don't have a way to simulate the future. They're very manual. So, I would say that they're simple because they're Excel and manual for the user, but they're very complex for someone like me to prepare for them. (Respondent A)

Furthermore, the use of the critical path method is also mentioned by several respondents

4.4.1 Lack of Integration Across Tools

A recurring pattern is that the many tools that are currently in use for different purposes are not entirely integrated into one, automatic system.

> So, there's lots of tools out there, but they currently don't talk to one another, so people feel like they're updating in multiple areas, which they are. And then having one source of truth can be challenging if information is not updated everywhere. It needs to be updated. Knowing what the truth is becomes challenging. (Respondent A)

> So of course, it could use a link to the skills matrix, which we do have separate. But it's not linked in any way to the resourcing tools we have, but maybe AI can do that in the future (Respondent E).

This suggests that the lack of integration between tools leads to duplicated work and reduces the reliability of information. Decision-makers lack a unified and up-to-date view of the information on resource availability and project needs.

4.4.2 Oversimplification of Resources

It is a recurring pattern that resources, specifically staff, are described within the organisation using skill matrices. However, one respondent pointed out some issues with skill matrices:

> We have tried that many times to do fantastic skill matrices to really map out what each and everyone can do within the organisation. But still, it doesn't. It's very difficult to capture everything in a skill matrix and say, this is exactly what this person can bring to a project. It's also a lot about the soft skills, et cetera, that collaboration. (Respondent D)

The structural simplification of resources may dull the complex nature of people management. Without considering the personality of individual staff, decision-makers may miss important factors that may affect individual performance in a project; this makes it difficult to properly match individuals to projects.

4.4.3 Reliance on Informal Workarounds

While tools and data are used to make decisions, they alone are not sufficient. They can act as a starting point, but decisions may also rely on personal judgement and intuition, as one respondent explained: Since I have been around quite a long time, obviously I use my experience a lot, but obviously we need to act on data' (Respondent D). Furthermore, coordination is not always done through the structured tier process, but also through direct conversations between individuals, as another respondent explained:

> We have conversations together. Let's call the other manager Angelica. So, I will speak with Angelica to say, OK, we have this big gap here. What's the situation within your skill area and the other skill areas? And see what's possible to do or not. And quite often we also have them conversations with the project team members. (Respondent B)

Informal coordination is used to address small issues quickly or to clarify uncertainties. These practices suggests that coordination is supported by informal mechanisms that take place outside of the clearly defined structure. While these informal mechanisms may improve flexibility and responsiveness, they also suggest that formal tools, methods and structure do not currently provide enough support in all situations.

5 Discussion

This chapter discusses the findings in relation to the research question. This will be done by discussing the findings from the results and comparing them to the theoretical framework. The aim is to interpret how resource allocation works in practice, its underlying mechanisms, and its challenges. The chapter is structured around the key findings from the results and analysis. The chapter then concludes with a synthesis of the findings, highlighting how different factors interact to shape resource allocation in practice.

5.1 The Role of Context in Late-Stage Drug Development

To properly understand the allocation challenges observed at AstraZeneca, one must first look at the underlying structure of late-stage drug development. The findings illustrate a work environment where resource allocation works as a continuous stream of adjustments rather than a rigid and predefined plan. This constant need to adapt is not necessarily an effect of the management, but rather a reflection of the structure of late-stage drug development. Because late-stage development is large in scale, highly regulated and highly resource-intensive, the consequences of incorrect decisions are severely magnified (Hwang et al., 2016). This means that the overall environment demands rapid reactions to any shifts in project status or resource availability, and it also explains why the organisation relies on a structured process to ensure that decisions are aligned.

A central theme in the findings is the difficulty of making allocation decisions when uncertainty is high. While one might expect uncertainty to decrease as a drug successfully passes early phases, the theoretical framework clarifies that the uncertainty in late-stage development instead rather changes in nature (Hampson et al., 2021). It shifts away from fundamental biological questions and becomes tied to whether earlier data will translate and hold up under the stricter conditions of the confirmatory late stage. Because failure rates remain substantial even at this late stage, long-term planning becomes unreliable. This is in line with the findings, where decision-makers stated to have difficulties navigating the uncertainty and could not rely on data alone. They are rather forced to interpret incomplete information and rely on expert judgement to bridge the gaps. This mirrors the theoretical understanding that estimating the probability of success in late-stage trials requires integration of prior knowledge and experience rather than transparent metrics (Hampson et al., 2021).

Allocation decisions are further complicated by multiple constraints, making resources critical. The findings reveal that the organisation intentionally runs with a resource deficit as a strategic decision to maximise profit. This strategy turns resource availability into a bottleneck. In many other industries, such resource constraints might be managed by extending deadlines or reducing the scope or quality of the work. However, in late-stage drug development, this is explained as not being an option. The respondents explicitly highlighted that quality is non-negotiable, since you can never compromise on anything that goes to a patient. Timelines are equally rigid due to clinical

milestones. Because the regulatory constraints of late-stage trials limit the possibility of making substantial changes during the execution of trials, managers face what one respondent described as ‘the impossible equation’. They are tasked with getting efficiency out of an understaffed organisation without being allowed to adjust time or quality.

Consequently, since flexibility at the individual trial level decreases due to these non-negotiable constraints, the organisation is forced to find flexibility elsewhere (Jiang et al., 2025). As stated by Jiang et al. (2025), flexibility shifts to the portfolio level, where organisations retain the ability to reallocate resources across their different projects. This explains the shifting priorities observed in the findings. To navigate the rigid demands of late-stage development, the organisation exercises its flexibility at portfolio level by constantly revisiting allocation decisions and moving people around to supply the needs of new high-priority projects. The ongoing work of one project can therefore be sacrificed to push more promising drugs to the market faster. While this strategic reallocation is necessary for business, the findings show it comes at a human and operational cost, since it disrupts individual productivity, complicates local coordination, and forces constant reactive problem-solving across the organisation.

The findings show that the key challenges of resource allocation in multi-project environments are not only rooted in organisational inefficiencies, but in environmental conditions related to late-stage drug development. High uncertainty, regulatory constraints, irreversible investments, and limited flexibility at trial level creates a setting in which optimal allocation cannot be determined beforehand but instead needs to be continuously revised (Jiang et al., 2025). This suggests that effective resource allocation is less about identifying a static optimal plan and more about developing decision making that can handle changing circumstances and operate under constant uncertainty. These conditions are likely not unique to AstraZeneca but might reflect industry-wide characteristics, implying that pharmaceutical firms broadly face similar allocation problems when managing late-stage development. Moreover, the findings reflect a need for decision models that go beyond simplified assumptions and capture the multidimensional and dynamic nature of late-stage development, as highlighted in the theoretical framework (Hampson et al., 2021; Jiang et al., 2025).

5.2 From Strategic Prioritisation to Reactive Resource Allocation

The environment at AstraZeneca is characterised by a high degree of uncertainty and complexity, with frequent priority changes affecting what is considered optimal. Therefore, the reactive approach relying on enacted processes and heuristic logic becomes a necessity rather than a choice. To explain why this approach is preferred, the applicability of the logical frameworks is analysed within AstraZeneca’s organisational environment.

The findings indicate that resource allocation within AstraZeneca is dependent on current organisational goals, exemplified by the prioritisation of different projects. From a theoretical perspective, this prioritisation can be interpreted as a heuristic decision rule at the tactical and

operational level, where it simplifies organisational complexity by providing a structured ranking of projects, thereby supporting decision-making in resource allocation (Kolisch & Hartmann, 1999). The results also indicate that this prioritisation structure is prone to change, resulting in shifting goals that trickle down the organisation and affect allocation decisions.

At a more abstract level, this same prioritisation structure reflects how organisational objectives are translated into relative value between projects from a strategic perspective. In this sense, prioritisation can be interpreted as an implicit objective function, where project rankings represent the organisation's directional preferences in resource allocation. This connection links the empirical findings to the optimisation logic influenced by Hillier & Lieberman (2001) by showing how organisational goals are expressed in a form comparable to an output of objective function. This shows that at a strategic level the portfolio can, and therefore should, be optimised as it implies the best possible outcome given constraints and information. However, this interpretation primarily holds at the strategic level, where decisions are made in aggregated terms and not affected by short-term operational constraints (Hendriks & Kroep, 1999). This distinction is important, as it suggests that optimisation logic is implicitly applied at the strategic level, but not at the tactical or operational level, where decisions instead rely on heuristic simplifications.

The theoretical connection makes it possible to assess the fit of optimisation logic by examining how well the assumptions regarding objective functions, constraints, and inputs align with the observed allocation mechanisms. Frequent shifts in portfolio prioritisation therefore indicate an environment in which the objective function changes over time, as it is continuously reapplied in a dynamic setting where new information emerges.

A frequently shifting objective function raises the question of how effectively resources can be reallocated in practice. The findings indicate that resource flexibility is constrained by factors such as specialist competencies, coordination requirements, and existing commitments. This implies that resources cannot be freely reallocated between activities without violating practical constraints. As a result, the repeated application of a tactical or operational objective function becomes difficult to implement in practice. This further limit the applicability of optimisation logic and reinforces reliance on heuristic and enacted approaches, where decisions are adjusted based on experience and situational judgement rather than strict optimisation.

Constraints are also observed to exhibit a degree of uncertainty. The results indicate that tactical uncertainty is partly driven by quarterly budget updates, which redefine constraints, while operational uncertainty stems from difficulties in accurately estimating activity durations and productivity. From a modelling perspective, this means that constraints are not deterministically defined, which challenges key assumptions required by some optimisation methods. Although approaches such as stochastic programming and approximate dynamic programming are designed to handle uncertainty, their practical implementation introduces additional complexity.

Both stochastic and approximative dynamic programming require detailed representations of real-world dynamics, including relationships, uncertainty, and outcome impacts. Consequently, complex environments necessitate complex models, which in turn require more extensive data collection and more demanding assessment decisions. Assuming that these assessments contain some degree of error, increased model complexity raises the risk of inaccurate representations, leading to a need for repeated adjustments. This increases both implementation time and resource use, thereby raising costs. In addition, the benefits of such models are uncertain and may not justify the investment required for development and maintenance. Taken together, these factors indicate that implementing optimisation logic in this context becomes a costly and uncertain endeavour, further explaining why it is not adopted at the tactical and operational level.

Instead, the findings show that uncertainty is managed through a continuous control process within the organisation, where deviations are addressed through quick, qualitative decision-making aimed at minimising negative impact. These decisions rely on heuristic reasoning, such as matching available resources to emerging needs and minimising allocation gaps. Furthermore, structural elements in the form of governance mechanism, such as pools of available personnel, support this reactive approach by enabling a degree of flexibility in allocation. From a theoretical perspective, this reflects the use of heuristic logic supported by enacted processes, rather than formal optimisation.

The coexistence of multiple decision-making frameworks across different levels creates a structural asymmetry in how resource allocation is governed. The findings suggest that strategic decisions are structured through formal governance, while operational execution follow a more informal governance, exemplified by the localised judgement and situational reactivity. This results in structural inefficiency as the interface between the levels are simultaneously managed through two different logics with different assumptions and goals. This is supported by the empirical findings as shifts in priority require realignment through the tier system, which is shown require an extensive coordination effort to ensure that organisational alignment is reached. This results in increased coordination cost and delays.

In summary, the prioritisation of projects can be interpreted as the application of optimisation logic at a strategic level, where organisational goals are translated into relative value between projects and the portfolio is optimised based on project's value to the company. However, shifting priorities, resource constraints, and environmental uncertainty create conditions in which these strategic intentions cannot be consistently implemented at tactical and operational levels. As a result, resource allocation becomes reactive, relying on heuristic decision-making and enacted processes. This demonstrates that, when applying the decision-making frameworks to the organisational context, the same conclusion is reached: due to complexity, uncertainty, and implementation costs, a reactive and non-optimal approach is not merely a choice, but a necessary response to the environment.

5.3 Tensions Between Organisational Alignment and Local Flexibility

This section discusses the tension between organisational alignment and local flexibility. The results governance mechanisms that are implemented in order to align different decision-levels with the organisation's overall goals also reduce the organisations agility in the dynamic environment. This challenges the theory, which expects that effective governance structures should improve both coordination and agility.

Strictly following governance structures creates various delays that reduce the organisation's ability to quickly respond to changes in the environment. According to Ahola et al. (2014), multi-project environments require adapted governance structures in order to improve information alignment and reduce agency problems. Furthermore, Too & Weaver (2014) suggest that governance mechanisms like Project Portfolio Management (PPM) are adopted to balance workloads against capacity and keep tactical operations effectively aligned with strategic objectives. These mechanisms should enable coordinated processes in practice. However, the findings from the interviews show that strictly following such structures may create long delays before a decision can be made regarding a change in the environment, such as sudden resource shortages or changes in regulations. This indicates that the current governance mechanisms implemented within the organisation structure might be ineffective and can be improved.

Greater local autonomy could improve agility but also risks misalignment and opportunistic behaviour when information is unevenly distributed. The findings indicate a clear desire among lower-level managers for greater decision-making authority, as they argue this would enhance the agility needed to operate in a dynamic environment. However, the reason for the limited access to decision-making authority at lower levels can be explained by Ahola et al.'s (2014) application of agency theory, which suggests that local managers operating with high autonomy under information asymmetry may prioritise their own project's short-term interests over the portfolio's long-term goals. This highlights that information alignment across the organisation is necessary in order to apply local decision-making authority without sacrificing organisational alignment. The reason for why full information symmetry is not implemented within the organisation is explained by respondent B, who says that it is unreasonable for lower-level managers to have full visibility and information regarding the project portfolio. The implication of this is that information asymmetry is a structural constraint that negatively affects organisational agility. But similarly to other governance mechanisms, local flexibility can be adjusted to different levels to find the best-suited structure.

The tier system, originally intended to balance governance flexibility, proves to not live up to its potential in practice, according to the findings. Theoretically, the tier process acts as a level-based management system designed to support a proactive working philosophy by shortening decision times and allowing lower levels to solve problems locally. According to Nenni et al. (2014) and Mahmoud et al. (2021), this system should allow decision-makers to focus on rapid problem-solving rather than chasing information. The findings, however, contradict the expectation. Rather

than shortening decision times and acting proactively, the results show that the tier process in this highly constrained environment is slow and reactive. Because the organisation operates with intentional resource deficits, local teams often lack the capacity or authority to resolve resource conflicts at their own level. Because of this, issues are consistently forced up the hierarchy.

The result is a structural tension where neither strict governance nor local flexibility alone is sufficient. This creates a situation where the intended purpose of the lean-based governance mechanism is hindered because of the coordination complexities. The findings illustrate that, while the theoretical framework assume that formal systems often seek to achieve an optimal balance of alignment and efficiency, the reality fails to accomplish this. Too much focus on strict alignment and rigid governance can slow down how quickly resources are allocated. On the other hand, with too much local flexibility there is a risk for misalignment and opportunistic behaviour.

5.4 Decision-Making Under Uncertainty and Information Constraints

The findings highlight that the high uncertainty of late-stage drug development complicates decision-making, limiting the effectiveness and accuracy of long-term planning. The difficulty of long-term planning suggests that the importance of formal planning processes may be reduced in uncertain environments. Instead, decision-making depends on shorter planning horizons and continuous adjustments.

Furthermore, the findings indicate that some resource allocation challenges emerge from the need for information to be interpreted based on managers' judgement and experience. While decisions are formally based on data regarding resource demand and availability, the reality is that broad knowledge about individual strengths, weaknesses, and personality is needed in order to accurately make decisions that increase project and individual productivity. This shifts decision-making authority toward managers who have extensive personal experience working with individuals within the organisation, introducing a subjective dimension into a process that is intended to be data driven. Furthermore, as this subjective knowledge takes many years to build up, this increases the organisation's reliance upon veteran managers and the need to keep them within the organisation. Together, high uncertainty and reliance on interpretation and judgement suggest that decision-making is not purely data-driven and analytical, but heavily dependent on managerial judgement. This suggests that there are limitations in the idea of purely analytical decision processes, as they do not work efficiently under uncertain conditions.

Unexpectedly, the findings regarding how decisions rely heavily on judgement and interpretation do not fully align with the theories of optimisation-based allocation logic, such as that of Hillier & Lieberman (2001), which assumes complete and quantifiable input information. Instead, reality shows that input information is highly uncertain and personal experience is not easily quantifiable. The gap can be explained by the high uncertainty that exists in the environment of late-stage drug development, which is not compatible with the assumptions of optimisation-based allocation logic.

However, the results do align well with Simon's (1979) theory of bounded rationality, since decisions are made with limited information and time constraints in practice. Also, decision-makers rarely focus on finding perfectly optimal allocation solutions, but instead on satisfactory solutions that fulfil project conditions. As a result, decision-making shifts from optimisation-based logics to heuristic- and rule-based logic with the purpose of making decisions that function well but are not necessarily optimal. Approaches such as priority rules or decomposition may be better suited within this context, since they can structure the complex problem of resource allocation into smaller, more manageable parts. Therefore, they may create more consistent and more transparent decision-making processes.

To conclude, managerial judgement plays a significant role in resource allocation, as managers utilise their experience and knowledge to make effective allocation decisions. This is largely due to the uncertain nature of late-stage drug development, which complicates formal decision-making processes, forcing managers to turn to informal mechanisms. The implications of these findings are that organisations should not only invest in developing data systems, but also in developing managerial expertise and cross-functional knowledge, since these are critical to making accurate decisions in uncertain environments. Furthermore, organisations may benefit from creating a formal structure between managers that promotes the sharing of personal knowledge, reducing the reliance on individual expertise.

5.5 The Gap Between Formal Systems and Enacted Processes

The theory, in combination with the presented results, strongly indicates that there are numerous formal and developed systems available for coordination of project-intensive organisations. These systems include governance systems as well as resource allocation methods. However, both the theoretical framework and the result suggest that the formal procedures are insufficient in practice. This in turn creates a gap between formal systems and enacted practices. Consequently, informal mechanisms are necessary to compensate for limitations in the formal systems.

The gap between formal systems and enacted practices distinctively connects with the findings explained by Feldman & Pentland (2003) regarding enacted processes. The study highlights the difference between the ostensive and performative dimensions of organisational routines. While formal systems represent the ostensive dimension by specifying how work should be organised, coordination in practice takes place in the performative dimension. The findings explain that it is not possible to fully predict or specify all actions in advance in an uncertain and complex environment, which requires continuous adaptation. Informal interactions and improvised communication thus become critical, as they are more tolerant of real-time adjustments than formal structures.

The empirical findings reinforce the argument that formal systems alone are insufficient and that a gap exists between established structures and enacted practices. The organisation is characterised by resource constraints, high time-pressure, and employees working across multiple projects

simultaneously. These conditions create friction and lead to frequent deviations from the original plans, where in practice, operational decisions are often made informally. This is further supported by Simon's (1979) concept of bounded rationality, where decision-makers tend to choose satisfactory, rather than an optimal solution. As a result, coordination shifts further towards informal, experience-based judgement, which strengthens the role of the performative dimension.

While informal mechanisms enable quicker responses to unfolding concerns and uncertainties, they also introduce new challenges. As actors interpret situations and make decisions based on their own judgement and experience, Okhuysen & Bechky (2009) highlight that the informal dynamics may disturb the intended formal procedures. The coordination in practice may weaken the intended structure of formal systems, and risks undermining accountability, predictability, and common understanding.

The gap between formal systems and enacted practices can be further explained through the insufficient integration and functionality of existing tools. The results indicate that there is a large amount of data available as a solid base for decision making and analysis. However, it is not readily usable in practice. Respondents describe how existing tools do not talk to each other, and that they lack sufficient analytical support. While the tools assume that the existing data is decision-ready, the reality shows that the data is fragmented and requires interpretation. Consequently, formal systems fail to provide the support they were designed for, as actors turn to informal coordination to bridge these shortcomings.

The findings further explain the limitations of formal governance mechanisms such as PPM and PMO. As highlighted by Too & Weaver (2014), the effectiveness of these mechanisms depends on accurate data, clear roles, and effective feedback loops. When data is incomplete or unreliable, structured decision-making becomes constrained and actors are instead forced to rely on informal interaction and experience-based judgement to sustain coordination. In this case, informal mechanisms actively compensate for the deficiencies of formal structures.

Overall, the gap between formal systems and enacted practices reflects a structural limitation in how coordination is created and implemented. While informal mechanisms enable organisations to function under conditions of uncertainty, the findings suggests that informal processes exists because no formal structure can properly handle the complex interdependencies and uncertainty that characterises late-stage drug development. Furthermore, this suggests that improvement of coordination does not only require more advanced formal systems, but above all, a better integration between formal structures and the practical enactment.

5.6 Synthesis: Rethinking Resource Allocation in Dynamic and Uncertain Environments

This section synthesises how resource allocation functions within the context of late-stage drug development and examines how the characteristics of this environment shape the decisions made.

Where relevant, suggestions for improvement are proposed in response to the challenges and constraints identified. To provide structure to the analysis, the discussion is divided into the three decision levels: strategic, tactical, and operational.

The environment of drug-development has a significant impact on the conditions of resource allocation. The process is highly uncertain while simultaneously having non-negotiable constraints, meaning flexibility must be created at the portfolio level rather than within individual projects. This environment leads to optimisation logic breaking down in practice. Constant unexpected events and priority changes lead to there being no stable objective function to optimise. In addition, constraints are unstable, input impacts are difficult to quantify, and soft skills as well as personal knowledge cannot be reduced to data, meaning that the assumptions required for optimisation are violated. Optimisation not being possible shifts the decision-making process to be more in line with Simon's (1979) concept of bounded rationality, where decisions are made with imperfect information, limited time, and have the goal of being adequate, rather than optimal. This implies that resource allocation cannot be optimised at an operational or tactical level. There can be an initial tactical plan of where resources are best allocated according to current priorities, but this plan will inevitably change as strategies shift. Instead, resource allocation at these levels must rely on heuristics and experience to make decisions.

However, at the strategic level, meaning what projects are pursued and how they are prioritised, there can be optimisation. In the results, projects are described to be chosen and prioritised based on their expected impact on the market. This implies that there is an objective function to assess and maximise, namely the total impact on the market. Moreover, time-to-market can be seen as a variable that can be manipulated by moving around resources. This is supported by Hwang et al.'s (2016) description of the impact of resource allocation in late-stage drug development. From this realisation, a simple optimisation model can be created by putting time-to-market as the main variable. This variable is given two constraints: a minimum and a maximum. The minimum represents the lowest possible time in which the project can realistically be completed. The maximum represents the point at which the project becomes obsolete and no longer generates value. The value of each project is then adjusted based on when it is completed, allowing timing to be integrated into the model. An additional constraint is placed on the total available time capacity within the company, ensuring the model reflects the real resource limitations. A rudimentary example of this using linear programming, which maximises the expected value of a portfolio, is given below:

$$Value\ function\colon \sum_{i}^{n} f_i(t_i) * p_i(t_i) - c_i(t_i)$$

$$Where\ f_i(t_i)\ is\ a\ function\ which\ gives\ the\ revenue\ of\ project\ i\ when\ completed\ at\ time\ t_i,$$

$$p_i(t_i)\ is\ the\ probablity\ that\ project\ i\ is\ completed\ at\ t_i, c_i(t_i)\ is\ the\ cost\ of\ project\ i\ given\ completion\ at\ t_i$$

$$and\ n\ is\ the\ total\ amount\ of\ projects.$$

$Constraints$:

$$T_{tot} \geq \sum_{i}^{n} t_i$$

$$t_i \in \left[T_i^{min}, T_i^{max}\right] \forall i$$

$$C_{tot}(T_{tot}) \geq \sum_{i}^{n} c_i(t_i) \forall i$$

More constraints and even synergies between projects could be added but, as always in optimisation, the problem with such a model would be to estimate the constraints and the values of the variables accurately enough for the optimisation to give any insight (Hillier & Lieberman, 2001). It also does not account for new projects appearing or any costs that arise before the project is started. However, it could be a useful tool on the strategic level, where planning horizons are longer, giving benchmark time-to-markets to pursue and could also give an indication if it would be beneficial to pursue a new project at all. While not in any way being a complete model, it highlights the simplicity of creating an optimisation model at this level and shows that the problems with resource allocation stem from constraints at lower levels, where complexity increases dramatically, and the problem instead moves to implementing the shifting priorities effectively.

At the tactical level, the projects should be divided into various streams that require different skills and amounts of time, and resources that fit these needs should then be identified (Hendriks & Kroep, 1999). Similar to this, interviewees describe that once projects have been identified, they divide them into different work paths. Using this method, AstraZeneca can identify how resources should be allocated, what tasks can be worked on simultaneously, and which need to be sequenced after one another. It quickly becomes obvious that much of the planning that impacts resource allocation at AstraZeneca is done at this level: timelines are set up, resources are assigned, and forecasts are created. One could assume that this would mean that the planning tools used by AstraZeneca would be highly complex and integrated with skill matrices of individual resources in order to give the optimal output. Surprisingly, the tools employed at this level by AstraZeneca seem to be relatively simple and largely experience-based. Multiple interviewees describe that their tools are rather primitive, and that some do not communicate with each other. Furthermore, they describe that the tools employed require extensive managerial expertise in order to be interpreted in a meaningful way. Also, they describe that the tools do not give suggestions on how to allocate resources, which instead has to be made manually by managers. While this ensures that managers develop substantial experience and have a clear understanding of their resources, it is likely slowing down decisions at this level. An area of improvement could be to integrate skill matrices into tools and give suggestions based on the specified tasks, while still allowing for soft

skills to be integrated into the decisions by managers. This would likely cut the time needed for allocating resources by creating a rough plan which only has to be manipulated slightly by managers, instead of the plan being created from scratch. Additionally, the reliance on managerial judgement may be seen as a weakness for pharmaceutical companies, as it creates dependence on managerial knowledge that may be difficult to maintain within the organisation. It may be beneficial to develop formal information-sharing structures for managers to share personal knowledge about team members' strengths, working styles, and performance. This could further improve decision-making, as it allows managers better understanding of the information underlying the skill matrices.

The operational level's main objective is to ensure that already specified tasks are completed in an efficient and timely manner (Anthony, 1965). This means that operations need to be able to react to shifts in the tactical plan and have the tools to handle these shifts. Flexibility was mentioned by interviewees to be the main driver for reactiveness, as being flexible means changes can be made quickly without too much of a negative impact. However, as described earlier, flexibility cannot be created within the project which implies it has to be created at a higher level, and is therefore dependent on organisational processes. These processes can be both formal or informal, where a trade-off often needs to be made regarding alignment and flexibility respectively.

Formal organisational processes, such as the tier system, appear to be the main factor slowing down reactiveness at AstraZeneca, while simultaneously being crucial for creating alignment across the organisation. Because of the often-slow processes, managers compensate through informal coordination. The findings suggest that allowing informal coordination on lower decision levels may increase flexibility. However, it is also highly dependent on managers being aware of and acting in accordance with organisational goals. Both Anthony (1965) and Hendriks & Kroep (1999) emphasise that information sharing across decision levels ensures that managers at lower levels understand how their work aligns with the organisation's goals. Without a clear picture of how projects are supposed to be prioritised and where they stand in the portfolio hierarchy, organisational strategy may be overshadowed in order to handle short-term operational problems (Ahola et al., 2014).

The rolling budget update employed by AstraZeneca gives managers the freedom to solve problems locally between updates while still having to remain aligned to the assigned budget for the given period. The defined interval between updates therefore effectively sets the boundary for local autonomy, as managers can exercise discretion within the given timeframe, but must still realign when the next update arrives. However, this means that the system's effectiveness is partly a function of how well the update cycle matches the pace at which conditions change. Despite this, interviewees still describe a desire for increased local flexibility, suggesting that even with the rolling update system in place, the current system may not be entirely sufficient to meet the flexibility demands at the operational level. The problem with allowing more local flexibility is,

as one interviewee described, that some information may be classified and not meant to be available for the entire organisation, meaning local flexibility needs to be restricted.

The desire for more local flexibility also resembles principles associated with lean management. The operational environment being highly uncertain and therefore having to work reactively sets the stage for a lean workflow, where demand dictates supply. Using a lean framework in this setting would mean assigning resources based on actual demand and not on where management believes demand will arise. AstraZeneca already include some lean aspects, such as the tier system and the rolling budget update, in their current work process. The difficulty with implementing a pure lean workflow in drug development is that the work is not standardised (Nenni et al., 2014). This limits the feasibility of assigning the right resources to the right place and adhering to standards and regulations. Therefore, the findings suggest that while lean principles may support flexibility in the uncertain environment of late-stage development, an effective implementation would require significant modifications to account for the non-standardised nature of the work. Unlike industrial production processes, coordination in late-stage drug development relies on specialised expertise across multiple functions. Consequently, the findings indicate that a completely reactive decision-making process may be difficult in practice, as organisational flexibility needs to be balanced against the need for organisational alignment. While lean principles may increase flexibility and responsiveness, they may also hinder the maintenance of organisational alignment and stable governance mechanisms.

The findings of this thesis can be summarised in relation to the main research question and its sub-questions as follows.

What are the key challenges of resource allocation in multi-project environments in practice and how can they be addressed?

The key challenges of resource allocation primarily stem from the environment of drug-development being highly uncertain, which leads to resource allocation having to react to changes in priorities and unforeseen problems. At the same time, AstraZeneca employs a strategy which deliberately understaffs the organisation in order to generate as much value as possible per resource, producing what interviewees describe as an impossible equation. These problems and constraints experienced by the organisation are most clearly understood by examining the different decision levels at which they occur. At the strategic level, the portfolio must be optimised in order to generate as much value as possible for the organisation. This could be addressed by employing an optimisation system based on time-to-market for each project. This variable is likely to be highly impactful in what value each project can generate and can also likely be manipulated rather easily by allocating resources according to the optimal time-to-market. At the tactical level, incomplete tools and the absence of system-generated allocation place a heavy burden on managerial judgement, likely slowing decisions down. The integration of automated allocation suggestions and skill-matrices into existing tools would likely reduce this burden and speed

decisions up drastically. At the operational level, reactiveness is constrained by formal processes, and while informal coordination partially compensates for this, the desire for greater local flexibility expressed by the interviewees suggests this may not be entirely sufficient. Theoretically, this sets the stage for a lean workflow to be implemented, however, the non-standardised and knowledge-intensive nature of late-stage drug development limits the practicality of a fully reactive coordination system.

How does uncertainty affect resource allocation decisions?

Uncertainty is the most fundamental challenge identified by the study. The unpredictable nature of drug-development means that no stable objective function can be created at the tactical or operational level. Instead, managers need to rely on bounded rationality, making decisions that are adequate, rather than optimal. Uncertainty also means that all tactical plans are temporary, requiring regular revisits in order to stay aligned with current priorities.

How do organisational constraints affect resource allocation?

Organisational constraints are found at multiple levels. The deliberate understaffing strategy creates constant tension between resource demand and supply. Formal processes, such as the tier system, create alignment but slow down reactiveness. Budget cycles and update intervals define the boundaries within which managers can act autonomously. Together, these constraints mean that resource allocation decisions are as much a matter of navigating organisational structure, as creating technically optimal decisions.

How does managerial judgement affect resource allocation decisions?

Managerial judgement plays a central role at both the operational and tactical levels. At the tactical level, the limitations of existing tools mean that plans are built largely from experience, and the interpretation of available data depends heavily on individual expertise. At the operational level, informal coordination driven by managerial judgement compensates for the slowness of formal processes. While this reliance on experience ensures that managers develop a deep understanding of the context of the organisation, it also introduces individual biases, creates a dependency on individual knowledge and may not always be transferable.

How are tools and systems used to support resource allocation in practice?

The tools currently employed by AstraZeneca are described as relatively primitive and disconnected from each other. They do not generate allocation suggestions and require managerial input in order to provide meaningful insight, which limits their ability to accelerate resource allocation. This creates a clear opportunity to develop tools that make it possible to integrate skill matrices, communicate across systems, and provide decision-making support, while still leaving

room for managers to give contextual judgement and account for the human factor of resource allocation.

6 Conclusion

This study aimed to identify the key challenges of resource allocation in multi-project environments in practice, and how they can be addressed. The findings from AstraZeneca, analysed through the theoretical framework, show that reactive allocation is an effect of structural constraints, that uncertainty makes optimisation-based logic difficult to apply in practice, and that governance mechanisms create tensions between alignment and local flexibility. These findings provide answers to both the main research question and the four sub-questions. Implications for future research are discussed accordingly.

6.1 Summary and Recommendations

The main challenges of resource allocation in late-stage drug development are rooted in the characteristics of the environment. Consequently, reactive resource allocation can be seen as a reasonable approach in response, rather than a failure of management. The findings show that flexibility cannot be created within individual projects and instead needs to be performed at the portfolio level through continuous reallocation of resources across projects. Resource allocation therefore functions not as a planned and stable process, but as a series of adjustments that respond to shifting priorities, unexpected events, and constrained capacity.

Uncertainty is one of the most significant challenges identified by the study, and it prevents the application of optimisation-based allocation logic at the intended level. The unpredictable nature of drug development means that no stable objective function can be maintained. Therefore, rather than striving for an optimal solution, managers make decisions that are adequate under time pressure and incomplete information. At the strategic level, however, where projects can be selected and prioritised based on expected value and time-to-market, an optimisation model focused on time-to-market specifically could serve as a useful benchmark, given that this variable has a large impact on the value each project generates and can be directly influenced through resource allocation.

Organisational constraints further complicate the allocation process by creating a tension between alignment and local flexibility. By granting greater decision-making authority to lower-level managers, flexibility could be increased. This would, however, require improved information sharing across decision levels to ensure that local decisions remain aligned with the organisational goals. Information alignment can be difficult in practice due to varying priorities and time horizons of different decision levels, as well as the uncertain nature causing information to be constantly changing.

Managerial judgement plays a central role at both the tactical and operational level, but the organisation’s heavy reliance on individual expertise makes it vulnerable. At the operational level, informal coordination driven by managerial judgement compensates for the slowness of formal

processes. However, reactiveness at the operational level remains constrained by formal processes, and while informal coordination partially compensates for this, the desire for greater local flexibility expressed by interviewees suggests that this compensation may not be entirely sufficient. This dynamic is further shaped by information asymmetry between decision levels, which influences how and by whom decisions are made. While experienced managers are knowledgeable of the organisational context in ways that formal systems cannot replicate, this knowledge takes years to accumulate and is not easily transferable. Therefore, organisations may benefit from establishing formal structures for sharing personal, experience-based knowledge, such as information regarding the strengths, working styles, and performance of employees.

The allocation tools currently used by AstraZeneca contribute to many of the identified challenges. The tools are relatively simple and separate from each other, and therefore they require extensive managerial input in order to get useful decision-support. As a result, the gap between formal systems and enacted processes means that coordination must rely on informal mechanisms to compensate for the limitations of formal systems. This gap also constrains the organisation's ability to develop more advanced analytical methods in the future, since integrated and reliable data would be needed for such developments. Integrating skill matrices and automated allocation suggestions into existing tools could meaningfully reduce the manual burden on managers and support more consistent decision-making.

In summary, the findings show that the key challenges of resource allocation in late-stage drug development come from the environmental characteristics of high uncertainty and organisational constraints. It is indicated that these characteristics cause planned and optimal resource allocation at the operational and tactical level to be structurally difficult to achieve in practice. This is because key assumptions of optimisation are broken by this environment. These challenges cannot be solved by eliminating reactivity but should instead be solved by increased agility and improved decision-support. At the strategic level, and optimisation-based method that focuses on time-to-market could be useful to improve resource allocation for the portfolio. At the tactical level, integrating skill matrices and allocation suggestions into existing allocation tools, as well as implementing an information-sharing structure for managerial knowledge, could reduce the dependence on managerial judgement. At the operational level, if done without sacrificing organisational alignment, balancing governance structures to allow local flexibility could increase the organisation's agility.

6.2 Future Research

The challenges and patterns identified in this study point to several areas for future research. Since the findings are based on a single organisation and a qualitative methodology, replicating the study across multiple pharmaceutical companies would help determine whether the challenges identified reflect broader industry patterns or are specific to AstraZeneca. Furthermore, combining

interviews with a quantitative data collection would further clarify the characteristic of the challenges, and provide a clearer picture of the industry.

Other research areas could build on whether portfolio-level optimisation tools can actually work in practice, given that data is often unknown and priorities shift frequently in late-stage drug development. Another area is to explore how tacit managerial knowledge gets passed on in settings where uncertainty is high.

The data fragmentation identified in this study also reflects a broader gap in the literature. Much of the existing literature on digital transformation in pharmaceutical project management focuses on technical implementation but directs less attention to the organisational conditions that need to be in place first. Addressing this gap would offer more practical guidance for companies looking to develop stronger resource allocation capabilities through digital tools in the future.

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Appendix: Interview Template

Background and role

- What is your role, and what do you normally do day-to-day?
- What is your involvement in resource allocation decisions?
- At what decision level and time horizon do you mainly operate (strategic (6 months -), tactical (1-6 months), operational (1-4 weeks))?

Understanding Resource Allocation Problems

- What different aspects are considered in resource allocation? (e.g. forecasting, etc.)

Estimating Demand & Capacity, Forecasting

- Which types of resources do you find are often the most constrained? (Specific roles or areas of expertise).
- Do you think that resource allocation methods should prioritise these resources?
- How do you manage an eventual conflict of resources between different projects?
- What do you believe is important when categorising tasks or resources? What are some general challenges?
- How trustworthy are these predicted demand estimations?

Changes in Demand & Capacity, Reallocation

- What do resource capacity changes usually look like? (e.g. a team member becomes ill)
    - How common are these?
    - What impact does these have?
    - How are these usually handled
- What do *scope-side* demand changes usually look like?
    - How common are these?
    - What impact does these have?
- What resources are considered in capacity planning? and how do they differ in:
    - Variation from estimation?
    - Severity of variation from estimation?
- What activities are considered in capacity planning? and how much do they differ in:
    - Variation from estimation?
    - Severity of variation from estimation?
- How is overallocation of resources identified, and which types of resources are most often overallocated?
- How is under-allocation of resources identified, and which types of resources are most often underallocated?

Prioritisation and Decision Dynamics

- What trade-offs do you personally have to make?
- How is prioritisation handled when projects have different levels of urgency, risk, or potential?
- What happens if a new project with higher potential emerges while resources are already committed elsewhere?
- How does the project baseline (e.g. how the estimated time, quality and success) change through time and what implications does it have on other projects in the portfolio?

Organisational context and structural challenges

- How does the matrix structure of the organisation influence who makes resource allocation decisions and how they are made?
- How is resource allocation formally structured and governed?
    - How does this differ from how things work in reality?
- How does information about resource allocation flow across decision-levels and functions?
- How are conflicts handled between the department side (team managers) and the project side (key decision makers & coordinators)?

Methods, Complexity and Decision Support

- What kinds of tools do you use and how would you describe them in terms of complexity and ease-of-use?
    - To what degree do you rely on experience compared to allocation technology?
    - At what point between fit and use do we find optimal effectiveness in practice?
    - In your experience, how important is data-driven analysis compared to experience-based intuition in allocation decisions?
- Do you use different methods for different types of resources?

Future Development and Improvement

- What is positive with current models?
- What characteristics do the models have that lead to these effects?
- What can be improved with current models?
- Looking ahead, how do you believe resource allocation practices need to evolve in complex R&D organisations?
    - How are characteristics needed in allocation methods to work well in a matrix organisation?
    - Does the sophistication of methods need to evolve?
- If you could improve one structural aspect of resource allocation processes in large R&D environments, what would it be?

Specific questions for Group 1 (*Strategic*)

- How do you ensure that long-term strategic portfolio decisions are feasible from a medium- and short-term capacity perspective?
- How do you ensure that long-term strategic decisions are feasible operationally?
- Is there a structured feedback loop from operational constraints back to strategic portfolio decisions? Or is it mostly top-down?
- What is the single biggest structural obstacle to effective resource allocation in late-stage R&D

Specific questions for Group 2 (*Planning and coordination*)

- Are people often split between projects? E.g. a person works 40% on project A and 60% on project B for the next 3 months. If so, does this affect their productivity?

Specific questions for Group 3 (*Operational*)

- How is resource allocation governed? Is there a systematic process for doing it?
- What is considered when coordinating different project teams?
- Do you find that if you let a team member go to another project in need, that you can reliably get them back when you need it? Or do you find that you must protect your resources?
- What methods are used for forecasting and how long are the planning horizons?

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