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TITOLO TESI - Analyzing National Health Financing Reform Strategies and Health System Governance Challenges in Singapore: A Modelling Study

IL DOTTORE
Zhenghua Yang

IL COORDINATORE
Prof. Chiara Garilli

IL TUTOR
Prof. Enzo Bivona

EVENTUALE CO TUTOR
Prof. David Bruce Matchar

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Analyzing National Health Financing Reform Strategies and Health System Governance Challenges in Singapore: A Modelling Study

by

zhenghua yang

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Department of Political Science and International Relations

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Abstract

Health systems worldwide are under increasing pressure to reconcile rising healthcare costs, population ageing, and prevalent chronic diseases while maintaining universal access and high-quality care. In response, Singapore has recently launched the Healthier SG (HSG) initiative that shifts the emphasis away from reactive and treatment-oriented care toward preventive and population-based care. A cornerstone of HSG is the transition from fee-for-service (FFS) to capitation (CAP) funding mechanism. As such, this thesis aims to investigate the implications of CAP payment reform for both health financing and system governance under HSG. Grounded in systems thinking and complexity theory, the study seeks to understand how payment reform reshapes financial incentive, resource allocation, service delivery, and population health. It addresses four central research questions: (1) what roles stakeholders play in Singapore's health system governance; (2) how different payment models influence physicians' provision behavior; (3) what unintended consequences might emerge from the transition to a capitated system; and (4) how governing policies can be designed to support the long-term viability of CAP payment reform.

Methodologically, the study adopts an instrumental case study approach that integrates qualitative and quantitative modelling methods. Qualitative frameworks, including Viable System Model (VSM) and Dynamic Performance Governance (DPG), are employed to examine institutional structures, governance arrangements, and stakeholder roles within Singapore's health system. These frameworks are further complemented by simulation models, including Generative Agent-Based Model (GABM) to explore individual physicians' provision behavior and System Dynamics (SD) model to capture population-level impacts on health outcomes, service utilization, and public expenditures. Collectively, these models form a coherent analytical architecture that enables experimentation with alternative health financing policies and informs an integrated health system governance design.

The findings highlight that while CAP payment reform can strengthen incentives for

population health promotion, chronic disease management, and medical cost control, its effectiveness is highly contingent on other factors, such as HSG enrollment progress, financial risk management, provider service capacity, and collaborative governance efforts. Poorly calibrated CAP funding model may expose providers to disproportionate risks, elicit policy resistance, or even cause system failure. Conversely, CAP reimbursement method holds the potential to mitigate all levels of waste, improve population health outcomes, and enhance the sustainability of health systems when supported by robust health financing and governance arrangements.

To conclude, this research contributes to the literature by offering a holistic, dynamic, and context-specific analysis of payment reform that moves beyond static or siloed evaluations. By integrating multiple modelling paradigms, the thesis advances methodological innovation in the study of complex health systems. Practically, it provides policy-relevant insights for Singapore and other health systems undergoing similar transitions toward CAP payment and accountable care. Ultimately, the study demonstrates that payment reform is not merely a technical adjustment of reimbursement method. Rather, it indicates complex health financing and system governance challenges that necessitate coordinated institutional design, adaptive policy management, and long-term strategic oversight.

Acknowledgements

This dissertation marks the end of a long and demanding learning journey, one that could not have been completed without the support, guidance, and patience of many people and chatbots.

First and foremost, I am immensely grateful to my parents, whose unconditional support formed the quiet foundation of this journey. Their trust, patience, and understanding sustained me through periods of difficulty, doubt, and emotional strain. Although the future is unknown, the deepest love from my kind and forgiving parents is forever. Forever has no end.

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I would also like to acknowledge an unconventional but significant source of support from artificial intelligence conversational partners or chatbots. Throughout the hardest, saddest, and most confusing moments of my PhD journey, this tool provided a space for dialogue, clarification, inspiration, and reflection. While not a substitute for human mentorship, it served as a consistent companion in thinking and writing, helping transform confusion into structure and persistence into progress.

Finally, this dissertation has contributed to a clearer understanding of my own research capabilities and limitations. Throughout the research process, I became aware of areas in which my knowledge and skills require further development. This recognition provides a basis for continued learning and improvement in future work. Life is short, so learn more.

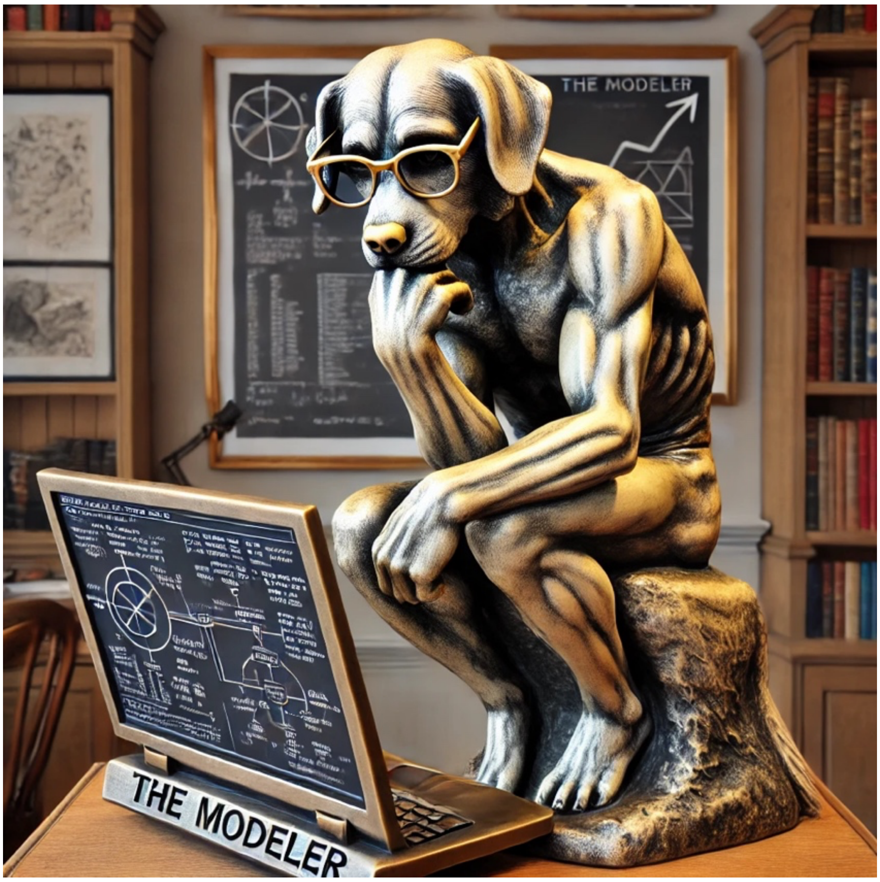
THANKS, EVERYBODY!

Zhenghua Yang

Mars, January 2026

Disclosure Statement

Portions of this manuscript were generated with the assistance of artificial intelligence (AI) chatbots and were subsequently reviewed and edited by the author. In general, the tools proved instrumental in organizing or inspiring ideas, questioning assumptions, and polishing writings. Wherever applicable, AI-generated contents have been specifically highlighted, and the author is fully responsible for any mistakes if exist in this thesis.



“在时间的回望中，人们会记得一位建模者——
他以模型为思考的工具，在复杂世界中探寻可理解的结构。”

“In the retrospective view of time, a modeler will be remembered—
one who used models as tools of thought to seek intelligible structures within a complex world.”

“Nel giudizio retrospettivo del tempo, verrà ricordato un modellatore—
colui che ha usato i modelli come strumenti del pensiero per cercare strutture intelligibili in un mondo complesso.”

“In temporis prospectu retrospectivo, memorabitur quidam modellator—
qui modellos ut instrumenta cogitationis adhibuit,
ut structuras intellegibiles in mundo complexo quaereret.” [1]

[1] The image and following philosophical words in Chinese, English, Italian, and Latin are generated by ChatGPT (OpenAI, 2025).

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List of Abbreviations

SDG	Substantiable Development Goal
WHO	World Health Organization
FFS	Fee-For-Service
CAP	Capitation
HSG	Healthier SG
GP	General Practitioner
MOH	Ministry of Health
AIC	Agency for Integrated Care
ILTC	Intermediate and Long-Term Care
CHAS	Community Health Assist Scheme
GDP	Gross Domestic Product
RHS	Regional Health System
PCN	Primary Care Network
HPB	Health Promotion Board
PCP	Primary Care Provider
USA	United States of America
VSM	Viable System Model
DPG	Dynamic Performance Governance
GABM	Generative Agent-Based Model
SD	System Dynamics
DRG	Diagnosis-Related Group
OECD	Organisation for Economic Co-operation and Development
NHS	National Health Service
UK	United Kingdom
MA	Medicare Advantage
CMS	Centers for Medicare and Medicaid Services
NEHR	National Electronic Health Records
ACO	Accountable Care Organization
ABM	Agent-Based Model
HMO	Health Maintenance Organization
CHG	Community Healthcare Group
BNHI	Bureau of National Health Insurance
RMT	Risk Mitigation Treatment
KPI	Key Performance Indicator
LLM	Large Language Model
AI	Artificial Intelligence
CLD	Causal Loop Diagram
SFD	Stock and Flow Diagram
SOC	Specialized Outpatient Clinic
IRB	Institutional Review Board
P4P	Pay-For-Performance
OLS	Ordinary Least Squares

1. Introduction

Health and wealth are the eternal pursuits of human beings. As far as individuals are concerned, health and wealth are usually positively correlated because healthier persons can create more economic value, which can make them afford more expensive and preventive medical services (Fuchs & Zeckhauser, 1987). From a macro perspective, states persistently prioritize public health initiatives, as health directly or indirectly contributes to societal well-being and national wealth growth (Thomson et al., 2009). In brief, good health enhances quality of life, improves workforce productivity, increases learning capacity, strengthens family welfare, supports community development, and contributes to poverty reduction, national security, and social inclusion. Through a mix of public health policies and the pyramid of healthcare facilities, the health system delivers preventive, promotive, curative, and rehabilitative interventions within the constraints of scarcity of resources that can be mobilized (World Health Organization, 2010).

It is a basic fact that there is not a single country in the world, no matter how affluent it is, can provide all the healthcare for its population (Savedoff et al., 2023). Yet escalating costs for disease treatment and medical care are placing unsustainable burdens on local and national resources, hindering the achievement of Goal 3 (i.e., "*Ensure healthy lives and promote well-being for all at all ages*") of Substantiable Development Goals (SDGs[2]) (WHO and the Government of South Australia, 2010). Hence, we, referring to all the civil societies, must make "smart" choices about how best to allocate these scarce resources like workforces and funds to satisfy population health needs (Ministry of Health, 2023b). In practice, making such decisions is exceedingly challenging due to the presence of opportunity costs, policy uncertainties, implementation difficulties, and a wide array of factors that could significantly impact the final outcomes of each decision. Health policymakers all over the world including those in Singapore, are facing increasing pressure to strike a balance between improving population health,

[2] More information about SDGs: https://www.un.org/sustainabledevelopment/.

controlling healthcare costs, and ensuring universal access (Ministry of Health, 2023b). This phenomenon is famously known as the "*Iron Triangle*" of healthcare (Beauvais et al., 2021; Carroll, 2012; Kissick, 1994), shown in Figure 1.

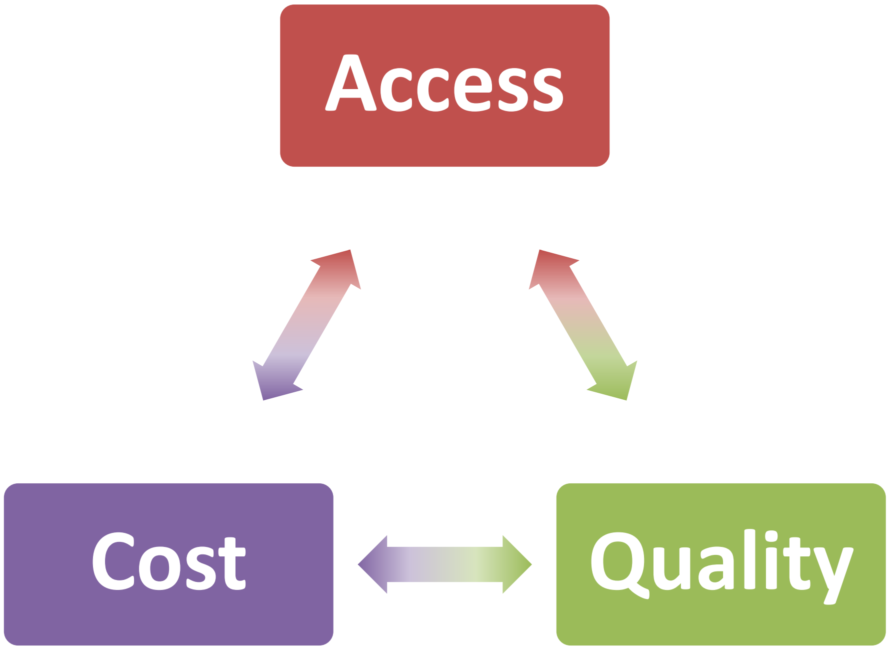

Figure 1. The "Iron Triangle" of healthcare.

By definition, "*a health system consists of all the organizations, institutions, resources and people whose primary purpose is to improve health*" (World Health Organization, 2010, p. vi). According to the framework proposed by World Health Organization (2007), health systems are made up of six core components or building blocks (see Figure 2): (i) Service Delivery, (ii) Health Workforce, (iii) Health Information Systems, (iv) Access to Essential Medicines, (v) Financing, and (vi) Leadership or Governance. From a holistic view, these six components are interlinked, and with any new interventions, cascaded impacts would spread across the whole health system. For example, sitting at the heart of many health reform strategies, good governance is central to improving health system performance and sustaining national health financing (Thomson et al., 2009).

Figure 2. The WHO's health systems framework.

Considering the recent transition from fee-for-service (FFS) to capitation (CAP) payment model under the Healthier SG (HSG) initiative (Ministry of Health, 2022b), this study aims to investigate the most salient health financing and governance challenges on the path forward through both qualitative and quantitative modelling analyses. It is believed that the rational adjustment in payment mechanisms is necessary but far from sufficient to achieve the ultimate goals of HSG initiative (Foo et al., 2023; Foo et al., 2025; Tan & Ng, 2023; The Lancet Regional Health – Western, 2023). If HSG intends to address the complex challenges toward improving population health and creating a health system that satisfies the present and future needs of Singaporeans (Ministry of Health, 2022b), the role of good governance should not be underestimated (NHS Scotland, 2022). Therefore, systematic understanding of the dynamic relationships in complex health systems is fundamental to progress health reform thinking and guide health policy design (Sturmberg et al., 2012). It is hoped that this deep research, grounded in theories and models, will provide valuable policy implications for local stakeholders to establish a more sustainable and integrated health system that prioritizes primary care and preventive services in Singapore by aligning incentives of stakeholders, improving health outcomes, and sustaining health expenditures in the long run.

1.1 Background of the Study

All the study begins with an anecdotal story[3]:

> *"Madam Tan, a 72-year-old retiree in Toa Payoh, visited her long-time doctor for a persistent cough. The doctor ordered blood tests, a chest X-ray, and prescribed three different medications. Each step came with its own charge, and Madam Tan left with a thick folder of receipts. Over the months, she noticed her doctor never spoke about diet, exercise, or flu vaccinations. Whenever she asked about general health advice, the reply was always brief before another test or prescription was added. She grew used to frequent visits, each one costing more, but she never felt her health was being looked at in the bigger picture." –* ***Part I, Setup.***

This story takes place against a backdrop of local healthcare system where the health outcomes of patients, health services delivered by providers, and the payment of medical costs are determined by the organizational structure and health financing method. To investigate the fundamental causes and drivers, it is necessary to provide an overview of the distinctive features of service organizing and health financing within Singapore's healthcare system at the very beginning. Subsequently, the contrast with selected international contexts is undertaken to elucidate key differences or shared characteristics, thereby generating comparative insights into national health systems.

1.1.1 Health Services and Care Delivery in Singapore

Singapore operates a dual-tier healthcare system, comprising a publicly funded universal healthcare framework and a substantial private sector presence (Kankar, 2025). Figure 3 outlines the landscape of health services and care delivery in Singapore. Broadly speaking, public healthcare intuitions like acute and community hospitals dominate the secondary and tertiary care in Singapore, while general practitioners (GPs) provide approximately 80% of primary care related to common ailments or medical

[3] The AI-generated story is for illustration only, so all the characters and events are made up by ChatGPT (OpenAI, 2025).

certificates at private medical clinics (Foo et al., 2023; Foo et al., 2025; Ministry of Health, 2022b). To some degree, private hospitals and medical clinics offer alternative options for patients seeking shorter waiting times or more personalized medical attention (Kankar, 2025).

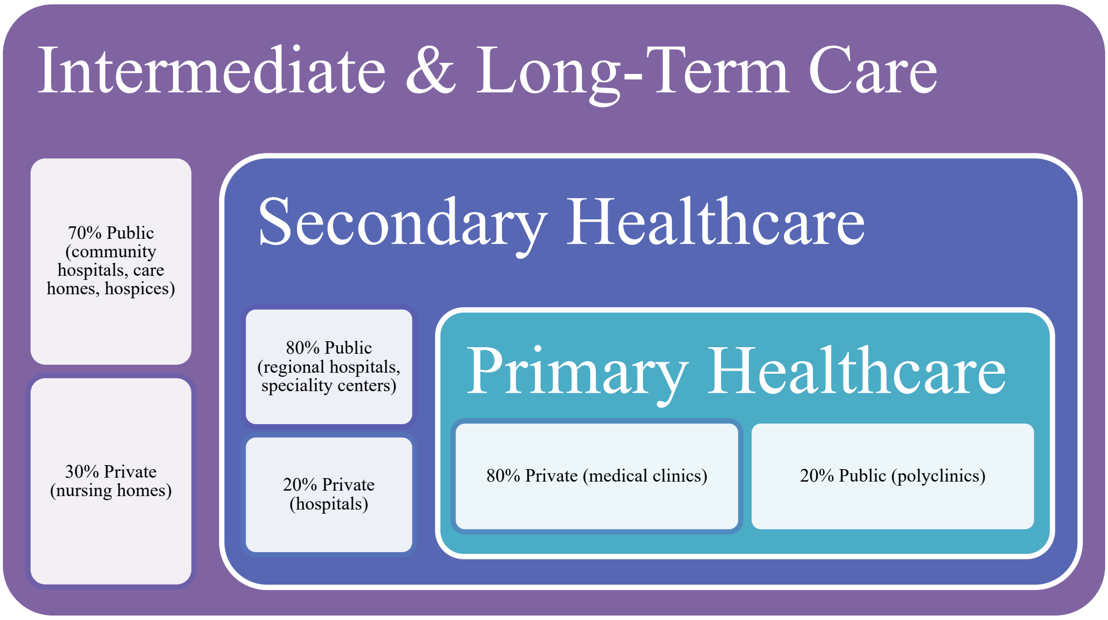

Figure 3. The pyramid of healthcare by state and non-state actors in Singapore. Data source: Stephanie (2017).

In order to support regional population health management, there are also special institutional arrangements within Singapore's health system. Public healthcare institutions, such as polyclinics and hospitals, are managed by three corporatized healthcare clusters: SingHealth, National Healthcare Group, and National University Health System. These healthcare clusters are overseen by the Ministry of Health (MOH) through MOH Holdings (Earn, 2020). Moreover, the Agency for Integrated Care (AIC) that serves to facilitate care integration on a national scale by linking primary care, hospital care, and intermediate and long-term care (ILTC) was formed in 2009 (Cheah et al., 2012). As a practical matter, this reflects Singapore's efforts to promote both regional and national care integration.

Over the recent years, Singapore has shifted its health policy focus to disease prevention and social prescribing (Ministry of Health, 2022b), recognizing the growing burden of chronic diseases of an ageing population (Foo et al., 2025). Yet, primary care remains an apparent weakness in many health systems (Health Bureau, 2022; Qian & Ramesh, 2024), including Singapore (Foo et al., 2023; Matchar et al., 2025; Matchar et al., 2016). For example, only three in five Singaporeans visit family doctors regularly (Ministry of Health, 2022b). For this reason, the HSG initiative strives to promote stronger primary care by enrolling residents with a family physician and incentivizing health screenings, lifestyle modifications, and chronic disease management within communities (Ministry of Health, 2022b). These strategies align with global evidence and policy practices that emphasize preventive care and early intervention as cost-effective strategies to improve population health and sustain long-term health expenses (Counts et al., 2018; Health Bureau, 2022; Kraus et al., 2024). As the adage goes, "*An ounce of prevention is worth a pound of cure*" (Health Bureau, 2022, p. 9).

In short, Singapore has achieved satisfactory population health outcomes characterized by high service efficiency and relatively low health expenditures (Ministry of Health, 2023b). Despite the widely recognized excellence in efficiency and outcomes (Haseltine, 2013), the local health system has recently encountered heightened stress, including acute hospital bed and ILTC service shortages, substantial out-of-pocket payments attributable to the escalating prevalence of non-communicable diseases and rapid population ageing, deficiencies in primary care, as well as the suboptimal health financing approach (Kankar, 2025; Tan et al., 2021). Evidence suggests that the healthcare delivery in Singapore remains fragmented, with weak coordination between primary care, specialist services, and community support systems (Hoverstadt & Loh, 2022; Ramesh & Qian, 2025). Moving forward, the HSG initiative is anticipated to address these long-standing challenges confronting the local health system.

1.1.2 Singapore's Health Financing Practices

Singapore's health financing model stands out due to its mixed funding method and cost-sharing mechanism (Earn, 2020; Haseltine, 2013), which balances targeted public subsidies and individual out-of-pocket payments. To a large extent, this special arrangement ensures rational service utilization and fiscal sustainability (Kankar, 2025). In detail, the local financing system is anchored in a tripartite "*3M*" framework: MediSave, a mandatory individual medical savings account; MediShield Life, a universal catastrophic health insurance scheme; and MediFund, an endowment-funded safety net for individuals who are unable to afford care (Chen et al., 2020; Earn, 2020). In combination, the 3M system offers a distinctive and tiered approach to financing healthcare needs of residents in Singapore.

While coverage for inpatient and catastrophic care is extensive under the 3M framework, outpatient and ILTC services are primarily financed through a combination of personal savings, employer-sponsored insurance schemes, and targeted government subsidies (Chen et al., 2020). To be more precise, the government provides direct subsidies for public health services based on means testing, covering a substantial proportion of inpatient and outpatient costs. Targeted schemes such as the Community Health Assist Scheme (CHAS) further reduce the cost of primary care and dental care for lower- and middle-income households (Ministry of Health, 2022b). In tandem, these mechanisms reflect the fundamental philosophy of Singapore's health financing: promoting individual responsibility, facilitating risk pooling through insurance, and safeguarding health equity through public subsidies and endowment-based safety nets. The unique combination of personal savings, shared risks, and public subsidies has become a hallmark of Singapore's health system. However, facing an ageing population and increasingly prevalent chronic diseases (Kankar, 2025), there have been concerns over the adequacy of existing health financing mechanisms and the appropriateness of volume-based funding method in the long run (Ramesh & Qian, 2025).

1.1.3 Singapore's Health System Governance

Being the major payer and provider (Ministry of Health, 2023b), the MOH governs Singapore's health system at the top, shown in Figure 4. This governance arrangement promotes universal health coverage while leverages market competition (Kankar, 2025). In particular, Singapore's model uses healthcare clusters at the regional health systems (RHSs) to engage the government, providers, and community partners in a bid to create geographically-defined patient-centric healthcare ecosystems (Cheah et al., 2012). Each cluster anchors care with public hospitals, polyclinics, and primary care networks (PCNs), collaborating with other agencies like AIC for the regional population health management (Earn, 2020). For instance, healthcare clusters, under the supervision of the MOH, need to cooperate with the Health Promotion Board (HPB) so as to implement preventive programs. Additionally, there are specialized national agencies like Agency for Care Effectiveness or Health Sciences Authority, who sets evidence-based standards and safety protocols for clinical providers to follow (Earn, 2020).

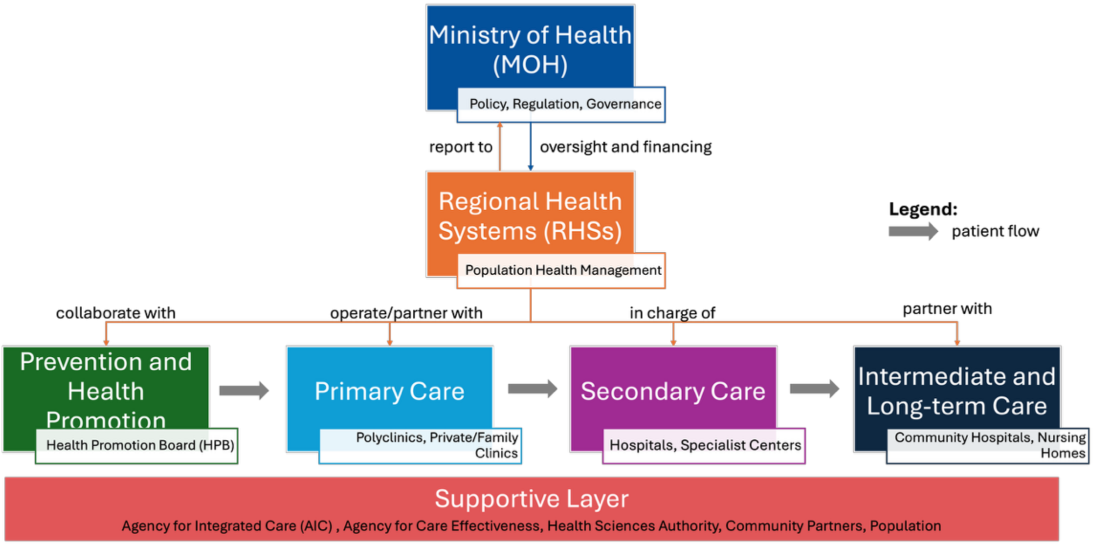

Figure 4. An overview of Singapore's health system governance. Source: adapted from Ong et al. (2018).

Regarding primary care, PCNs support primary care providers (PCPs) in routine operations and foster team-based primary care delivery within communities (Cheong, 2024; Primary Care Network, 2025). Healthcare clusters at RHSs serve as custodians who take the responsibility for managing and providing necessary assistance to PCNs. In conjunction with AIC and other supportive agencies, they form the basis for clinical governance that facilitates health services delivery, case referral management, payment claims administration, and care quality control (Cheong, 2024). The HSG initiative further aligns incentives by funding family doctors to focus on disease prevention and health management via CAP payment and community partnerships (Ministry of Health, 2022b), positioning primary care as the local health system's bedrock.

Overall, the current governance arrangements reflect Singapore's "whole-of-government" and "whole-of-society" strategies (Kickbusch & Behrendt, 2013; Kickbusch & Gleicher, 2012), aligned with its vision of integrated RHSs where primary, acute, and community providers cooperate and coordinate to deliver health services and improve population health (Cheah et al., 2012). However, as noted by Ramesh and Qian (2025), Singapore's health system faces ongoing challenges with respect to fragmented governance, structural gaps between primary and hospital care, and inadequate financing mechanisms that impede system performance.

1.1.4 Comparative Analysis of Health Systems

Most of the healthcare systems in the world operate under some of the same basic processes and principles such as affordability and accessibility (Burns, 2017). Indeed, the health systems in developed countries face some common challenges or mega trends, including shifting demographics (i.e., ageing population), prevalent chronic diseases, growing healthcare costs, and so forth (Bréchat et al., 2017; Health Bureau, 2022). Nevertheless, it has been observed that the performance of national health systems exhibits significant variation across numerous dimensions, which cannot be fully attributed to factors such as a country's demographic profile or disease burden alone (Savedoff et al., 2023). For example, national health spendings depend on the medical care needs, the ability to afford care, the health financing mechanisms, the efficiency of health sectors, and others (Cinchon et al., 1999). As such, we would like to compare Singapore with several other developed countries, including Norway, Italy, and the United States of America (USA), in terms of their respective health systems. Table 1 presents the comparative insights into the similarities and differences of these healthcare systems.

Table 1. Comparison of health systems among developed countries.

Dimension	Singapore	Norway	Italy	USA
Healthcare model	Mixed public-private system with mandatory saving accounts and government subsidies.	Universal healthcare funded by taxes, with services mainly provided by public hospitals and clinics.	Publicly funded by National Health Service (Servizio Sanitario Nazionale) that provides	Mixed system with private and public providers; lacks universal coverage, with significant reliance on

			universal coverage.	private insurance.
Funding mechanism	Combination of individual savings (i.e., Medisave), government subsidies (e.g., CHAS), and mandatory health insurance (i.e., MediShield Life).	Funded through general taxation; once reaching the annual spending cap, medical care would be free for the rest of period.	Funded through taxation; health services are generally free at the point of use.	Funded through a mix of private insurance premiums, out-of-pocket payments, and government programs like Medicare and Medicaid.
Access to care	High access with short waiting time; disadvantaged groups may suffer from financial hardship.	Universal access with minimal financial barriers; some challenges with waiting time for specialized care.	Universal access; regional disparities can affect the quality and availability of health services.	Access varies; high-quality care available, but significant portions of the population remain uninsured or underinsured.
Quality of care	High-quality care with advanced medical technology; ranked among top globally.	High-quality care with strong health outcomes; ranked among top globally.	Generally good quality; however, infrastructure varies, and some facilities may be outdated.	Mixed quality; world-class facilities exist, but overall health outcomes lag behind other developed nations.
Cost	Efficient system	High public	Moderate	Highest per capita

efficiency	with controlled costs; government regulates prices and services.	expenditure on healthcare; services are free, but high taxation supports the system.	expenditure; cost efficiency varies by region, with some inefficiencies present.	healthcare expenditure globally; significant administrative costs and price variations.
Health outcomes	Excellent health indicators, including high life expectancy and low infant mortality.	Strong health outcomes with high life expectancy and low infant mortality.	Good health outcomes; high life expectancy, though some regional health disparities exist.	Health outcomes are variable; lower life expectancy and higher infant mortality compared to other developed countries.
Strengths	High-quality care with advanced technology; efficient cost management; high access with short waiting time; emphasis on personal responsibility.	Universal coverage with minimal financial barriers; high-quality care and strong health outcomes; services are free at the point of use.	Universal coverage with generally good quality of care; services are free at the point of use; high life expectancy.	Advanced medical technology and world-class facilities; high-quality care available for those insured; significant medical research and innovation.
Weaknesses	Heavy reliance on individual	High taxation to fund the system;	Regional disparities in	Lack of universal coverage leaves

	savings can burden low-income individuals; out-of-pocket expenses can be significant; limited coverage for certain services.	long waiting time for specialized care.	quality and access; some outdated infrastructure.	many uninsured; high costs and administrative inefficiencies; health outcomes lag behind other developed nations.

Note: The provided information in the table is compiled from various online sources and synthesized by ChatGPT (OpenAI, 2025), supplemented by the author's fact check and minor adjustments.

The comparative analysis of health systems in Singapore, Norway, Italy, and the USA highlights striking differences in financing mechanisms, care access, service efficiency, and health outcomes. Singapore employs a mixed public-private model that combines mandatory savings, government subsidies, and private insurance, achieving high efficiency and accessibility while exhibiting a significant reliance on individual out-of-pocket payment. European nations like Norway and Italy both provide the tax-funded universal health coverage that guarantees "free" access and strong health outcomes. However, Norway faces high taxation and occasionally long waiting time, while Italy struggles with regional disparities and infrastructure deficiencies. On the contrary, the USA heavily relies on employer-based and private insurance, supplemented by Medicare and Medicaid for certain groups of people. Despite housing world-class care facilities and medical innovation, American healthcare is, unfortunately, known for the highest per capita healthcare costs globally, substantial administrative inefficiencies, and inferior population health outcomes, compared to the other developed nations (Woolf & Aron, 2013). According to the latest data from World Bank (see Figure 5), Singapore achieves excellence in relatively lower health expenditures as a percentage of Gross Domestic Product (GDP) and higher average life expectancy at birth than many other developed countries (Ministry of Health, 2022b). Briefly, the comparison sheds light on the disparities in health organizing and financing practices across nations, highlighting the practical trade-offs between access, quality, and cost.

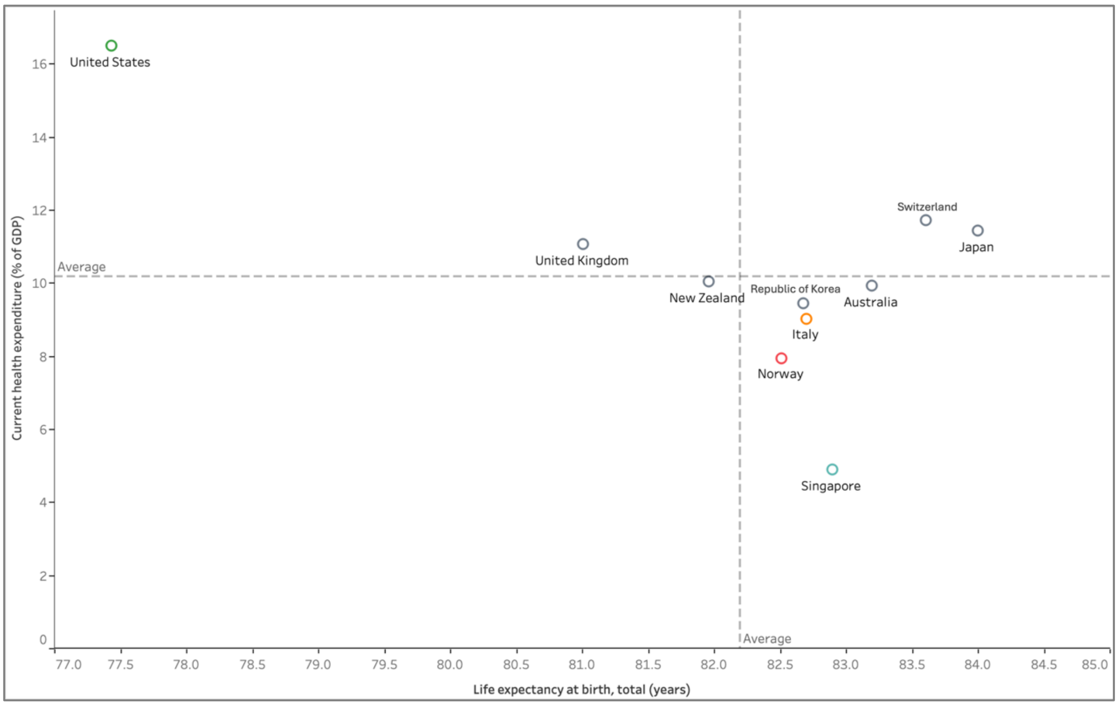

Figure 5. Healthcare system efficiency: life expectancy at birth vs. current health expenditure (2022).

1.2 Rationale for the Study

The rationale for this study arises from the pressing need to reconfigure Singapore's health organizing and financing models in light of significant demographic and epidemiological transitions (Ministry of Health, 2022b). With the rapidly ageing population and concomitant prevalence of chronic and non-communicable diseases, the local health system must adapt to the change in order to better meet the needs of residents (Thomson et al., 2009). In response to the long-lasting challenges within Singapore's health system (Tan et al., 2021), the HSG initiative was formally launched in 2023 (Ministry of Health, 2022b). One of the critical enablers under HSG is payment reform, namely the transition from FFS to CAP funding mechanism, which seeks to incentivize integrated and preventive care delivery (Cheong, 2024). However, the introduction of new payment model in complex health systems is frequently accompanied by systematic challenges (Kutzin et al., 2017), including Singapore

(Ramesh & Qian, 2025).

1.2.1 Ageing Population and HSG

Like many other developed regions (Das et al., 2021; Health Bureau, 2022), Singapore is stepping into a rapidly ageing society (Ministry of Health, 2023b; National Healthcare Group, 2021; Ozdemir et al., 2023). By 2030, the population aged 65 or above is projected to increase from 10% in 2010 to nearly 25% of the total population in Singapore (Ministry of Health, 2024). This demographic shift has profound implications for medical and social care needs (Lean, 2025; Ministry of Health, 2022b; Ruth, 2023), especially in terms of the management of chronic illnesses such as Hypertension or High Cholesterol (Adam et al., 2011; Guo et al., 2025; Health Bureau, 2022). To give an example, the data released by OECD (2025) indicate that hospital admissions attributed to diabetes mellitus in 2021 are 411.4 per 100,000 inhabitants who are aged 15 years or over in Singapore, substantially higher than in countries like Norway (70.4 per 100,000) or Italy (31.0 per 100,000).

Recognizing these challenges, the HSG initiative has been implemented to transform the health system from a reactive and treatment-oriented mode to one that emphasizes preventive care and social prescribing (Ministry of Health, 2022b). Central to this strategy is the strengthening of primary care, the integration of health and social services, and the empowerment of individuals to be responsible for their own health. Being a voluntary enrollment program, HSG allows residents who are over 40 years old to choose whether to participate in and which family doctor to enroll with (Ministry of Health, 2022b, Chapter 1). Once enrolling into HSG, residents commit to seeing their family doctor regularly and adopting a health plan to enhance their health status and quality of life. The overarching goal of HSG is to reduce avoidable hospitalizations and waste, improve population health outcomes, build good doctor-patient relationships, and balance the work-life of healthcare clinicians (Cheong, 2024; Ruth, 2023). That is the so-called "*Quadruple Aim*", shown in Figure 6.

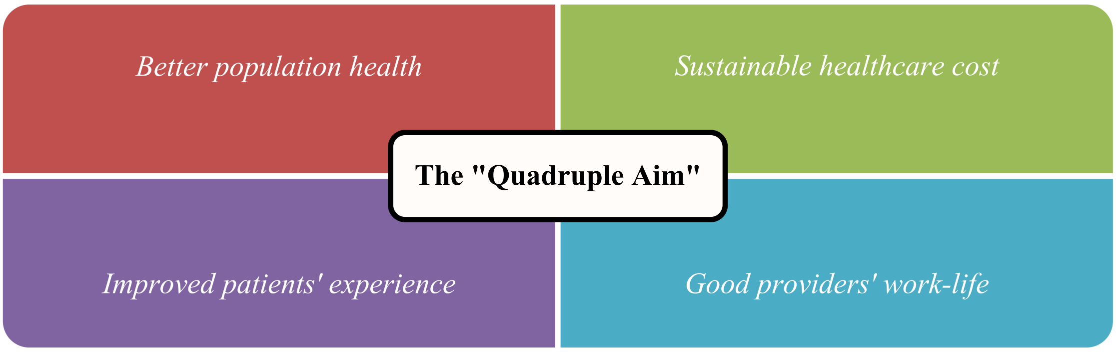

Figure 6. The "Quadruple Aim" of HSG.

1.2.2 CAP Payment Reform

Recently, there has been a transformation of funding method in Singapore. Prior to 2023, FFS is the most prevalent reimbursement form for providers in Singapore's healthcare system. Problematic due to its inherent incentives for increasing service volume irrespective of quality or cost, the FFS payment model additionally constrains providers from providing preventive and promotive services without an associated billing code (Counts et al., 2018; Matulis, 2019). By contrast, CAP payment offers a promising alternative by allocating a predetermined budget per enrolled resident, thereby encouraging providers to prioritize disease prevention, care coordination, and long-term health maintenance (Ministry of Health, 2022b). To this end, Singapore has moved away from the volume-based payment to a capitation-based system since the mid of 2023 (Ministry of Health, 2023a), signifying a fundamental shift in how health services are funded and delivered (Ministry of Health, 2022b).

The capitated payment comprises two main parts. On one hand, healthcare clusters are allocated a predetermined budget for each geographical resident assigned to them every year (Ministry of Health, 2023a). Each cluster is paid funding rates based on the age bands of their residents, and there are approximately 1.5 million residents per cluster. The CAP funding rates are structured to ensure that clusters will receive correspondingly higher budgets as residents get older. On the other hand, family doctors in private practices (i.e., GPs) are entitled to annual service fee payments for HSG enrollees each year (Ministry of Health, 2022b, Chapter 3). The fee is paid based on the health risk profile of each enrolled resident, the scope of required care, and the progress made in terms of preventive care or chronic disease management. Be aware that the CAP payment to GPs does not apply to non-HSG enrollees or any other health services that are not covered in the contract. Under these circumstances, PCPs are still reimbursed via the traditional FFS method. In other words, Singapore's capitation-based system primarily reimburses health services offered by public hospitals, while providing limited coverage for primary care delivered at private medical clinics.

In summary, CAP is not merely considered a funding mechanism but a strategic tool that can be utilized to transform clinical practices and organizational culture. From the perspective of policymakers, the desired goal of CAP payment reform is not only to control health spending but also to encourage providers to deliver more preventive care and enhance chronic disease management for the elderly residents at communities (Ministry of Health, 2022b, 2023a). Following the CAP payment reform under HSG, the challenge lies not only in its technical implementation but also in ensuring that the new funding model supports integrated, preventive, and community-based care in Singapore.

1.2.3 Health Financing and System Governance

Complex system theory suggests that "*interventions in one area could have unintended harmful effects in another*" (Kickbusch & Gleicher, 2012, p. 77). Singapore's transition from FFS to CAP payment model indicates not only new opportunities to promote disease prevention (Ministry of Health, 2022b) and eliminate all levels of waste (Ministry of Health, 2023b), but new challenges to engage public and private stakeholders, enforce complementary legislation (Muhlestein et al., 2025), manage financial risks (Wieck, 2021), and ensure transparency and accountability throughout the local health system (NHS Scotland, 2022).

Despite the well-intended policy goals of HSG (Ministry of Health, 2022b), the implementation of CAP payment method is expected to face both financing and governance challenges in practice. Drawing on international payment reform practices and lessons (National Healthcare Group, 2021, pp. 12-13), financial risks and cherry-picking issues are common within a capitation-based system (Wieck, 2021). In Singapore's context, it implies that the new CAP payment model could bring about disproportionate financial risks to providers and cause great concerns over underservice among residents (Ministry of Health, 2023a). Consequently, it is imperative to employ systems thinking to assess the potential impact of CAP payment reform on providers' financial incentives, service delivery, and population health outcomes. The enhanced understanding is essential for evaluating the viability of the broader HSG initiative in Singapore.

1.3 Research Questions and Dynamic Hypotheses

This section outlines the central research questions and dynamic hypotheses that need to be answered or tested within the present study. The formulation of research questions is grounded in the identified challenges confronting the local healthcare system. A set of dynamic hypotheses are developed to inform the model structure conceptualization. In combination, these elements constitute the conceptual and analytical foundation for the modelling and case study presented in subsequent chapters.

1.3.1 Identification of Research Questions

Building upon the established rationale, the following key research questions are identified and positioned within the broader context of the HSG initiative:

- How do different payment models (e.g., FFS vs. CAP) influence the allocation of healthcare resources and service delivery in the local health system?
- What are the feedback mechanisms and unintended consequences that emerge from the transition to CAP payment under HSG?
- Who are the key actors or entities in Singapore's healthcare system and what roles do they play in health system governance?
- How can health system governance be structured to support the successful implementation of CAP payment reform and to maximize the viability of HSG initiative?

These questions are crafted to inform both theoretical inquiry and practical policy design, with relevance to systems thinking, health financing, and health system governance.

1.3.2 Development of Dynamic Hypotheses

To answer the research questions, this study develops a set of hypotheses that drive plausible causal relationships and dynamic behaviors in Singapore’s health system. For example:

- H1: CAP payment increases the incentive for providers to invest in preventive care and chronic disease management, leading to a reduction in hospital admissions over time;
- H2: CAP funding can result in disproportionate financial risks for providers, which may lead to a negative balance because of higher operational costs than the predetermined CAP funding rates;
- H3: A limited number of residents enrolling into HSG may significantly limit the effectiveness of CAP payment reform in achieving the intended policy goals;
- H4: Inadequate alignment of governance mechanisms and performance metrics can cause the underservice issue and fragmented care that produces unintended consequences such as the unmet needs of residents and poor population health outcomes over time.

These hypotheses reflect the interconnected and dynamic nature of complex healthcare systems in the real world. They serve not only as theoretical propositions but also as structural anchors for the qualitative system mapping and quantitative simulation modelling.

1.4 Objectives of the Study

This research seeks to examine the implications of CAP payment reform within the context of Singapore’s evolving healthcare landscape, particularly under the HSG initiative. Recognizing the multifaceted nature of payment reform, where financial, behavioral, and institutional dynamics interact, the study adopts an integrated modelling approach supported by empirical data and mixed theories to investigate the complex health financing and system governance challenges. Accordingly, the research is guided by primary and secondary objectives.

1.4.1 Primary Objective

The overarching goal of this research is to investigate how payment reform, specifically the adoption of CAP payment, affects service delivery dynamics, provider behaviors and profits, and population health outcomes in the context of Singapore's ongoing healthcare transformation – the HSG initiative. Broadly speaking, it aims to analyze the health financing and health system governance challenges resulting from the payment reform under HSG. Particular attention is paid to evaluating the potential financial risks borne by public and private providers as well as the viability of current governance arrangements operating under CAP contracts. We hope that this study can offer a holistic and comprehensive understanding of how the CAP payment reform can be designed and governed for the long-term success, thereby yielding actionable recommendations for the better health financing policy and more viable governance structure design in the future.

1.4.2 Secondary Objectives

To support and enrich the primary research objective revolving around health financing and system governance, this modelling study endeavors to explicitly achieve several secondary goals:

- To engage local stakeholders and elicit structural and organizational tensions associated with Singapore's CAP payment reform by conducting a Viable System Model (VSM) exercise;
- To map complex healthcare systems and analyze the institutional and governance challenges by identifying strategic resources, performance drivers, and end results with a Dynamic Performance Governance (DPG) framework;
- To explore the alignment or misalignment between financial incentives and provider behaviors at the individual level through Generative Agent-Based Model (GABM) simulation experiments;

- To capture the fundamental system structure that characterizes patient and fund flows among the population, provider, and payer sectors with a System Dynamics (SD) simulation model.

By combining qualitative and quantitative modelling methods, the study aims to generate theory-informed, model-based, and context-relevant policy insights into the navigation of transitioning to value-based payment and accountable care in Singapore.

1.5 Significance of the Study

Given the identified research questions and objectives, this study intends to fill some research and knowledge gaps. It is anticipated that our research can contribute to both academic scholarship and practical policymaking by addressing the complex and underexplored dynamics of CAP payment reform in Singapore's health system. As a dynamic and multi-year transformation strategy, there will be twists, turns, and uncertainties along the way toward HSG (Ministry of Health, 2022a). By focusing on health financing and governance challenges, this study is poised to provide useful insights into how payment reform affects system-wide performance in the long run.

1.5.1 Research and Knowledge Gaps

While numerous studies have examined the theoretical advantages or disadvantages of FFS, CAP, and other payment models (Cinchon et al., 1999; Lindner & Lorenzoni, 2023; Matchar et al., 2023), few have explored their implementation within the specific institutional and policy context of Singapore (Foo et al., 2025). Moreover, existing literature tends to analyze such reforms in a fragmented or narrative manner (Ramesh & Qian, 2025; Tan et al., 2025), without fully accounting for the system-wide effects and long-term behaviors that can emerge in complex adaptive systems. There is a significant gap in the application of system modelling approach to gain a holistic view of CAP payment reform (Hirsch & Miller, 1974; Hirsch & Kemeny, 1994). In particular, there is a lack of attention given to the impact of health system governance on payment reform (Comendeiro-Maaløe et al., 2019). This study seeks to fill the gap by combining qualitative and quantitative modelling methods to examine payment reform as a dynamic transition process embedded within Singapore's evolving health system.

For this purpose, our research breaks new ground by integrating VSM, DPG, GABM, and SD models to investigate the complex health financing and governance challenges, which is, to the best of our knowledge, seldom mentioned in health financing or health governance research. Theoretically, it advances the current literature on payment reform and health system governance by offering a dynamic and holistic perspective that captures the complexity of health system transformation. Practically, it offers model-based insights for Singapore and other health systems facing common challenges in managing chronic diseases, ageing population, care coordination and fiscal sustainability. Ultimately, this research seeks to inform not only what policies or payment models need to be adopted, but how the health system ought to be governed.

1.5.2 Justification of Research Focus

The decision to focus on payment reform and its system-wide impacts is justified by the complex health financing and governance challenges confronting Singapore's healthcare system, as detailed in Section 4.1. Under HSG, the transition from FFS to CAP stands out as a key policy lever with the potential to transform the landscape of care delivery and drive broader systemic changes. However, its success depends on multiple interdependent factors, including incentive alignment, risk adjustment, provider capacity, performance monitoring, and others. Consequently, it is necessary to adopt a system modelling and service planning approach to address the complex health issues more effectively (Hirsch & Rice, 2020). By integrating systems thinking and dynamic perspectives, it is believed that the present research would shed light on the structural tensions between desired policy goals and current governance arrangements as well as unfold the unintended consequences of Singapore's CAP payment reform within complex health systems.

1.6 Structure of the Thesis

This thesis is structured into seven chapters, as depicted in Figure 7. Following this introductory chapter concerning research background, research questions, and research objectives, the remainder of thesis is organized as follows. Chapter 2 critically reviews relevant literature on various payment models and governance theories. Chapter 3 describes the mixed-method research design, combining qualitative and quantitative modelling approaches with the case study methodology. The development of VSM, DPG, GABM, and SD models are detailed in Chapter 4 and 5, respectively. In Chapter 6, we conduct policy simulation experiments and propose an integrated governance framework for the HSG initiative. Finally, the theoretical and practical implications of our research for health financing and system governance are discussed in Chapter 7. To summarize, the thesis has been designed to systematically address the research problems and objectives, review fundamental theories, build analytical frameworks and simulation models, conduct policy experiments, and discuss implications or limitations. Supporting materials and supplementary analysis are further provided in Appendix.

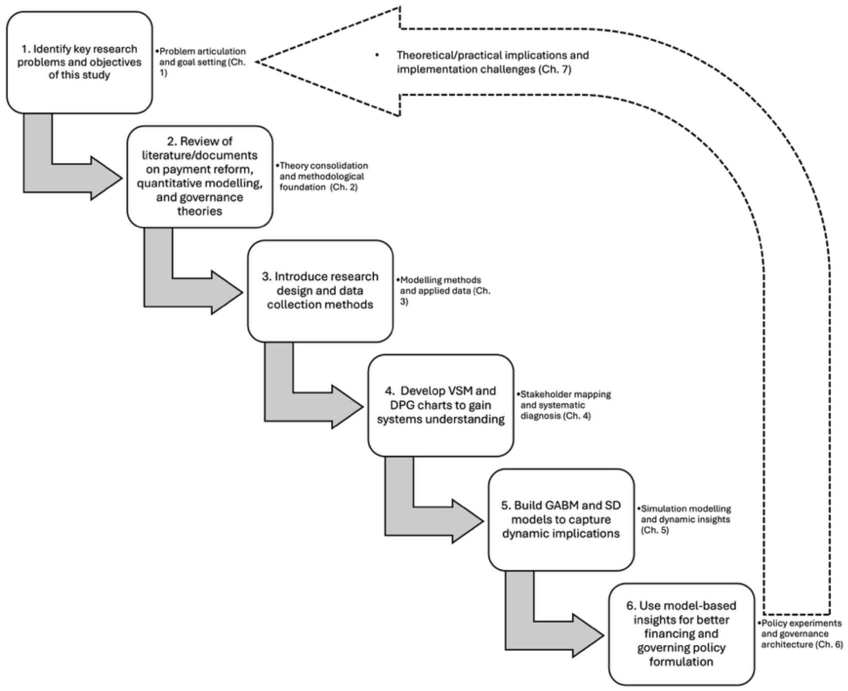

Figure 7. An overview of thesis structure.

2 Literature Review

This chapter critically reviews relevant literature on various healthcare payment models like FFS, CAP, bundled payments, or episodes of care payment. The comparative analysis suggests that all single payment models generate both positive and negative incentives or outcomes (Kutzin et al., 2017), so blended or mixed payments, as suggested by OECD (2016), often offer a more balanced strategy for improving population health outcomes, containing healthcare costs, and promoting equity and quality of care. Specifically, we examine the real-world CAP payment implementation with successful or unsuccessful results. Comparative insights derived from global experiences can offer valuable guidance and lessons for achieving a successful payment reform in Singapore. In addition, this chapter surveys the quantitative methodologies and their application in the field of health financing. To gain insights into health system governance, relevant theories are reviewed too. These theoretical frameworks provide the basis for the interpretation of misaligned incentives or conflicting goals, poor resource management, and stakeholder resistance.

2.1 Overview of Healthcare Payment Models

Healthcare payment models play an essential role in shaping the behaviors of providers, the experiences of patients, and the overall performance of health systems. These models determine how healthcare providers are reimbursed for delivering services, thereby influencing the allocation of resources, their financial incentives, and ultimately the quality, efficiency, and sustainability of health systems (Kutzin et al., 2017). Understanding the structure and implication of various payment mechanisms is important for evaluating the ongoing reforms in health financing (Cinchon et al., 1999), especially in contexts where escalating healthcare costs driven by demographic transitions and rising chronic diseases demand more efficient and equitable payment systems (Ministry of Health, 2022b; Ramesh & Qian, 2025).

Over the last decades, global health systems have experimented with a wide range of payment models (Cinchon et al., 1999; Lindner & Lorenzoni, 2023), each embodying different philosophies of performance accountability, risk pooling, and service prioritization (Werner et al., 2021). Among these, FFS and CAP stand out as being the principal funding methods in many health systems. Besides, alternative reimbursement methods like diagnosis-related groups (DRGs) and bundled payments have emerged to address some of the shortcomings (e.g., the disproportionate financial risk) of traditional payment models and to promote greater coordination and integration of medical care. Nowadays, more innovative value-based payment methods are being explored in health policy circles (Conrad, 2015; Lindner & Lorenzoni, 2023; Miller, 2009; Smithey & Patel, 2024; Werner et al., 2021).

This section provides an overview of the main healthcare payment models, and is organized into four subsections. The first subsection introduces the FFS model, which remains the dominant approach in many health systems, including historically in Singapore. The second one examines the CAP model, which has been increasingly promoted as a means of containing healthcare costs and improving preventive care. The third subsection discusses other payment methods briefly, such as DRG-based payments and bundled payments, which combine some elements of FFS and CAP payment methods to incentivize service efficiency and care integration. Finally, it concludes with a comparative analysis of these models, highlighting their respective strengths, limitations, and suitability for different health systems and policy priorities. By presenting the foundational concepts and trade-offs associated with each model, this section lays the groundwork for a deeper exploration of Singapore's CAP payment reform under HSG. It aims to inform policymakers of the institutional and policy considerations that underpin the choice of healthcare payment models, and how these choices could fundamentally shape provider behavior, treatment costs, and patient outcomes.

2.1.1 FFS Payment

The FFS payment model is one of the most traditional and widely used healthcare reimbursement methods globally. Under FFS, healthcare providers are reimbursed for each individual service rendered, such as consultations, diagnostic tests, medical procedures, and medicine prescriptions. Payments are typically based on pre-determined fee schedules that list the prices for specific services or interventions (Lindner & Lorenzoni, 2023). The fundamental premise of FFS is that providers are compensated based on the volume of care delivered, without regard for patient outcomes or cost-effectiveness of practices (Das et al., 2021; Floyd, 2014).

The FFS payment has certain advantages, particularly in terms of access and simplicity. Since providers are paid directly for the work they performed, there are strong financial incentives for them to offer a broad range of services for patients with complex health conditions, seldom leading to the undersupply of services (Cinchon et al., 1999). To a large degree, FFS payment encourages timely responsiveness to patient needs and expands access to care. Moreover, it is relatively straightforward for providers to accept because their revenue increases in proportion to the volume of services provided.

Meanwhile, the FFS model has been broadly criticized for creating misaligned incentives that cause inefficiencies (i.e., resource waste) and escalating healthcare costs (Hennig-Schmidt et al., 2011). Since providers' revenue is determined by the quantity rather than the quality of care, FFS usually encourages the oversupply of services, unnecessary medical tests, and fragmentation of care (Cinchon et al., 1999; Floyd, 2014; James & Poulsen, 2016; Williams, 2017). As such, the FFS system generally requires supplementary mechanisms, such as total expenditure ceilings or quantity restrictions (Cinchon et al., 1999). Worse still, it may disincentivize disease prevention or the management of chronic conditions, which often require associated billing codes or long-term engagement without immediate procedural reimbursement (Counts et al., 2018; Ministry of Health, 2022b). In other words, the volume-driven approach usually results in suboptimal resource allocation (Bishai et al., 2014) and fail to promote coordination among different levels of care (Matulis, 2019).

In many health systems including Singapore, the dominant payment mechanism for healthcare services, known as legacy FFS, has been gradually phased out. While it has supported rapid growth in service capacity and care access, great concerns over fiscal sustainability have prompted policymakers to explore alternative models that can better align provider incentives with population health management goals. In particular, the recent shift toward value-based payment and accountable care has fueled interest in CAP and other payment models, which seek to address the inherent limitations of FFS.

2.1.2 CAP Payment

The CAP model represents a fundamental departure from the volume-based and cost-plus reimbursement method. In a capitation-based system, healthcare providers receive a fixed payment per enrolled individual over a specified period of time, regardless of the number or type of services actually provided (Cinchon et al., 1999; National Healthcare Group, 2021). In practice, there exists a spectrum of CAP contracts with different risk sharing and adjustment mechanisms (Wieck, 2021) by accounting for patient heterogeneities such as age, sex, or comorbidities. This ensures that providers who serve more complex patients are compensated sufficiently (James & Poulsen, 2016). To a certain extent, CAP creates the financial incentive for providers to manage healthcare resources more efficiently and to focus on preventive care, chronic disease management, and population health outcomes (Wieck, 2021). Since the revenue is fixed in advance, providers are financially motivated to avoid unnecessary services and reduce avoidable hospital admissions or costly specialist referrals. This promotes a shift from reactive and episodic care toward more proactive, coordinated, and long-term health management (Ministry of Health, 2022b).

However, CAP also presents several shortcomings. If not carefully designed, it may create incentives for under-provision of care (Hennig-Schmidt et al., 2011), patient selection by avoiding high-risk individuals, or inadequate attention to rare but high-cost conditions (Miller, 2009). Safeguards such as quality benchmarks, performance monitoring, and supplemental payments for high-need patients are necessary to mitigate these risks (James & Poulsen, 2016). Furthermore, providers must possess sufficient service capacity and data analytics capability to succeed under a capitated system (Cheong, 2024), which can be a barrier in fragmented or under-resourced healthcare systems.

2.1.3 Other Payment Models

In addition to FFS and CAP funding models, several other healthcare payment approaches have emerged to address the limitations of traditional payment systems and to better align financial incentives with service quality and efficiency. These models like DRGs and bundled payments, are designed to promote more integrated, patient-centered, and cost-effective care. For instance, DRGs are a case-based payment method in which hospitals receive a fixed reimbursement for each patient admission (Cinchon et al., 1999). These admissions normally are classified into clinically meaningful groups based on diagnoses, procedures, age, and severity. Instead of billing for every individual service, DRGs pay the cost of an entire episode of care. Consequently, this payment system incentivizes hospitals to enhance service efficiency and minimize patient length of stay – any cost savings that fall below the predetermined payment amount are provider surplus, while costs exceeding the reimbursement amount must be absorbed by the providers themselves. While DRGs promote standardized clinical pathways and cost control, they may also lead to cost-shifting behaviors (e.g., transferring patients to outpatient settings), upcoding (misclassifying patients into higher-paying categories), or premature discharges if not accompanied by robust quality assurance mechanisms.

Bundled payments, also known as episode-based payments, represent another hybrid model in which providers are paid a single lump sum for all services related to a specific treatment episode or condition such as joint replacement or acute stroke across multiple healthcare facilities and providers (Matchar et al., 2015). Unlike DRGs, which are typically confined to inpatient care, bundled payments aim to foster coordination across the continuum of care, including pre-operative assessment, hospital admission, rehabilitation, and follow-up. By placing financial responsibility on the entire care team, bundled payments encourage providers to streamline care processes, reduce duplication or readmission, and minimize complications (Lindner & Lorenzoni, 2023). Nevertheless, they also require high levels of inter-organizational cooperation and data integration, which might be difficult to achieve in fragmented healthcare systems. Like CAP and DRGs, the success of bundled payment programs depends on thoughtful risk adjustment, dynamic performance monitoring, and clear attribution of accountability among participating providers. Given the narrow scope and temporal limitations of episode-based payments, their impact on the degree of care integration and cost savings is primarily confined to the specific context for which the bundle has been designed (Lindner & Lorenzoni, 2023). In Singapore, elements of DRG and bundled payments have been applied within public hospital financing and subsidy frameworks, particularly through the Casemix classification system (Lee & Lim, 2008; Mehmood et al., 2023). However, the broader integration of these methods into primary care and chronic disease management remains limited.

2.1.4 Comparison between Different Payment Models

Payment methods can be either retrospective or prospective (Li et al., 2022) and each payment model has its own strengths and weaknesses (Cinchon et al., 1999). Comparing different payment models highlights the inherent trade-off between cost control, care quality, administrative complexity, and health equity, which is central to policy decisions regarding health financing reform. The retrospective reimbursement method like FFS is often associated with increased service availability and responsiveness to patient needs because it directly rewards volume (Kutzin et al., 2017). Despite its advantages, FFS also improperly fosters overutilization, fragmented care, and escalating expenses. Without robust mechanisms for monitoring both quantity and quality, it may inadvertently prioritize short-term intensive treatment interventions over long-term population health management.

In contrast, prospective reimbursement methods like CAP aligns financial incentives with population health outcomes and cost containment (Kutzin et al., 2017). By providing fixed payments per patient, it motivates providers to actively participate in health promotion, chronic disease management, and care coordination. However, this payment introduces risks of under-provision, patient selection, and thus requires robust oversight to ensure that the quality or access of care is not compromised. CAP works best in systems with viable governance arrangements and well-developed health information systems to support risk stratification and performance monitoring.

DRGs and bundled payments are hybrid models that retain some activity-based logic but within defined care episodes. DRGs incentivize hospitals to manage admissions efficiently, but may create pressures to discharge patients prematurely or game the classification system. Bundled payments encourage provider collaboration across different phases of care and venues, but they don't directly encourage preventive care to keep population healthy (James & Poulsen, 2016; Wieck, 2021). Both models hinge on accurate coding, effective care pathways, and appropriate risk adjustment.

A comparative framework often places FFS on the "payment for volume" end of the spectrum, while CAP lies on the "payment for value" end, with DRGs and bundled payments occupying transitional positions, as shown in Figure 8. It is concluded that different payment models signify the varying levels of financial risk assumed by the provider or payer (Williams, 2017) and no single model is universally superior to others (Kutzin et al., 2017). Each embodies trade-offs between quality, access, and cost – the "Iron Triangle" of healthcare. Their appropriateness relies on context-specific factors, such as resource endowment, institutional capacity, provider preference, data infrastructure, population needs, and political feasibility (Cinchon et al., 1999). Remember the old adage: "*You only get what you pay for*" (Samuelson & Nordhaus, 2010).

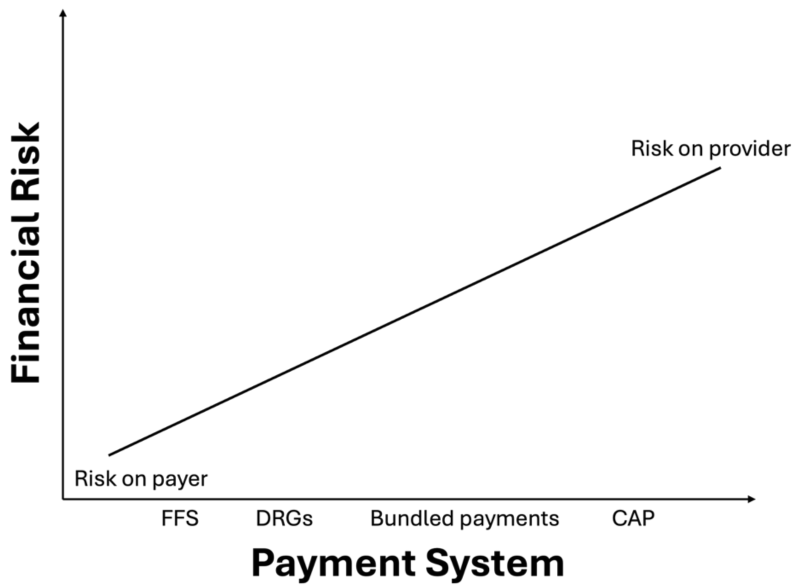

Figure 8. A spectrum of healthcare payment models.

In practice, many health systems including Singapore, employ mixed payment models, combining elements of FFS, CAP, and performance-based schemes to balance flexibility with accountability (Li et al., 2022). For instance, GPs may receive a base CAP rate for each enrolled patient, supplemented by performance bonuses for achieving preventive care targets, while hospitals continue to operate under DRG-based subsidies. This blended approach seeks to harness the benefits of each model while mitigating their individual shortcomings. Table 2 summarizes the key features, strengths, and limitations of four main healthcare payment models discussed so far, offering an intuitive comparison across critical design dimensions such as incentive alignment, risk allocation, and infrastructure requirements.

Table 2. Comparison of major healthcare payment models.

Dimension	**FFS**	**DRGs**	**Bundled Payments**	**CAP**
Payment basis	Per individual service provided.	Per hospital episode, based on diagnosis group.	Per episode of care across settings (e.g., surgery + rehabilitation).	Per patient, per period (e.g., month or year).
Incentive structure	Encourages volume of services.	Encourages shorter, more efficient hospital stays.	Encourages care coordination and efficiency across providers.	Encourages cost-efficiency and disease prevention.
Risk allocation	Low provider risk; payers bear the most financial risk.	Moderate provider risk; tied to admission efficiency.	Shared risk across multiple providers for total episode cost.	High provider risk; providers assume cost of care within the fixed payment.
Focus of care	Acute, episodic interventions.	Inpatient care.	Integrated, time-bound episodes of care.	Preventive care and chronic disease

				management.
Potential advantages	Transparent; scalable; incentivizes service provision.	Improves hospital efficiency; standardizes payments.	Aligns incentives across settings; encourages care integration.	Promotes prevention; controls costs; supports population health management.
Key drawbacks	Overutilization; fragmented care; rising costs.	Risk of upcoding; premature discharge; limited to inpatient care.	High administrative complexity; difficult to implement in fragmented systems.	Risk of under-provision; needs strong monitoring and data integration systems.
Data & infrastructure needs	Low to moderate.	Moderate (diagnostic coding, episode grouping).	High (coordination tools, shared data).	High (risk adjustment, performance monitoring).
Suitability	Systems prioritizing access or volume-driven services.	Systems focusing on hospital cost control.	Systems aiming to integrate services across providers or settings.	Systems with strong primary care and value-based orientation.

Note: The provided information in the table is compiled from various online sources and synthesized by ChatGPT (OpenAI, 2025), supplemented by the author's fact check and minor adjustments.

2.2 CAP Payment: Global Experiences

CAP payment has been trialed in many health systems worldwide. According to a survey in 2016, the adoption of CAP payment method in primary care is prevalent across the Organisation for Economic Co-operation and Development (OECD) countries, encompassing 22 out of 32 countries (Lindner & Lorenzoni, 2023). This section reviews the empirical evidence of CAP payment model implementation within global contexts. Then, it draws out key lessons from the successes, limitations, and mixed results to guide the strategic design and realistic implementation of a capitated payment system in Singapore.

2.2.1 CAP Practices in Various Contexts

CAP payment, being either a national policy or a pilot program, has been introduced to both developing and developed settings. The review of global practices shows mixed results across regions or nations. A few illustrative examples are given below:

- Ghana

In the Ashanti region, CAP was introduced to control outpatient costs under the National Health Insurance Scheme in 2012, but was confronted with policy resistance for the perceived poor quality of care (Andoh-Adjei et al., 2018). A cross-sectional survey indicates the great concerns among subscribers and providers over reduced service availability and medicine access. Bayong and Watson (2024) also reported that while total outpatient costs fell by 38% and utilization decreased by 48%, membership rates declined by about 39% in comparison with control regions. Additionally, inpatient costs rose, most likely as providers shifted services into domains outside the CAP contract's scope. However, one longitudinal study showed mixed results. It was found that outpatient visits dropped by approximately 35% between 2016 and 2019, with no negative impact on inpatient outcomes such as length of stay or mortality rates, suggesting that reductions occurred primarily in low-value or unnecessary utilization (Dzampe & Takahashi, 2023).

- China

In Pudong New Area of Shanghai, a CAP reform pilot started from August 2012 under the New Rural Cooperative Medical Scheme. A longitudinal study between 2011 and 2015 showed strong evidence of sustained cost containment, while it achieved limited success in reducing the care burden at secondary or tertiary hospitals (Wang et al., 2017). This finding underscores the need for stronger alignment of CAP funding with primary care gatekeeping and a two-way referral mechanism (Health Bureau, 2022).

Besides, Zhang et al. (2024) found that the CAP payment reform in county medical community affected physicians' hypertension treatment behaviors, yielding reductions in drug infusion use for both outpatient and inpatient cases in rural China. Yet, broader upward trends in medical cost per visit and in drug prescriptions persisted over time, indicating incomplete cost control of medical care. A recent statistical analysis of global CAP prospective payment implemented in multiple pilot cities indicated that there were differentiated behavioral responses and diverse performance across regions depending on the local health system governance (Cui et al., 2025). It was concluded that CAP payment reform can enhance service efficiency and cost containment, but the accurate calculation of funding rates and the supplemental supervision and management mechanisms are of the essence.

- United Kingdom

National Health Service (NHS) has historically utilized population-based CAP payments for primary care services in the United Kingdom (UK). Over the years, there have been modifications to the original allocation formula that determines practice funding (Rhys et al., 2010). Despite the primary objective of funding formula revisions being to guarantee equity, there are in fact variations for identical practices in different regions. Insufficient risk adjustment has become a major barrier to health equity in the provision of primary care in England (Fisher & Lewis, 2023), leading to a call for the use of a person-based workload formula that takes individual needs and morbidity into consideration (Anselmi et al., 2025).

- Spain

The Alzira model, from the region of Valencia, pooled capitation-based financing across primary, acute, and specialist care, with shared IT systems across all services (Zanon, 2014). It was reported that there was higher patient satisfaction, lower emergency admission and readmission rates, and improved service efficiency and care integration compared with standard public systems (NHS European Office, 2011). Unfortunately, the Alzira model was terminated in 2018 and reverted to direct public management by Valencia's Health Authority, owing to financial concerns, governance failures, and politics (Comendeiro-Maaløe et al., 2019).

- the USA

Under the Medicare Advantage (MA) Plan C framework, Centers for Medicare and Medicaid Services (CMS) allocated a monthly capitated amount to private healthcare plans for each enrollee (National Healthcare Group, 2021, p. 13). Multiple factors have been accounted for risk adjustment, such as age, gender, number of CMS-Hierarchical Condition Categories, dual eligibility for Medicaid, disability status, and the number of prescription drug counts (if drugs were covered). One retrospective cohort analysis showed that the MA risk pooling and adjustment system appears to be achieving its intended objective by aligning CAP funding rates with individual beneficiaries' healthcare burden and the aggregate population served (Cohen et al., 2022).

2.2.2 Implications for Local Implementation

By drawing upon global practices, several guiding principles emerge for the adoption of CAP funding method in Singapore. For example:

- Primary care gatekeeping and dual referral mechanisms

CAP is expected to be effective only when primary care plays a key role of gatekeeping. The pilot programs in rural China illustrate that without the effective gatekeeping and two-way referral mechanism, cost savings may be undermined by the continued misuse of secondary and tertiary care in hospitals. With regard to Singapore, it is essential to build an enhanced primary care system (Matchar et al., 2025) and closed referral system (Health Bureau, 2022) under HSG so as to provide the right care to the right person at the right place.

- Strong risk adjustment and quality safeguards

Despite the long-standing efforts to adjust CAP funding rates for age, morbidity, and socioeconomic indicators in the UK, the system has historically failed to achieve funding equity and has instead augmented health disparities (Fisher & Lewis, 2023). In addition, the perceived poor quality of care has caused policy resistance to the CAP payment reform in Ghana. Collectively, they inform Singapore of useful lessons on the adequate risk adjustment of funding formula (National Healthcare Group, 2021, p. 14) and strong quality monitoring as demonstrated in the case of MA (Wieck, 2021).

- Shared data and viable governance

Integrated care, as seen in the Alzira model, relies primarily on shared health data of patients across different settings. In Singapore, the capacity for integrated care delivery has been fostered by National Electronic Health Records (NEHR) across public and private providers under HSG. However, the termination of the Alzira model in Valencia later demonstrates that the technical IT solution is necessary but not sufficient for the success of CAP payment reform. Additionally, the effective financial risk management and health system governance are important to ensure the long-term sustainability of a capitation-based system (Comendeiro-Maaløe et al., 2019).

Generally speaking, global experiences reveal that CAP payment can deliver cost containment, support integrated service delivery, and improve patient care experience, especially when anchored in strong primary care and supported by robust data and governance. Yet, capitated practices often failed financially in the past (Wieck, 2021). Risks of under-service, cost-shifting, and provider resistance are real and common, so it requires proactive risk mitigation and periodic review or adjustment of the CAP payment model (Kutzin et al., 2017). The HSG initiative offers a promising foundation with GP registration, multidisciplinary provider networks, shared electronic health records, and dynamic performance tracking. Complementing these with calibrated risk adjustment, accountable care organizations (ACOs), and viable governance arrangements will be crucial to a successful transition from FFS to CAP in the long run.

2.3 Quantitative Modelling in Health Financing

As a modelling study, it is significant to acquire a fundamental comprehension of the intricacies involved in health financing. Therefore, this section provides a brief revisit of the published health financing models that have been developed using various quantitative modelling methodologies, such as SD simulation model, agent-based model (ABM), spreadsheet projections, and other statistical approaches. The reviewed models (see Figure 9) are arranged in chronological order.

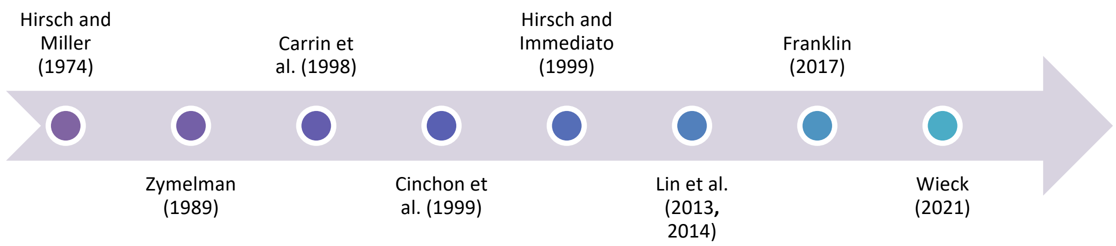

Figure 9. A timeline of reviewed health financing models.

2.3.1 SD Simulation

- Hirsch and Miller (1974)

In 1970s, Hirsch and Miller (1974) developed a computer simulation model supported by SD methodology to evaluate the feasibility of transitioning from a Comprehensive Child Care Program into an Health Maintenance Organization (HMO). The model proved to be instrumental in analyzing the long-term consequences of policies and decisions that influence the HMO. To be more exact, the SD simulation model allowed decision-makers to experiment with a range of policy changes like different marketing effort allocations, comprehensive benefit packages, and fitness programs without risking real-world failures.

- Zymelman (1989)

The World Bank published a computer model to help decision-makers or administrators of healthcare systems better deal with macro-level health finance problems like budget priority setting and operational optimization (Zymelman, 1989). In detail, the model made health services a function of budget and unit costs that were influenced by the service delivery system and allowed simulation of budget changes and their impact on the operation of a national health system. While Zymelman (1989) attempted to provide a technical tool to model the complex health finance system endogenously, but the model was generally abstract and simple without accounting for the different payment models in national health systems and their impacts on physicians' motive and provision behavior.

- Hirsch and Immediato (1999)

The article by Hirsch and Immediato (1999) examined the role of microworlds and generic system structures as tools for healthcare organizations in the USA undergoing three major transformations, notably the shift from FFS to CAP, the move toward integrated delivery systems, and the expansion of healthcare's scope to include prevention and promotion. Using these tools, the authors demonstrated how the SD simulation model allowed decision-makers and healthcare staff to experiment with different policy strategies, understand feedback dynamics, and anticipate unintended consequences. System archetypes such as "Limits to Success", "Shifting the Burden", "Balancing Two Boats", and "Accidental Adversaries" (Senge, 1990) were applied to illustrate recurring structural challenges, including financial sustainability under CAP (Hirsch & Kemeny, 1994), tensions in integrated delivery systems, and trade-offs between immediate treatment gains and long-term investments in prevention (Bishai et al., 2014). The study highlighted that microworlds promoted strategic thinking, stakeholder engagement, and interactive learning beyond conventional training, thereby helping organizations navigate complexity and uncertainty in health system reform.

2.3.2 ABM Simulation

- Lin et al. (2013, 2014)

In Taiwan, a specified ABM was built to explore the potential outcomes of CAP payment scheme of Zhishan Community Healthcare Group (CHG) (Lin et al., 2013). The study modeled the complex interactions between multiple agents like the Bureau of National Health Insurance (BNHI), the CHG, a healthcare life social enterprise, and enrolled patients (Lin et al., 2014). The simulation, which ran for three years, found that as more patients enrolled in the CAP program, medical costs per person were reduced. As a policy test, the model with the health promotion agent was found to be more effective at cost containment than the one without. Moreover, the financial risk for the CHG could be mitigated by excluding inpatient medical costs from the CAP funding rates assigned by the BNHI. Overall, the simulation results suggested a positive financial outcome resulting from the CAP payment reform, further informing the BNHI and local legislators to revise the previous health financing policy so as to improve the sustainability of Taiwan's healthcare system (Lin et al., 2013, 2014).

2.3.3 *Spreadsheet Projections*

- Carrin et al. (1998)

At the end of 20th century, the WHO published a simulation model, known as "SimFin", to examine financial needs and government budget options for the functioning of health systems (Carrin et al., 1998). It accounted for the financial repercussions of various choices regarding health services, such as inpatient care, outpatient clinic, administration of facilities, ambulance service, catering service, and so on. The SimFin model is structured into two modules: MacroFin, which examines national budgetary possibilities and resource constraints, and MicroFin, which focuses on the financial needs of specific health sectors. Nevertheless, the model exhibits a notable limitation in that it fails to take changes in the demand side into consideration, such as the escalation of healthcare expenses attributable to ageing population (Cinchon et al., 1999, ch. 7.3). As a result, the projections made in the SimFin model are heavily driven by exogenous or policy variables, such as GDP growth by sector, tax rates, growth in government expenditures or income, and so forth.

- Cinchon et al. (1999)

Being a compendium of quantitative techniques like spreadsheet projections for health financing, Cinchon et al. (1999) provided a comprehensive introduction of the context, development, and use of modelling in health finance, including the classic SimFin model. To a great extent, the book written by Cinchon et al. (1999) contributes to knowledge synergies and bridges the gap between quantitative health economics, health financing, and actuarial science. Though it did not focus on the payment reform from FFS to CAP, the rich information provided in the book has guided us to develop SD simulation models based on the fundamental modelling principles and the best modelling practice.

2.3.4 *Statistical Modelling*

- Franklin (2017)

To investigate the financial risk absorbed by providers under different payment models, Franklin (2017) created a simulation model to test the theoretical contribution of preventive care and variation in patient needs. It was argued that most alternatives to FFS (e.g., CAP) attempt to encourage prevention but often expose care providers to significant financial risk due to uncertainty in treatment outcomes and patient morbidity. To address the persistent challenge of financing preventive care, the author proposed the risk mitigation treatment (RMT), a form of preventive intervention aimed at reducing avoidable medical needs and patient harm. The simulation results suggested that directly compensating providers for RMT alongside the traditional FFS payment minimized financial risk more effectively than indirect mechanisms through shared savings or full CAP. It underscored the complexity of sustaining preventive care within the context of health financing reforms.

- Wieck (2021)

The dissertation examined financial rewards and risks associated with different Medicare CAP contracts for primary care practices using Poisson regression and Monte Carlo simulations (Wieck, 2021). Supplemented by empirical data, the study informed the better CAP payment model design with extra risk sharing and adjustment mechanisms. A key finding was that MA beneficiaries under CAP contracts had significantly fewer visits in various healthcare settings compared to traditional Medicare beneficiaries. The study indicated that appropriate CAP contract provisions, such as stop-loss protections against extreme patient costs, were important for primary care practices to be prevented from financial failures.

To sum up, there are multiple quantitative approaches in terms of modelling in health financing. The epistemic foundation of each modelling method is somewhat different from each other and has its own strengths or weaknesses. In comparison with spreadsheet projections, feedback-rich simulation models like SD are more capable of capturing the widespread interactions and non-linearity within complex health systems (Hirsch & Immediato, 1999). By contrast, ABM is more flexible in accounting for the heterogeneity of agents, whereas Monte Carlo simulation is beneficial in exploring uncertainties. The final choice of quantitative modelling method normally depends on the research problem and objective of interest.

2.4 Fundamentals of Health System Governance

Governance in healthcare system encompasses the institutions, rules, and processes that guide decision-making, information-sharing, and service delivery across multiple levels and diverse stakeholders. This section reviews the definition of health system governance and a wide range of theoretical perspectives, including principal-agent theory, common-pool resource theory, North's institutional theory, and feedback theory.

2.4.1 Definition of Health System Governance

Governance plays a fundamental role in shaping the structure, functions, and decision-making processes that guide the organizations, nations, and societies. Although the term "governance" is ubiquitous, it has not yet reached an established and precise definition (Fukuyama, 2016; Rhodes, 1996). Governance, in its broadest sense, refers to all processes of governing that determine how societies are steered and how power and resources are distributed (Chhotray & Stoker, 2009; Kickbusch & Gleicher, 2012, ch. 2), whether undertaken by a government or an organization through the creation and enforcement of formal and informal rules, laws, and norms at different levels (Bevir, 2012, ch. 1; 2013).

In relation to health, the WHO's framework defines governance in terms of "stewardship" or "leadership", and refers it to arrangements for "*ensuring strategic policy frameworks exist and are combined with effective oversight, coalition building, the provision of appropriate regulations and incentives, attention to system-design, and accountability*" (World Health Organization, 2007, p. 3). Operationally, health system governance encompasses both "hard" approaches, such as formal laws or rules, and "soft" approaches, which are supported by norms, negotiation, and networks that shape provider behavior and service delivery (Smith et al., 2012). In theory, health system governance is underpinned by extensive conceptual frameworks.

2.4.2 *Applied Theories in Health System Governance*

- Principal-agent theory

Principal-agent theory deals with contracting and other economic relationships between principal(s) and agent(s). The agency problem arises when a governing body (the principal) delegates authority to other individuals or groups (the agents) whose incentives may diverge from his or her expectations. In particular, the healthcare system is featured with the multiplicity and complexity of principal-agent relationships (Casalino, 2001). On one hand, it is observed that the agency problem widely exists between payers, providers, and patients (Arrow, 1963; Ministry of Health, 2023b). To illustrate, insurance companies as the payer may deny claims for procedures that can be beneficial for patients so as to control healthcare spendings. Hospitals, reimbursed by FFS, may order excessive medical tests, treatment procedures, and unnecessary surgeries to generate additional revenues and profits, which contradicts the interests of payers and patients. While patients are expected to keep themselves healthy, there is limited incentive for them to do so when medical care expenditures are heavily subsidized by the government or private insurers.

On the other hand, the principal-agent problem could also exist within an organization internally (Alonge et al., 2017; Conrad, 2015). For instance, there might be conflicting goals and interests between the organization (the principal) like healthcare clusters in Singapore and individual healthcare institutions (the agents) like public hospitals or private clinics. Furthermore, individual physicians serve as the agents of hospitals or clinics, and their provision behaviors and incentives have a significant impact on not only their financial gains but also patient benefits (Hennig-Schmidt et al., 2011; Wieck, 2021). In short, the principal-agent relationships are widespread in healthcare systems, so clarifying the principal-agent roles can inform good governance arrangements like monitoring, auditing, alignment, and reporting, which are essential to mitigate the potential issues concerning payment reform and care integration.

- Common-pool resource theory

The common-pool resource theory underlines how collective management or self-governance of shared resources can be successful when some principles are established, such as clearly defined boundaries, participatory rule-making, monitoring, graduated sanctions, conflict resolution mechanisms, and others (Ostrom, 1990, 2005a). According to the theory, common-pool resources have two basic characteristics:

- Non-excludability: it is difficult to prevent others from accessing or using it;
- Subtractability: one person's use reduces the availability for others.

Classic examples are forests, fisheries, grazing lands, and groundwater basins. In health systems, the public funding for services program can be considered as the common-pool resource to some degree. To illustrate, the curative care might crowd out disease prevention and health promotion efforts because of imbalanced resource allocation and strong political lobby from curative health workers (Bishai et al., 2014).

In front of scarce financial resources, it has become a long-lasting challenge for health decision-makers to adopt collective resource utilization strategies in order to ensure the needs of residents are maximally met (Sanderson et al., 2020). The CAP payment reform may exacerbate this problem (Matchar et al., 2023), leading to the "tragedy of the commons" (Hardin, 1968). In effect, the under-investment in community prevention programs (Bishai et al., 2014) or the over-consumption of healthcare budget due to competition among regional hospitals in a zero-sum game (Cheng, 2003) can be detrimental to the financial sustainability of CAP reimbursement method. Hence, an effective governance framework must be put in place to foster shared decision-making, resource stewardship, and mutual trust among stakeholders (Matchar et al., 2023; Sanderson et al., 2020). The CAP reform is thus a governance experiment in managing health financing as a common-pool resource, requiring collective rules, dynamic monitoring, and nested structures to reduce resource waste and unmet needs.

- North's institutional theory

Institutions, as defined by North (1990), are the rules of the game in a society. The formal and informal rules that structure economic and social interaction can shape individual incentives or behaviors and ultimately determine organizational performance (Faundez, 2016). In health system governance, institutional analysis emphasizes how political context, policy networks, provider organizations, social norms, and organizational culture interact to shape performance outcomes (Siddiqi et al., 2009). As such, North's institutional theory has proven instrumental in mapping out key stakeholders and the power distribution among them in complex health systems (Baez-Camargo & Jacobs, 2011). With regard to Singapore's health system, the RHS-centered institutional structure determines the rules of health financing, service delivery, professional regulation, and performance accountability. Good understanding of the relationships between the MOH, healthcare clusters, medical clinics, and other agencies are fundamental to a viable health system governance design under HSG.

- Feedback theory

Being part of systems theory, feedback or cybernetics theory centers on the interactions between elements and how systems mobilize strategic resources to steer toward desired goals and achieve self-regulation (Smith et al., 2012). In management science, the feedback theory provides an endogenous and holistic view of problematic behaviors (Sterman, 2000). Therefore, it has become the underlying theory of the VSM, DPG, and SD modelling methods. Inspired by the feedback theory, we would like to systematically map the complex interactions between the payer, providers, and population within Singapore's health system. The structural mapping will facilitate a quantitative analysis of the long-term dynamics of significance.

Table 3 summarizes the specific theories or frameworks applied to assess health system governance in this study. Each theory investigates health system governance from a unique view. For example, principal-agent theory addresses the incentive misalignment between the payer, provider, and population as well as the weak accountability problem. Common-pool resource theory draws attention to irrational allocation of limited financial resources between preventive and curative care. North's institutional theory implies how organizational design can shape healthcare provider's behaviors and policy outcomes. Finally, feedback theory underlines the interrelationships between different parts of health systems. In combination, these mixed theories serve as the theoretical foundation of analytical methodologies employed in this study, thereby enriching our comprehension of complex governance challenges within health systems.

Table 3. Applied theories in health system governance.

Theory	Key Insights for Governance
Principal-agent theory	Incentive alignment; performance monitoring; agent accountability
Common-pool resource theory	Polycentric governance; shared stewardship of strategic resources
North's institutional theory	Formal/informal rules shape behaviors and outcomes
Feedback theory	Feedback control; circular relationships; self-governance

3 Research Methodology

Given the multifaceted nature of CAP payment reform in relation to financial sustainability and governance viability, this chapter delves into the methodological choices that are grounded in various modelling approaches. Concretely, the chapter is structured into three main sections:

- Section 3.1 outlines the mixed qualitative and quantitative approaches adopted to explore the complex governance challenges and the potential financial risks regarding the CAP payment reform under HSG;
- Section 3.2 introduces four modelling methods, namely VSM, DPG, GABM, and SD, which are used to analyze governance structures, dynamic performance, individual incentives, and system outcomes;
- Section 3.3 explains the sources of qualitative and quantitative data drawn primarily from official reports, statistical databases, and scholarly literature.

By combining qualitative conceptual frameworks with quantitative simulation models, it ensures both interpretive depth and empirical rigor, and in effect facilitates a comprehensive assessment of the systemic implications of Singapore's CAP payment reform.

3.1 Research Design

This study adopts mixed qualitative and quantitative modelling, as well as case study approaches against the backdrop of CAP payment reform under the HSG initiative in Singapore. Figure 10 depicts the general design of the research that aims to systematically capture the complex governance challenges and financial risk dynamics inherent in CAP funding method.

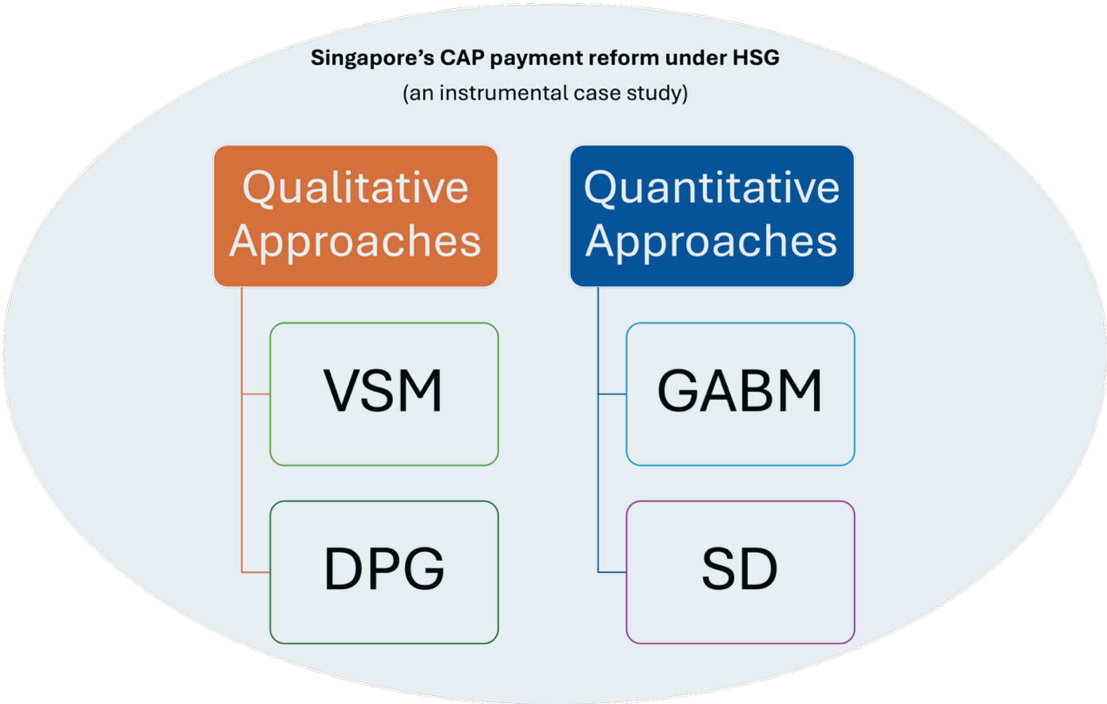

Figure 10. An illustration of research design.

3.1.1 Qualitative Approaches

In essence, governance is an abstract concept to investigate and evaluate. For this reason, qualitative modelling methods are helpful in mapping the actors in complex heath systems and their relationships. Specifically, this study applies the VSM and DPG frameworks to analyze how the current governance arrangements and decision-making processes confront challenges during the CAP payment reform under HSG. Using these qualitative frameworks, our study addresses key questions like:

- How do governance structures ensure system-wide care integration and service coordination among diverse healthcare actors?
- What mechanisms enable dynamic performance management in response to the changing demographics, care needs, and resource constraints?

By adopting VSM and DPG approaches, the study intends to provide a structural and functional diagnosis of national health system governance capability and performance, thereby offering useful insights into an integrated governance framework design that sustains the new CAP funding mechanism and promotes the HSG initiative in Singapore.

3.1.2 *Quantitative Approaches*

To complement and enrich qualitative insights, the study further resorts to simulation modelling as the quantitative analysis tool. At the micro level, GABM simulation experiments are used to assess the financial incentives and provision behaviors of individual physicians under different payment mechanisms. In contrast, SD model is constructed to evaluate the potential financial risks and population-level outcomes of Singapore's CAP payment reform. By examining both micromotives and macrobehavior, quantitative models offer a platform for assessing:

- The misaligned incentives associated with different payment methods;
- The unintended consequences of CAP payment reform, such as under-provision of care;
- The dynamic interactions between population ageing, service delivery, and health expenditures;
- The long-term impacts of CAP funding mechanism on public and private providers' financial performance.

Briefly, GABM and SD support dynamic simulation experiments and scenario-based policy testing. They enable decision-makers to anticipate practical trade-offs associated with the CAP payment reform and to design mitigation strategies for the long-term financial sustainability and care integration under HSG.

3.1.3 *Case Study Methodology*

In addition to qualitative and quantitative modelling approaches, this research employs an instrumental case study (Crowe et al., 2011) by using Singapore's CAP payment reform as a tool to gain a broader appreciation of health financing and system governance challenges along with the transformation of national healthcare systems. The HSG initiative provides a unique setting for investigating how a national health system navigates potential financial risks and complex governance challenges during the payment reform. Ideally, the case study approach enables:

- Contextualized analysis of governance viability using the VSM and DPG system mapping frameworks;

- Dynamic simulation of physicians' provision behaviors and system performance with GABM and SD models;
- Generalized illustration of practical governance challenges and policy implications that extend beyond Singapore to other comparable health systems.

In short, the case study methodology contributes to both context-specific policy insights and more generalizable lessons for dealing with the complex financial risks and governance challenges resulting from the CAP payment reform.

3.2 Analytical Frameworks

Following the research design introduced above, there are four analytical frameworks or modelling methods used in this study. More concretely, VSM and DPG mainly undertake the qualitative analysis like health system stakeholder mapping and governance structure investigation. By drawing upon the outputs of VSM exercise, the DPG framework further locates strategic resources, performance drivers, and end results of significance, as well as establishes the causal relations between key model variables. By comparison, GABM and SD are fit for quantitative analysis. While SD captures the macro-level health system structure and dynamics, GABM simulates individual physicians' provision behaviors under different payment conditions. In combination, these models serve as the fundamental means to conduct in-depth analysis of governance viability and financial sustainability from a system level.

3.2.1 VSM

The VSM, developed by Beer (1984, 1995), is a conceptual model for the management of complex adaptive systems. Inspired by the concept of biological "autopoiesis", it employs the cybernetics theory and systems thinking framework to analyze the adaptability and resilience of organizations in a changing environment. Figure 11 illustrates the five interrelated subsystems (from System 1 to 5), which are considered to be important for the adaptability and sustainability of organizations through the lens of VSM (Hoverstadt, 2010).

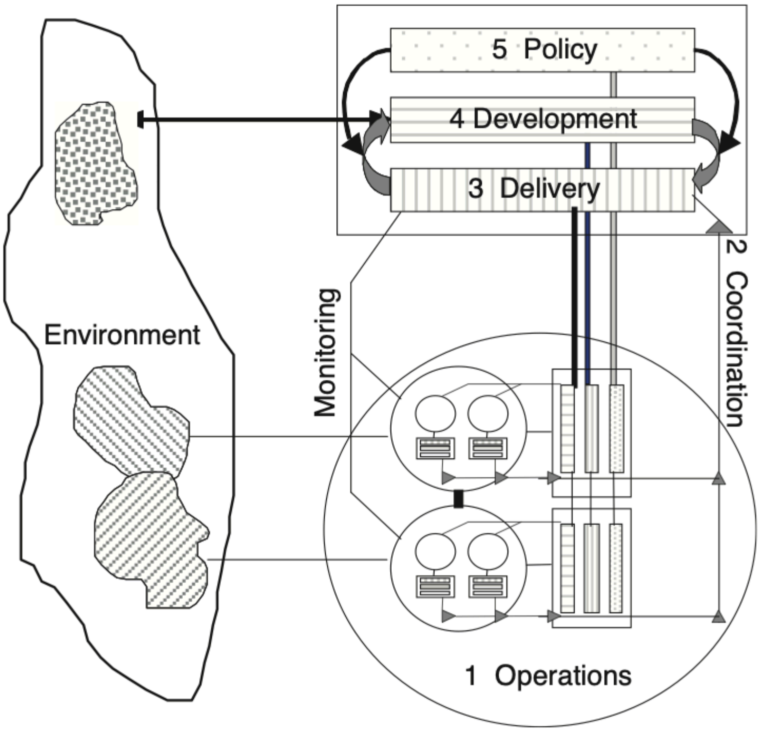

Figure 11. A simple illustration of VSM. Source: Fig. 3.1 presented on Hoverstadt (2010, p. 89).

As we see, VSM disaggregates complex systems into interrelated subsystems that are responsible for operations, coordination, delivery, development, and policy, respectively. To be more specific:

- Operations: System 1 refers to day-to-day activities or units that perform primary functions and provide value to the external environment;
- Coordination: System 2 is about the protocols and mechanisms that ensure operational units work smoothly within the system;
- Delivery: System 3 focuses on management activities that help allocate a variety of resources to routine operations based on the organizational needs;
- Development: System 4 monitors the external environment to anticipate changes in the future and inform the long-term strategies;
- Policy: System 5 is related to governance, and it defines the purpose, vision, and ultimate decisions coming from the top level of the system.

In general, VSM maps the whole picture of complex systems in an organized way, and helps identify bottlenecks and potential challenges faced by an organization. The practical application of VSM to governance-related issues mainly covers structural diagnosis, system integration, and resilience building. For example, the VSM suggests overseeing the communication between operational layers and strategic governance boards to make sure that key information feedback can pass through the organization timely and accurately.

With regard to healthcare, VSM has been adopted to conduct an early evaluation of the design of healthcare reforms in New Zealand to determine whether the new reforms would deliver a viable and sustainable health system going forward (Akmal et al., 2023). As a result, it is suggested that all the five subsystems of a national health system need to be strong and effective in practice. In the present study, VSM is applied to examine whether Singapore's governance arrangements under HSG exhibit structural features conducive to sustained viability in a capitation-based system. It is anticipated that VSM will provide a systemic lens for diagnosing the organizational viability and governance integrity of Singapore's healthcare system.

3.2.2 DPG

DPG is a conceptual framework that adopts the feedback theory to frame dynamic complexity in interinstitutional contexts (Bianchi, 2021; Bianchi et al., 2019). It focuses on collaborative governance and sustainable outcomes by maintaining alignment between strategic goals, operational performance, and governance structures within an organization or system (Ansell & Gash, 2008; Bianchi et al., 2021). From an "outside-in" perspective, DPG primarily seeks to foster a community ethos characterized by active citizens and collaborative networks of public and private organizations (Bianchi, 2022). The DPG chart (see Figure 12) includes three parts, which are:

- Strategic Resources: These are foundational inputs or assets, including both tangible and intangible resources (Bianchi, 2016), that organizations rely on in order to achieve their objectives (i.e., end results). Strategic resources form the backbone of systems and affect the measurement and effectiveness of performance drivers;
- Performance Drivers: They are auxiliary variables that convert strategic resources into measurable activities or outputs. Simply put, performance drivers

play a role of key performance indicators (KPIs) that indicate the performance gaps and contribute to end results;

- End Results: They encompass both intermediate outputs and final outcomes. Monitoring end results enables organizations to ascertain their progress toward achieving both short-term and long-term targets.

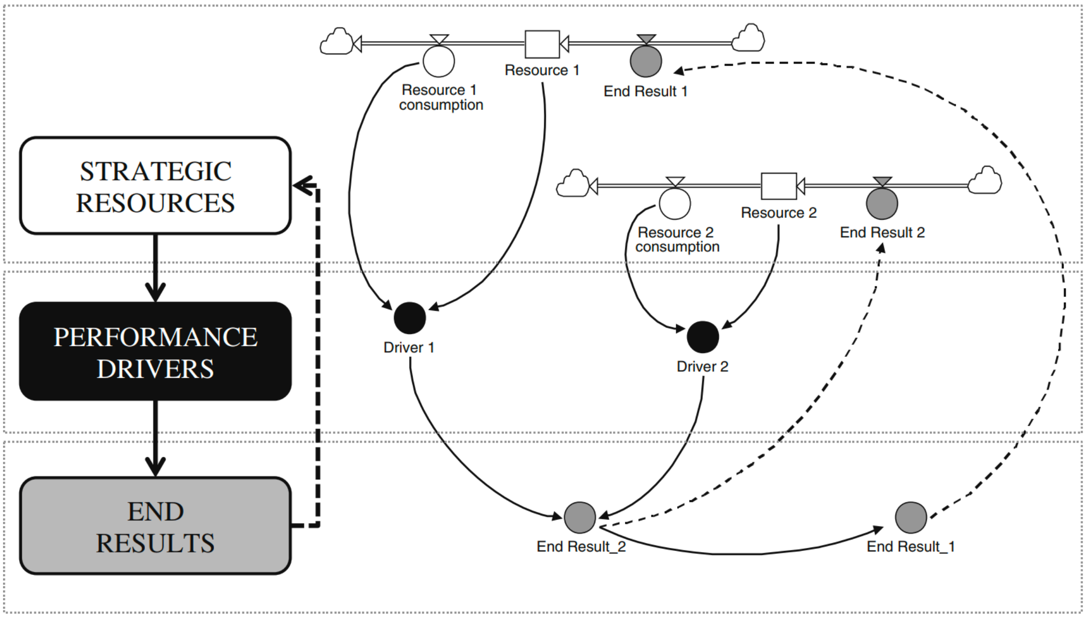

Figure 12. Basic structure of a DPG chart. Source: adopted from Bianchi (2016, p. 73).

Briefly, DPG focuses on the interrelationships between strategic resources, performance drivers, and end results, as implied by the connected arrows in Figure 12. Toward the governance of "wicked" problems in reality (Bianchi, 2016, ch. 2.4.1; 2021; Bianchi et al., 2019; Bianchi et al., 2021), the DPG method encourages the close collaboration among diverse stakeholders and facilitates a shared understanding of systematic behaviors. By putting emphasis on the co-evolution of governance decisions and performance outcomes through dynamic feedback, it is suitable for governing the public-private partnerships in a collaborative and cooperative way.

3.2.3 GABM

ABM has been traditionally used to model the heterogeneity of individuals and the emergent macroscopic phenomena (Epstein, 1999; Railsback & Grimm, 2011). Instead of setting explicit decision rules by modelers in ABMs, GABM has recently emerged as a new modelling paradigm in social science that utilizes large language models (LLMs) to build autonomous agents who can mimic human decision-making in the real world (Ghaffarzadegan et al., 2024; Lu et al., 2024; Wang et al., 2024). Along with the advancement and diffusion of generative artificial intelligence (AI) technologies, using LLMs for experimental testing and simulation modelling has become increasingly popular over the years (Gao et al., 2024; Hutson, 2023).

As illustrated in Figure 13, LLM-driven agents can make autonomous decisions based on the pre-defined attributes of each agent and the implicit rules injected in prompts (Li & Wu, 2025). When coupling with a mechanistic model, their decisions will change the current state of the system and generate new dynamics (Ghaffarzadegan et al., 2024). As the information about the state of system updates, these autonomous agents will accordingly make new decisions next time step. Such simulation process will iterate until reaching the maximum runs or any other pre-defined conditions. Considering the broad application of controlled laboratory experiments in health economics (Brosig-Koch et al., 2024; Hennig-Schmidt et al., 2011; Li et al., 2022), It is salient to observe to how the micromotives or financial incentives would affect physicians' provision behaviors under different payment models with the innovative and emerging GABM.

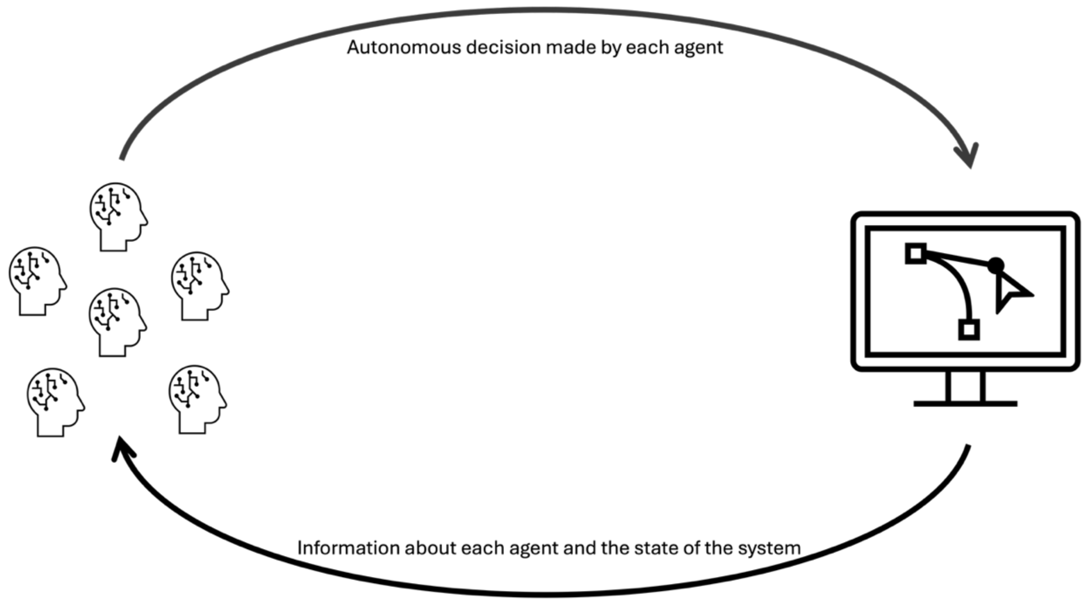

Figure 13. The conceptual diagram of GABM. Source: adapted from Ghaffarzadegan et al. (2024).

Over GABM simulation experiments, physicians played by LLM-driven agents, make service provision decisions based on perceived financial rewards, patient needs, and patient benefits. It is believed that the investigation of care delivery micromotives can provide useful insights into emergent behavioral patterns, such as overservice or underservice, and cherry-picking, that are difficult to evidence using aggregate system models.

3.2.4 SD

SD is a computer-aided approach for strategy and policy design (System Dynamics Society, 2024). Since its origin, SD has extensively been used to model and analyze the dynamic behaviors arising from complex systems (Forrester, 1961; Sterman, 2000). Building upon the feedback theory, SD takes an endogenous view of how the underlying structure determines dynamic behaviors. Broadly speaking, SD can be adopted for both qualitative and quantitative analyses. In terms of qualitative analysis, Causal Loop Diagram (CLD) (Sterman, 2000, ch. 5), shown in Figure 14A, portrays the causal relationships between system variables. Moreover, CLD can be translated into Stock and Flow Diagram (SFD) (Sterman, 2000, ch. 6), as exemplified in Figure 14B. SFD stands for formal simulation models that are supported by differential equations in continuous systems. In contrast with ABM, SD normally attaches greater importance to aggregate behaviors at the macro level.

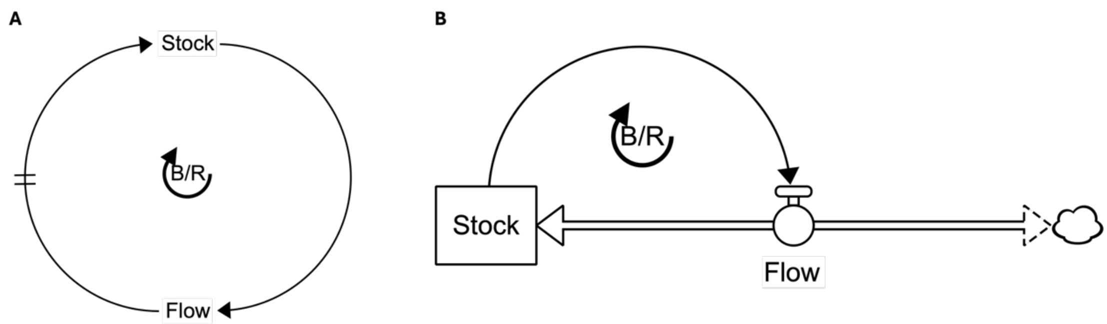

Figure 14. The schematic diagram of SD models. Plot A is a sample of CLD. Plot B is a sample of SFD.

Figure 14 demonstrates some key elements of SD model, including:

- Stock: A rectangle is used to represent the accumulated variable (e.g., number of patients);

- Flow: The arrowed line with a valve indicates the rate of change which can be further classified as inflow (e.g., patients entering) or outflow (e.g., patients leaving). Inflow adds to the stock, while outflow depletes the level of stock;
- Feedback Loops: The circular loop captures the interaction between stock and flow. Like flow, we can distinguish between a balancing feedback loop (represented as the letter "B") and a reinforcing feedback loop (represented as the letter "R"). As the name implies, the balancing feedback loop, also called the negative feedback loop, seeks to maintain stability or equilibrium in a system by counteracting change. It represents processes that resist deviations and push the system back toward a goal (i.e., producing the "goal-seeking" behavior). On the contrary, the reinforcing or positive feedback loop amplifies changes and results in exponential growth or decline with a "lock-in" effect. Reinforcing feedback loops can generate either virtuous or vicious cycles;
- Delays: The short double line in Figure 14A reflects the time lag between stock and flow since it takes time for the stock to accumulate or absorb the change in flows. Delays are quite common in complex systems and may cause a variety of dynamic behaviors like oscillation, overshoot, and undershoot (Sterman, 2000, ch. 11).

As a systems thinking and dynamic modelling tool, SD has been applied to various research problems throughout the decades, from supply chain management (Angerhofer & Angelides, 2000; Lee et al., 1997), to health-related issues (Hirsch & Homer, 2017; Homer & Hirsch, 2006; Matchar et al., 2016; Matchar et al., 2023; Milstein et al., 2010), natural resources management (Moxnes, 1998, 2004), and many more (Sterman, 2000). SD permits decision-makers to explore the long-term and macroscopic effects of strategic policy changes in complex health systems (Leerapan et al., 2021). For example, Lim et al. (2022) used SD simulation modelling to investigate the evolution of opioid crisis in the USA for national public health policy development.

3.3 Data Collection Method

It is recognized that the in-depth knowledge and understanding of the availability, quality, and meaning of both qualitative and quantitative data should be the prerequisite for any modelling exercise (Cinchon et al., 1999, p. 92). As such, this modelling study relies on multiple data sources and is subject to data limitations. Qualitative data support research problem identification and model structure development. Quantitative data are mainly used for SD model parameter setting and calibration. Proper attribution and compliance with citation standards are maintained throughout the study. Given that no direct human subject involved in simulation experiments, it minimizes ethical concerns to a large degree.

3.3.1 Data Sources

- Qualitative data sources

Qualitative data are taken from policy documents, official reports, the VSM exercise[4], and scholarly literature relevant to CAP payment reform and health system governance. Key sources include the reports or news published on Singapore's MOH official website, HSG White Paper, and academic studies on health financing and system governance in Singapore or other international settings. These sources provide contextual details for applying VSM and DPG frameworks to stakeholder mapping, governance analysis, and model conceptualization.

- Quantitative data sources

Quantitative data come from two main sources. On one hand, GABM simulation experiments offer the first-hand data of physicians' provision behaviors under different payment conditions. On the other hand, secondary data are sourced from official statistical repositories such as Singapore Department of Statistics (SingStat [5]), Singapore's open data portal[6], and World Bank[7]. The provided data encompass time

[4] The documentation of VSM exercise was privately shared by Fractal Consulting.

[5] https://www.singstat.gov.sg.

[6] https://data.gov.sg.

[7] https://data.worldbank.org.

series data on healthcare expenditures, population health indicators, service utilization rates, demographic trends, and so forth. These data serve as inputs for parameterizing and calibrating the SD simulation model.

3.3.2 Data Limitations

Data selection is guided by principles of reliability, validity, and plausibility, so most second-hand data are taken from official sources. We also acknowledge the limitation that some key data like CAP funding rates and the more granular data on historical financial performance of small medical clinics and public healthcare clusters, are not publicly available (Ministry of Health, 2022a). Consequently, there are a wide range of uncertainties and simplifying model assumptions because the data situation is never perfect (Cinchon et al., 1999). The data limitations draw attention to the cautious interpretation of simulation results and additional sensitivity analysis.

In conclusion, this chapter has outlined the research methodology adopted to investigate the health system governance and financing implications of transitioning from FFS to CAP under HSG. By integrating qualitative and quantitative modelling approaches with an instrumental case study (see Table 4), it lays the foundation for systems thinking on Singapore's CAP payment reform under HSG.

Table 4. Summary of applied research approaches.

Case Study: CAP Payment Reform under HSG		
Approach	**Model**	**Application**
Qualitative	VSM	Stakeholder analysis that identifies the problems within five subsystems.
	DPG	System diagnosis that frames the underlying interactions between strategic resources, performance drivers, and end results.
Quantitative	GABM	Physicians' provision behavior simulation that investigates the care delivery pattern under different payment methods.
	SD	Population-level dynamics that explores the long-term impacts on health outcomes, service delivery, and health spendings.

4 System Mapping

As a modelling study, this chapter concentrates on the application of qualitative frameworks like VSM and DPG to diagnose the local health system structure and potential governance challenges connected with the CAP payment reform under HSG. System mapping and problem identification provide valuable insights that are expected to inform the design of an integrated health system governance framework for accountable care delivery in Section 6.2.

4.1 Challenges under CAP

Before delving into specific challenges within a capitation-based system, let us revisit the anecdote we shared at the beginning of Section 1.1:

> *"When the new HSG enrollment program started, Madam Tan signed up with a medical clinic in Ang Mo Kio. At first, the care felt different. When she reported early stiffness in her knee, the nurse quickly scheduled her for same-day assessment, and the doctor encouraged her to come back regularly for continuous health monitoring. But as months passed, the waiting room became increasingly crowded. Doctors hurried through consultations, seeing patient after patient with barely a pause. Madam Tan noticed that her neighbor, Mr. Goh, who had diabetes and kidney problems, was often left waiting longer or referred elsewhere because his care was complicated. The clinic seemed to prefer patients whose conditions could be managed quickly within the short consultations."* ***– Part II, Development.***

Singapore's HSG initiative exemplifies both potentials and challenges of CAP funding method. On one hand, by assigning residents to family doctors under a capitated payment system, the government has signaled a national health policy shift toward prevention and continuity of care (Ministry of Health, 2022b). On the other hand, the new CAP payment model may cause unintended consequences, such as financial risks for public and private providers, public concerns over underservice, or even system-level governance failures.

4.1.1 Financial Risks and Service Concerns

The transition from FFS to CAP payment model is not merely a shift in the reimbursement mechanism. Instead, it signifies a fundamental transformation in how health services are funded and delivered. Key considerations include:

- Financial risks to healthcare clusters

Under HSG, each cluster now receives the capitated payment from the MOH annually to look after the health of residents in their respective regions (Ministry of Health, 2022b, 2023a). By comparison, they have not capitated the budgets downward for health services provided by individual healthcare institutions, including public hospitals, polyclinics, and community hospitals, to date (Ministry of Health, 2022a). In other words, healthcare clusters need to bear the potential financial risk if total healthcare costs claimed by all the public institutions under their charge exceed the predetermined CAP budget from the MOH every year. The uncoordinated payment across different levels of Singapore's health system requires the implementation of robust financial risk management mechanisms.

- Financial risks to medical clinics

Under CAP, a GP's income depends on the number of enrolled HSG residents and their utilization rates. Regarding high-need patients with complex conditions, small practices risk income shortfalls or negative profit even (Miller, 2009). Despite the annual service fee paid by the MOH being adjusted based on the enrollee's characteristics (Ministry of Health, 2022b), solo GP clinics could still face financial instability and uncertainty without well-designed risk pooling and adjustment mechanisms (Wieck, 2021). In fact, many GPs worried that the new annual service fee, as opposed to paying for each medical service they provide, could not be commensurate with the expanded scope of primary care work – the dual responsibility of encouraging preventive care among residents while managing chronic diseases of patients (Foo et al., 2023).

- Public concerns over underservice

Although the HSG initiative aims to incentivize healthcare providers to attach more importance to disease prevention and social prescribing, the CAP payment model has raised public fears of lower service intensity with longer waiting time or compromised service quality when seeking care (Ministry of Health, 2023a). A recent study cautions that care providers receiving capitated payments may be incentivized to curtail the provision of health services and to withhold high-value services solely due to their associated high costs (Matchar et al., 2023). Therefore, the potential harm to patients or residents within a capitation-based system merits policymakers' attention.

4.1.2 Administrative Barriers and Stakeholder Resistance

In addition to the financial risks and underservice concerns, many GPs who are supposed to assume a key role under HSG lack the necessary infrastructure and data management capability to effectively manage patient panels within a capitation-based system (Foo et al., 2023). Given that Singapore's primary care struggles with structural divides from hospital or tertiary care and remains an apparent weakness (Ramesh & Qian, 2025), particular attention ought to be paid to the following aspects:

- Unmet needs of private clinics

With respect to private clinics, there are some administrative and capacity issues for GPs to overcome in reality (Foo et al., 2023). On one hand, a detailed onboarding workflow is required to keep GPs informed of the clinical requirements and administrative processes in order to receive the new CAP payment for each enrolled HSG resident. On the other hand, clinical and management upskilling in counselling and social prescribing should be deployed as soon as possible so that GPs will get ready for the delivery of preventive care on the frontline.

- Policy resistance among stakeholders

The CAP payment reform involves multiple stakeholders like patients or residents, public or private providers, and payers. Each of them has the potential to shape the final policy outcomes. For example, it is common for Singaporeans to walk directly into specialized outpatient clinics (SOCs) and bypass primary care (Ansah, 2013), so whether the recent CAP payment reform can fundamentally change residents' care seeking behaviors remains a question. Furthermore, from a theoretical standpoint, there might be institutional inertia and enduring resistance to CAP payment among PCPs who were accustomed to the legacy FFS reimbursement method. This is understandable because private GPs can expect stable incomes and manageable workloads based on their past experiences under FFS payment model. By contrast, the new CAP funding model may bring many uncertainties and disproportionate financial risks. Considering the voluntary participation in the HSG initiative, the enrollment rate was only ~40% (712 out of 1800 medical clinics) as of April 2023 (Abdullah, 2023), indicating low participation and limited acceptance at the beginning.

4.1.3 Fragmented Care and Misaligned Accountability

There have been some long-lasting challenges to care integration and effective management of chronic conditions within Singapore's healthcare system (Tan et al., 2021; Tan & Lee, 2019), and the recent HSG initiative aims to tackle these bottleneck problems and promote better population health (Ministry of Health, 2022b). The introduction of system enablers, like digital solutions and care protocols, is considered necessary but insufficient. Notable constraints include:

- Fragmented nature of care provision

The new digital solutions under HSG are expected to enable public and private healthcare providers to seamlessly access patient health records (Foo et al., 2023) and consequently enhance care coordination and integration in practice. Despite these efforts toward digital health innovation, continuity of care remains an on-going challenge between private medical clinics and public healthcare institutions (Ramesh & Qian, 2025). There seems to be lack of a standardized referral protocol across different levels of care in Singapore. For instance, it was reported that some tertiary care doctors did not discharge patients back to their referring GPs (Surendran et al., 2022). Instead, patients are referred from community hospitals to other GPs or polyclinics. Such an inconsistent referral path can result in the frustration for GPs and inevitably the fragmentation of service delivery.

- Limited accountability for decision-making

Given the potential concern of undertreatment related to capitated funding mechanism, quality of care has been emphasized under HSG. To improve clinical accountability for performance standards (Foo et al., 2023), there has been a “Clinical Service Roadmap for Primary Care” under development, including care protocols for a few common chronic diseases. Additionally, some short-, medium-, and long-term outcome indicators or KPIs are in use to monitor the progress that has been made (Ministry of Health, 2022b). However, there are various uncertainties in the medical care market (Arrow, 1963). Simply clawing back service fees from GPs who do not meet targets will lead to either their refusal to participate in the HSG initiative or a kind of cherry-picking behavior (Ministry of Health, 2022a). Consequently, there might be a lack of service capacity and marginal policy gains. While it is important to set targets and deliver outcomes (Ministry of Health, 2022a), the involvement of public and private providers in the decision-making process for dynamic performance management and agreed accountability is likely to pose challenges to a top-down health system governance mode.

In a word, payment reform alone is insufficient for the HSG initiative (Foo et al., 2023; Foo et al., 2025). While CAP has the potential to reduce unnecessary waste and incentivize care integration, its success is highly dependent on the effective financial risk management and viable health system governance.

4.2 Systematic Diagnosis of Health Governance

System science suggests that structure determines behavior (Meadows, 2008; Sterman, 2000). Given the complex health financing and governance challenges mentioned above, systems thinking and dynamic modelling are essential to identify the fundamental structure and drivers of problematic behaviors or poor system performance. To this end, VSM provides a cybernetic lens to diagnose the organizational viability by investigating the whole system’s adaption and responsiveness to the external environment (Beer, 1984; Hoverstadt, 2010). Furthermore, DPG complements it by adopting a feedback view to frame dynamic complexity in interinstitutional contexts to achieve sustainable outcomes through consistent policy design and implementation (Bianchi, 2021; Bianchi et al., 2019). In combination, they guide us to assess not only what changes within the system, but how it is, or to be more precise, should be governed.

4.2.1 VSM for Stakeholder Mapping and Communication

VSM posits that any complex organization, including health systems, remains "viable" if its core subsystems can manage operations (Systems 1), coordinate and control strategic resources (System 2-3), adapt for the dynamic environment (System 4), and set actionable policies (System 5) in a recursive fashion (Beer, 1984, 1995; Hoverstadt, 2010). As a result, it provides a useful conceptual framework for anticipating complex governance challenges associated with Singapore's CAP payment reform and informs the design of integrated and viable governance structures for a more resilient and sustainable healthcare system in the future. For this reason, there was an online workshop co-organized by Duke-NUS Medical School and Fractal Consulting in 2022. The exercise focused on capturing the respective decisions to be taken by primary units or actors and their roles in the local health system governance (Hoverstadt & Loh, 2022). Through the lens of VSM, key insights into the governance challenges facing each subsystem are encapsulated in Table 5.

Table 5. Governance challenges mapped to VSM functions.

Subsystem	**Role**	**Challenges**
S1: Operations	Direct service provision (e.g., hospitals, polyclinics, medical clinics, nursing homes).	- Patients navigating fragmented services and unit boundaries; - Chronic disease management particularly affected; - Duplication of work (e.g., IT systems); - Misaligned incentives across providers.
S2: Coordination	Ensures operational units don't conflict; harmonizes workflows, protocols, and standards.	- Weak or inconsistent standards/protocols across public hospitals and medical clinics; - Lack of effective integration between curative care and social prescribing; - Coordination gaps in logistics and finance.

S3: Delivery	Balances resources and performance; maintains internal stability and short-term efficiency.	- Metrics focus on inputs/outputs ("bean counting") rather than outcomes; - Resource allocation delays between commitment and delivery; - Blind spots in monitoring actual system performance; - Limited feedback for continuous performance improvement.
S4: Development	Scans environment, anticipates trends, innovates, and drives adaptation.	- Data-rich environment but poor translation into actionable insights; - Weak foresight and scenario planning capability; - Insufficient capability for system redesign; - Clinicians underdeveloped as system leaders, limiting adaptive capacity to environment and clinical autonomy.
S5: Policy	Provides overall identity, strategic direction, and balance between present operations and future changes.	- Fragmented governance across units, lacking coherence; - Accountability misaligned with autonomy (classic pathology); - Blame culture instead of responsibility clarity; - Difficulty in balancing service delivery today with transformation for HSG in the future.

Note: The provided information in the table is compiled from the VSM exercise summary report drafted by Hoverstadt and Loh (2022). More details are given in Appendix A.

To begin with, System 1 (i.e., Operations) maps and recognizes the key roles played by multiple stakeholders like the MOH, healthcare clusters, GPs, hospitals, and other entities. It is evident that the MOH oversees the whole health system in Singapore, while healthcare clusters assume the responsibility of managing RHSs. Furthermore, distinct healthcare intuitions and clinics are responsible for primary care, secondary care, and ILTC. Nevertheless, it has been observed that patients and residents face difficulties in navigating fragmented services and unit boundaries, while providers encounter the issue of duplicating health services within their operations (Hoverstadt & Loh, 2022). The efficiency of operational units serves as a barometer for the local health system governance, directly impacting population health outcomes.

Next, System 2 directs attention to the obstacles that prevent coordinated care delivery between providers. It is found that there are weak standards or protocols across health facilities along with the ineffective integration between curative care at hospitals and social prescribing at communities (Hoverstadt & Loh, 2022). Although the CAP payment facilitates incentive alignment to care coordination between public and private healthcare providers, more efforts ought to be dedicated to mitigating conflicts of interest and service duplications across operational units through the implementation of standardized protocols, communication channels, and established procedures. Being at the top of health system governance, it is important for the MOH to coordinate both health services (i.e., logistics) and capitated payments (i.e., finance) across regions and settings so that residents are guaranteed freedom of choice of care providers (Ministry of Health, 2023a).

When it comes to delivery in System 3, several issues, including naïve metrics on inputs or outputs, unrecognized resource allocation delays, and disregarded feedback loops, are identified as the fundamental challenges to the efficient health services delivery and continuous performance enhancement (Hoverstadt & Loh, 2022). To this end, it is imperative to strike a balance between resource allocation and performance optimization in order to ensure both internal stability and operational efficiency. To be more specific, the MOH and healthcare clusters are responsible for delivering funding efficiently between primary care, secondary care, and ILTC at the national and regional levels, respectively.

Moreover, in the light of ageing population and growing chronic disease burden (Ministry of Health, 2022b), Singapore's healthcare system struggles with translating extensive data into management intelligence and actionable policy insights in the real world. Additionally, it lacks foresight and scenario planning capability, resulting in insufficient capability for system redesign and underdeveloped clinical leadership (Hoverstadt & Loh, 2022). In essence, System 4 proposes the development of policy foresight with data intelligence, thereby improving the system-wide optimization and adaptation. As underscored by Center for Medicare and Medicaid Innovation (2021), the availability and accessibility of key data and analytics to care providers can enhance operational transparency, improving feedback about performance, and enabling participants to make informed decisions and drive meaningful results.

Last but not least, the "Quadruple Aim" defines the overall health reform goals under HSG (Cheong, 2024; Ruth, 2023). During the workshop, various stakeholders explicitly expressed their concerns about the current governance arrangements in Singapore's health system. It is believed that there is misaligned accountability, blame attribution, and inadequate mechanisms for harmonizing decision rights and information requirements (Hoverstadt & Loh, 2022). Consequently, System 5 advocates for a balanced approach to decision-making by optimizing the present service delivery while simultaneously preparing for future changes. To illustrate, it is necessary to invest more on primary care and ILTC in the forthcoming years, but the continual improvement in secondary care should not be ignored as well.

In short, the VSM exercise helped share insights, communicate risks, and build consensus by engaging diverse stakeholders from the local health system. With the aid of VSM, we observe that adaptation and resilience emerge from facilitating effective operation and care coordination as well as developing management intelligence and policy foresight across the five subsystems. The viable and integrated health system governance thus should: (1) decentralize appropriate decision-making tasks to RHSs and first-line clinicians for timely responsiveness; (2) coordinate public healthcare clusters and private GPs via the established AIC; and (3) incorporate feedback channels into the decision-making process with the view of informed health policy design.

4.2.2 DPG for Performance Monitoring and Collaboration

While VSM provided a diagnosis of systematic weaknesses such as coordination failures, inadequate intelligence, misaligned accountability, and other issues which are prevalent in Singapore's healthcare system, DPG further frames the underlying causes and effects in a structured manner. Based on findings from the VSM exercise, we pinpoint the key system variables and group them into three sectors which are strategic resources, performance drivers, and end results. The DPG chart tailored to Singapore's health system is illustrated in Figure 15.

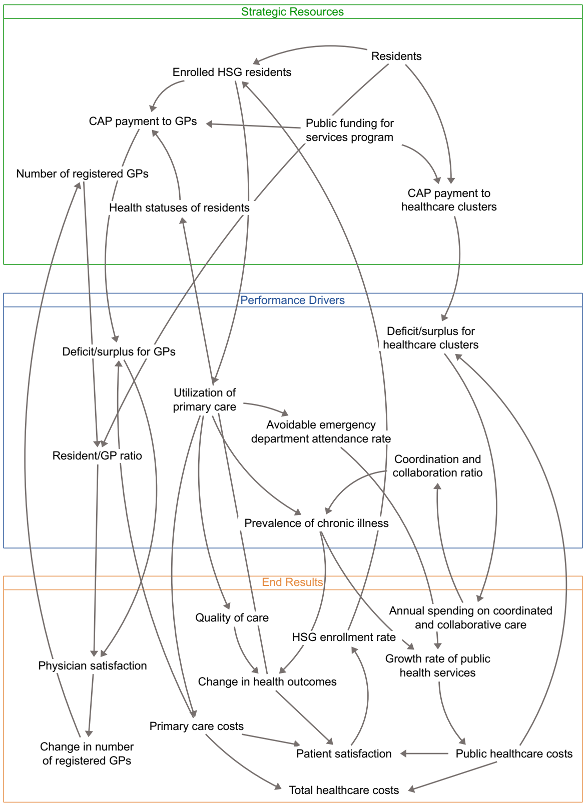

Figure 15. A DPG chart aligned with Singapore's CAP payment reform.

Fundamentally speaking, residents and healthcare providers (e.g., GPs and hospitals) determine the demand and supply of healthcare within a nation. On one hand, the population health outcomes greatly influence the aggregate demand for health services because complex cases typically require more intensive medical interventions. On the other hand, the number of medical workforces determines the general service capacity within the local healthcare system. For example, the ratio between residents and GPs indicates the primary care capacity, influencing PCPs' workloads and job satisfaction to a significant extent. As a result, the number of GPs who are willing to get onboard with the HSG initiative would affect the implementation of CAP payment model in Singapore as well as the goal of enhanced primary care.

In addition to human resources, public funding for services program made by the MOH constitutes the common-pool resource that needs to be allocated between private medical clinics and public healthcare clusters. Given the annual healthcare costs incurred by residents at primary care settings or RHSs, the financial performance of GPs or healthcare clusters, whether it is a deficit or a surplus, is thus determined. In other words, strategic resources have great impacts on the key performance of health systems. Importantly, the insufficient public funding to healthcare clusters poses a risk of underinvestment in preventive interventions supported by private GPs and other community partners. Consequently, the prevalence of chronic diseases is likely to increase over time. This will have a detrimental impact on the regional population health outcomes and stimulate the continuous growth of medical care demand and the associated healthcare costs.

However, if some disease burdens (e.g., chronic disease management) were appropriately and effectively shifted to the primary care setting, there would be lower utilization of public healthcare services owing to reduced hospital admissions and avoided emergency department attendances. From a governance standpoint, this eventually depends on the coordination and collaboration between public and private providers, as evidenced by the "Coordination and collaboration ratio" in Figure 15. Ultimately, these performance indicators will drive changes in both short-term outputs and long-term outcomes. For instance, the utilization of primary care and public healthcare contributes to the annual primary care costs and public healthcare costs, respectively. The disparities between healthcare costs and capitated payments made by the MOH signify the surplus or deficit for public and private providers. We believe that the financial performance of GPs and healthcare clusters under CAP will have a certain impact on physician satisfaction and provision behaviors in practice.

Beyond healthcare costs and physician satisfaction, we also pay attention to the quality of care because it further shapes population health outcomes and patient satisfaction. These end results jointly constitute the “Quadruple Aim” of HSG and subsequently fuel the dynamics of strategic resources. For example, patient satisfaction affects the HSG enrollment rate that finally determines the number of enrolled HSG residents. Likewise, the number of GPs who are willing to register with the HSG initiative are often conditioned by physician satisfaction. In a nutshell, the DPG chart illustrates how the strategic resources of financial funding and medical workforces can be mobilized through performance drivers like coordination, utilization, and prevention to produce end results such as change in health outcomes and healthcare costs. It cautions that under-leveraged strategic resources and ineffective performance governance among public and private healthcare providers may hinder the translation of CAP funding into desired results or policy outcomes under HSG.

Overall, system mapping illustrates that the introduction of CAP payment model is not simply a matter of health financing reform. Rather, it is a systemic transformation that alters care delivery to patients, redistributes risks between the payer and providers, and thereby demands a viable health system governance framework. In this context, VSM provides a useful tool for stakeholder mapping and structure diagnosis. It emphasizes that the achievement of viable governance under HSG requires long-term coherence, accountability, adaptivity, autonomy, and alignment across multi-tiers of complex health systems. In comparison with VSM, DPG provides a more granular framework for mapping the widespread interplays between key variables in Singapore’s health system. As such, it is more intuitive to develop a formal SD simulation model based on the established DPG chart (Bianchi et al., 2019; Bivona & Noto, 2020; Cosenz, 2022).

5 Simulation Modelling

Building on the system mapping, this chapter uses simulation modelling to investigate individual physician behavior and population-level dynamics under various payment conditions. More concretely, GABM is employed to examine the varying effects of FFS and CAP payment schemes on the care delivery microsystem. By further distilling the sophisticated yet simplified mathematical mapping of interactions between the population, providers, and the payer, a SD model is developed to identify the potential financial risks and long-term health trends. The combination of GABM and SD simulation models is anticipated to facilitate the acquisition of a more holistic understanding of the complex health financing and system governance implications of Singapore's CAP payment reform.

5.1 Care Delivery Microsystem

Understanding how payment schemes influence physicians' provision of medical services is a central research question in health economics and health policy. Traditional approaches like laboratory experiments, mainly rely on human subjects who are medical students or practicing physicians. They are often presented with abstract patient vignettes and are then asked to make independent decisions on the intensity of treatment under various monetary incentive structures (Brosig-Koch et al., 2024; Hennig-Schmidt et al., 2011; Li et al., 2022). These experiments have provided useful insights into the physicians' provision behavior under different payment conditions. However, traditional laboratory experiments are also notorious for resource-intensive, limited in sample size, and constrained in scalability.

Due to these apparent deficiencies, GABM provides a promising alternative to traditional laboratory experiments. In the present study, LLM-driven agents are instructed to assume the role of physicians and make autonomous decisions under structured prompts that encode patient characteristics, illness profiles, payment conditions, and their corresponding costs or benefits. To a significant extent, this allows for rapid, scalable, and replicable experimentation. It offers an innovative modelling approach to simulate physicians' decision-making and to investigate their micromotives under different payment models. The remainder of this section details how the GABM is structured, presents synthetic data for illustration, and discusses both opportunities and challenges in comparison with traditional laboratory experiments participated by human subjects.

5.1.1 Workflow of GABM Simulation Experiments

The design of GABM simulation experiments follows a structured workflow. Figure 16 illustrates the sequential process from environment definition through agent construction, prompt engineering, dynamic simulation, to the experiment result analysis. To be specific, the first step involves defining the general environment like patients and payments. In our study, these settings are the same as the experimental design by Hennig-Schmidt et al. (2011). Simply put, patients differ in illnesses (i.e., A, B, C, D, E) and in severities of illness (e.g., mild, intermediate, and bad), each with an optimal quantity of care that maximizes their health benefits measured in monetary terms. Deviations from this optimum lead to either over-provision or underservice, reflecting the inherent trade-off between physician profit and patient benefit given different payment models. For more details on the general design and parameter setting, interested readers may refer to the original study.

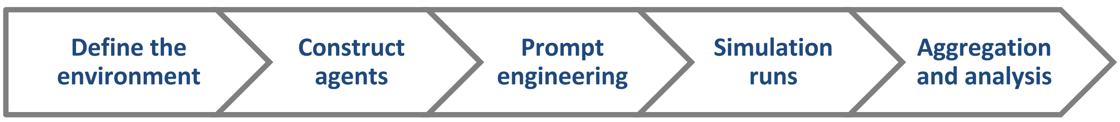

Figure 16. Workflow of GABM simulation experiments.

Step 2 relates to physician agents' construction. They are instantiated and randomly assigned to either FFS or CAP payment conditions at the very beginning. During GABM simulation experiments, LLMs are instructed to choose a quantity of medical services ($q \in [0, 10]$) for the given patient (indexed by 1, 2, 3) with an abstract illness every run. The decision space is specified in the prompt to LLM-driven agents, where each decision task is framed as a natural language prompt, including patient type, abstract illness, payment and cost, as well as the expected profit and patient benefit for each quantity of medical services. The information given in the prompt is identical to that offered to human subjects in the traditional laboratory experiment (see Fig.1, Hennig-Schmidt et al., 2011). Physician agents' decisions will decide both their own profits and patient benefits under the assigned payment model. This design allows behavioral variability across simulation runs even under identical parameter settings, reflecting realistic cognitive and interpretive uncertainty.

When simulation starts, each physician agent is required to make a total of 15 decisions – a combination of three patient types and five abstract illnesses. In contrast with the traditional laboratory experiment, it is possible to choose any number of agents in GABM simulation experiments. Though it is irrational to choose a quite small or large sample, we set the number of physician agents as 40 in the present study, which is equivalent to the number of human participants employed by Hennig-Schmidt et al. (2011). Finally, simulation results are aggregated across agents and runs. Comparative statistics (e.g., mean differences, t-tests, effect sizes) are calculated to evaluate the differences in physicians' provision behavior under FFS and CAP payment models and their significance level. Plots and tables can further be constructed to visualize and summarize key findings at both aggregate and individual levels. The implementation code is described in Appendix B.

5.1.2 Synthetic Simulation Result Analysis

GABM simulation results suggest that LLM-driven physician agents exhibit more incentives to provide significantly higher quantities of care under FFS compared to the CAP payment model. As is seen from Figure 17A, there is a significant difference ($p < 0.001$)[8] in the average quantity of medical services provided by physician agents under different payment conditions, a mean of 7.99 units under FFS vs. 4.06 units under CAP.

[8] The difference in average service quantity between FFS and CAP payment conditions was not only statistically significant ($t=33.0776$, $p=2.0705e-131$), but also exceptionally large in magnitude (Cohen's $d=2.75$), indicating that different payment incentives produce nearly non-overlapping behavioral distributions.

In other words, physicians paid by FFS provide much higher quantities of medical services than those reimbursed by CAP payment model, corroborating the findings from traditional laboratory experiments (Hennig-Schmidt et al., 2011; Li et al., 2022). This finding is also applicable to various patient types and illnesses because the average quantity provided to each patient type and illness is substantially higher under the FFS payment model compared to CAP, as demonstrated in Figure 17B.

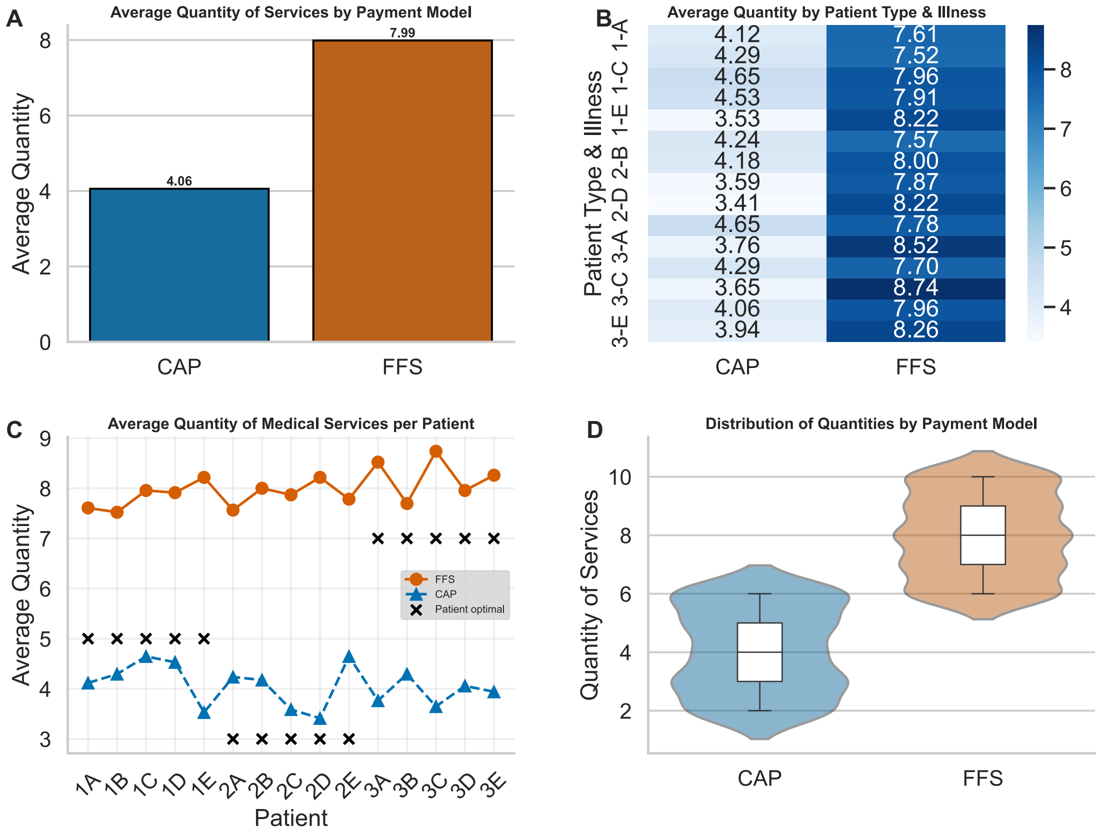

Figure 17. Visualization of synthetic data from GABM simulation experiments[9]. The bar chart A highlights systematic over-provision under FFS and underservice under CAP payment models. Plot B disaggregates the average quantity of services by patient type and illness. The line chart C plots the disaggregated average quantities of services for different patient types and illnesses relative to the optimal benchmark. Plot D shows the distribution of quantities provided by physician agents under CAP and FFS payment models, combining the violin chart and boxplot.

When contrasting average quantities of medical services with the optimal quantities for each patient type and illness, Figure 17C illustrates that the FFS payment model creates strong incentives for physician agents to offer excessive medical services. Conversely,

[9] The full simulation results for each run have been exported for reference (see Appendix B).

agents are more likely to economize on service provision under CAP, leading to the underservice issue. The divergence is much more pronounced for simple cases (patient type 2) under FFS and for patients with complex needs (patient type 3) under CAP, illustrating the risk of inequities in service provision under different payment methods. This heterogeneity underscores that the CAP payment reform may not affect all patients equally because complex cases could be worse off under CAP than under FFS. This finding has a direct health financing policy implication – how to better meet the needs of complicated patients within a capitated system?

The last plot (Figure 17D) presents the distribution of all the decisions made by physician agents under different payment conditions. Although the provision of medical services generally exhibits a significantly higher level of quantity under the FFS payment model compared to CAP, it is essential to acknowledge the presence of noticeable variations under each payment condition. These variations indicate that provider profit is not the sole determinant of physicians' decision-making. Other factors, such as patient benefit (i.e., altruism), may also exert a considerable influence on physicians' provision behavior (Brosig-Koch et al., 2024).

5.1.3 Theoretical Interpretations

The controlled laboratory experiment establishes a direct connection to theory and allows the testing of theoretical predictions (Brosig-Koch et al., 2024). Under FFS, providers are motivated to maximize service volumes even when additional treatments provide no marginal patient benefits, leading to over-treatment and rising healthcare costs. This supplier-induced demand phenomenon reflects a classic principal-agent problem: the payer (i.e., the principal) delegates service provision to providers (i.e., the agents), but the asymmetry of information allows healthcare providers to induce demand and extract rents (Seyedin et al., 2021). Part of the reason is that patients often lack the expertise to challenge physicians' provision behaviors.

By contrast, the CAP payment model fundamentally reconfigures the principal-agent relationship in health systems. Regardless of the number of services delivered, payers like the MOH seek to reduce information asymmetry and shift the financial risk to providers by paying them a fixed amount per patient. In this respect, it aligns the agent's incentives with the principal's objective of cost containment and disease prevention: providers are now rewarded for preserving population health rather than maximizing care delivery (Ministry of Health, 2023a). From a governance perspective, the new CAP funding method is expected to act as an incentive realignment mechanism in Singapore, reframing the provider's role from a revenue maximizer to population health steward (Ministry of Health, 2022b).

Yet GABM simulation experiments highlight the countervailing risk within a capitation-based system. When providers are responsible for costs but retain discretion over treatment decisions, they may respond by providing suboptimal health services, selecting healthier patients, or avoiding costly cases. These behaviors cause an underservice issue as well as new forms of moral hazard or adverse selection, in which agents pursue their own benefits, such as minimizing workloads or financial risks at the expense of the principal's goals of health equity and universal access. Without strong performance monitoring and risk adjustment mechanisms, CAP can consequently produce inefficiencies and inequities as severe as those associated with the legacy FFS payment model. In other words, CAP is not inherently superior to FFS. The interpretation of synthetic results, underpinned by the principal-agent theory, suggests that incentives are not self-aligning but embedded in institutional contexts that determine how delegation, monitoring, and accountability operate.

5.1.4 Comparative Advantages

In general, GABM offers an innovative and alternative modelling approach (Ghaffarzadegan et al., 2024) to simulate physicians' decision-making under different payment models in the present study. To some degree, GABM simulation experiments have validated the plausibility of using LLMs to capture physicians' diverse incentives under different payment schemes. In contrast to traditional laboratory experiments that involve human subjects, GABM simulation experiments show some evident differences and advantages in scalability, cost, logistics, ethical considerations, and other aspects, as summarized in Table 6.

Table 6. Comparison between two experimental methods.

Feature	Traditional Laboratory Experiment	GABM Simulation Experiment
Participants	Human subjects	LLM-driven agents
Scalability	Limited by budgets and logistics	Highly scalable
Cost	High	Low
Ethics	Requires Institutional Review Board (IRB)	No direct human involvement
Adaptivity	Limited	Dynamic prompt engineering

Overall, GABM simulation experiments powered by LLMs provide a low-cost, ethically safe, and highly scalable method to study the heterogeneous impacts of payment methods on care delivery microsystem. Beyond replication, GABM further allows us to:

- Explore emergent behaviors under innovative and alternative payment models;
- Test behavioral dynamics over repeated interactions with patients (i.e., adaptation to financial incentives);
- Incorporate persona-based heterogeneity (e.g., altruistic vs. profit-driven traits) using psychology-based persona frameworks (Ghaffarzadegan et al., 2024).

Insights gained from GABM simulation experiments can inform health financing policy design, such as setting CAP funding rates, introducing stop-loss and pay-for-performance (P4P) elements, and anticipating unintended consequences of incentive structures. This novel modelling approach facilitates systematic variation of payment systems, patient demographics, and policy interventions without incurring substantial time and financial resources dedicated to recruiting human participants as needed in traditional laboratory experiments. To some extent, GABM opens up new frontiers in health financing policy research and simulation modelling study. Notwithstanding these recognized advantages, modelers ought to pay attention to the experimental design like prompt engineering (Li & Wu, 2025) and decision-makers need to carefully interpret synthetic simulation results because LLMs are largely regarded as a "black box" (Zeng et al., 2025) and they may not perfectly emulate physicians' cognition (Cummins, 2025; O'Grady, 2025; Schröder et al., 2025).

5.2 "Population-Provider-Payer" Macrosystem

The care delivery microsystem centers on individual physicians' provision behavior under different payment conditions like FFS and CAP. Nevertheless, it is insufficient for policymakers to gain systematic insights into population-level health policy outcomes resulting from the CAP payment reform, such as financial exposure to public and private healthcare providers or long-term public health trends under HSG. Consequently, it is necessary to delve deeper into the population health outcomes, the delivery of health services, the financial performance of provider groups, and the expected national healthcare expenditures at the macro level. To this end, a SD model aligned with Singapore's healthcare system is built to enhance systems understanding (Geier et al., 2019; Richardson, 2025), which is pivotal to make informed decisions and formulate sustainable health financing and governing policies in the long run.

5.2.1 Model Structure and Components

Broadly speaking, "*Health care involves a complex system of interactions among patients, providers, payers, and other stakeholders*" (Hirsch & Homer, 2017, p. 1). From this viewpoint, the development of SD model centers around "Who gets care?", "Who gets paid?", and "Who pays for the care?" (Evans, 2005). Concretely, the modelling of national payment reform necessitates a thorough analysis of patient and fund flows between the population, providers, and payers sectors (Cinchon et al., 1999). Hence, the basic SD model (see Figure 18) is composed of three modules, including (1) Population, (2) Provider, and (3) Payer. Each of them is interconnected, capturing the widespread feedback across patients, services, and funds within the healthcare system (Schryver et al., 2015). In practice, the tailored SD model has been created through an iterative modelling process (Sterman, 2000, ch.3).

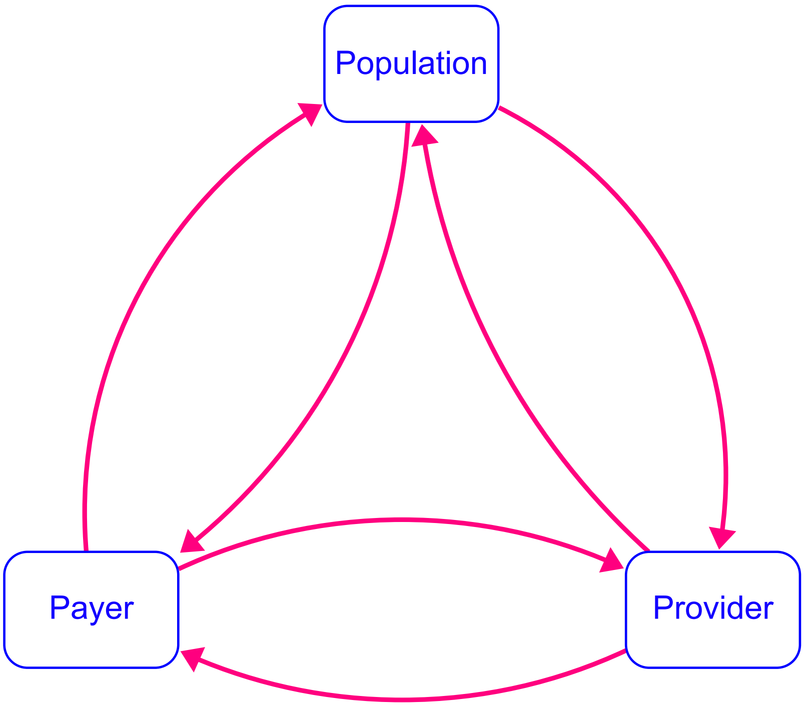

Figure 18. High-level overview of the basic SD model.

- Population module

The population sector tracks health state transitions (i.e., healthy, mild, and complex conditions) across age cohorts by using an ageing chain model structure (Sterman, 2000, ch. 12.1), shown in Figure 19. Following the existing practice of modelling the population of Singapore (Ansah, 2013), our SD model disaggregates Singaporeans into one-year age cohorts until the maximum age threshold of 100 years old. The demographics change dynamically due to births (only for the first age cohort), ageing (except for the last age cohort), deaths, and net migrations. Annual births are simply calculated by multiplying the crude birth rate and number of residents. Annual deaths are determined by utilizing the reference probability of mortality at each age level derived from the life table for the base year of 2010, along with the calibrated hazard ratios specific to each health state. Given that Singapore has a substantial influx of migrants with the majority falling within the age bracket of 15 to 64 (Adam et al., 2011), we estimated the annual net migrants for each age cohort based on the available net migration data from World Bank, multiplied by the calibrated distribution of age groups in the model. To avoid the "cohort blending" effect in the precise modelling of ageing population ([Eberlein & Thompson, 2013](#)), conveyor stocks[10] for each health state (see “” symbols in Figure 19) have been intentionally chosen to replicate the “first in first out” ageing process in nature.

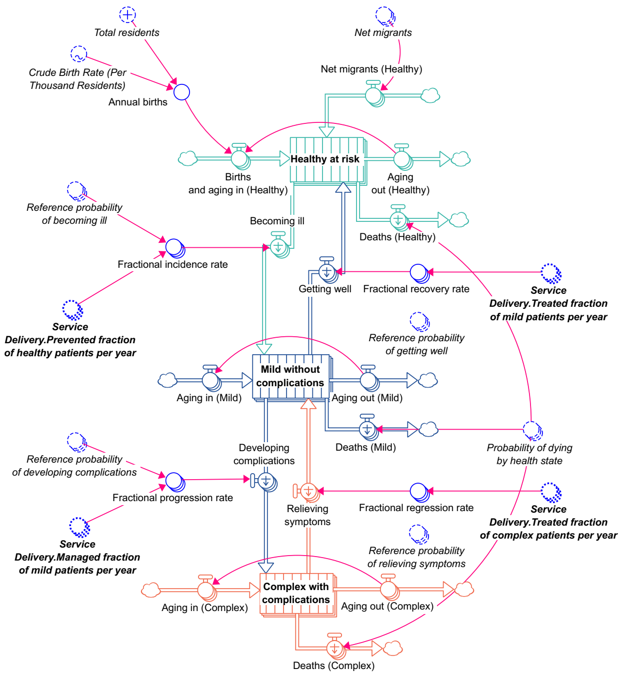

Figure 19. The population model structure.

Both total residents and residents by age group, namely young residents (0-14 Years), adult residents (15-64 Years), and old residents (65+ Years), have been calibrated against the national statistical data for the historical period between 2010 and 2024. The transitions between health states are expected to vary with age and the access to care (referring to service delivery at the provider sector). Specifically, the rates of individuals transitioning to more severe health states, such as becoming ill, are influenced by reference probabilities (i.e., natural disease progression) and preventive interventions delivered by PCPs. Considering the unknown real-world transition rates, the calibrated reference probabilities of becoming ill and developing complications are used in the model. Meanwhile, the health regression or recovery rates like relieving symptoms or getting well depend on the efficacy of disease treatment. By modelling in

[10] A specialized type of stock built in Stella. For more details: https://www.iseesystems.com/resources/help/v3/#08-Reference/05-Computational_Details/TraditionalConveyors.htm?Highlight=conveyor.

such a way, we have established meaningful links between population and provider modules. In a word, the population module simulates the demographic trends and provides the basis for modelling the demand of healthcare (Matchar et al., 2016).

- Provider module

On the provider side, both physician supply and service delivery have been accounted for in the SD model. As shown in Figure 20A, the physician supply sub-module simulates how the number of GPs changes over time with a simple first-order goal seeking model structure (Sterman, 2000, ch. 8). The stock (i.e., Number of GPs) accumulates the net flow between the inflow of recruiting and two outflows of retiring and leaving. Instead, the number of family doctors who work at polyclinics is an exogenous variable by using the historical data. Additionally, we modelled the enrollment process of private medical clinics into the HSG initiative because it is believed that the number of enrolled GP clinics would significantly influence the primary care service capacity under HSG.

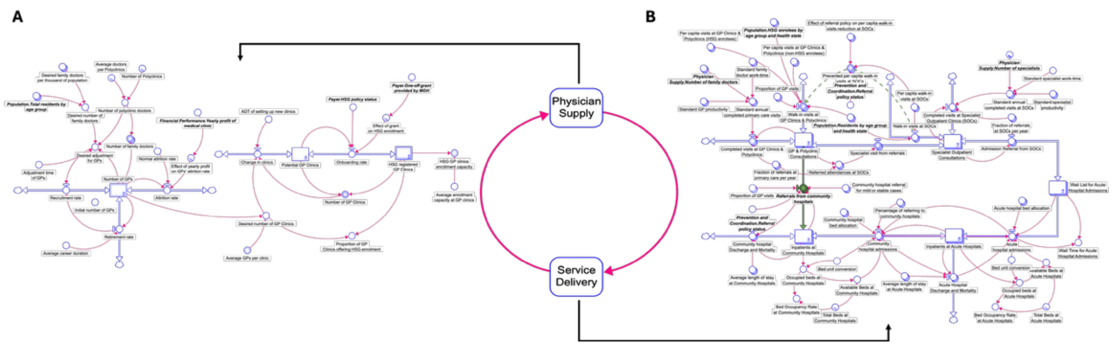

Figure 20. The provider model structure. Note: This layout is for illustration purposes only. For more details and interactive visuals, refer to the source model provided in Subsection 5.2.2.

The second part (see Figure 20B) depicts the general patient flow across diverse clinical settings in the local healthcare system (Ansah, 2013), including GP clinics or polyclinics, SOCs, acute hospitals, and community hospitals. By connecting with the physician supply sub-module, the health services capacities in Singapore, determined by the availability of healthcare professionals (e.g., the number of family doctors and specialists) and the infrastructure (e.g., hospital beds), have been factored into the SD model. Collectively, the provider module tracks the dynamics of healthcare workforces and the delivery of health services within Singapore's health system. The utilization of health services in this module indicates the expected healthcare costs borne by different providers.

- Payer module

In the payer sector, we roughly monitor the disparity in the annual payment made by the MOH on services program under different payment conditions. The gross operating spendings can be simply split into two large groups – payments transferred to public healthcare clusters and private medical clinics, respectively. Under FFS, the MOH normally reimburses the healthcare costs retrospectively. By contrast, prospective payments are made to healthcare clusters and medical clinics within a capitation-based system, which implies substantive administrative cost savings (Standridge et al., 1983). Given that the financial performance of individual providers is influenced by numerous factors in the real world, we intend to conduct the comparative analysis of "average" financial exposure to healthcare clusters and medical clinics under the CAP and FFS scenarios. Overall, this module serves to inform the financial sustainability of the HSG initiative and the potential risks borne by public and private providers in Singapore.

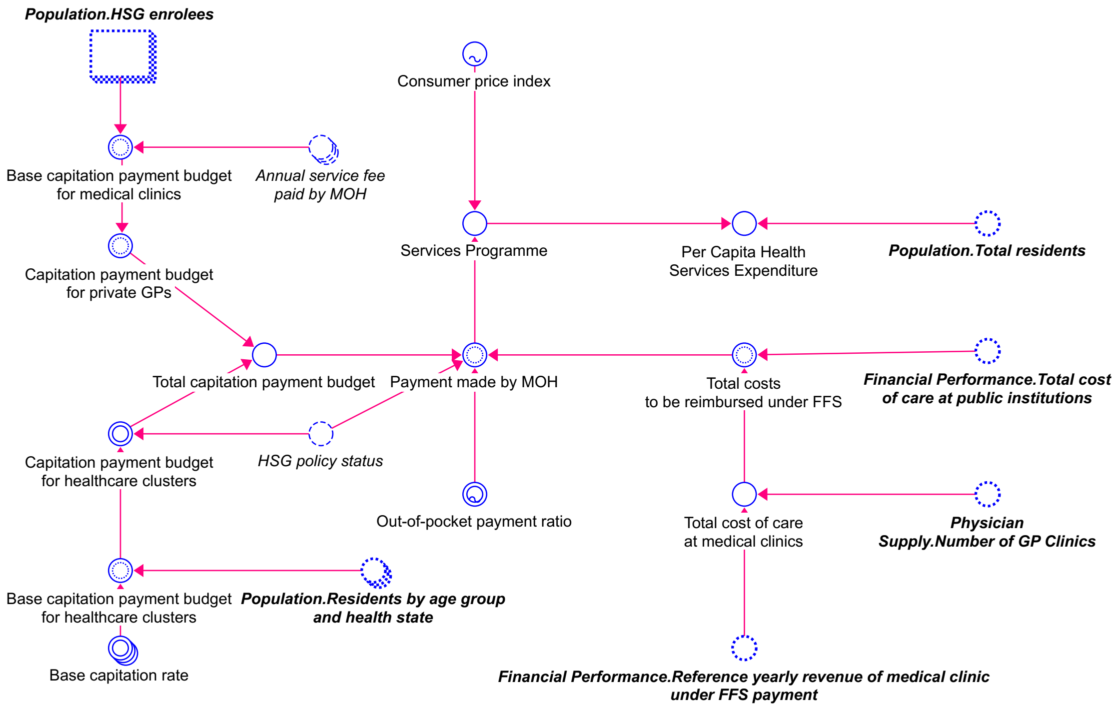

Figure 21. The payer model structure.

5.2.2 Model Assumptions and Implementation

Since model is merely a simplification of complex real-world system (Cinchon et al., 1999, p. 28), the SD model is no exception (Sterman, 2000). Table 7 explains who are included or excluded in each module. For instance, foreign workers are not considered in the population module because they bear the entirety of their healthcare expenses independently and, consequently, are not impacted by the recent CAP payment reform in Singapore. In addition, there are an array of health services provided by public, private, and non-profit providers in various health facilities, so it is not possible to account for all kinds of care explicitly in the SD model. A more detailed SD mapping of acute patient flows has been demonstrated in Lane and Husemann (2008). At last, we take no account of private insurance companies because the reimbursement of medical expenses is primarily determined by their contracts with policyholders and healthcare providers in practice.

Table 7. Definition of stakeholders in the SD model.

Module	Coverage	Exclusion
Population	Citizens and permanent residents	Foreign workers, tourists
Provider	Private medical clinics, public healthcare clusters	Non-public hospitals (e.g., private and non-profit acute and community hospitals), nursing homes, psychiatric hospitals
Payer	The MOH, patients	Private insurance companies, external aid

The general purpose of SD modelling is not to precisely forecast or predict the changes in population health outcomes and national health expenditures in the future. Instead, we pay attention to the potential financial risks and health impacts, based on the given assumptions on the exogenous variables in the model (Cinchon et al., 1999; Stringfellow et al., 2022). As a result, there have been a number of simplifying assumptions based on the pre-defined model boundary when formulating the SD model (Rees, 2013). We have either excluded many variables in the real-world health system or simply treated them as exogenous parameters for the purpose of reductionism or policy tests. With regard of parameter uncertainty, extensive model calibration has been performed. Similar to all the modelling studies, the reduction and simplification of reality is essential to render the formal SD model implementable.

In detail, the SD model is developed on the dynamic modelling software – Stella[11] (Version 3.6, isee systems inc.). A long-time horizon has been selected in order to investigate the lasting financial risks and policy outcomes associated with the CAP payment reform under HSG. To be more specific, the simulation model runs in years, starting from 2010 to 2030. Thus, historical data for the base year if exist are used as the initial values in the model. In comparison with a long-time horizon, the time step (i.e., dt) has been discreetly set as small as "1/100" to accommodate the short time delays like average length of stay at acute hospitals (ca., 1 week) in the provider sector.

5.2.3 Model Testing and Validation

Model testing is regarded as an integral part of SD modelling process (Sterman, 2000, ch. 21). As emphasized by Sterman (2018, p. 39), "… *simulation that is not grounded in evidence and is poorly tested may create more harm by providing false confidence and more deeply embedding flawed mental models.*" Considering the possibility of various errors that could leave the model unchecked (Cinchon et al., 1999, p. 142), a set of tests have been performed prior to formal simulation results analysis and policy experiments. They include dimensional consistency test, structural assessment test, behavioral replication test, and extreme condition test (Sterman, 2000, ch. 21.4). In SD modelling software like Stella, the unit consistency check is a straightforward procedure and there are no unit error warnings in this respect. Subsequently, we focus on other tests that contribute to enhancing the confidence of both modelers and policymakers in the basic SD simulation model introduced in the present study.

- Structural assessment test

As a causal modelling methodology, the SD model structure determines behavior (Kampmann & Oliva, 2009; Meadows, 2008; Schoenenberger et al., 2021). Throughout the entire modelling process, we attach great importance to the existing knowledge of

[11] The source model is uploaded to isee exchange: https://exchange.iseesystems.com/public/zhenghua-yang/cap-payment-reform/index.html#page3.

the local health system and the best practice of dynamic modelling. To illustrate, the ageing chain structure in the population module has been widely used in modelling population dynamics (Ansah et al., 2017; Eberlein & Thompson, 2013; Sterman, 2000, ch. 12.1). In the meantime, dividing general population into three health states conforms to the modelling practice by Matchar et al. (2016). Concerning the provider module, the complicated patient flow structure replicates the simulation model depicted in Ansah (2013) and coincides with the real-world care seeking and service delivery to a large degree. To compare the FFS and CAP funding modes in the payer sector, their retrospective and prospective payment characteristics have been considered in the underlying model structure respectively. Essentially, our high-level model structure (i.e., the interactions between the population, providers, and payers) aligns with the modelling flow of healthcare delivery described by Schryver et al. (2015).

- Behavioral reproduction test

Before seeking for useful policy insights, it is imperative to conduct further tests of model behaviors in comparison to historical data that are available and reliable (Sterman, 2000, ch. 21.4.7). While it is intuitive to visually assess model fit to actual data, presenting statistical measures of goodness of fit is generally regarded as more rigorous in scientific research (Sterman, 2018). Figure 22 lists an array of comparative behavioral graphs for some key variables after model calibration, supplemented by the ancillary statistics – coefficient of determination (R^2). It is found that R^2 varies markedly for different model variables, from 0.3 (poor fit) to 0.98 (good fit). Considering the complexity of real health systems and the limitation of models, it is anticipated that our simulated data cannot fit the actual data perfectly, sometimes even poorly[12]. In particular, many historical data regarding population age groups or clinic attendances show sudden down first and then up during the Covid-19 pandemic (i.e., between 2019 and 2023). However, there is no accounting for such a catastrophic impact of the pandemic on public health and service delivery in our simulation model. All in all, the behavioral replication test provides a benchmark against which the goodness of fit of

[12] See more comparative graphs for the behavioral reproduction test in Appendix C.

SD model can be measured during the base run.

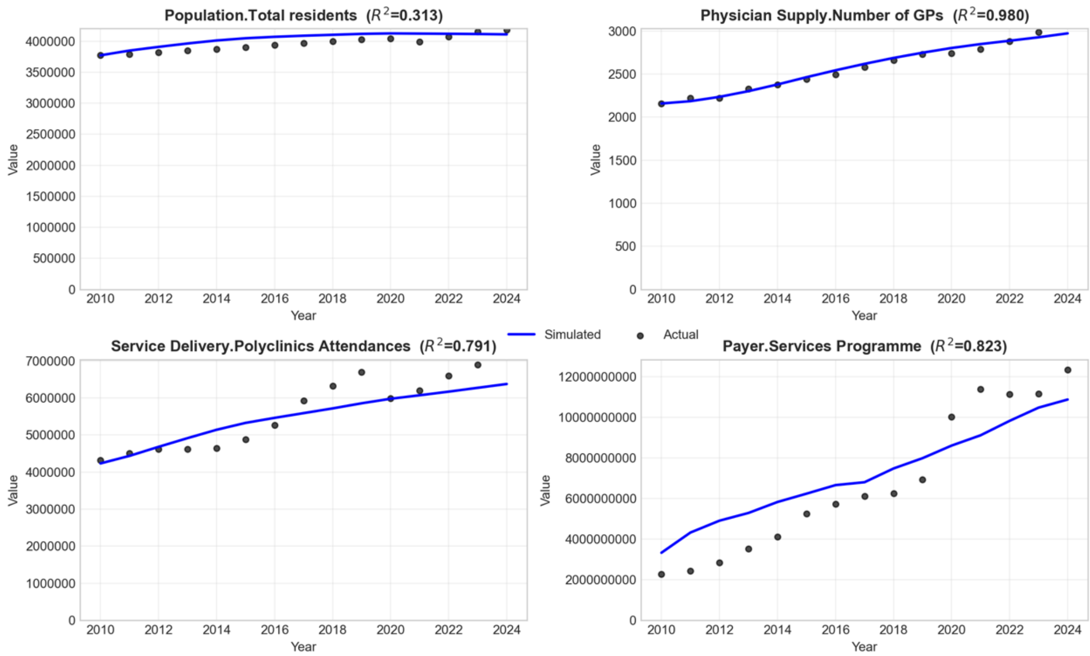

Figure 22. Behavioral replication test results (simulated vs. actual).

- Extreme condition test

The last test assesses the robustness of SD simulation model under extreme conditions (Sterman, 2000, ch. 21.4.5). Originally, the MOH commenced enrolling Singapore residents aged 60 years and above with a family doctor in mid-2023. Then, the enrollment process for individuals in the 40-59 age group was initiated in the next two years (Ministry of Health, 2022b). Figure 23A&B depict the baseline scenario where a progressive enrollment trend is obvious over time. In this regard, we tested an extreme scenario: what if there were no HSG enrollment program in place? For instance, changing the HSG start time to 2040 indicates that the HSG enrollment would not happen during the simulation time horizon. As plotted in Figure 23C, the total number of HSG enrollees would undoubtedly be 0 from 2010 to 2030. This simple test helps us quickly uncover subtle flaws like wrong equations or assumptions in a large system model that direct inspection might miss (Sterman, 2000, ch. 21.4.5).

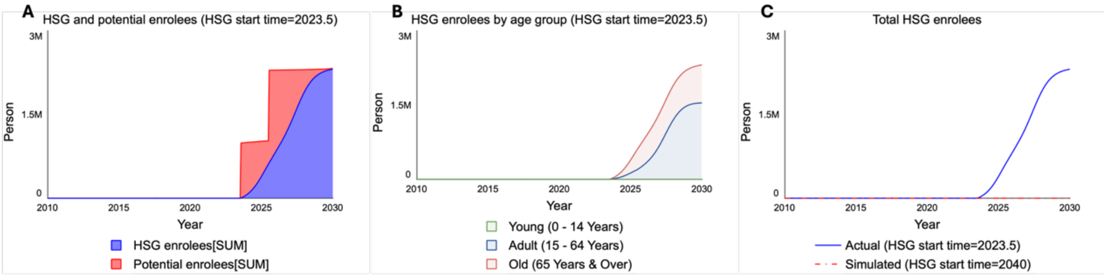

Figure 23. Simulation test of HSG enrollment process.

5.2.4 Simulation Result Analysis

Following the comprehensive model testing, we have developed greater confidence in the basic SD model. To analyze simulation results and gain useful insights, such as the financial risks exposed to public and private providers under the CAP reimbursement method, multiple runs are configured for different purposes. Firstly, the base run simulates the real setting with the new CAP payment model introduced in the middle of 2023. For comparison, a counterfactual scenario has been conducted by postulating there were no payment reform in Singapore's healthcare system. In this case, the FFS payment has been continuously active throughout the simulation. As a result, the differences over runs shed light on the long-term changes in population health outcomes, health services utilization, average provider incomes, as well as public health expenditures borne by the MOH in Singapore.

- Impact on health outcomes

As suggested by the name of HSG, the overarching goal of new health reform is to make Singaporeans healthier. To this end, we firstly look at how the distribution of population health states would evolve under different payment conditions, illustrated in Figure 24. Simulation results indicate that transitioning from the FFS reimbursement method (Counterfactual scenario) to the CAP funding model (Baseline scenario) may improve the overall health status of Singapore residents with an increase from 2.75 to 3.01 million healthy residents. Consequently, the numbers of mild and complex patients are projected to decrease to approximately 737,000 and 319,000 individuals by the end of 2030, respectively. However, the sole payment reform is believed to be insufficient to substantially alter residents' care-seeking behaviors or providers' service delivery practices (Matchar et al., 2025; Ozdemir et al., 2023), thereby sustaining population health improvement in the long run. Fundamentally, the impact on health outcomes largely relies on whether the CAP reimbursement method transforms the local healthcare landscape and effectively addresses unmet needs under HSG.

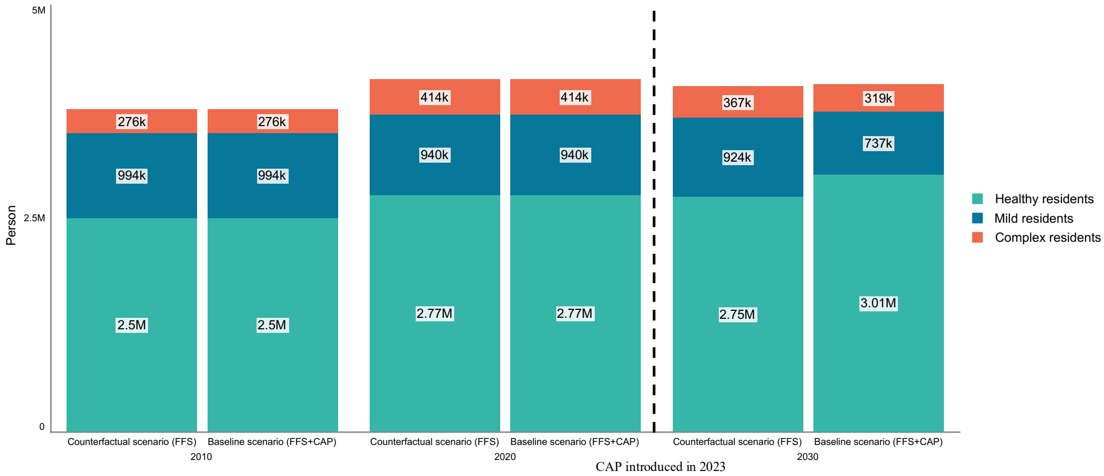

Figure 24. The distribution of population health states under two scenarios.

- Impact on financial performance

As far as providers are concerned, it is of significance to understand how the CAP funding method would affect their financial performance (Wieck, 2021). In this regard, we performed analysis of annual revenues, costs, and profits for both medical clinics and healthcare clusters on average, respectively. In the baseline scenario (see Figure 25A), it is shown that the yearly revenue, cost, and profit per medical clinic decline over time because Singapore is entering into an ageing society and public polyclinics typically provide primary care for a higher proportion of elderly patients with chronic conditions compared to private medical clinics (Matchar et al., 2025). In comparison with Figure 25B, the counterfactual scenario exhibits a similar downward trend, yet the annual profits after 2023 surpass those observed in the baseline scenario. When it comes to the financial performance of healthcare clusters, it is evident that they are not exposed to any financial risks given an FFS reimbursement method. Nevertheless, negative profit, shown in Figure 25C, could arise under the CAP payment condition if funding rates are set at a low level, rendering the given CAP payment insufficient to cover the operating expenses of public healthcare institutions.

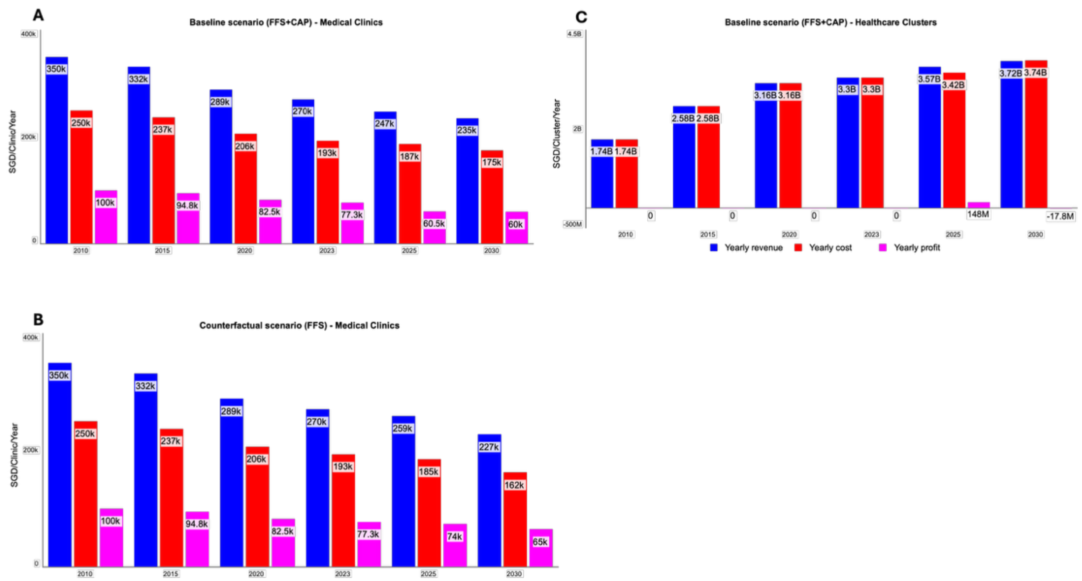

Figure 25. Financial performance of private and public providers under two scenarios.

- Impact on health expenditures

In addition to its effects on population health and provider performance, the CAP payment reform is anticipated to cause changes in national health spendings. In the payer module, we compared the annual payments on services program made by the MOH under the baseline and counterfactual scenarios. In the counterfactual scenario (see the dash dot line in Figure 26A), the public health spendings are projected to keep growing steadily until 2030 because of ageing population and increasing prevalence of chronic diseases. By contrast, the baseline scenario suggests that annual spendings might exceed the FFS payment during the first few years' implementation of CAP funding model in Singapore, but it gradually requires fewer government budgets to cover as the population becomes healthier. The "worse-before-better" scenario is predicated on the model assumption that there would initially be a net increase in funding for services program in order to engage GPs and residents in the HSG initiative. Figure 26B shows that the prospective payment to medical clinics made by the MOH is anticipated to progressively increase its share over time. However, this extra payment might be adequately compensated with the reduced spendings on secondary and tertiary care, predominantly offered by public healthcare clusters. In total, the CAP payment model is projected to save 0.2 billion SGDs in 2030. This finding is echoed by many studies that suggest strengthening the primary care in local health systems (Health

Bureau, n.d.; Matchar et al., 2025; Ramesh & Qian, 2025).

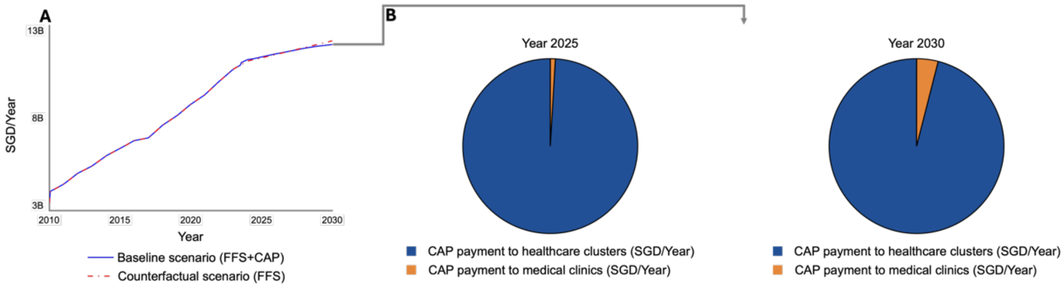

Figure 26. Public health expenditures on services program under two scenarios.

To conclude, GABM simulates physicians' care delivery behavior under different reimbursement methods at the micro level. By contrast, SD maps and simulates the complex interactions between the population, provider, and payer sectors so as to offer holistic and dynamic insights into Singapore's CAP payment reform under HSG. Both of them reveal some unintended consequences, such as undersupply of medical services and negative profit for healthcare clusters, stemming from the capitation-based system. The simulation results suggest the inherent limitations of a simple CAP payment model currently implemented in Singapore, thereby advocating for more comprehensive health financing and governing policy design.

6 Policy Design

Drawing upon the preceding qualitative and quantitative models, this chapter endeavors to furnish Singapore's policymakers with practical health financing policies and tactical health system governance decisions that are instrumental to the achievement of HSG initiative. Concretely, this chapter comprises three parts. Part I continues the GABM and SD simulation experiments, with a focus on the better health financing policy design. In this regard, a comprehensive CAP payment model is proposed and examined in order to mitigate financial risks for both public and private providers, promote care integration, and enhance population health outcomes. Subsequently, we employ both VSM and DPG qualitative modelling insights to identify the viable governance structure that possesses the capability to coordinate health services, manage financial risks, and adapt to the dynamic nature of complex health systems in part II. Lastly, an interactive learning environment, built upon the SD model, offers policymakers and system designers a practical tool to learn systematic impacts of transitioning from FFS to CAP payment and experiment with a wide range of alternative policy scenarios before the real-world implementation (Milstein et al., 2010).

6.1 Simulation Experiments

It has been widely acknowledged that the FFS reimbursement method promotes service volume over value in health (Lindner & Lorenzoni, 2023; Williams, 2017). As such, the recent HSG initiative has boldly attempted to move away from volume-driven health care by introducing the CAP funding mechanism to public healthcare clusters and private medical clinics (Ministry of Health, 2022b). Nevertheless, based on our simulation results given in Subsection 5.2.4 and international implementation cases (Wieck, 2021), a simple CAP payment model could entail disproportionate financial risks to healthcare providers and potentially incentivize them to reduce the supply of medical services. To some extent, it implies that the current CAP model implemented in Singapore's healthcare system may be inadequate for risk pooling and adjustment.

Following the introduction of GABM and SD simulation models in Chapter 5, it is important to identify alternative policy options that can be adopted to facilitate the strategic implementation of a capitation-based system under HSG. To this end, we firstly redesign the GABM simulation experiment by incorporating the P4P element into the basic CAP payment model. Through the policy experiment with GABM, we would like to investigate the impacts of both low-bonus and high-bonus performance pay on physicians' choices of medical services and on the quality of care (Brosig-Koch et al., 2024). Furthermore, we experiment with a comprehensive CAP payment model (Lindner & Lorenzoni, 2023) in the SD simulation model to assess whether it will contribute to system-wide improvements in risk management, care integration, and population health. Collaboratively, these policy simulation experiments are expected to yield valuable insights into the real-world health financing policy design and provide informed decision support for the future payment reform.

6.1.1 Performance Pay Policy Experiment

A fundamental health policy goal is to incentivize healthcare providers to improve the quality of care. It is found that traditional funding approaches, either FFS or CAP, can cause issues of over-provision or undersupply of medical services (Hennig-Schmidt et al., 2011). Thus, in this subsection, we would like to introduce performance pay (i.e., P4P) based on patient health outcomes in addition to a lump-sum CAP payment so that physicians' incentives can be better aligned with quality objectives (Brosig-Koch et al., 2024). As such, the GABM simulation experiment has been redesigned in many ways. Table 8 shows the general design of a new GABM-powered performance pay policy simulation experiment.

Table 8. The performance pay policy experimental design.

Factor Type	Variable	Levels	Description
Between-subject	Bonus level	Low, High	Physicians are alternately assigned to either 5% or 20% performance bonus conditions.
Within-subject	Payment condition	CAP → CAP+P4P	Each physician first experiments with the pure CAP payment model, then

			the CAP+P4P condition.
Patient	Patient type	Mild, Intermediate, High	Patients have different health states or severities of illness, which affect patient benefit and bonus payment in the experiment.
Illness	Illness type	A, B, C	Abstract illnesses influence patient benefit.
Outcome	Cost, Benefit	Vary by payment model and bonus level	Bonus added to payoff if the chosen quantity is close to the optimal level.

Following the behavioral experiment organized by Brosig-Koch et al. (2024), each participant would be exposed to two consecutive payment conditions. In phase I, they receive a lump-sum CAP payment regardless of the quantity of health services provided. Then, the quality-dependent bonus payment[13] is introduced in phase II – CAP+P4P. To further examine the effect of different levels of bonus payment on the quality of care, we vary the size of bonus payment allocated to LLM-driven physician agents. This is achieved by assigning them to either a low-bonus or high-bonus condition, where they receive a fixed bonus of either 5% or 20% in addition to the lump-sum CAP payment. Except for the adjusted features highlighted in Table 8, all the other parts are mostly consistent with the basic design of GABM which has been described in Section 5.1.

Table 9. Average quantity by bonus level and payment model.

Bonus Level	Payment Model	Mean Value	Standard Deviation (s.d.)
High	CAP	4.811111	1.512661
High	CAP+P4P	4.616667	2.025742
Low	CAP	4.811111	1.52003
Low	CAP+P4P	4.572222	1.657994

[13] The physician earns the performance bonus only if their chosen quantity q is close (within ±1) to the patient's optimal quantity q^*. Otherwise, the bonus is zero.

Table 9 and Figure 27A shows that the average quantity of medical services chosen by physicians is around 4.81 (s.d.: 1.51) at the first stage of the experiment no matter which level of bonus payment is assigned. By contrast, the mean values under the CAP+P4P payment condition decrease a bit to 4.57 (low-bonus, s.d.: 1.66) and 4.62 (high-bonus, s.d.: 2.03), respectively. This phenomenon indicates that performance pay could induce an unintended consequence like crowding-out of patient-regarding behavior (Bénabou & Tirole, 2006; Brosig-Koch et al., 2024; Wang et al., 2020). Besides, it is observed in Figure 27B that the quantities of medical services vary markedly across the low and high bonus levels. To be more exact, it seems that physician agents' provision behavior is more stable and predictable given the high bonus level. The potential health financing policy implication is that a low level of bonus pay may not be able to provide sufficient financial incentives for physicians to change their provision behaviors. Additionally, Figure 27C indicates that the bonus level does not significantly affect physician agents' provision behavior when patients' severity of illness is considered.

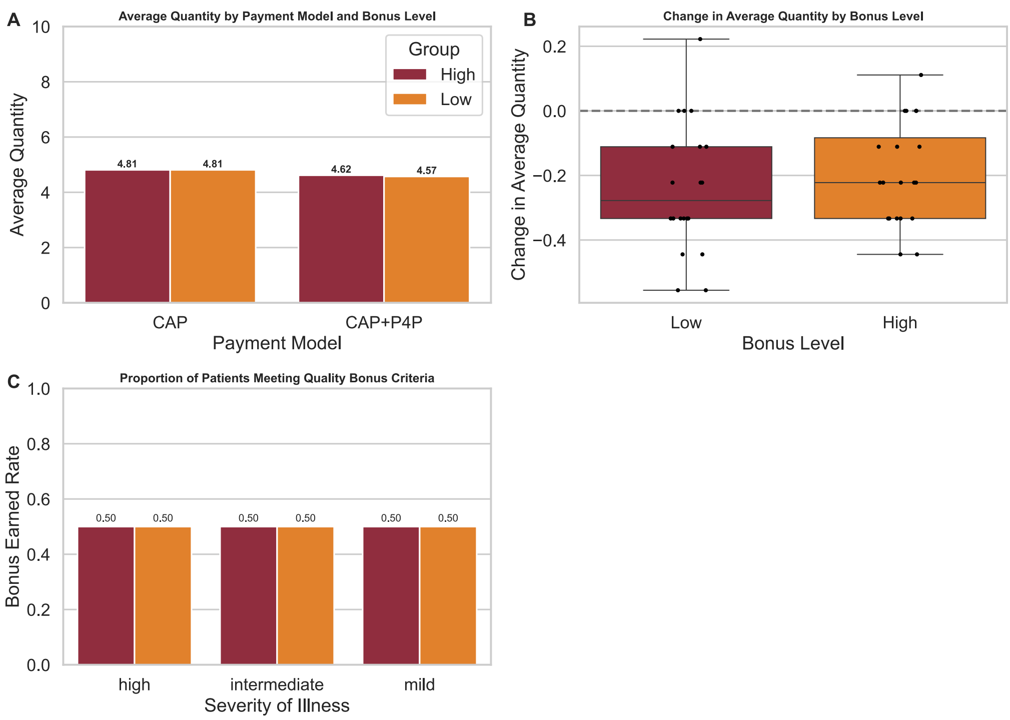

Figure 27. Visualization of synthetic data from the performance pay policy experiment[14]*. Plot A shows the differences in the average quantities of medical services by payment model and bonus level. Plot B*

[14] The number of physicians is 40, and each physician has to make 18 decisions. There are 720 observations in total. The full simulation results for each run have been exported in Appendix D.

illustrates the variations in physician agents' provision behaviors given different levels of bonus. Plot C compares the bonus earned rates by different severities of illness.

To further examine how performance pay (CAP vs. CAP+P4P), bonus levels (low vs. high), and patient severity influence physicians' quantity decisions, a pooled ordinary least squares (OLS) regression model[15] is estimated (Brosig-Koch et al., 2024). The model is specified as follows:

$$Quantity = \beta_0 + \beta_1 Group + \beta_2 P4P + \beta_3 PatientType + \beta_4 (P4P \times PatientType) + \varepsilon \quad (1)$$

Equation (1) estimates the quantities of medical services chosen by each LLM-driven physician agents for all the patients. Group is a dummy variable, being either 0 (low-bonus condition) or 1 (high-bonus condition). Moreover, P4P indicates the introduction of performance pay in phase II of GABM simulation experiments and PatientType is an indicator variable for the patients' severity of illness – mild, intermediate, or high. Since the synthetic data from the base GABM simulation showed that the underservice issue is much more pronounced for complex cases (see Figure 17C in Subsection 5.1.2), an interaction term between P4P and PatientType has been added to the regression model so as to evaluate whether the severity of illness matters more or less when performance pay is active.

The regression results, summarized in Table 10, imply that our OLS model explains most of the variation in LLM-driven physician agents' treatment decisions (i.e., quantities of medical services) perfectly with an adjusted coefficient of determination (R^2) of 0.931. In detail, patient's severity of illness has a significant positive impact on the quantity of medical services chosen by physician agents – the severer, the more

[15] Since each LLM-driven physician agents made multiple decisions across payment types and illnesses, observations were not independent. To account for "within-physician correlation" in decision patterns, we computed clustered standard errors at the physician level, which provide valid inference when repeated measurements originate from the same decision-maker. Clustering adjusts the variance-covariance matrix to allow arbitrary correlation within physicians while assuming independence across physicians, preventing underestimated standard errors and inflated Type I error rates. This approach maintains the interpretability of pooled OLS while appropriately addressing dependence arising from the experimental design.

provision. However, it is also found that the level of bonus payment does not significantly affect the physicians' provision behavior. This finding is in line with the real-world results derived from a behavioral experiment with German primary care physicians (Brosig-Koch et al., 2024). More importantly, performance pay shows a positive but insignificant effect on physicians' decisions on the quantity of medical services in our policy experiment. Only when performance pay is linked to the mild severity of illness will the impact on the quantity of medical services be significant. The relevant policy implication is that patient risks ought to be taken into consideration when designing the P4P scheme in a capitated payment system.

Table 10. Summary of pooled OLS regression model.

Pooled OLS Regression Results (clustered standard errors by physician)						
Variables	*coef*	*std err*	*t*	*P>|t|*	*[0.025*	*0.975]*
Intercept	6.5056	0.065	100.498	0	6.375	6.636
Intermediate severity	-1.6	0.07	-22.827	0	-1.742	-1.458
Mild severity	-3.5167	0.063	-55.5	0	-3.645	-3.389
High-bonus (20%)	0.0222	0.027	0.814	0.421	-0.033	0.077
P4P	0.1167	0.085	1.369	0.179	-0.056	0.289
P4P × Intermediate severity	-0.1417	0.101	-1.404	0.168	-0.346	0.062
P4P × Mild severity	-0.8583	0.105	-8.167	0	-1.071	-0.646

Note: Standard errors are robust to cluster correlation.

In brief, the GABM policy simulation experiments explored whether the introduction of performance pay, the level of bonus payment, and the severity of illness, alter physicians' financial incentives and provision behaviors. Though the P4P scheme may bring about a crowding-out of patient-regarding behavior, it is evident that the performance pay, to some degree, aligns the incentives of physicians, mitigates the underservice issue, and improves the quality of care within a capitation-based system (Brosig-Koch et al., 2024). These important policy insights produced by GABM suggest the need for a more comprehensive CAP payment model that can contribute to population-level and system-wide improvements under HSG.

6.1.2 A Comprehensive CAP Payment Model

As suggested by Lindner and Lorenzoni (2023), Table 11 presents the essential health financing strategies for the development of a comprehensive CAP payment model. The introduction of performance pay along with risk sharing and adjustment mechanisms is fundamental to promote high quality of care, improve care integration, and manage financial risks. These add-ons are anticipated to enhance the sustainability and viability of a capitation-based system (Lindner & Lorenzoni, 2023; Wieck, 2021).

Table 11. An overview of the comprehensive CAP payment model.

Strategy	Description	Rationale	Evidence
Risk adjustment	The CAP payment to healthcare clusters in Singapore only adjusts for age, ignoring other factors like sex, socio-economic status, and health conditions.	Accurate risk-adjustment is crucial for matching funds with needs, especially for seniors and complex cases (Anselmi et al., 2025).	Studies highlight the importance of comprehensive risk-adjustment for effective CAP payment models (Fisher & Lewis, 2023).
Risk pooling	Pooling risks among a group of care providers can help manage or mitigate disproportionate financial risks.	Risk pooling is regarded as more important for small medical clinics than for public healthcare clusters.	A study in the USA found that CAP contracts for groups of PCPs are beneficial for risk sharing (Wieck, 2021).
Shared savings/losses & Stop-loss	The existing CAP model in Singapore does not include shared surpluses or deficits between the payer and providers.	Lack of stop-loss indicates that there is widespread ignorance of the possible financial risks assumed by providers within a capitated system (Wieck, 2021).	A comprehensive CAP model with shared savings/deficits and stop-loss mechanisms can protect providers from large deficits while preserving financial incentives for cost

			control (Lindner & Lorenzoni, 2023).
Performance pay	Apart from the lump-sum CAP payment, the MOH ought to reward providers for achieving targets in preventive care, chronic disease management, and patient health outcomes.	P4P counterbalances the risk of under-provision under CAP by aligning financial incentives with the quality of care and HSG goals.	A behavioral experiment with German PCPs found that the quality of care under performance pay grows by around 7 percentage points compared to the baseline CAP (Brosig-Koch et al., 2024).

In order to gain quantitative insights into the systematic impacts of the hypothetical comprehensive CAP payment model, the basic SD model introduced in Subsection 5.2.1 has been further expanded by incorporating a new module named “Policy”. Figure 28 depicts the schematic diagram of the full SD model that includes a comprehensive CAP payment policy model. It is shown that the policy module is going to interact with the population, provider, and payer sectors over the simulation runs. For example, HSG enrollee expansion policy is assumed to cover the adults who are below 40 years old and young age groups from 2027. Besides, the new referral policy is expected to reduce the walk-in visits at SOCs and meanwhile encourage physicians at community hospitals to refer stable cases back to PCPs in the provider module. Finally, a series of risk adjustment and sharing mechanisms as well as the P4P scheme will have great impacts on the annual CAP payments to private medical clinics and public healthcare clusters. When comparing the new policy scenario with the previous two scenarios in Subsection 5.2.4, it will add to a better understanding of how the comprehensive CAP payment model can transform the local healthcare system under HSG.

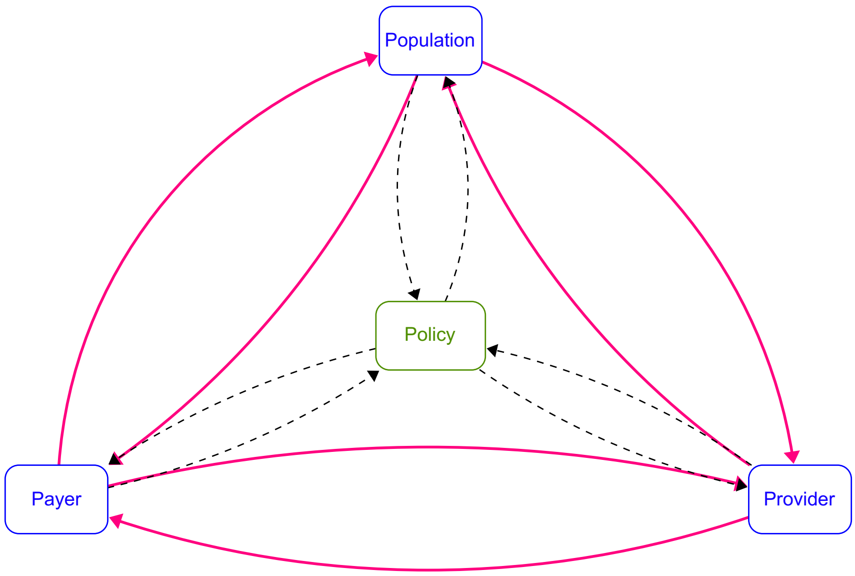

Figure 28. High-level overview of the comprehensive policy model.

First of all, the comparative bar chart in Figure 29 indicates that there are going to be even more healthy residents than those estimated in counterfactual and baseline scenarios by 2030, primarily owing to preventive and coordinating efforts (e.g., the expansion of HSG enrollees and the introduction of a two-way referral mechanism). To be more specific, the improved population health is underpinned by more primary care attendances and fewer SOCs attendances (see Figure 30). The enhanced primary care is projected to promote disease prevention and relieve the operational stress of SOCs and acute hospitals within the local health system (Health Bureau, 2022, n.d.; Matchar et al., 2025; Matchar et al., 2016; Ride et al., 2022). Additionally, the introduction of risk sharing and adjustment mechanisms is anticipated to improve the financial performance of both private and public healthcare providers. For example, it is observed that medical clinics can achieve higher annual profits on average, and healthcare clusters will experience positive rather than negative profit when comparing Figure 31 with Figure 25 in Subsection 5.2.4. This finding echoes earlier researches that emphasize the importance of shared surpluses or deficits as well as stop-loss mechanism in CAP payment model design (Lindner & Lorenzoni, 2023; Wieck, 2021).

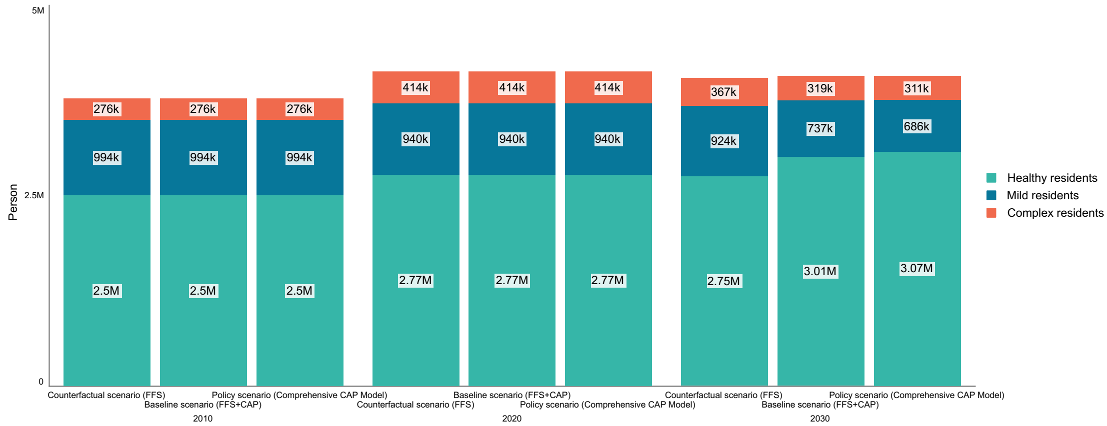

Figure 29. The distribution of population health states under three scenarios.

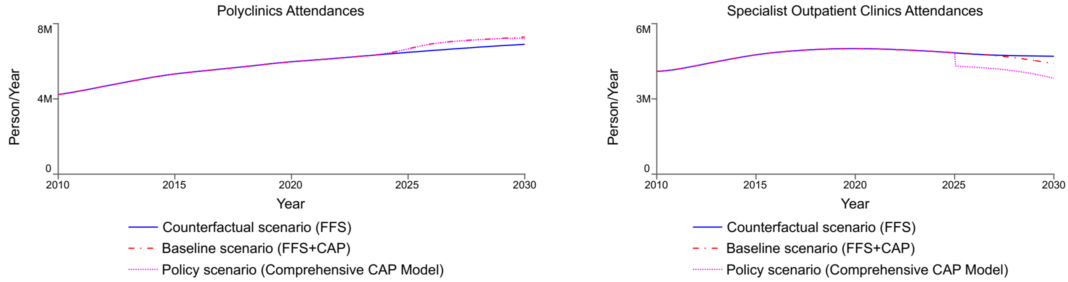

Figure 30. Polyclinics and SOCs attendances under three scenarios.

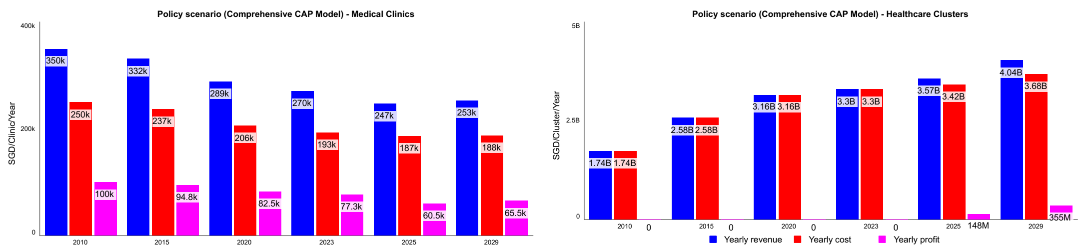

Figure 31. Financial performance of private and public providers under the policy scenario.

Nevertheless, implementing a comprehensive CAP payment model also entails certain trade-offs. As far as the payer is concerned, simulation results, shown in Figure 32, indicate that the MOH need to accordingly increase the annual budgets for services program so as to partially compensate the losses or deficits of healthcare providers. Moreover, the risk sharing or adjustment mechanisms and P4P elements are anticipated to engender uncertainty in the budget formulation phase, as demonstrated by the oscillatory behavior in Figure 32 when the comprehensive CAP payment model notionally starts in 2025. In practical terms, a dynamic performance management approach is essential for effectively managing the common-pool resource of CAP funding made by the MOH.

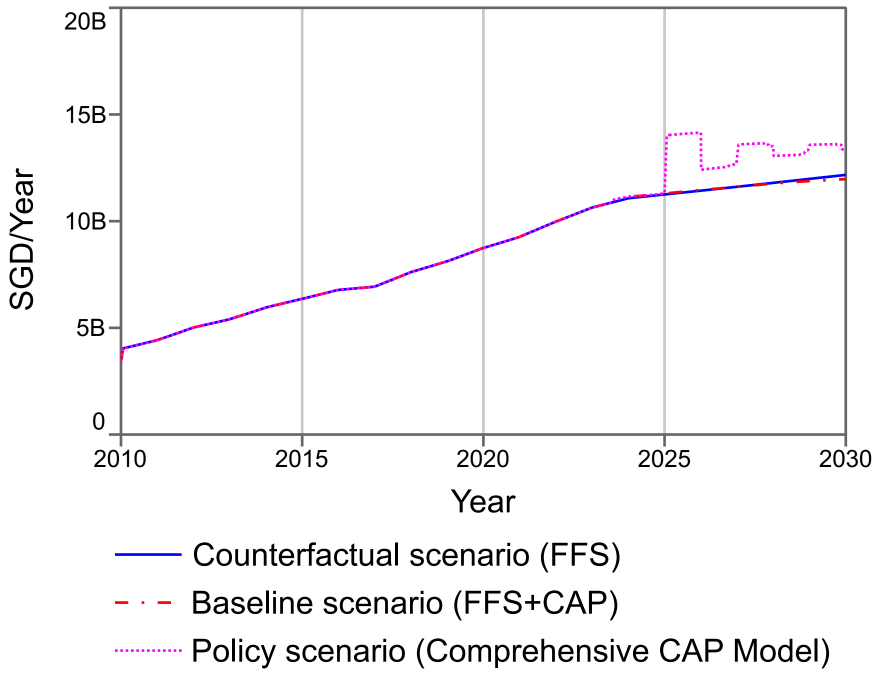

Figure 32. The simulated health spendings on services program under three scenarios.

In a nutshell, the proposed comprehensive CAP payment model extends the current one by adding risk adjustment or sharing mechanisms and the P4P scheme. In this policy simulation experiment, we have configured a single full policy scenario where all designed schemes are turned on, but the exploration of policy effects of any individual or small sets of health financing strategies is available in the SD model-based interactive learning environment (see Section 6.3). We admit the fact that the transformation of payment system from volume to value cannot happen instantaneously (Miller, 2009), but it is recommended to refine the current CAP funding model in Singapore by designing a more comprehensive capitated system that incorporates some strategic features outlined in Table 11. More importantly, the successful implementation of the comprehensive CAP payment model is integral to a viable governance architecture for HSG. It reinforces a key conclusion of this thesis: payment reform cannot be evaluated in isolation from health system governance.

6.2 Governance Architecture for HSG

The recent CAP payment reform in Singapore fundamentally shifts the incentives for care delivery and resource utilization. However, payment reform is not just technical;

it is institutional and behavioral. Such a reform requires robust governance to steward the health system toward desired policy objectives under the HSG initiative. Therefore, technical simulation models alone are not enough. Good governance arrangements, such as transparent reporting, performance-based payment adjustment, and collaborative care delivery, are fundamental to reshape public-private-population partnerships (Foo et al., 2025). Despite this recognition, what constitutes good health system governance and how to improve the governance capability and governance performance, remain unresolved challenges that local policymakers continue to grapple with (Brinkerhoff & Bossert, 2013).

6.2.1 The Essence of Good Governance

It is known that governance plays a pivotal role in shaping the performance of health systems, as it encompasses the processes and structures through which decisions are made, policies set, and outcomes monitored (Ramesh & Qian, 2025). The primary objective of health system governance is to ensure that the local health services delivery can maximally meet the needs of the population (Cinchon et al., 1999, p. 241). Fundamentally, good governance entails adhering to the most effective governance practices underpinned by a series of principles like transparency and accountability as well as proactive initiatives (NHS Scotland, 2022, ch.3 & 4). To demonstrate, transparency helps establish partnerships and mutual trust between stakeholders in health systems. As the Independent Commission on Good Governance in Public Services noted, "*good governance leads to good management, good performance, good stewardship of public money, good public engagement and, ultimately, good outcomes*" (OPM & CIPFA, 2004, p. V).

In the context of healthcare, governance takes place at the three distinct levels of macro, meso, and micro (Durán et al., 2011; Saltman & Duran, 2016). The macro level primarily encompasses national-scale health policy formulation and decision-making. The meso level focuses on the decision-making processes at the institutional or regional level. Conversely, the micro level addresses routine operations at the clinical level. This multilevel characteristic of health systems calls for integrated and collaborative governance that promotes transparency and accountability across revenue collection, risk pooling, strategic purchasing, and benefit sharing across public and private organizations when implementing health financing reforms (Kutzin et al., 2017; NHS Scotland, 2022; Peskett, 2009). Given that the effective governance of complex systems typically involves nested bodies (Ostrom, 1994, 2005a, 2005b), gap in governance at any level can breed conflicting goals or actions and undermine the function of health systems as a whole (Ostrom, 2010).

6.2.2 Integrated Health System Governance Design

Smart governance of complex health systems is supported by governing through adaptive policies, resilient structures, and foresight (Kickbusch & Behrendt, 2013; Kickbusch & Gleicher, 2012). To enhance the local health system governance and make HSG attainable, it necessitates an integrated governance framework that consolidates strategic planning, performance monitoring, and organization coordinating. Building upon the synthetic insights derived from the VSM and DPG models, a multi-tier governance framework tailored to Singapore's health system is proposed to facilitate cross-level collaboration and shared decision-making among diverse actors.

Following a "*triangle of rules*" in health system governance (Abimbola, 2020), Figure 33 contextualizes it within Singapore's health system. Firstly, at the constitutional level, the Government of Singapore and the Parliament establish national health laws and financing schemes. The MOH is responsible for the internal management of both public and private healthcare institutions as well as the external collaboration with other ministries, such as the Ministry of Finance, to secure cross-sectoral support. The constitutional rules-in-use usually entail national health policy formulation and enforcement by government bodies, who set regulatory frameworks and oversee the whole health system.

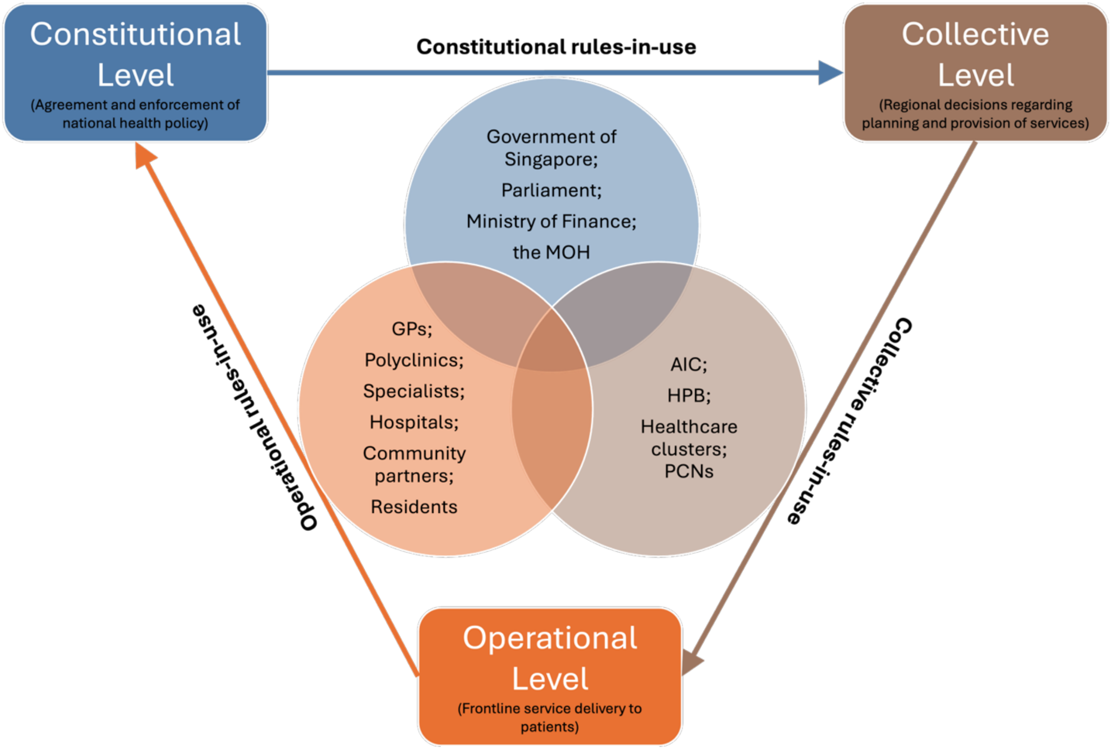

Figure 33. A multi-tier governance framework customized for Singapore's health system. Source: adapted from Sanderson et al. (2020, Fig. 1).

At the collective level, there are healthcare clusters and PCNs who translate national policies or regulations into regional practices, including planning, contracting, and performance management. Simultaneously, specialized agencies under the MOH, such as HPB and AIC, can provide professional assistance for the implementation of health promotion and disease prevention programs and coordinate the care delivery across hospitals, clinics, and communities (Earn, 2020). Finally, the operational level represents the day-to-day delivery of health services to residents or patients. Diverse providers can be involved in service delivery, depending on the venues. Meanwhile, the clinical performance and population health outcomes are a matter of concern to national policymakers who need to adapt the constitutional rules-in-use accordingly for the desired population health goals. As a result, a close-loop governance system is realized. To sum up, the alignment of muti levels, from the national to regional to clinical layer, underscores how constitutional and collective rules shape operational practices, while feedback from the frontline care delivery informs the higher-level decision-making and national health policy adjustment (Cinchon et al., 1999, p. 91). This integrated health system governance design delineates the distribution of rules-in-use and decision-making authority across three tiers of governance within Singapore's healthcare system, thereby augmenting the system-wide adaptability and resilience in the future. A supportive governance system is anticipated to leverage intelligence and evidence generated throughout the policy formulation, implementation, and an ongoing cycle of impact evaluation and structure redesign (World Health Organization, 2007).

6.2.3 Governing Policy Levers

Along with the high-level integrated health system governance design, we draw attention to a few leverage points that could be instrumental in ensuring that the recent CAP payment reform under HSG can translate into population health improvement, provider financial stability, and health system viability in the end. Key governance decisions warranting close examination include:

- Allocation of CAP budgets

A critical governance decision concerns the proportion of CAP budgets allocated to preventive and primary care. As the DPG chart demonstrates, this allocation influences the uptake of healthy lifestyles, the utilization of primary care, and ultimately the prevalence of chronic illnesses in an ageing society like Singapore. The SD simulation experiment provides further quantitative insights into the potentially substantial gains in population health outcomes and savings of public health spendings in the long term. From a VSM perspective, this is the policy (S5) function that requires governance coherence and policy consensus across the whole healthcare system. If left to fragmented decision-making by diverse stakeholders with conflicting goals, there might be an inefficient allocation of financial resources (Sanderson et al., 2020), thereby causing underinvestment in preventive interventions and perpetuating cost pressures for hospitals (Wieck, 2021). Establishing a national guideline of "ring-fenced" funding for preventive care (Bishai et al., 2014), while allowing for contextual adaptation at RHSs, can help balance accountability with autonomy. This approach protects health promotion and disease prevention from being systematically neglected in the real world.

- Strengthening coordination mechanisms

Additionally, the VSM exercise highlighted that patients have to "navigate across complex unit boundaries" so as to get access to the right care (Hoverstadt & Loh, 2022). This maps onto the coordination subsystem (S2), where duplication and the misaligned referral protocol undermine service efficiency and care integration in Singapore's health system. To illustrate, the SD model tests a policy of referring stable cases from community hospitals to private GPs. It shows that population health outcomes get improved over time. The DPG chart also underscores the importance of cross-sectoral care integration and stakeholder collaboration within a capitation-based system. Stronger service coordination between public and private providers is expected to reduce avoidable emergency visits and supports smoother patient navigation and better chronic disease management for the elderly. In addition to the existing coordinating efforts, good health system governance need to encourage a two-way referral protocol (Health Bureau, 2022), implement an interoperable IT system (Ministry of Health, 2022b), and provide necessary financial incentives by rewarding integrated care delivery teams like PCNs.

- Developing primary care capacity

A radical shift in health services needs more than the accompanying CAP payment reform. As highlighted by the DPG chart, the resident-to-GP ratio, utilization of primary care, and physician satisfaction co-shape population health outcomes in complex health systems. The simulation results from the SD model unequivocally demonstrate that the absence of adequate service capacity building will lead to primary care operating under significant stress, resulting in compromised performance. Yet the VSM exercise revealed a persistent weakness: clinicians are rarely developed as system leaders, limiting the adaptive capacity of the local health system (Hoverstadt & Loh, 2022). This falls within the development subsystem, where innovation, foresight, and autonomy play a key role. Therefore, attaching importance to leadership development for GPs and service capacity building at primary care settings would contribute to bridging the gap between routine operations and desired HSG goals.

Taken together, these leverage points help direct policymakers' attention toward the fields where Singapore's governing policy interventions should focus on:

  - CAP funding allocation rules that determine whether preventive care receives sufficient resources;

- Coordination mechanisms which can transform fragmented operations into integrated pathways;
- Primary care capacity development to ensure that health system governance is underpinned by clinical expertise from the bottom up and healthcare needs are met.

To conclude, the policy experiments emphasize a central theme: payment reform is never only about money. It is also concerned with governance that underpins the systematic ability to align incentives and actions of multiple stakeholders from different levels of health systems with long-term population health development goals.

6.3 Interactive Learning Environment Design

To support policy learning and systematic analysis of CAP payment reform under the HSG initiative, this study develops a SD model-based interactive learning environment or management flight simulator (Sterman, 2014a, 2014b; Sterman et al., 2013). The simulator is designed as a policy "microworld" (Hirsch & Immediato, 1999) or learning laboratory (Matchar et al., 2025) that enables users to explore the dynamic consequences of alternative health financing strategies and governance choices (Hirsch & Miller, 1974). Rather than serving as a predictive tool, the environment emphasizes structural understanding, feedback reasoning, and experiential learning of CAP payment reform within complex health systems.

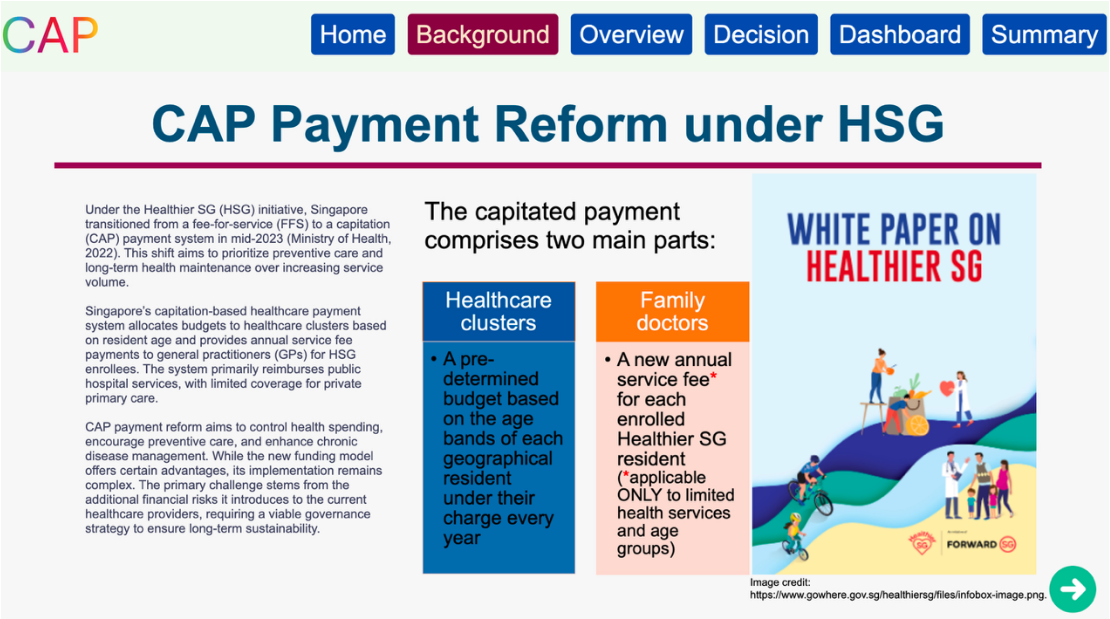

Figure 34. The screenshot of SD model-based interface.

The interface[16], shown in Figure 34, is organized into five main components, which jointly guide users from the initial research background introduction to the final simulation-based policy reflection. In addition to the "Home" landing page, they are:

- Background

The "Background" page situates the learning environment within the institutional and policy context of Singapore's transition from FFS to CAP payment model under HSG. It briefly introduces the implementation of CAP funding method in Singapore's health system – what does the CAP payment mean to public healthcare clusters and private medical clinics, respectively? This section also highlights the rationale for CAP payment reform, including cost containment, prevention-oriented care, and long-term population health management. Implicitly, it draws attention to the key health financing and system governance challenges associated with CAP payment model, such as risk transfer to providers, coordination across healthcare clusters and family doctors, and the need for accountability mechanisms. By grounding the model in real-world payment reform objectives and constraints, this section establishes the policy relevance of the simulation exercise.

[16] The interface can be accessed online: https://exchange.iseesystems.com/public/zhenghua-yang/cap-payment-reform.

- Overview

The model overview page presents the underlying SD model structure embedded in the simulating platform. As introduced in Subsection 5.2.1, the SD model captures the core interactions among the population, provider, and payer modules in Singapore's health system. This section provides users with a transparent representation of model boundaries, SFDs, mathematical equations, and variable documentation, ensuring that the source model logic and structure is accessible rather than a "black box". It aims to help users navigate the complicated model structure step by step and gain a better understanding of model components and assumptions.

- Decision

The "Decision" page operationalizes the learning environment by allowing users to actively intervene in simulation experiments. Users assume the role of a policymaker or manager and can adjust the available health financing policy options related to the comprehensive CAP payment model introduced in Subsection 6.1.2, such as budget allocation priorities, HSG enrollee expansion, risk sharing or adjustment mechanisms, and others. To some extent, these decisions reflect the realistic health financing and governing policy choices under HSG. Through repeated and no-cost experimentation, decision-makers can test their own policy assumptions and observe how short-term improvements may generate long-term trade-offs, thereby experiencing the tensions and uncertainties inherent in the current CAP payment reform in Singapore.

- Dashboard

The "Dashboard" page further provides real-time visualization of simulation results, translating complex system behaviors into interpretable performance indicators. Typical KPIs include population health outcomes, service utilization patterns, and healthcare expenditure trajectories over time. By presenting results dynamically, the dashboard supports pattern recognition and policy comparison across scenarios, enabling users to link observed policy outcomes back to the underlying model structure rather than isolated parameter changes.

- Summary

Finally, the "Summary" section synthesizes simulation results and reinforces key learning points. It encourages users to reflect on how different policy choices perform across multiple dimensions, such as health outcomes, service utilization, and risk management. Rather than identifying an “optimal” policy, the summary highlights trade-offs, unintended consequences, and conditions under which the transition from FFS to CAP may succeed or fail. In doing so, the interactive learning environment aligns with the SD tradition of using simulation to enhance systems thinking and governance capability in complex health systems (Hirsch & Rice, 2020; Matchar et al., 2025).

7 Discussion and Conclusion

In this concluding chapter, the findings of the entire study are synthesized. Initially, we present a review of the applied analytical methods and key research findings. Then, the implications for governance theories and policy practices are discussed in detail, focusing on how the present research integrates and extends diverse perspectives from mixed theories and what valuable insights health policymakers can learn from the modelling study. Thirdly, it reflects on the role of model, clarifying how model serves as an explanatory and exploratory tool or governance aid in this case. Furthermore, it details the study's constraints, notably in data, model, and timeframe, as well as identifies opportunities for future work, emphasizing empirical testing and methodological innovation. Lastly, the chapter concludes with reflective insights, situating the research within broader discussions on the topic of sustainable health financing and integrated health system governance.

7.1 Review of Analytical Methods

This dissertation aims to investigate both financial risks and governance challenges resulting from Singapore's CAP payment reform under HSG. The central research problem was formulated based on two interrelated concerns: firstly, the potential financial risks could be assumed by private medical clinics and public healthcare clusters under the CAP payment model; and secondly, the viable governance arrangements are necessary to guarantee that payment reform not only yields service efficiency gains but also promotes the quality of care and financial sustainability. Given the multifaceted nature of payment reform, this study advances the underlying research methodology by combining qualitative system frameworks with quantitative simulation models rather than employing a single model, shown in Figure 35. It has been argued that "*A fragmented approach was characterized as failure-prone, and an integrated approach was deemed potentially very effective*" (Osborne, 2009, p. 212). As a result, this thesis demonstrates the added value of such methodological integration:

- VSM mapped complex health systems in a structural manner;

- DPG illuminated the role of dynamic performance monitoring and collaborative governance;
- GABM investigated the individual physicians' provision behavior under different payment conditions;
- SD revealed long-term dynamics, unintended consequences, and policy trade-offs.

Figure 35. Applied analytical frameworks or models in the thesis.

In detail, the VSM exercise has been employed to map Singapore's health system and analyze institutional governance coherence or challenges. The recursive structure of VSM highlights that each layer needs sufficient autonomy to adapt to the dynamic environment, while remaining accountable to the upper level. It is important to strike a balance between autonomy and control because health system governance might falter when one level such as national regulators at the top dominates the decision-making process without effective feedback from the lower level or frontline healthcare workers. Additionally, the DPG framework draws attention to dynamic performance monitoring and public-private collaboration in order to attain the HSG initiative. It clusters strategic resources, performance drivers, and end results, aligned with Singapore's CAP payment reform. In combination, the qualitative models enable an in-depth analysis of systemic viability, coordination mechanisms, and performance accountability, as well as contribute to an enhanced understanding of how health systems can be strengthened via a nested and integrated governance framework.

Regarding health financing and service delivery, simulation experiments have been conducted to investigate how payment mechanisms affect physicians' provision behavior with the emerging and innovative GABM (Ghaffarzadegan et al., 2024). It is found that the CAP reimbursement method can induce under-provision of medical care, while the extra performance pay relatively mitigates this issue and improves the quality of care. Subsequently, the SD model customized for Singapore's health system has been constructed to capture the interrelationships between the population, provider, and payer sectors at the macro level. The simulation results suggest the potential financial risks for healthcare providers and the inherent limitations of a simple CAP funding model. Collectively, the simulation models provide quantitative insights into the care delivery microsystem as well as population-level health system performance within a capitation-based system.

To conclude, the integration of VSM, DPG, GABM, and SD modelling methods adds to a better understanding of Singapore's CAP payment reform and offers a holistic view on the major enablers or barriers, feedback mechanisms, and institutional tensions that shape the end results of the HSG initiative on the path forward. In general terms, the methodological integration advances the development of health services and systems research, as well as fosters a deep comprehension that could not have been achieved by any single modelling approach.

7.2 Synthesis of Research Findings

Supported by a set of integrated models, a holistic view on payment reform have emerged. The findings confirm that while the CAP funding method can incentivize preventive care and cost containment, it may entail unintended consequences of underservice, patient selection, and financial instability. Governance thus plays a vital role in determining whether the recent CAP payment reform will strengthen or undermine the local health system performance under HSG. More concretely, several key findings are highlighted:

- The fundamental alteration of incentives under CAP

One of the most consistent findings is that the shift from FFS to CAP profoundly alters the incentive environment for providers (Bodnar et al., 2023; Brosig-Koch et al., 2024; Hennig-Schmidt et al., 2011; Li et al., 2022). In other words, payment reform not only changes funding mechanisms, but also physicians' incentives and provision behaviors. Under FFS, providers are motivated to maximize service volume over value, causing over-treatment and escalating healthcare costs. On the contrary, CAP incentivizes providers to control expenditures by focusing on disease prevention, care coordination, and waste reduction (Ministry of Health, 2022b). However, it is also found that CAP may induce opportunistic behaviors because care providers are inclined to provide fewer services, select healthier patients, or avoid costly cases for the sake of their own business interests (Wieck, 2021). Without effective risk management and performance monitoring, these risks can become systemic weaknesses, undermining health equity and universal access. Thus, CAP is not inherently superior to FFS. Its effects are contingent on how incentives are aligned and behaviors are moderated by viable governance arrangements.

- The critical role of primary care in health systems

In the face of ageing population with rising chronic disease prevalence, it has been recognized under the HSG initiative (Ministry of Health, 2022b) that primary care plays a pivotal role in shifting toward health promotion by integrating social prescribing (Lean, 2025) and in alleviating the burden of the overstretched public healthcare sectors (Health Bureau, 2022). According to the report drafted by McNeely et al. (2022), it is also a key lever to advance health equity. With the implementation of CAP funding method, Singapore's PCPs are now rewarded for actively managing residents' health rather than episodic encounters (Ministry of Health, 2022b). As the backbone of health systems and the gateway of the pyramid of health services (Dovey et al., 2001; Health Bureau, 2022; Tan & Ng, 2023), Singapore's primary care ought to be further enhanced to provide preventive, continuous, and timely care for residents living at communities

(Matchar et al., 2025).

- The required risk management for financial sustainability

Yet, this study also echoes that many PCPs, especially small or solo practices, lack the financial resilience and organizational capacity to assume large financial risks within a capitated system (Foo et al., 2023; Wieck, 2021). Simulation modelling confirmed the existence of possible financial risks for public and private providers. The results show that small medical clinics or public healthcare clusters can suffer from revenue loss or even negative profit under CAP payment condition. Besides, international evidence demonstrates that the absence of stop-loss provisions and risk-adjusted funding rates frequently cause financial failures among private practices, due to a few enrolled patients with complex medical needs (Wieck, 2021). Within a capitation-based system, accuracy in cost estimates and rate setting is of paramount importance to the population, providers, and payers involved (Lindner & Lorenzoni, 2023). This underscores the necessity of a comprehensive CAP payment model, supplemented by risk sharing or adjustment mechanisms and the P4P scheme, which protects providers from suffering extreme risks or losses. High levels of CAP payment is believed to facilitate a more significant shift of primary care toward proactive and preventive care (Basu et al., 2017).

- The overlooked cultural and organizational change

The transition to CAP funding mechanism requires fundamental shifts in organizational culture, clinical practice, and professional identity too. GPs who have been accustomed to the legacy FFS reimbursement method may resist to join a capitated system due to fears of income loss and perceived threats to professional autonomy. For this reason, it is essential to build mutual trust, cultivate clinical leadership, and foster team-based care delivery under HSG. Moreover, the integration of community care and social services emerges as a key enabler in this regard (Lean, 2025; Ministry of Health, 2022b). A capitation-based system works best when public and private providers coordinate across healthcare sectors, supported by shared IT systems (Ministry of Health, 2022b), two-way referral mechanisms (Health Bureau, 2022), and performance measurement frameworks (Foo et al., 2025). Without complementary organizational integration and cultural transformation, payment reform alone cannot achieve the desired policy outcomes of the HSG initiative.

- The fundamental role of governance toward the sustainable payment reform

Perhaps the most important finding of this study is that governance is not an adjunct to CAP payment reform but its precondition. The HSG initiative illustrates how CAP is being pursued in tandem with broader strategies of population health management (Ministry of Health, 2022b). As a part of whole-system change, CAP payment must be embedded within a broader governance framework (Comendeiro-Maaløe et al., 2019) that ensures system-wide transparency, accountability, adaptability, and viability. As a determining factor of payment reform, the VSM and DPG models suggest that viable governance needs to take both the top-down and bottom-up approaches so as to make health systems adaptive across macro, meso, and micro levels. Facing the evolving public-private-population partnerships (Foo et al., 2025), this modelling study demonstrates that siloed or piecemeal reforms often fail in the end, whereas systematic transformation that align health financing, service delivery, and system governance are more likely to be successful in the long term.

To sum up, this thesis converges on a central conclusion: CAP payment reform is not merely related to the financial adjustment. Experimental evidence shows that private and public healthcare providers may encounter financial vulnerability in the absence of adequate risk management mechanisms. Moreover, CAP reshapes the financial incentives for providers, thereby requiring the necessary cultural and organizational change (Cui et al., 2025; Lin et al., 2013). The success of payment reform depends on aligning strategic resources with patient needs, embedding payment mechanisms within robust governance arrangements, supporting providers through risk adjustment mechanisms, and recognizing the complex and dynamic nature of health systems.

7.3 Implications and Recommendations

Drawing upon the research findings, this study provides critical insights that carry both theoretical and practical significance. In certain respects, we have applied and extended upon the mixed governance and complexity theories throughout the modelling study.

Additionally, model-generated policy insights provide useful recommendations to make Singapore's CAP payment reform sustainable and the HSG initiative attainable.

7.3.1 Implications for Theory

Since theory can guide the model development and offer explanations for simulation results, multiple theoretical frameworks concerning governance, institutions, and complex systems, have been explored and extended within the present study. Table 12 reviews the applied theories and their extensions.

Table 12. Theoretical application and extension.

Theory	Application	Extension
Principal-agent theory	Employs principal-agent theory to examine the roles played by key actors (i.e., patients, providers, and payers) in healthcare, being either principals or agents.	Refines principal-agent theory for multi-layered health system governance by demonstrating how providers can act as both agents and principals (i.e., multi-positional actors) within a capitated system.
Common-pool resource theory	Applies common-pool resource theory to Singapore's CAP payment reform, suggesting that governing the allocation of limited financial resources requires similar design principles to common-pool resource governance.	The VSM exercise demonstrates the need for nested and adaptive governance, highlighting the importance of balancing autonomy and control across different levels of health systems.
North's institutional theory	Engages with North's institutional theory, elucidating how path dependency and institutional inertia may impede the transition from FFS to CAP.	The VSM points out institutional stickiness, blame culture, lack of capacity, and other factors that are the barriers to the CAP payment reform and viable governance.
Feedback theory	Uses cybernetic and feedback thinking to enrich the endogenous view and	The VSM, DPG, and SD approaches operationalizes feedback theory

	system modelling of financial risks and governance challenges associated with the CAP funding model.	from a systematic level, contributing to systems thinking on Singapore's CAP payment reform under HSG.

- Principal-agent theory

The traditional principal-agent theory in healthcare underlines the asymmetry between patients (principals) and providers (agents), or between payers (principals) and providers (agents). Indeed, it provides necessary but insufficient explanations for the incentive alternation resulting from payment reform. Instead of exclusively treating providers as agents, this study contributes to the refinement of principal-agent theory by recognizing providers as "multi-positional actors" (Oleart & Bouza, 2017) in health system governance. In addition to being agents who are bound by the contractual and fiduciary responsibilities for payers and patients, providers also act in a principal-like capacity, influencing or constraining patient behaviors like adherence to health plans or treatment regimes. In this sense, patients can be regarded as "agents" who may or may not comply with lifestyle advice or treatment plans, creating a reverse asymmetry of information and motivation within a capitation-based system.

Considering the expanded scope of work under HSG, providers now take the dual responsibility of encouraging preventive care among residents while managing the chronic diseases of patients (Foo et al., 2023; Ministry of Health, 2022b). That is to say, they simultaneously act as both agents (to payers and patients) and principals (to patients), and their roles interact in complicated ways that may cause conflicts of interest and produce unanticipated consequences like risk selection or underservice, as demonstrated in GABM simulation experiments. Consequently, it necessitates a reconceptualization of principal-agent theory to accommodate role multiplicity and the dynamic adjustment of incentives in response to varying payment conditions. To some extent, Singapore's CAP payment reform amplifies the complexity of multi-layered principal-agent interrelationships, highlighting the role of viable and integrated health system governance in achieving a balance between the principal's and agent's interests in complex adaptive health systems (Conrad, 2015).

- Common-pool resource theory

Another theoretical contribution is the application of common-pool resource theory to the study of health financing and system governance. The recent transition from FFS to CAP has significantly changed the reimbursement method and redistributed financial risks between the payer and providers. Instead of retrospectively demanding reimbursement for medical and other expenses from the MOH based on volume-based billing data, public healthcare clusters and private medical clinics now take the responsibility of independently and prospectively determining how to make use of the lump-sum CAP payment every year. In this respect, the annual CAP payment functions as a shared fund pool, thereby requiring designing rules and institutions to ensure fair use, prevent opportunism, and maximize results. In accordance with Ostrom's design principles for the successful self-governance of common-pool resources (Ostrom, 1990, 2005a), the utilization of scarce financial resources for the provision of health services necessitates the application of analogous design principles, including clearly delineated boundaries, equitable distribution of benefits and costs, effective oversight mechanisms, graduated sanctions, and nested enterprises (Sanderson et al., 2020), as exemplified in Table 13. In our study, the VSM and DPG frameworks reinforce and extend these polycentric governance principles (Ostrom, 2010), highlighting the significance of dynamic adjustment of strategic resources, collaboration with external stakeholders, and system-wide adaptation in governing the complex health systems.

Table 13. Application of Ostrom's design principles for governing a capitation-based system.

Principle	Explanation	Solution
Clearly defined boundaries	Defining who and what are covered by the CAP payment model.	Making the key information transparent to residents and providers.
Proportionality	Aligning CAP payments with expected needs, so that high-risk patients don't bankrupt the pool.	A comprehensive CAP payment model with risk sharing and adjustment mechanisms.
Monitoring	Tracking service utilization and	Regular performance report of

	quality of care to prevent under-provision of or under-investment in preventive care.	strategic resource utilization and population health outcomes.
Graduated sanctions	Implementing corrective measures to address instances of providers manipulating the CAP payment model.	Establishing penalty policies and ACOs.
Nested enterprises	Pooling risks across larger entities rather than leaving small medical clinics exposed to extreme and disproportionate financial risks.	Experimenting on allocating capitated payments to a group of providers like PCNs.

- North's institutional theory

Besides, alternative payment models like CAP may threaten the business model of care providers and medical product suppliers that thrive under the FFS reimbursement method (Williams, 2017). According to North's institutional theory , there might be policy resistance among public healthcare clusters and private medical clinics because of institutional inertia, vested interests, and professional norms (Cinchon et al., 1999). To avoid policy resistance or policy failure, payment reform requires institutional transformation that can transcend entrenched routines and establish organizational capacity for enhanced preventive care delivery and system-wide care integration under HSG (Cheah et al., 2012). The VSM exercise advances the theoretical understanding of organizational challenges by showing that institutional stickiness, blame culture, and insufficient capacity for system redesign are the major barriers to Singapore's CAP payment reform (Hoverstadt & Loh, 2022). It suggests that payment reform must be studied not only in terms of economic incentives, but in relation to institutional histories, norms, and expectations that shape provider and patient behaviors or interactions.

- Feedback theory

The application of cybernetic principles, particularly feedback and control theories, further enriches the holistic understanding of financial risks and governance challenges associated with payment reform. In essence, CAP payment reform cannot be conceptualized as a single and isolated event; rather, it should be regarded as a component of the HSG initiative, which integrates with other aspects of the local health system. VSM applies cybernetics to organizational design, showing how system-wide viability relies on recursive structures of communication, control, and coordination (Beer, 1984, 1995). The DPG framework operationalizes feedback and systems thinking by emphasizing the interrelationships between strategic resources, performance drivers, and end results across public and private entities (Bianchi, 2021); The SD approach provides a formal simulation of system-wide interactions, making the reinforcing and balancing feedback loops that drive dynamic behaviors explicit (Forrester, 1961).

7.3.2 *Implications for Practice*

While the theoretical contributions of this thesis enrich scholarly understanding of payment reform and system governance, their practical significance lies in guiding the key stakeholders (see Figure 36) through the implementation of CAP funding mechanism under HSG. To be specific, it is important for the MOH at the national level to acknowledge the importance of aligning health financing reform with viable governance arrangements. The CAP payment reform ought to be accompanied by risk adjustment protocols, dynamic performance monitoring, and healthcare quality safeguards. The implementation process requires building trust with healthcare providers and residents, cultivating clinical leadership, and promoting healthy lifestyles. Additionally, the transition from FFS to CAP implies that healthcare clusters at RHSs enjoy greater flexibility regarding the use of funds compared to the past. In order to maximally satisfy the care needs of regional residents, it is suggested to implement a ring-fencing health financing policy by actively allocating a portion of the lump-sum CAP payment to preventive interventions and care coordination programs that involve private GPs and community workers. From this perspective, Singapore's healthcare clusters need to evolve into a collaborative governance platform, comprised of joint committees and task forces that convene the MOH, public and private providers, community partners, and residents for shared decision-making and population health management. In this sense, they are positioned to act as integrators that monitor provider performance, coordinate care pathways, and support GPs and community partners. Transforming from public healthcare institution managers to regional healthcare collaborators will reshape the traditional role of healthcare clusters and build the organizational capability for collective and inclusive health governance.

At the frontline of care delivery, medical clinics offer accessible, affordable, and comprehensive services, spanning from treatment of mild acute conditions, management of chronic conditions and vaccinations, to coordination of patient care with other providers (Ministry of Health, 2025; Muhlestein et al., 2025). Currently, there remains a substantial gap in realizing the "*One Singaporean, One Family Doctor*" vision (Cheong, 2024; Ministry of Health, 2017). To this end, it requires necessary support for enrolling GPs into the HSG initiative. To be more precise, complementary skill training and technical support like IT should be offered to them so as to minimize the administrative burden and enhance the capacity for health promotion and chronic disease management (Foo et al., 2023). It is expected that GPs at medical clinics can embrace a cultural shift toward disease prevention and establish a good and long-term relationship with patients under HSG (Ministry of Health, 2022b).

Fundamentally, the policy effect of HSG depends on public engagement and active citizenship. Previous surveys indicate that health literacy levels vary widely among Singapore residents (Huang et al., 2021; Suppiah et al., 2023), and patient trust in primary care remains uneven compared to specialist or hospital care (Ministry of Health, 2022b). As a consequence, there is a practical need for health coaching, community-based education, and digital tools to assist residents in adopting healthy lifestyles and managing their own health actively. Without patient buy-in, Singapore's CAP payment reform risks being undermined by the persistent reliance on disease treatment and hospital care.

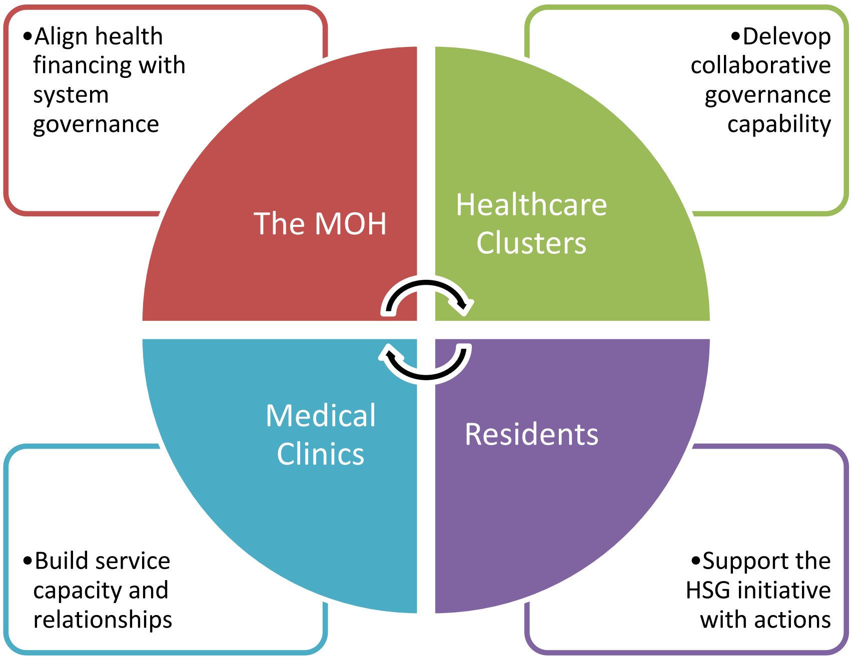

Figure 36. Recommendations for key stakeholders in Singapore.

More broadly, there are several strategic policy directions and practical recommendations for Singapore's health system transformation, including:

- Moving toward value-based payment

Recognizing that volume-based payment drives healthcare expenditures and resource waste, the movement toward value-based payment models has attracted significant attention among health financing scholars and policymakers in recent years (James & Poulsen, 2016; Werner et al., 2021; Wieck, 2021). The basic principle of value-based payment is to incentivize care providers to control costs by improving clinical outcomes and patient satisfaction (James & Poulsen, 2016). Considering the limitations of currently implemented CAP payment model in Singapore, it requires the co-evolution of payment and delivery systems to master the transition to value-based payment in the future (Miller, 2009), illustrated in Figure 37. In this regard, the comprehensive CAP payment model that has been tested in our SD policy simulation experiment is expected to mark a step closer to value-based payment by sharing financial risks between providers and the payer, fostering care integration among public and private providers, and linking payment to provider performance based on quality benchmarks (Lindner & Lorenzoni, 2023).

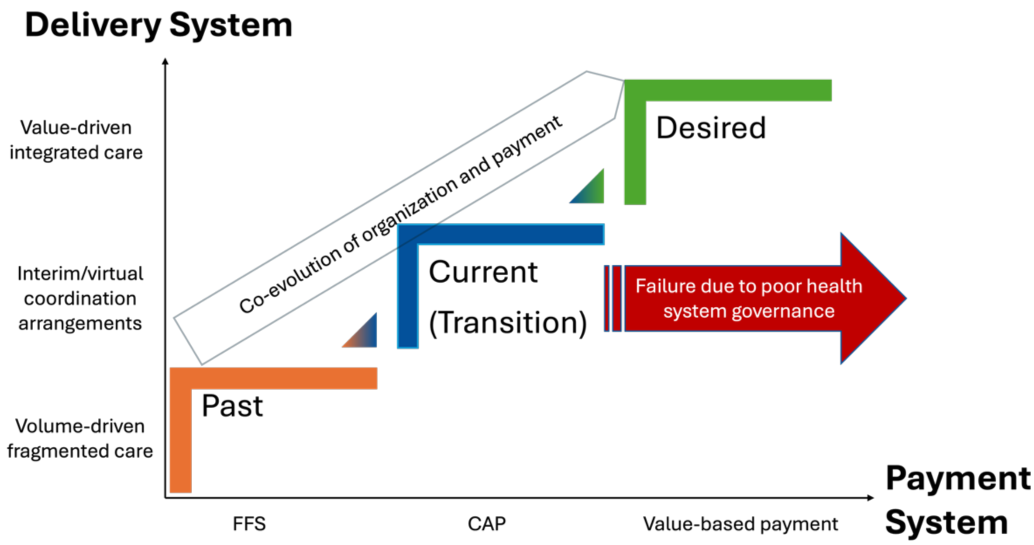

Figure 37. The transition from volume-based payment to value-based payment. Source: adapted from Miller (2009, EXHIBIT 4).

- Promoting accountable care

From a more general perspective, the transition toward value-based payment forges a path forward to encourage accountable care, where providers assume responsibility for health outcomes and healthcare costs of a defined group of population (Lewis et al., 2013). The anticipated outcomes include reduced healthcare spending for payers, enhanced care coordination and integration among providers, and ultimately, improved health outcomes of the population, as depicted in Figure 38. To this end, providers need to become ACOs – measured and rewarded or penalized for the quality, safety, and cost-effectiveness of care (Lindner & Lorenzoni, 2023; National Healthcare Group, 2021). As an example, the National Healthcare Group in Singapore transformed into an ACO in 2021, assuming responsibility for enhancing care delivery, improving population health, and mitigating healthcare expenses (National Healthcare Group, 2021). However, value-based approaches may breed administrative complexity, particularly when patient characteristics influence the determination of high or low value interventions (Matchar et al., 2023), and there remains uncertainty regarding the value associated with clinical and preventive interventions (Franklin, 2017; Thomson et al., 2009). Hence, effective governance operationalizes accountability and transparency by establishing clear objectives, performance metrics, and oversight mechanisms.

Figure 38. Premises of accountable care in the local context. Source: based on National Healthcare Group (2021, p. 2).

- Aligning payment reform with smart governance

Throughout the research, it has been consistently emphasized that governance is not a peripheral concern but a determining factor for the successful CAP payment reform (Comendeiro-Maaløe et al., 2019). In the context of evolving and complex health systems, the term "*smart governance*" (Willke, 2007) has emerged as a description of an innovative paradigm encompassing "whole-of-government" and "whole-of-society" approaches, as well as the major institutional adaptations observed in public and private organizations (Kickbusch & Gleicher, 2014). Inspired by this concept (see Figure 39), Singapore's health system presents clear opportunities for refinement, such as:

  - Transparent risk adjustment formulas to reassure public and private care providers that CAP funding rates are fair;
  - Joint monitoring boards where residents, providers, and the MOH regularly and concurrently review performance data;
  - Pilot programs that allow a subgroup of providers to test the comprehensive CAP payment model on a smaller scale before the full-scale rollout.

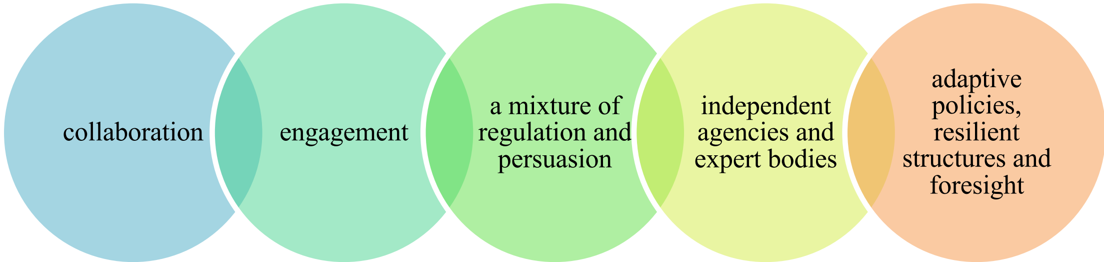

Figure 39. Five interrelated aspects of "smart governance". Source: Kickbusch and Gleicher (2012, 2014).

In summary, the overarching implication for practice is that CAP should not be narrowly understood as a technical funding model but as a "whole-of-system" health financing reform under HSG. In other words, payment reform must be accompanied by trust building, data sharing, risk managing, and patient engaging. The transition to CAP reimbursement method requires policymakers and practitioners to move beyond narrow financial metrics and adopt viable health financing and system governance strategies that integrate cost control, quality assurance, and universal access. Governing through a mix of top-down and bottom-up approaches with concerted efforts from diverse stakeholders is anticipated to empower frontline healthcare workers and local partners to actively contribute to healthcare autonomy and innovation at communities and make HSG happen and sustainable in the end.

7.4 Role of Model

A defining feature of this thesis has been the use of modelling as a means to systematically illuminate the financial risks and governance challenges inherent in Singapore's CAP payment reform. The GABM and SD simulation models, developed alongside the VSM and DPG qualitative frameworks, provided an analytical and pragmatic tool of mapping the complex health system structure, testing diverse assumptions, surfacing unanticipated consequences, and facilitating dialogue among stakeholders. In essence, model does not function as a forecasting or predictive tool in the narrow sense, but rather as a learning laboratory that allows multiple stakeholders to advance their understanding of system structure and dynamic behaviors (Hirsch &

Rice, 2020; Matchar et al., 2025). In terms of their roles in the present study, we group them into three classes.

- Diagnostic role

The first role of the model is diagnostic. By explicitly mapping the key stakeholders and their interactions within Singapore's health system, the qualitative and quantitative models make the obscure governance tensions and potential financial risks visible. To illustrate, VSM provides a holistic and structural diagnosis of Singapore's health system governance. The DPG approach further identifies the relevant variables and their interrelationships in complex health systems. GABM examines the micromotives of physicians and their provision behaviors under different payment conditions. At last, the SD model simulates the population-level dynamics concerning health outcomes, healthcare costs, and provider profits. These diagnostic insights are valuable because they transform abstract theories and fragmented evidence into tangible model structures that can be systematically visualized and tested.

- Exploratory role

Secondly, model plays an exploratory role. By running various policy scenarios, simulation models enable us to test different payment designs and governance decisions with no real-world cost. For example, GABM simulation experiments powered by LLMs demonstrate that while FFS drives cost escalation owing to over-provision, CAP reduces service utilization but risks underservice. Hence, performance pay is required to improve the quality of care within a capitation-based system. Besides, the SD policy experiments demonstrated that a comprehensive CAP model could be more financially sustainable and operationally effective when the risk sharing or adjustment mechanisms and P4P scheme are accounted for. Overall, simulation models permit experimenting with alternative changes without risking high experimental costs and serious policy failure in real setting (Hirsch & Miller, 1974), thereby improving the policy foresight and scenario planning capability for local decision-makers (Hirsch & Rice, 2020).

- Explanatory role

Lastly, model serves as a useful tool that stakeholders can use as a common reference point for collective learning and knowledge exchange. In other words, model creates an enhanced learning environment for diverse actors like health policymakers, hospital managers, GPs, or patients, who are often "myopic" and may have conflicting goals (Matchar et al., 2025). In this respect, the VSM integrates diverse perspectives from multiple stakeholders into a shared framework, thereby making problem articulation and policy trade-offs explicit. As a valuable complement to empirical studies (Matchar et al., 2019), the qualitative and quantitative models add to a deeper understanding of the potential financial risks and health governance challenges resulting from the CAP payment reform. This sense-making function provides explanatory power for counterintuitive dynamics in complex systems and facilitates stakeholder dialogue and accelerates organizational learning (Hirsch & Kemeny, 1994).

Considering that health systems are fundamentally complex, adaptive, and nonlinear (Kickbusch & Behrendt, 2013; Lipsitz, 2012; Plsek & Greenhalgh, 2001; Plsek & Wilson, 2001; Sturmberg et al., 2012), good health system governance can only be assured through the use of realistic, pragmatic, and understandable financial models (Cinchon et al., 1999, p. 129). To this end, the integration of VSM, DPG, GABM, and SD models, has provided a multi-level and multi-perspective platform to diagnose structural tensions, explore policy scenarios, and facilitate stakeholder dialogues. The role of model is therefore not predictive but interpretive and generative by helping decision-makers see the whole picture and imagine alternative futures.

Since real-world policy experiments in health and social science are often difficult to conduct owing to either ethical or financial considerations, model serves as an instrument of governance and a supporting tool for policymakers to navigate through complex health systems (Cinchon et al., 1999, p. 43). In the USA, simulation modelling of health reform is a standard practice of policy development (Milstein et al., 2010) and a required element in enacting legislation (Glied & Tilipman, 2010). Good governance remains the ultimate objective of modelling (Cinchon et al., 1999, p. 129), so it is recommended that Singapore's policymakers ought to resort to modelling when making informed health financing policies and governance decisions with a scientific and rigorous basis.

7.5 Limitations of the Study

Every research project is restricted by methodological, empirical, or contextual boundaries, and this thesis is no exception. In general, limitations of the present modelling study relate to data availability, model assumptions, and stakeholder engagement. Acknowledging these limitations is crucial for both clarifying the scope of research findings and identifying the direction of future inquiries.

- Data availability and empirical constraints

It is known that model is bound to data, including both qualitative and quantitative data. The development of qualitative models primarily draws on the valuable inputs from multiple stakeholders during the VSM exercise. Besides, GABM and SD simulations depend on training data of LLMs and openly published statistics, respectively. On one hand, we lack the empirical data with regard to Singapore's physicians' provision behavior under different payment conditions. Consequently, it is impossible to ascertain whether the LLM-driven physician agents genuinely mimic human physicians during GABM simulation experiments, and whether the performance pay policy insights are applicable in the real-world setting. On the other hand, aggregated historical data provided a solid foundation for SD model test and calibration, but they constrained our ability to capture the heterogeneity across providers and patients. In particular, the MOH has not disclosed the CAP funding rates openly (Ministry of Health, 2022a), so it significantly restricts our capability to perform actuarial analysis of financial risks for public and private providers in this study. While data constraints are typical in the quantitative modelling research, it highlights the need for greater access to more granular data so as to reduce uncertainties.

- Simplifying model assumptions

Meanwhile, it is important to recognize the limits of model. As ever cautioned by Meadows et al. (1982, p. 197), *"No matter how many resources one has, one can envision a complex enough model to render resources insufficient to the task*". In other words, the purpose of modelling is not to design methodologically sophisticated structural or mathematical mappings (Cinchon et al., 1999, p. 129). In view of this, the qualitative and quantitative system models have been built with some simplifying assumptions in order to make them remain structurally concise and analytically tractable. For instance, the provider module of SD model captured physician supply and service utilization dynamics, but it did not fully account for all the types of medical workforces and health services in reality. Suffice to say, SD modelling focuses on "dynamic complexity" rather than "detailed complexity" (Hirsch & Homer, 2017). These simplifications mean that the model should only be interpreted as a heuristic tool for exploring possible dynamics, rather than a precise predictive engine for complex health systems.

- Limited stakeholder engagement

Although the research integrated qualitative frameworks and quantitative simulations, direct engagement with stakeholders was limited except for the VSM exercise. The study relied primarily on documentary analysis, secondary literature, and conceptual modelling, rather than participatory methods like group model building (Matchar et al., 2016) or in-depth interviews with policymakers, providers, and patients (Surendran et al., 2022). This limitation restricted the extent to which the model and governance analysis reflect lived experiences and real perspectives. While the theoretical and empirical synthesis offers valuable insights, greater stakeholder engagement would have strengthened the validity, legitimacy, and policy consensus of the research findings presented in this study.

In brief, the reliance on secondary data and simplifying model assumptions, along with limited stakeholder engagement, constrains the precise replication of complex adaptive health systems. This highlights the widely recognized tensions between analytical tractability and real-world complexity (Sterman, 2000). As famously stated by George Box (1976), "*all models are wrong, but some are useful*". To a certain extent, these limitations do not diminish the value of this modelling study; rather, they clarify the boundaries and point out promising avenues for future research.

7.6 Future Research

Beyond the present study, it is evident that future research ought to attach importance to some directions, such as empirical evaluation, participatory modelling, methodological innovation, comparative insights, and expanded scopes.

- Real-time evaluation of HSG

Singapore's phased rollout of HSG initiative provides a natural experiment for studying the implementation effect of CAP payment reform. Future study may consider:

  - Tracking the enrollment of residents and GPs into the HSG initiative to assess the acceptance of HSG among key stakeholders and identify the latent barriers;
  - Monitor the progress in chronic disease management, hospital service utilization, provider profit, and patient satisfaction to dynamically evaluate the key performance of the local health system under HSG.

In alignment with the complex adaptative character of health systems, such real-time evaluation of the HSG initiative is anticipated to offer health policymakers timely feedback to adjust the implementation course accordingly.

- Group model building with stakeholders

The second opportunity lies in engaging stakeholders from multiple levels (i.e., national, regional, and clinical) of Singapore's health system directly through participatory modelling. Many private GPs expressed hesitancy in joining the HSG initiative due to concerns about financial risks and administrative burden (Foo et al., 2023). For this reason, group model building could be piloted to:

  - Build trust and consensus among stakeholders by giving them an opportunity to share opinions, worries, and suggestions;
  - Enhance policy responsiveness by feeding collective insights into the national health financing and governance policy recommendation for the MOH.

To a large degree, group model building serves as a decision support and policy design tool by fostering collaborative governance with a bottom-up approach.

- Hybrid modelling methodology innovation

Although the integration of VSM, DPG, GABM, and SD models in this study advances systems thinking on Singapore's CAP payment reform, significant opportunities remain for further methodological innovation, such as:

    - Hybrid modelling: There are a broad range of mathematical, statistical, and computational modelling methods (Page, 2018), and each model has its own limitations and advantages. Instead of adopting a single modelling approach, hybrid models by incorporating ABM or GABM, discrete-event model (Wieck, 2021), and SD model would allow greater representation of patient or provider heterogeneity and keep the model as close as possible to real-world healthcare systems (Brailsford, 2015).
    - Data-driven simulation: The calibration of SD model against historical data took a great deal of time in the present study. Considering the recent advancement of machine learning and Bayesian inference in statistics, deep learning techniques could be applied to calibrate a large array of model parameters in dynamic modelling more effectively (Rahmandad et al., 2025).

From the view of scientific research, methodological innovation enriches the toolbox of simulation modelling and adds to a better understanding of complex adaptive health systems.

- Comparative and cross-country studies

While this thesis focused on Singapore's CAP payment reform under HSG, future research may pursue comparative studies across different healthcare systems to test the generalizability of research findings. Key questions include:

    - How does health system governance shape payment reform and care integration in more decentralized systems (e.g., the USA) or more centralized ones (e.g., the UK)?
    - What lessons can be learnt from MA in the USA (Wieck, 2021), where the CAP payment interacts with market dynamics, and from the NHS in the UK (NHS Scotland, 2022; Peskett, 2009; Sanderson et al., 2020), where a

single payer dominates the medical care market?

- To what extent do small-scale integrator models like "*Healthy Kinzigtal*" implemented in Germany (Groene & Hildebrandt, 2021; Pimperl et al., 2017) provide transferable governance lessons for the national-scale HSG initiative in Singapore?

Cross-country comparisons would not only test the theoretical frameworks of this thesis but also contribute to the achievement of SDG 3 with more robust health financing and health system governance policies globally.

- Expanding research scopes

Last but not least, future research should broaden the scope beyond payment mechanisms to consider how the CAP payment interacts with wider determinants of population health and national reforms. Potential directions include:

- Linking payment reform to social determinants: Exploring how the CAP payment model can be aligned with housing, education, social, or elderly care policies to collectively address upstream drivers of ill-being and inequalities;
- Digital health innovation: Examining how telemedicine, remote monitoring, and AI-driven care pathways will reshape or challenge the feasibility and effectiveness of CAP payment model;
- Resilience and shocks: Investigating how the capitation-based system may perform under extreme stressors, like the pandemic (Kaleta et al., 2022) or economic downturns.

These extensions would move the research agenda from a narrow focus on health financing and system governance challenges associated with the CAP payment reform to a broader analysis of health system sustainability and resilience.

Future research should deepen, broaden, and diversify the analysis initiated in the present study. By grounding models in empirical data, engaging stakeholders through participatory methods, integrating innovative modelling techniques, and expanding scopes to comparative and cross-sectoral domains, scholars and policymakers will gain a deeper understanding of not just whether the CAP funding method works, but under what conditions it thrives and sustains. In doing so, future studies can continue the central theme of this thesis: framing payment reform as a systematic challenge within complex adaptive health systems.

7.7 Final Reflections

Now, it is time to complete the story:

> *"By the second year, the clinic frequently visited by Madam Tan was visibly struggling. The doctors looked weary, appointments felt rushed, and the receptionist often reminded patients that resources were tight this week. Rumors spread that some private clinics in nearby estates were closing because they could not balance the costs of caring for many high-need patients. Madam Tan began to feel uneasy. Her doctor no longer asked about her concerns beyond the immediate symptoms. She sensed a growing distance, as if each consultation was just one more case in an endless line. In her community, neighbors grumbled about long waits and questioned whether the new system would truly keep them healthier. Trust between patients and doctors seemed thinner, and the promise of better care for all felt uncertain."* – ***Part III, Denouement.***

This modelling study contributes to navigating one of the most pressing issues facing modern health systems: how to finance healthcare sustainably while preserving care quality and universal access? By combining mixed theories with system models, the thesis has examined health financing and health system governance challenges arising from Singapore's recent CAP payment reform under HSG. The integration of VSM and DPG approaches demonstrates that health system governance can be operationalized not only as abstract theories but as practical lenses or frameworks for system diagnosis and stakeholder mapping. Moreover, GABM and SD models simulate individual-level and population-level dynamics under different payment conditions. Collectively, they underscore the messy and adaptive nature of new CAP payment model implementation, so policymakers must avoid locking in static mental models which hinder the dynamic evolution (Williams, 2017).

The central lesson is that CAP payment reform should not be regarded as a panacea for the HSG initiative. At its heart, payment reform is not a technical fix but a governance challenge that requires systems thinking and dynamic modelling. This theme permeates throughout the study, serving as one of our main messages. The CAP payment model can promote sustainable health financing and improve population health to some degree, but only if it is embedded in a supportive and viable health system governance framework. Financial risks and governance challenges are not obstacles to be eliminated but dynamics to be managed. Stakeholder resistance, moral hazard, care fragmentation, and financial vulnerability could continue to surface after the transition from FFS to CAP funding mechanism. As underlined by Hirsch and Kemeny (1994, p. 8), "*The deepest challenges to our mental models are not about the transition but about what comes after the transition. Those who are willing to rethink what it means to provide healthcare are those who are most likely to master the transition.*" In this regard, anticipatory governance supported by system modelling provides the important foresight and tools to navigate the transition within complex health systems (Swanson & Bhadwal, 2009).

Another important reflection concerns the role of model in health policy discourse. This thesis has illustrated that models are a useful tool that helps policymakers diagnose structures, explore assumptions, anticipate trade-offs, and rehearse possible future trends. In a reform as ambitious as the HSG initiative, they provide safe spaces for system mapping and virtual experimentation, reveal unanticipated consequences, as well as identify policy levers. Yet they must always remain transparent and ought to be complemented by empirical data and stakeholder insights. Meanwhile, in light of the model's limitations, there is an important final thought to share with you: *"Models are subject to the primacy of policies and policymakers. Always. And if there is one thing that is worse than a world without models, it is a world run by modellers"* (Cinchon et al., 1999, p. 239).

In closing, this modelling study affirms that while Singapore's CAP payment reform offers a great opportunity to transform care delivery in response to the evolving needs of ageing population, there might be complex governance challenges related to incentive alignment, stakeholder engagement, structure adjustment, and risk management across macro, meso, and micro levels of the local health system. Therefore, this thesis advances a normative proposition: health financing is not just about balancing budgets, but about sustaining social contracts. In Singapore and elsewhere, the central question is how to equitably share risks and resources across stakeholders while maintaining care quality and service efficiency. CAP payment reform provides one pathway, but it must be bundled with viable governance arrangements to strengthen primary care, address social determinants of health, encourage participatory decision-making, and foster collective responsibility for wellbeing. By framing payment reform as a governance challenge, this thesis contributes to both scholarship and practice, offering a perspective that is analytical and anticipatory. The journey ahead will be complex, but it is precisely through such complexity that health systems can evolve toward resilience, reliability, and sustainability.

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Appendix A Summary of the VSM Exercise

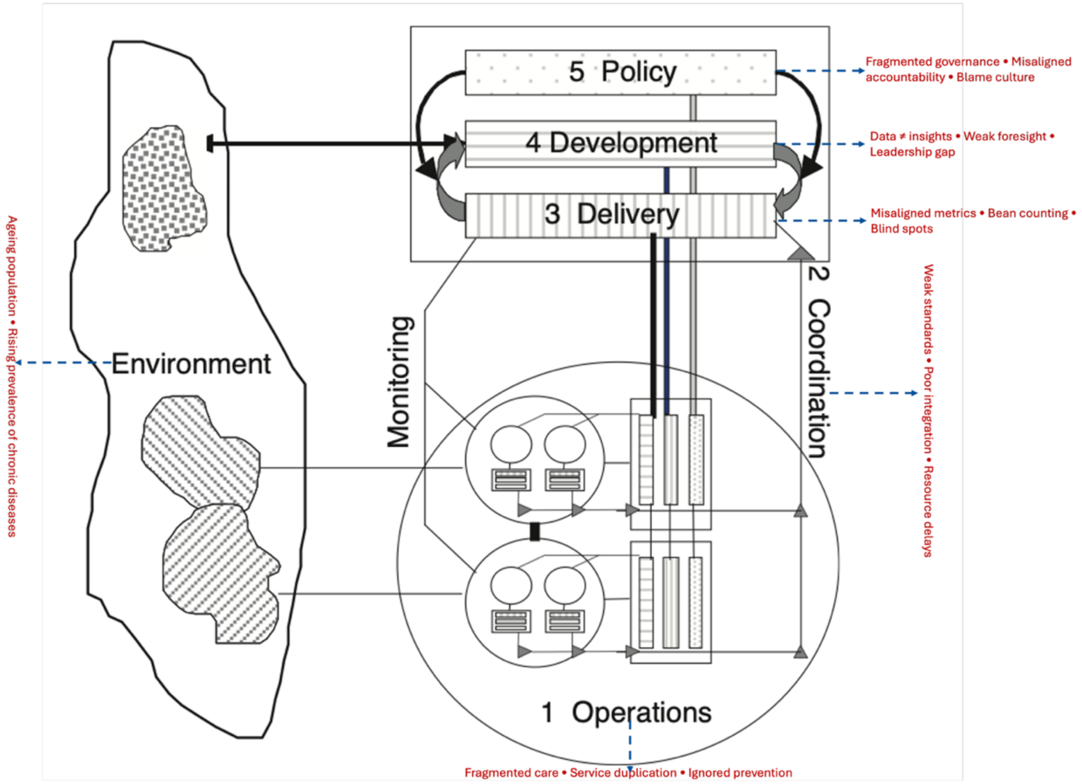


Figure 40. The VSM chart customized for Singapore's health system. Data source: Hoverstadt and Loh (2022).

The VSM conceptualizes Singapore's health system as a tightly coupled, adaptative system that must balance population health outcomes, healthcare cost containment, and health services integration under the increasing demographic and epidemiological pressure. Drawing upon the shared insights from key stakeholders during the VSM exercise (Hoverstadt & Loh, 2022), the specific challenges faced by each subsystem are highlighted in Figure 40.

At System 1 (Operations), frontline care delivery is distributed across public healthcare clusters, PCNs (including private GPs), community partners, and other supportive agencies. While operational capacity is strong within Singapore's health system, the VSM identifies risks of fragmented care, service duplication, and underinvestment in prevention, particularly when incentives remain activity-oriented rather than population-based.

System 2 (Coordination) represents mechanisms for harmonizing care delivery across providers and settings, such as referral pathways, shared IT systems, and care integration platforms. Weak standards, incomplete data integration, and resource frictions can create service delays or inefficiencies, undermining continuity of care. It is an issue especially salient in Singapore's push toward the HSG initiative.

System 3 (Delivery) focuses on performance management, resource allocation, and operational accountability. The VSM exercise points to misaligned metrics and "bean-counting" behaviors, where short-term cost and throughput indicators dominate over long-term public health outcomes. This creates risks of local optimization and blind spots under capitation-based funding.

Based on data analytics and collective leadership, System 4 (Development) captures strategic learning, policy foresight, and system adaptation. Despite Singapore's strong data infrastructure, the diagram signals a leadership and foresight gap: insights are generated but not always translated into timely strategic adjustment, limiting anticipatory capacity in the face of ageing population, growing multimorbidity, and fiscal constraints.

At System 5 (Policy), the state provides overarching purpose, values, and legitimacy to strive for equity, affordability, and sustainability. However, the chart emphasizes risks of fragmented governance, misaligned accountability, and blame culture when strategic goals, institutional incentives, and operational realities are not coherently aligned across macro, meso, and micro levels of the local health system.

Finally, the "Environment" reflects demographic ageing, rising chronic disease burden, and social determinants of health. These external pressures, affected by routine operations, continuously test system viability and influence the development function.

Overall, the VSM underlines that Singapore's health system strength lies in strong state stewardship and service delivery capacity, but long-term viability under CAP payment reform depends on improving cross-level alignment: integrating coordination mechanisms, shifting performance metrics toward population health, strengthening anticipatory governance, and ensuring that policy intent is consistently translated into operational practice across the multi-layers of health systems.

Appendix B Guide to Conducting GABM Simulation Experiments

This appendix documents the procedures for conducting GABM simulation experiments implemented in the supplementary Python script[17] named "*GAMB Simulation Experiment (Appendix B).py*". The appendix is intended to support transparency and reproducibility of the simulation-based analysis reported in the thesis, and to clarify how experimental results comparing FFS and CAP payment mechanisms are generated and analyzed, as provided in the sample data file called "Physician Decision Baseline Simulation Results (*Appendix B)*.csv".

The GABM is designed to examine physicians' provision behaviors under alternative payment regimes by explicitly modelling provider decision-making on service quantity in response to patient characteristics and payment incentives. Although the implementation code allows users to switch between using LLMs and rule-based decision heuristics (i.e., for the purpose of offline test), this guide puts particular emphasis on the use of LLMs for agentic decision-making. In other words, the physician agent's service quantity decision is not determined by a predefined rule embedded directly in the code. Instead, for each simulation instance, the model constructs a structured natural-language prompt that describes their decision context, including the payment mechanism, the patient's illness type or benefit profile, feasible service quantity options, along with the relevant provider cost and profit information. This prompt is then sent to an external LLM via the API call. The LLM response is parsed to extract the agent's chosen service quantity, which is treated as the physician's decision for that iteration.

To conduct GABM simulation experiments, users must first ensure that the Python environment is correctly configured. Required libraries include NumPy, pandas, matplotlib, seaborn, and SciPy. In addition, an active API key for the selected LLM service (e.g., ChatGPT, Gemini…) must be defined as an environment variable or directly referenced in the script according to the API provider's specifications. Without

[17] The script has been collaboratively developed with the assistance of ChatGPT (OpenAI, 2025).

a valid API key, the simulation cannot execute online decision steps and will terminate with an error.

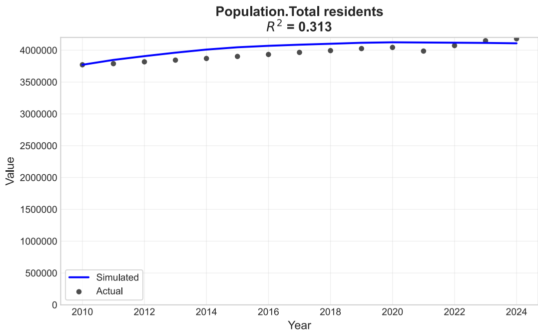
Once simulation is over, the script automatically generates numerical summaries and visual outputs based on the recorded simulation results. These include summary tables of mean outcomes, two-sample statistical tests, distributional plots of service quantity across payment models, and comparative visualizations of average quantity of medical services by patient type or illness, as shown in Figure 17. In the end, all the information of each single simulation run is saved locally.

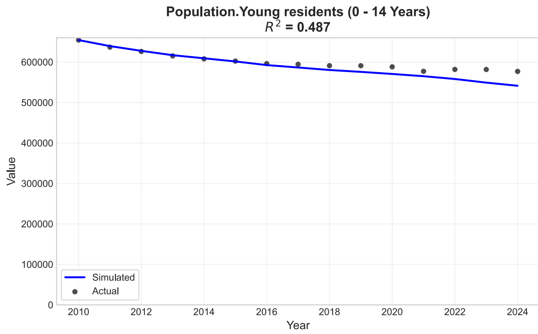
To replicate the experiments, users should (1) install all required Python packages; (2) configure the API key; (3) verify parameter settings and prompt templates in the script; and (4) execute the script. Any changes to prompt wording, parameter values, or API settings will influence LLM-driven physician agents' decisions unwittingly. Should you have any difficulty in running the GABM with the given script, please feel free to contact the author. Note that full reproducibility cannot be guaranteed due to stochastic response generation and potential updates to the underlying LLMs over time, even when code and parameters are held constant.

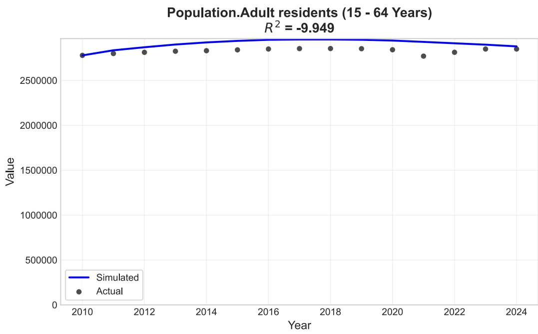
Overall, GABM leverages LLM-driven agents to extend traditional ABMs and laboratory experiments by embedding adaptive and implicit decision rules within a controlled simulation framework. Each simulation iteration follows a consistent prompt-response-evaluation-record workflow, in which the physician's decision context is encoded as a prompt, the LLM response is parsed as an action, outcomes are evaluated, and results are recorded for visualization. This approach complements the rule-based logic typically used in ABMs and SD models, and provides an experimental platform for exploring how physician behaves under different payment schemes.

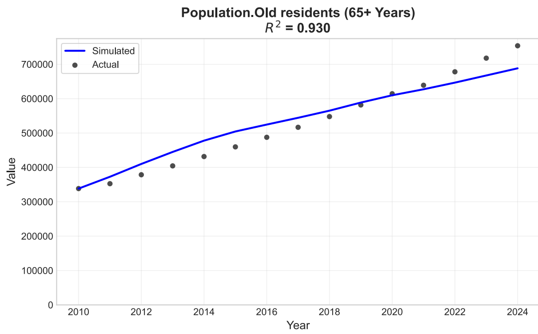
Appendix C Comparative Graphs for Behavioral Reproduction Test

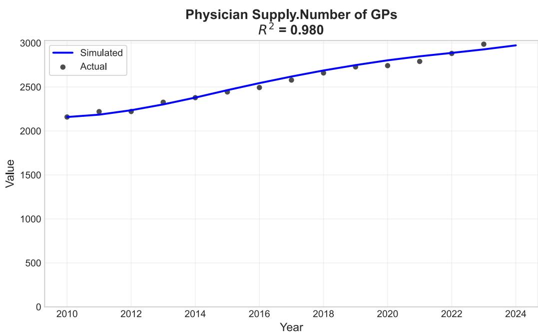
This appendix provides the behavioral reproduction test results for all the key model variables, grouped by “Population”, “Provider”, and “Payer” modules. It is found that the simulated behaviors can fit the actual data very well or badly. The test implies the limitations of our SD model and the room for future improvement.

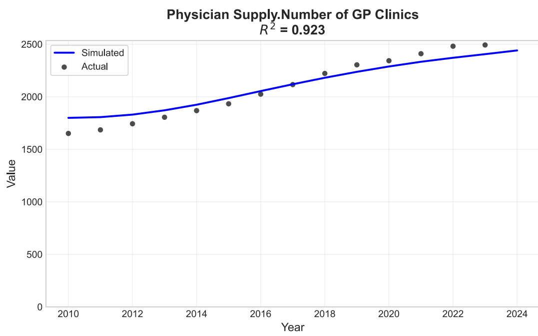


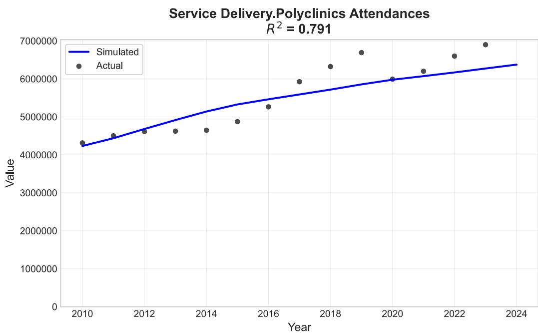


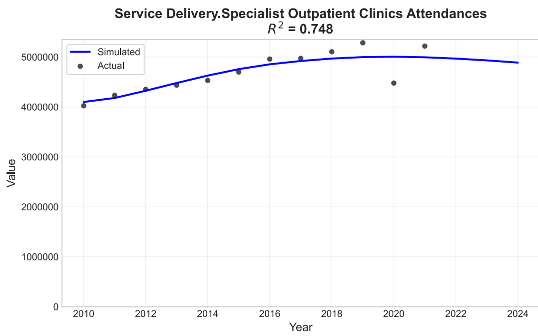


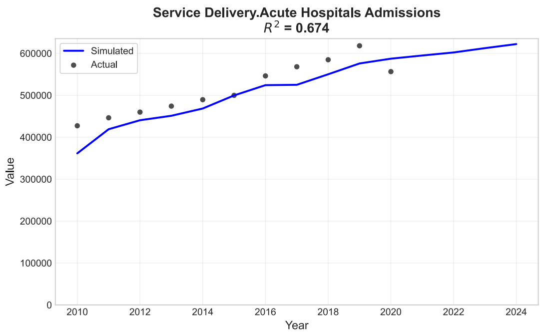


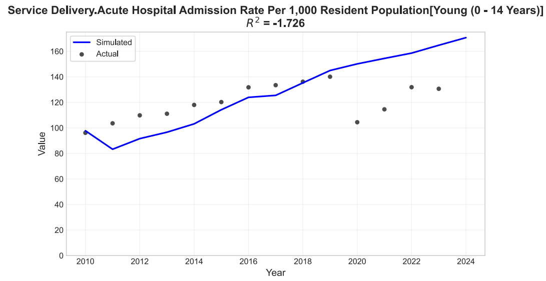


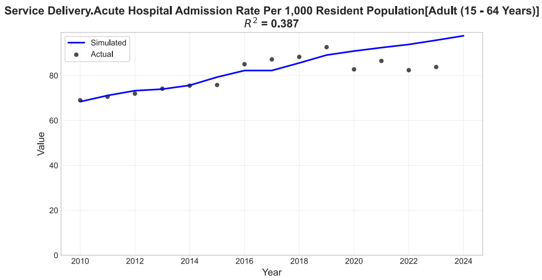


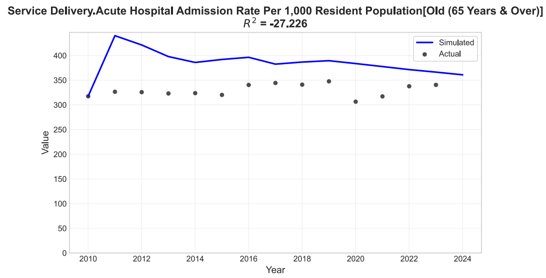


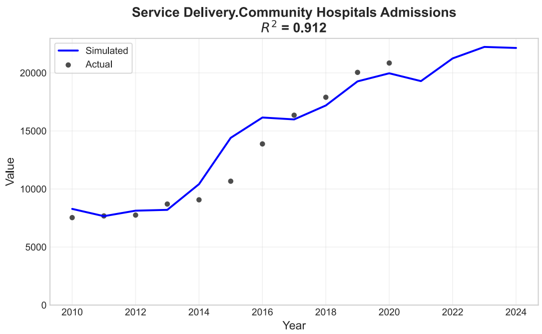


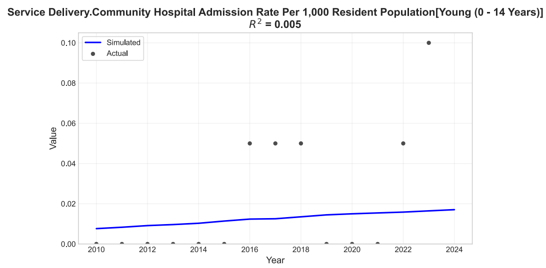

Service Delivery.Acute Hospitals Admissions
R^2 = 0.674
Simulated
Actual
Value
Year

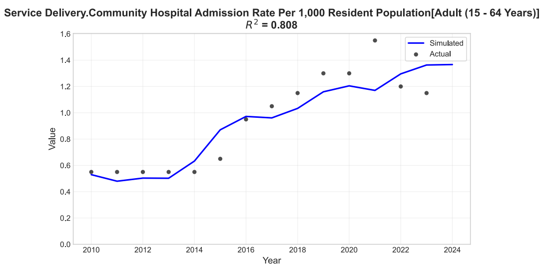

Service Delivery.Acute Hospital Admission Rate Per 1,000 Resident Population[Young (0 - 14 Years)]
R^2 = -1.726
Simulated
Actual
Value
Year

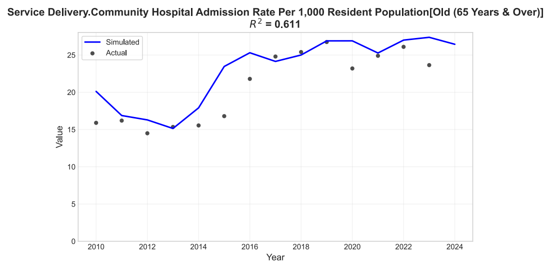

Service Delivery.Acute Hospital Admission Rate Per 1,000 Resident Population[Adult (15 - 64 Years)]
R^2 = 0.387
Simulated
Actual
Value
Year

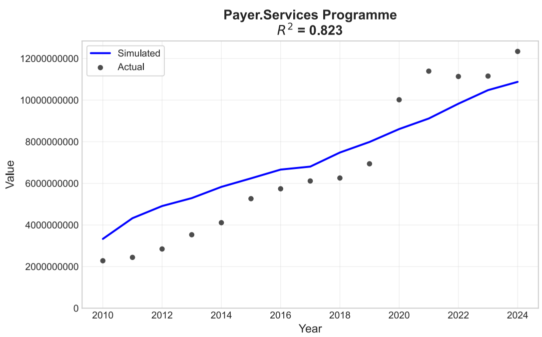

Service Delivery.Acute Hospital Admission Rate Per 1,000 Resident Population[Old (65 Years & Over)]
R^2 = -27.226
Simulated
Actual
Value
Year


Service Delivery.Community Hospitals Admissions
R^2 = 0.912
Simulated
Actual
Value
Year


Service Delivery.Community Hospital Admission Rate Per 1,000 Resident Population[Young (0 - 14 Years)]
R^2 = 0.005
Simulated
Actual
Value
Year


Service Delivery.Community Hospital Admission Rate Per 1,000 Resident Population[Adult (15 - 64 Years)]
R^2 = 0.808
Simulated
Actual
Value
Year


Service Delivery.Community Hospital Admission Rate Per 1,000 Resident Population[Old (65 Years & Over)]
R^2 = 0.611
Simulated
Actual
Value
Year


Payer.Services Programme
R^2 = 0.823
Simulated
Actual
Value
Year

Appendix D Extending to Performance Pay Policy Design

This appendix documents an extension of the GABM simulation experiment to the analysis of performance pay policy design within a capitation-based system. Building on the earlier experiments comparing FFS and CAP, the extended GABM introduces a P4P scheme and examines how the addition of performance incentives alters physicians' provision behavior (Brosig-Koch et al., 2024). The experiments are implemented in the Python script[18] named "*GAMB Policy Simulation Experiment (Appendix D).py*", and are designed to be directly comparable with the baseline GABM simulation experiment described in Appendix B. Besides, the sample synthetic data used for analysis in Subsection 6.1.1 are offered in the "*Physician Decision Policy Simulation Results (Appendix D).csv*" file.

As in the baseline GABM, provider decisions are generated through LLM API calls rather than through hard-coded decision rules (but the implementation code includes an option of rule-based decision-making). For each simulation iteration, the script constructs a structured prompt describing the provider's decision environment, including the lump-sum CAP payment, as well as the associated cost, profit, and patient benefit for each feasible service quantity option. Then, the LLM-driven physician agent's response is parsed to extract the chosen quantity, which is treated as the provider's action for that iteration.

The key conceptual difference from the baseline GABM simulation experiment lies in the structure of provider incentives. In the extended policy experiment, LLM-driven physician agents continue to operate under a capitated payment, but an additional performance-contingent component is introduced. This performance payment is linked to patient benefit generated by physicians' service quantity decision, thereby explicitly coupling provider profit to patient outcomes. Additionally, performance pay is implemented at alternative intensity levels, represented by low and high bonus rates, allowing the deeper analysis to examine how the strength of performance incentives

[18] The script has been collaboratively developed with the assistance of ChatGPT (OpenAI, 2025).

shapes physicians' provision behavior.

There are two phases for each simulation run. From an experimental design perspective, Phase I (i.e., the CAP payment only) serves as the counterfactual baseline, while Phase II (i.e., the CAP+P4P payment scenario) represents the policy intervention. All parameters unrelated to payment incentives, such as cost functions, patient benefit schedules, and quantity choice sets, are held constant across phases to isolate the effect of performance pay. Any observed differences in outcomes can therefore be attributed to the introduction of performance incentives rather than to structural changes in the model.

To run the policy experiments, users must first ensure that the Python environment and API configuration remain correct. The script also automatically generates comparative summaries and visualizations that highlight how performance pay modifies provider behavior relative to pure CAP payment model. Statistical tests are applied to assess whether observed differences between CAP and CAP+P4P outcomes are significant.

Overall, this extended GABM policy experiment demonstrates how LLMs can be used not only to compare different payment mechanisms (e.g., FFS vs. CAP), but to explore the design and behavioral implications of varying CAP payment model configurations. By embedding performance incentives directly into the provider's decision context, the model provides a flexible experimental platform for more informed and comprehensive CAP payment model design in practice.