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Optimizing Caregiving Systems: A Strategic Analysis of Family, Government, and Institutional Interactions

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Abstract

As global populations age rapidly, caregiving for the elderly has emerged as a critical challenge, particularly due to the fragmented roles played by families, governments, and institutions. This paper reconceptualizes caregiving as a strategic decision-making process rather than a purely emotional or moral undertaking. Through a thematic synthesis of 16 game-theoretic empirical studies, it identifies systemic inefficiencies rooted in coordination failures, free-riding behaviour, and asymmetrical burdens—particularly along gender and cultural lines. The study divides its literature analysis into two domains: intra-family role allocation and the influence of governmental and institutional policy. It finds that caregiving within families often functions as a non-cooperative public goods game, while government interventions are frequently either overly generalized or narrowly targeted, leading to suboptimal support. To address these strategic mismatches, the paper proposes a cooperative game-theoretic model integrating Lagrangian optimization for efficiency with Shapley Value allocation for fairness. This model formalizes caregiving as a shared burden between families, institutions, and governments, and identifies optimal strategies for cost-sharing and stable cooperation. The paper thus contributes a new conceptual and prescriptive framework to optimize caregiving systems under growing demographic and economic pressure.

Keywords: *Strategic Caregiving; Game Theory; Multi-Agent Coordination; Eldercare*

1. Introduction

1.1 The Ageing Population

Global demographics are undergoing a landmark shift as the population rapidly ages. Notably, in 2024, the global life expectancy at birth reached 73.3 years, marking an increase of 8.4 years since 1995.

This surge in life expectancy has led to a substantial rise in the number of older individuals, with projections indicating that the population aged 60 and above will escalate from 1.1 billion in 2023 to 1.4 billion by 2030. Naturally, this growth in the aging population has led to an increase in the need for care services, as a significant portion of the elderly population requires assistance with daily activities and medical care — particularly those with chronic or severe health conditions. In the United States alone, approximately 34.2 million adults have provided unpaid care to individuals aged 50 or older in the past year. Unequivocally, caregiving is an issue of pressing concern to the entire population. As Rosalynn Carter once poignantly noted, "There are only four kinds of people in the world: those who have been caregivers, those who are currently caregivers, those who will be caregivers, and those who will need caregivers." This universal reality underscores the societal relevance of caregiving and the urgent need to understand how caregiving decisions are made and sustained.

1.2 Informal and Familial Caregiving

This growing care need has largely been met by informal caregivers—unpaid individuals, typically a spouse, partner, family member, friend, or neighbour, who assist with daily living and medical tasks. Among these, family members play an especially vital role: 85% of caregivers in the U.S. are relatives. As a result, caregiving is deeply embedded in family systems and disproportionately impacts their physical, emotional, and financial well-being. The burden associated with these responsibilities can be considerable (Monga et al., 2024). Tasks such as lifting, mobility assistance, and administering medication contribute to musculoskeletal injuries and chronic pain. Caregivers also report elevated levels of stress, anxiety, and depression, linked to the relentless nature of caregiving and the emotional toll of watching a loved one's health decline. Studies consistently show that caregivers experience higher rates of depressive symptoms and worse physical health outcomes compared to non-caregivers. The financial and social repercussions are equally pronounced. Many caregivers reduce their work hours or leave the workforce entirely to meet caregiving demands, leading to lost income and long-term reductions in retirement savings. Research estimates that unpaid caregiving can delay retirement by up to 21 years due to redirected financial resources and missed contributions. In parallel, the intensive time commitment often results in social isolation, as caregivers lack time to maintain relationships or engage in recreational activities, contributing further to burnout and emotional fatigue.

1.3 The Strategical Problem

While family remains the backbone of informal eldercare, the true challenge lies in optimizing the interactions between caregivers, government institutions, and private care providers. Caregiving is no longer a purely personal arrangement; it is embedded within a fragmented ecosystem where each stakeholder operates under different constraints, incentives, and expectations. Families often act in isolation without formal coordination mechanisms, while governments attempt to influence caregiving behaviour through subsidies, mandates, or tax policy (Barczyk & Kredler, 2017; Calvó-Perxas et al., 2018). Meanwhile, private institutions pursue operational efficiency, often misaligned with quality and equity goals unless moderated through targeted regulation (Zhang et al., 2022; Shi et al., 2023). Failures in this multi-agent environment are not due to a lack of will, but to coordination breakdowns, incentive mismatches, and informational asymmetries. Government supports are frequently either too broad to account for caregiver heterogeneity or too narrow to be accessible (Wieczorek et al., 2022). Private care systems may focus on cost-efficiency at the expense of trust, continuity, and user empowerment (Zhang et al., 2023). Within families, unstructured role negotiation results in burden asymmetries that damage relationships and compromise care outcomes (Pezzin et al., 2003; Knoef & Kooreman, 2012). These interlocking inefficiencies produce systems that are not only fragile and unsustainable, but also contribute to widespread caregiver distress, health deterioration, and inequity (Gérain & Zech, 2019; Sharma et al., 2016). Without integrated, strategic frameworks to align the behaviour of governments, institutions, and families, caregiving defaults to reactive, ad hoc responses that falter under demographic and economic

pressure. Framing caregiving as a multi-agent decision problem—where success depends on cooperation, incentive alignment, and behavioural insight—is therefore essential to designing equitable, effective, and future-ready care systems.

1.4 Contribution of This Study

This paper suggests a game-theoretic and decision-scientific framework to examine the strategic complexities of caregiving within a multi-agent system that includes families, government institutions, and private care providers. Cooperative game theory—the formal analysis of interdependent decision-making—serves as the foundation for understanding how caregiving strategies emerge and interact to create equitable responsibilities. Unlike psychological or sociological frameworks that emphasize normative roles or emotional bonds, game theory allows for the structured modelling of strategic behaviour where outcomes depend on the actions of others.

Methodologically, this research involves the thematic synthesis of existing models and empirical studies, organized across eight papers into two key domains. Domain A examines intra-family role allocation, revealing how caregiving responsibilities are often mis-distributed due to bargaining asymmetries, proximity biases, and sibling free-riding. Domain B expands this lens to analyse how government policy and institutional design — through subsidies, mandates, regulation, and support services—shape strategic caregiving behaviour at a systemic level. Each domain highlights a distinct set of strategic frictions and coordination failures. Together, they form the basis for constructing a prescriptive roadmap for caregiving reform. This dual-pronged Optimizing Caregiving Systems: A Strategic Analysis of Family, Government, and Institutional Interactions Approach — integrating theoretical models with empirical insights — illuminates not only how caregiving systems deteriorate under strain, but also how they can be optimized through targeted interventions.

This study aims to identify caregiving strategies that foster cooperation, efficiency, and fairness across stakeholders. It examines the mechanisms through which caregiving decisions are made — whether through voluntary familial negotiation or formal institutional policy—and investigates the conditions under which these decisions lead to stable or suboptimal outcomes. While past work has modelled caregiving as a bargaining game (Pezzin et al., 2005), a public goods dilemma (Bergeot, 2023), or a spatial strategy (Maruyama Johar, 2017), few have attempted a domain-based synthesis that extracts generalizable, policy-relevant solutions.

By framing caregiving as a multi-level decision problem—rather than a purely emotional or cultural act—this paper contributes a normative foundation for reforming care at the household, institutional, and policy levels. It offers not only academic insight but also proposes a game theoretic model designed to equitably divide the total value derived from caregiving among the three agents involved in an era of demographic and economic stress.

2. Literature Review and Systematic Analysis

This section is a holistic discussion of the multi-agent interactions. To begin, these interactions are first broken into 2 distinct facets. They are: A: Caregiver Role Allocations (i.e intra-family interactions), and B: The Role of Governments and Private Institutions (bridges the family interactions with these external agents). A total of 16 papers were used across both the domains, which will be used to guide the ensuing analysis.

2.1 A: Caregiver Role Allocation

Caregiver role allocation refers to the distribution of caregiving responsibilities among multiple agents to reduce individual burden for the overall welfare of both the caregivers and the care receiver. Due to the increasing demand for Home Health Care, coordinating and regulating caregiver role allocation has increased importance today (Sharifnia et al., 2024). As such, optimal caregiver role allocation should be discussed. Study A1 by Pezzin et al., (2003) provides a game-theoretic perspective into caregiver role allocation through a two-stage negotiation model, which analyses how living arrangements (stage 1) **and** temporal and economical transfers (stage 2) are determined for an elderly, disabled parent, by their two children. The paper, using backward induction (solving the first stage using the second one), shows that the outcome of caregiving negotiations is not always pareto-efficient.

The first stage models the parent's living arrangement, where each child independently decides whether to offer co-residence. The parent makes a decision based on the available options: nursing home (A_n), living alone (A_o), or co-residing with one of the children (A_1, A_2). If neither child offers co-residence, the parent resorts to living in the nursing home or independent living. If only one child offers, the parent has no alternative. If both offer, the parent chooses based on expected well-being and financial incentives. The decision of each child depends on caregiving costs, time constraints, and inheritance expectations. Thus, the child's utility function is

$$U_i = U\,(C_i\,, U_p) - \beta T_i\,, \qquad (1)$$

Where $C_i = Y_i - M_i$ is consumption after monetary transfers M_i , T_i is caregiving effort, and β is the disutility of caregiving. The parent's utility, on the other hand, depends on private consumption and the supply of health services:

$$U_p = U\,(C_p, H_p), \qquad (2)$$

where H_p is care received. An equilibrium emerges wherein caregiving is underprovided- because each sibling wants to maximise their utility by reducing their contribution. Interestingly, if there is a potential inheritance, at least one child provides care, but if caregiving is expensive (β is high), both may not contribute, leading to institutional care.

In the second stage, children allocate financial and temporal caregiving resources. Transfers can be tied (T_i , designated for health) or untied (Y_i , which the parent spends freely). The parent's discretionary income is thus:

$$Y_o = Y_p + Y_g + Y_1 + Y_2. \qquad (3)$$

Total spending on consumption (C_p) and healthcare (Hp) follows:

$$C_p + H_p = Y_o + T_g + T_1 + T_2, \qquad (4)$$

Where T_g is government healthcare support. There are two cases: (1) If all health costs are covered by tied transfers, extra tied transfers directly increase healthcare expenditure, while untied transfers go to private consumption. (2) If tied transfers are insufficient, untied transfers affect healthcare spending. Through this mechanism, the children play a Cournot-Nash game, strategically adjusting contributions to minimize personal cost. This leads to an under-provision problem, meaning that the total caregiving falls short of optimal levels.

The study provides crucial insights into optimal caregiving strategies. First, caregiving improves when siblings coordinate contributions, either through binding agreements or external incentives such as tax benefits. The equilibrium of the caregiving game suggests that, in the absence of binding

commitments, caregiving is underprovided due to strategic non-cooperation. An optimal strategy involves cooperative caregiving agreements, ensuring that each sibling contributes fairly rather than relying on the other.

Second, inheritance-linked rewards increase caregiving but can reinforce gender-based caregiving inequities, as daughters often bear a disproportionate burden. To counteract this, role allocation should incorporate either equitable inheritance structures or direct compensation, such as caregiver stipends, ensuring fairer caregiving distribution.

Third, caregiving subsidies or direct government support can reduce the private burden, leading to a more balanced allocation. This helps reduce caregiver and care-receiver burden simultaneously. The study's model shows that increasing government-provided tied transfers (T_g) directly boosts healthcare provision, while untied transfers (Y_g) enhance parental autonomy but do not necessarily optimize health outcomes. Thus, an optimal caregiving allocation mechanism requires financial incentives, binding commitments, and policy interventions to correct the inherent free-rider problem and improve caregiving efficiency.

The next paper, A2, is "Care for Elderly Parents: Do Children Cooperate?" by Bergeot (2023). Similar to the previous paper, it analyses cooperation between child caregivers of an elderly parent. This paper deepens our understanding of caregiver role allocation, supporting and adding on to Pezzin's results using a 2-step analysis **combining (1) empirical data with a (2) game-theoretic analysis.** It agrees with the results of A1 that suggests that children do not fully cooperate. Instead, strategic interactions supercede altruism, with strategic free-loading being commonplace. The paper models both cooperative (siblings maximise joint utility) and non-cooperative caregiving (each sibling maximises their individual utility). The utility function for each child is defined as (where ai = 1 denotes the child's provision of informal care, and $a0$ denotes free-loading):

$$u_i(a_i|a_{-i}) = \begin{cases} u_{\alpha i}a_{-i}, & \text{if } a_i = 0 \\ u_{\beta i} + u_{\alpha i}a_{-i} + u_{\gamma i}a_{-i}, & \text{if } a_i = 1 \end{cases} \quad (5)$$

where $u\alpha i$ represents the "utility of having a sibling participating in the caregiving", $u_{\beta i}$ is the "private utility of caregiving", and $u\gamma i$ denotes "additional individual utility (disutility) of caregiving when having a sibling participating in care provision." In the cooperative model, siblings maximize joint utility by internalizing the externality (see $u_{\alpha i}$, $u_{\gamma i}$), leading to a function given by

$$W(a_1, a_2) = u_1(a_1|a_2) + u_2(a_2|a_1). \quad (6)$$

Cooperation occurs when caregiving efforts are complementary and the game is supermodular[1], satisfying the condition

$$W(1, 1) - W(0, 1) > W(1, 0) - W(0, 0), \quad (7)$$

Where the LHS denotes the "marginal gain in welfare induced by the participation of child 1 when child 2 is a caregiver" and the RHS denotes the "marginal gain in welfare induced by the participation of child 1 when child 2 is NOT a caregiver". The holding of this inequality, in essence, ensures that both siblings prefer caregiving together over individual efforts.

[1] "Supermodular games are those characterized by "strategic complementarities" – roughly, this means that when one player takes a higher action, the others want to do the same." - Stanford University

In contrast, under the noncooperative model, each sibling maximizes their individual utility, leading to the best response function:

$$ai \quad max\, u_i(a_i \mid a_{-i}). \qquad (8)$$

In equilibrium, a sibling provides care if (submodular):

$$u_{\beta i} + u_{\gamma i} > 0. \qquad (9)$$

This equation is based in the fact that, in a non-cooperative game, each sibling ignores the positive externality they have on the other sibling's utility. The parent care-receiver can have no child caregiver if each child's preference for joint participation is low enough. The analysis of the French CARE survey support the game-theoretic findings, by showing that caregiving is a non-cooperative public goods game. Bergeot (2022) thus confirms that caregiving follows a noncooperative model, meaning that siblings act strategically rather than altruistically when deciding how much care to provide. In addition to modelling strategic interactions between siblings, Bergeot (2023) also highlights the gendered nature of caregiving roles. The study finds that daughters are significantly more likely to provide care, aligning with broader societal norms that associate caregiving with women. This reinforces existing inequities, as sons are more prone to free-riding or offering minimal support, especially in non-cooperative family structures. The empirical data from the CARE survey supports this asymmetry, indicating that caregiving expectations and burdens are unevenly distributed along gender lines, further exacerbating the inefficiencies inherent in informal caregiving. This insight underscores the need for gender-sensitive policies and delegation strategies in optimizing caregiving role allocation.

A unique insight from this study is that caregiving's positive externality[2]: on the other sibling is often not internalized, meaning strategic freeloading here leads to underprovision of care **as well as** lower sibling well-being. This public goods problem implies that current levels of informal care are suboptimal, reinforcing the need for intervention to push families toward a cooperative equilibrium. Unlike prior studies, Bergeot demonstrates that caregiving participation increases when the parent has severe ADL limitations or **when a sibling is a sister** and Bergeot also supports the game theory with empirical data that supports the conclusions, offering a unique perspective in this review. Bergeot's work suggests that forcing siblings into cooperative caregiving would increase aggregate care receipt and reduce unmet needs, but a policy that manages this is difficult to design and implement. An alternative strategy would be to increase publicly funded formal care (especially since evidence reveals that formal care has no significant displacement effect on family caregiving). By supplementing informal care rather than substituting it, state-funded schemes can perhaps resolve the inefficiencies of caregiving allocation, while relieving familial caregiving pressures. Bergeot (2022) thus makes a strong case for the combination of family and public caregiving policies for better care allocation.

The next paper, A3: Bargaining Power, Parental Caregiving, and Intergenerational Coresidence by Pezzin, Pollak, and Schone (2005), follows a similar trend, as they examine how bargaining power and household structure influence caregiving decisions for elderly parents by using a game-theoretic model. The utility functions of the children in this paper are similar to that in A1, wherein both children strategically adjust the same depending on their sibling's contribution, looking to reduce it. The change in co-residence, the authors assert, leads to a change in bargaining power (bargaining power refers to the ability to influence caregiving responsibilities, here), and thus the resultant difference-in-differences equilibrium forms:

$$C_{ji} = \beta_0 + \delta\phi_i + \alpha_1\Delta I_i + \alpha_2\Delta O_i + \alpha_3 K_{Bi} + \epsilon_{ji} \quad (10)$$

[2] Here, positive externality refers to the fact that a sibling's contribution has an impact on the other sibling's well being

The equilibrium analysis shows that when a sibling begins coresiding with a parent ($\Delta I_i = 1$), non-resident siblings strategically reduce their caregiving. Conversely, when a parent stops living with a sibling ($\Delta O_i = 1$), non-resident siblings significantly increase their caregiving contributions, leading to inefficient burden allocation. This shift occurs because coresident children experience a decline in bargaining power, as their proximity to the parent increases expectations of caregiving, allowing non-resident siblings to leverage their distance to minimize their own contributions. The study affirms the game-theoretic analysis using empirical data from the Health and Retirement Study (HRS-AHEAD), as the data analysis found that non-co-residing children reduce by about 7.3 hours per month; "in contrast, non-resident children whose parent and sibling(s) cease coresiding increase their hours of care by a substantial 16.8hr". Pezzin, Pollak, and Schone (2005) thus found that role allocation is a strategic bargaining process rather than an altruistic decision, where siblings adjust their caregiving based on their bargaining power. The study's key finding is that parental coresidence weakens the bargaining power of the coresiding child, leading to a redistribution of caregiving responsibilities. When a sibling moves in with the parent, non-resident siblings reduce their caregiving efforts, free-riding on the coresiding sibling's contributions. Conversely, when a parent stops coresiding, non-resident siblings increase their caregiving efforts, forming a noncooperative equilibrium. This is critical for planning optimal caregiving strategy. Without intervention, caregiving will remain inefficiently allocated, entrenching gender and money resource-based burden asymmetries. To counter strategic free-riding, policy needs to: Provide tax credits or direct payments to informal caregivers, make inheritance changes legal to recognize caregiving efforts, and expand formal care subsidies to reduce reliance on unpaid care.

The next paper, A4: Efficiency in family bargaining: living arrangements and caregiving decisions of adult children and disabled elderly parents by Pezzin, Pollak, and Schone (2006), which examines how efficiency shapes caregiving decisions, particularly when siblings decide whether to provide care or shift responsibilities. Using a Nash bargaining framework, it demonstrates that caregiving arrangements are often inefficient due to incomplete contracts and strategic free-riding. This paper has lots of overlap with Pezzin, Pollak, & Schone (2005) (particularly bargaining power and role allocation), and so only the efficiency perspective of this paper will be discussed. The efficiency analysis reveals that while the second-stage equilibria can be Pareto efficient given a fixed living arrangement, the overall game may still produce inefficient outcomes. This inefficiency arises primarily from the noncooperative nature of the first stage. The inability to make binding commitments means that strategic behaviour at the initial stage can lead to suboptimal allocations in the long run. For example, a child might avoid inviting the parent to coreside, anticipating that doing so would impose greater caregiving costs later, even if coresidence would be efficient in a fully cooperative setting. While cooperative solutions ensure efficiency at the second stage, they fail to address inefficiencies in the first stage. Moreover, the folk theorem suggests that repeated interaction among family members could sustain efficient outcomes, but the presence of endgame considerations (e.g., the finite nature of caregiving needs) limits the feasibility of such arrangements. Notably, when the parent lives independently, Pareto efficiency is plausible but not guaranteed, as it relies on frictionless bargaining assumptions. In contrast, when the parent coresides with one child, efficiency is less likely due to strategic interactions between the coresident and noncoresident siblings, where the latter may underprovide care. Overall, this means that even if caregiving resources are distributed optimally given a fixed living arrangement, the initial choice of whether the parent coresides with a child or lives independently can still lead to suboptimal outcomes. The model used here thereby highlights efficiency barriers, stemming from commitment issues, bargaining power, and strategic free-loading.

Building onto the idea of efficiencies we have the next paper A5, "The Effects of Cooperation: A Structural Model of Siblings' Caregiving Interactions", by M. Knoef & P. Kooreman (2012). The authors examine sibling interactions in caregiving decisions using a structural game-theoretic model to determine whether caregiving follows a cooperative or noncooperative equilibrium, drawing comparisons between both one child and two child families. This study uniquely quantifies the welfare gains of cooperation,

offering an empirical perspective on how shifting siblings toward cooperative caregiving could significantly improve caregiving efficiency, an aspect not explicitly addressed in previous studies.

This paper applies game theory to analyse how siblings decide on the amount of informal care they provide to their elderly parents. The central question is whether these decisions are made cooperatively, optimizing joint well-being, or noncooperatively, where each sibling acts independently, taking the other's behaviour as given.

In the noncooperative framework, each sibling makes caregiving decisions independently, treating the other's choices as given. Since caregiving imposes time and financial trade-offs, the model incorporates a *Quantal Response Equilibrium (QRE)*, which accounts for bounded rationality and uncertainty in decision making.

The probability that sibling i chooses caregiving level m is given by:

$$p_{i,m} = \frac{exp(\lambda E(U(ti,m|pj)))}{\sum_{k=1}^{12} exp(\lambda E(U(ti,k|pj)))} \quad (11)$$

Where:

- $E(U(t_{i,m}|p_j))$ represents the **expected utility** of sibling i given caregiving choice $t_{i,m}$ and the probability distribution p_j of their sibling's choices.
- λ is a **rationality parameter**, where higher values indicate more precise decision-making, and lower values introduce randomness.
- The denominator ensures the probabilities sum to 1 across all possible caregiving levels.

Unlike a standard Nash equilibrium, which assumes fully rational players, QRE allows for *imperfect decision-making*, better capturing real-world behaviour where siblings do not always act optimally.

In contrast, the cooperative framework assumes that siblings maximize a joint utility function:

$$U(t_1, t_2) = \gamma U(t_1) + (1 - \gamma)U(t_2), \gamma \in [0, 1] \quad (12)$$

Where:

- $U(t_1)$ and $U(t_2)$ are the individual utility functions of the two siblings.
- γ represents the weight placed on one sibling's utility relative to the other.

This model assumes that caregiving is **negotiated** to balance both siblings' interests rather than each acting independently. It captures scenarios where siblings might agree to split caregiving duties based on work schedules or financial constraints.

To assess which model better fits observed caregiving behaviour, the authors conduct estimations using caregiving data from the *Survey of Health, Ageing, and Retirement in Europe (SHARE)*. To test which model better explains caregiving decisions, key parameters (e.g., preferences for leisure, consumption, and caregiving) are estimated using maximum likelihood estimation (MLE) with data from SHARE. The models then generate caregiving predictions, which are compared to actual observed behaviour. Likelihood ratio tests and mean squared error (MSE) evaluate model fit, identifying whether cooperative or noncooperative decision-making better aligns with real-world caregiving patterns. This approach ensures the models accurately capture care-giving dynamics. Knoef & Kooreman (2011)

estimate that 71% of siblings are noncooperative, resulting in underprovision of care relative to the socially optimal cooperative equilibrium. Their calculation indicates that if siblings were forced into cooperation, aggregate informal caregiving would increase considerably but at the expense of lower full-time labour supply. This suggests a policy trade-off—while cooperation enhances caregiving efficiency, it might have economic costs, underscoring the importance of well-balanced policy interventions.

The next paper, A6, to be reviewed is: "Do Siblings Free-Ride in 'Being There' for Parents?" by Maruyama & Johar (2017). This paper introduces a spatial facet, as it analyses the ways in which siblings strategically determine where to reside in relation to their aging parents, adding geographic proximity to caregiving role distribution. Contrary to prior research on time and financial caregiving transfers, this paper points out the ways in which spatial free-riding is made possible, with siblings consciously moving further away so that they can offload caregiving tasks on others who live closer.

The paper models siblings' location choices in providing parental care as a sequential participation game, solved using subgame perfect Nash equilibrium (SPNE) via backward induction. Each sibling i derives utility from living near or far, represented as

$$u_i = u_{\alpha i} + u_{\beta i} + u_{\gamma i},$$

Where $u\alpha i$ captures altruistic benefits toward the parent, $u\beta i$ represents individual costs or benefits from proximity, and $u\gamma i$ reflects strategic interdependencies among siblings. Given the sequential nature of decisions, older siblings may exploit a first-mover advantage akin to a Stackelberg leader, influencing younger siblings' responses. This advantage is formalized as

$$u_1\,(1,\,1) - u_1\,(0,\,1) = -u_{\alpha 1} + u_{\gamma 1},$$

Where the leader internalizes the reaction function of the follower. The game exhibits a public goods dilemma, paralleling a prisoners' dilemma, in which individual incentives lead to a free-riding equilibrium. The inefficiency arises when

$$u_\alpha > 0,\ u_\gamma > 0,\ u_\beta < 0,$$

Indicating that while altruism and complementarities in caregiving increase welfare, the private cost component $u\beta$ drives defection. The equilibrium outcomes are assessed using Pareto and Kaldor-Hicks efficiency criteria, demonstrating that the observed strategy profile may not maximize family welfare. The presence of strategic substitution, wherein the marginal benefit of caregiving decreases as others participate, exacerbates the free-riding problem, leading to coordination failures that result in suboptimal caregiving arrangements. Somewhat similar to A5, a counterfactual simulation was conducted, comparing observed location decisions under noncooperative behaviour with a cooperative scenario in which siblings maximize joint welfare. The methodology follows a maximum simulated likelihood (MSL) approach with Monte Carlo integration, solving for equilibrium location configurations based on estimated parameters. The study uses U.S. Health and Retirement Study (HRS) data from 1998, 2004, and 2010, tracking demographic and locational information of elderly parents and their children. The paper finds that siblings make noncooperative location decisions regarding their elderly parents, leading to underprovision of proximate living due to a free-riding problem. In multi-child families, 18.3% more parents would have had at least one child nearby if decisions were made cooperatively. While strategic interaction plays a role, the dominant factor is the public goods problem, where each sibling hopes another will take on caregiving responsibilities. The study validates its conclusions by comparing alternative behavioural models, confirming the empirical relevance of externalities and the limited role of sequential decision-making. Now that we have looked at role allocation, it is important to look at how culture and gender affect role allocation. To do this, 2 more studies will be looked at in brief: A7, "Gender differences in caregiving among family - caregivers of people with mental illnesses" by Sharma

et al., (2016) and A8, "Cultural Diversity Impacts Caregiving Experiences: A Comprehensive Exploration of Differences in Caregiver Burdens, Needs, and Outcomes" by Tran et al., (2023). Looking at the gender differences first, A7 empirically investigates the impact of gender on the caregiving experience of family members of mentally ill individuals in a Chinese sample. Employing structured interviews and standardized psychological scales, the research identifies that female caregivers report significantly greater burden, emotional distress, and caregiving strain than their male counterparts. Interestingly, female caregivers scored significantly higher on the Zarit Burden Interview (mean = 51.2) compared to men (mean = 44.3; $p < 0.01$). Women also are more engaged in daily caregiving activities and report being more inclined to put the patient's needs ahead of their own. Still, the authors point out that although gender differences are observed, gender by itself explains only a small percentage of the variance for negative caregiving outcomes.

Moving onto the cultural dimension, A8 examines the role of culture in shaping caregiving burden, information needs, and support experiences of informal caregivers between White, Hispanic, and Asian American populations. Based on national survey responses and structured interviews, the research discovers statistically significant variations in caregiver concerns and availability of resources between cultures. For instance, Asian American caregivers were more likely to experience stress regarding their family's medical information, whereas White caregivers were more aware of and more likely to utilize government support systems. Hispanic caregivers, on the other hand, indicated strong family devotion but restricted access to formal services. Interestingly, only 38% of Asian American caregivers were confident in accessing healthcare systems, as opposed to 62% of White caregivers. These results emphasize that caregiving behaviours and burdens are heavily influenced by cultural values and access to systems, affirming the importance of culturally responsive support models and interventions that mirror group-specific caregiving experiences.

2.1.1 Summary

Thus, Caregiving role assignment is a profoundly strategic process informed by interdependence, asymmetry, and social expectation. Throughout the studies, a recurring finding is that caregiving is a non-cooperative public goods game in which family members, especially siblings, underprovide care through strategic freeriding and absence of enforceable commitments. Physical proximity and coresidence, ostensibly healthy, tend to transfer bargaining power and provoke further withdrawal on the part of non-resident members. Efficiency is seldom realized, since early-life decisions (such as residence) are made in strategic anticipation of future burden. In addition, gender and cultural norms severely distort role allocation: daughters disproportionately shoulder caregiving burden, and cultural acquaintance with healthcare systems affects participation and perceived burden. Most importantly, these dynamics are not merely theoretical but empirically validated - for instance, caregiving burden changes by 7.3 hours/month if a sibling coresides, and women systematically report higher burden scores than men. One of the most obvious inefficiencies is the positive externality of caregiving: one sibling's effort extends to the others, but this is seldom priced into their strategic calculations

Table 1. Summary of Key Papers on Game-Theoretic and Empirical Caregiving Role Allocation

Serial No.	Author(s)	Brief Overview	Contribution to Analysis
A1	Pezzin, Pollak, & Schone (2003)	Introduces a two-stage game theoretic model for caregiving: Stage 1 (living arrangements), Stage 2 (resource allocation).	Establishes the **bargaining power** framework, showing that **coresident children are disadvantaged** in negotiations. Reveals how lack of binding agreements leads to **underprovision and strategic imbalance** in caregiving.
A2	Bergeot (2023)	Empirically tests cooperative vs. non-cooperative caregiving using game theory and data from the French CARE survey.	Confirms that caregiving is a **noncooperative public goods game**. Shows **strategic free-riding** and how siblings fail to internalize caregiving externalities. Adds depth by incorporating **gender asymmetries**—daughters care more.
A3	Pezzin, Pollak, & Schone (2005)	Studies changes in caregiving behaviour when a sibling starts or stops coresiding with the parent.	Highlights how **coresidence weakens bargaining power**, prompting **nonresident siblings to reduce their efforts**. Shows caregiving is a **strategic bargaining game** influenced by physical proximity.
A4	Pezzin, Pollak, & Schone (2006)	Applies a Nash bargaining model to examine Pareto efficiency in caregiving outcomes.	Shows that while second-stage caregiving may be efficient, **first-stage decisions (living arrangements) are often suboptimal**. Reveals long-term inefficiencies due to **non-binding commitments and foresight limitations**.
A5	Knoef & Kooreman (2012)	Compares cooperative and noncooperative caregiving using a **Quantal Response Equilibrium** model.	Finds **71% of siblings behave noncooperatively**, resulting in care underprovision. **Quantifies welfare losses** and shows that **cooperation increases care but reduces labour supply**, revealing a **policy trade-off**.
A6	Maruyama & Johar (2017)	Models caregiving as a spatial game where siblings strategically decide how close to live to aging parents.	Introduces a **Stackelberg game structure** showing that **first-mover siblings manipulate location to shift burden**. Demonstrates **spatial free-riding** and links geography to strategic caregiving decisions.
A7	Sharma et al. (2016)	Explores gender differences in caregiving stress and involvement among family caregivers in China.	Shows that **female caregivers report higher burden scores (mean = 51.2 vs 44.3, $p < 0.01$)** and take on more caregiving tasks. Highlights the need for **gender sensitive delegation** and policy to correct **role asymmetries**.
A8	Tran et al. (2023)	Compares caregiver burden and access to support across White, Hispanic, and Asian American groups.	Reveals **culturally-driven differences** in caregiver stress and system navigation. For example, **only 38% of Asian American caregivers felt confident navigating healthcare systems** vs 62% of White caregivers. Urges **culturally responsive caregiving strategies**.

2.2: The Role of Governments and Private Institutions

While much of caregiving occurs within the informal domain of families, it does not operate in a policy vacuum. Governments play a pivotal role in shaping the incentives, constraints, and support systems that define the caregiving landscape. As the demand for home-based eldercare rises, particularly with aging populations and increased life expectancy, the strategic decisions made by caregivers are increasingly intertwined with public policies—such as financial subsidies, paid leave, tax credits, and formal respite care services. These interventions can either alleviate or exacerbate burden, influence intra-family caregiving negotiations, and determine whether care is delivered formally, informally, or not at all. Thus, government intervention is not just a background condition—it is an active strategic variable that influences whether caregiving systems remain cooperative, equitable, and sustainable. This domain explores how such policies shape caregiving behaviours, improve (or undermine) efficiency, and provide levers for designing more optimal caregiving ecosystems. The first paper, B1, is "Evaluating Long-Term-Care Policy Options, Taking the Family Seriously" by Barczyk and Kredler (2017). This paper models LTC decisions as a dynamic game between elderly parents and adult children, focusing on strategic intrafamily bargaining over informal care. A key innovation is the inclusion of informal caregiving as an endogenous margin of policy response. The model, calibrated to U.S. data, replicates observed care arrangements and labour supply behaviour with high accuracy. It finds that combining subsidies for informal care with modest Medicaid reductions can yield substantial welfare gains for families and the state.

Barczyk and Kredler (2017) construct a dynamic, recursive, non-cooperative game between elderly parents and adult children to evaluate long-term care (LTC) policy. The model embeds altruism, strategic bequests, and intra-family bargaining over informal care (IC) into a general equilibrium framework with overlapping generations. Eachperiod, agents solve Hamilton–Jacobi–Bellman (HJB) equations:

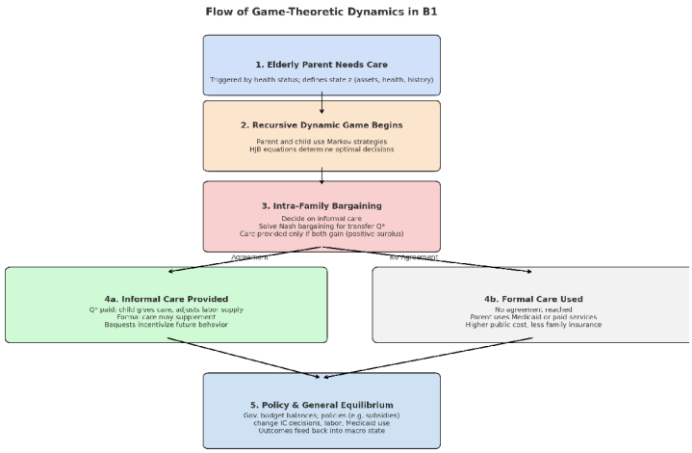

Figure 1. Flow of Game-Theoretic Dynamics in B1

$$\rho Vi\ (z) = V_{jk}^{i}\ (z) + J_i + H_{i,1}(z,V^p,V^k)$$

Informal care arises endogenously through Nash bargaining. The transfer from parent to child Q^* maximizes the weighted product of surpluses:

$$Q^* = \arg\ Q \geq 0 max\ \{[Sk\ (Q)]^{\omega}\ [Sp\ (Q)]^{1-\omega}\}$$

Care is provided if both agents are better off:

$$h = \begin{cases} 1 \text{ if } S_p(Q), S_k(Q) \geq 0 \\ 0 \text{ otherwise} \end{cases}$$

The model characterizes equilibrium behavior through policy rules and value functions consistent with market clearing and a balanced government budget. Policy simulations reveal that informal care responds significantly to subsidies, crowding out Medicaid use. The framework illustrates how micro-level family dynamics and bargaining processes aggregate into macroeconomic outcomes under alternative LTC policies.

The model developed by Barczyk and Kredler (2017) suggests that the most efficient and sustainable caregiving strategy combines moderate formal care subsidies with continued support for informal care, rather than fully expanding or eliminating public programs like Medicaid. This policy mix aligns incentives across agents by supporting family-provided care without crowding it out, thus avoiding strategic withdrawal or free-riding. The model highlights that informal care is a flexible, policy-sensitive margin of adjustment within families, and that treating caregiving as a strategic decision process improves the precision of policy evaluation. A key contribution is the formal integration of intra-family bargaining into long-term care design, revealing how well-calibrated policies can sustain both efficiency and equity in care provision. This supports the broader framework of caregiving as a multi-agent decision problem, where institutional mechanisms can enhance cooperation and reduce burden asymmetries. More broadly, it could be said that the paper offers a roadmap of sorts for how public intervention can unlock more sustainable, family-cantered caregiving.

The next paper, B2, to be reviewed is: "Evolutionary Game Analysis of Community Elderly Care Service Regulations Based on Omni-Feedback Mechanism" by Zhang, Liu, and Wang (2022). This paper models strategic interactions between the government, service providers, platforms, and elderly users in community care. It introduces an omni-feedback mechanism and shows how subsidies, penalties, and user feedback can align incentives to improve service quality and cooperation in formal caregiving systems. This study constructs a four-player evolutionary game model involving: Government (regulates via penalties & subsidies), Elderly Care Service Providers (choose high- or low-quality care), Information Platforms (choose to conduct return visits or not), Elderly Individuals (choose online vs offline evaluation/complaints). Each actor updates their strategy over time based on replicator dynamics—modelling bounded rationality and adaptive learning, rather than perfect foresight.

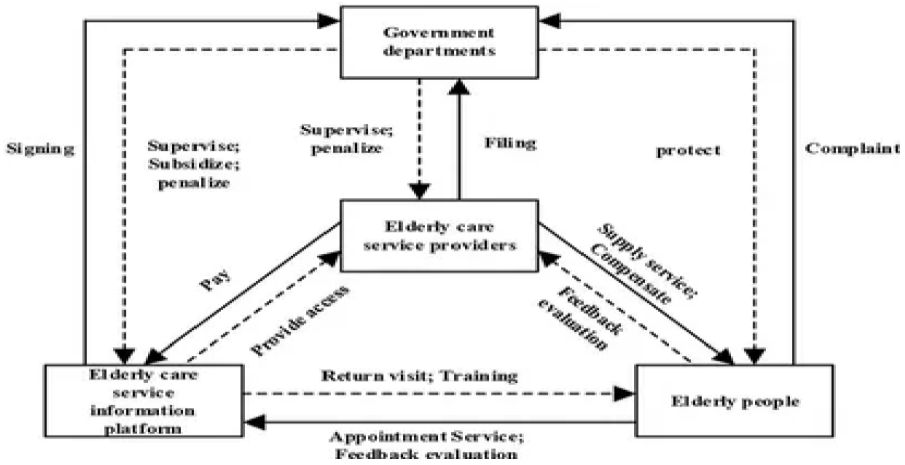

Figure 2. Strategic Interaction Model from Zhang et al. (2022)

Let x, y, z, $w \in [0, 1]$ denote the probabilities of providers offering high-quality services, platforms conducting positive return visits, the government enforcing regulation, and elderly individuals engaging in online feedback, respectively.

Payoff functions are explicitly derived under economic assumptions (e.g., service costs C_{sh},C_{sl} , penalties F_s, F_e, reputational effects Is, Ds), leading to expected utilities such as:

$$U_x = (1 - \alpha)R_s - C_{sh} + wI_s + (1 - w)\gamma I_s$$

For providers, and

$$U_y = \alpha R_s - C_{eo} - C_{ei} + wI_e + (1 - w)\gamma I_e + S$$

For platforms. Strategy evolution is governed by Malthusian-type replicator equations, such as:

$$\dot{x} = x\,(1 - x)\,(U_x - \underline{U}_x),$$

Where $\underline{U}_x$ is the average payoff of providers. Threshold values (e.g., $w0$, $x0$) are derived analytically to characterize behavioural phase transitions. Coupled replicator dynamics induce interdependencies between agents' strategies. Stability analysis is conducted via Lyapunov theory and Jacobian matrices, enabling identification of Evolutionary Stable Strategies (ESS) across the system. Zhang, Liu, and Wang (2022) conclude that high-quality elderly care can be sustained through a decentralized system driven by user feedback, platform accountability, and targeted government intervention. Their evolutionary game model shows that empowering elderly individuals to provide feedback and incentivizing platforms to respond reduces the need for constant government regulation. This approach reframes caregiving governance as a cooperative, self-correcting system, offering a cost-effective and scalable strategy for improving service quality in community-based eldercare settings. Building on B2's analysis of regulatory feedback in community care systems, B3 examines the strategic behaviour of care institutions and families of disabled elderly under China's long-term care insurance. Hu and Zhang (2023) construct a two-player evolutionary game model showing how government subsidies and differentiated tax rates affect the stability of caregiving strategies, finding that moderate public intervention leads to a stable equilibrium of professional institutional care alongside home-based family care.

This paper develops an evolutionary game model to analyse strategic interactions between *care institutions* and *disabled families* in China's long-term care system. The game is modelled in continuous time using replicator dynamics, where strategy shares evolve based on relative payoffs. Care institutions choose between providing *simple care* and *professional care* (with probability p), while disabled families choose between *in-home care* and *institutional care* (with probability q). The expected payoffs to care institutions are given

As follows. For professional care:

$$u_1 = q[P_2 + T_2 - C(1 + \delta)] + (1 - q)\,[(1 - t)P_2 + \rho T_2 - C(1 + \delta)],$$

And for simple care:

$$u_2 = q(P_1 + T_1 - C) + (1 - q)\,[(1 - t)P_1 + \rho T_1 - C].$$

The average payoff is $u = pu_1 + (1 - p)u_2$, and the replicator dynamic for p is:

$$\frac{dp}{dt} = p(1 - p)\,(\alpha_1 q + \beta_1),$$

Where:

$$\alpha_1 = t\,(P_2 - P_1) + \frac{(1-\rho)Y(\tau 2 - \tau 1)}{\theta}, \quad \beta_1 = (1-t)(P_2 - P_1) + \frac{\rho Y(\tau 2 - \tau 1)}{\theta} - \delta C.$$

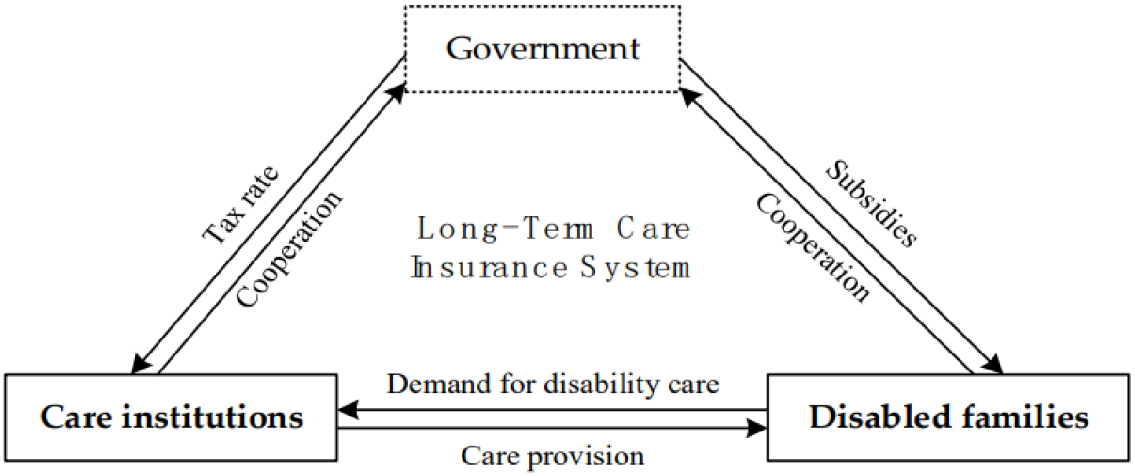

Figure 3. Chinese Interaction Model from Hu & Zhang (2023)

Similarly, the expected payoffs to disabled families are:

$$v_1 = p[Y\,(1-\tau_2) - P_2 + W] + (1-p)\,[Y\,(1-\tau_1) - P1 + W]\,,$$

$$v_2 = p[Y\,(1-\tau_2) - tX - (1-t)P_2] + (1-p)\,[Y\,(1-\tau_1) - tX - (1-t)P_1],$$

With replicator dynamic:

$$\frac{dq}{dt} = q(1-q)\,(-\alpha_2 p + \beta_2),$$

Where:

$$\alpha_2 = t\,(P_2 - P_1),\ \beta_2 = W + tX - tP_1.$$

The system admits five Nash equilibria, including interior equilibria (p^*, q^*), where:

$$p^* = \frac{W + tX - tP1}{t\,(P2 - P1)}, \quad q^* = \frac{\delta C - (1-t)\,(P2 - P1) - \frac{\rho Y\,(\tau 2 - \tau 1)}{\theta}}{t\,(P2 - P1) + \frac{(1-\rho)Y\,(\tau 2 - \tau 1)}{\theta}}$$

Together, these equations capture how institutional and household behaviours co-evolve under economic and policy constraints, providing a formal mechanism to assess how changes in costs, subsidies, and preferences dynamically shape the long-term equilibrium structure of the care ecosystem. To estimate the model's behavioural dynamics, Hu and Zhang (2023) conduct a numerical simulation based on calibrated parameters drawn from China's long-term care pilot programs. Rather than employing econometric estimation, the authors assign plausible values to key variables such as service cost, subsidy rate, and tax levels. They then solve the replicator dynamic equations numerically to analyse how policy configurations influence the evolution and stability of caregiving strategies between families and care institutions. Hu and Zhang (2023) conclude that government subsidies and tax rates significantly influence the strategic behaviour of care institutions and families of disabled elderly individuals. Their

evolutionary game model demonstrates that excessive intervention can destabilize the system, while moderate subsidies and differentiated taxation lead to a stable equilibrium of professional institutional care alongside home-based family care. The study's unique contribution lies in modelling long-term care insurance as a dynamic two-agent game, bridging institutional incentives and family decision-making. Within Domain B, it deepens our understanding of how policy design can align multi-agent interests to promote sustainable caregiving strategies.

Extending B3's focus on subsidy-driven strategy between families and institutions, B4 examines how government regulation shapes the evolving behaviors of private senior care institutions and elderly individuals. Zhang et al. (2023) develop a three-player evolutionary game model to show how subsidies, penalties, and trust dynamics jointly determine the stability and quality of senior care services.

The paper constructs a **triadic evolutionary game model** among government departments, private pension institutions, and the elderly, applying the **replicator dynamic framework** to describe boundedly rational decision-making under uncertainty. The game uses **continuous strategy probabilities**—x, y, and z—to denote the likelihoods of choosing regulation, standardized operation, and service participation, respectively. Central to the model are **replicator dynamic equations** for each agent, derived via **Malthusian fitness comparison** between strategy payoffs and population averages.

For example, the government's dynamics are expressed by:

$$\frac{dx}{dt} = x(1-x)\left[y(-\theta s - \lambda\eta p) - za + \pi_1 + \lambda\eta p + c_2 - c_1\right]$$

Similar forms are developed for private institutions (y) and the elderly (z), incorporating subsidies, penalties, and operational costs:

$$\frac{dy}{dt} = y(1-y)\left[x(\theta s + \lambda\Delta\pi + \lambda\eta p) + z(c_6 - c_7) - \Delta\pi + c_4 + c_7 - c_3 - c_6\right]$$

$$\frac{dz}{dt} = z(1-z)\left(xa + yc_8 + \pi_3 - c_5 - c_8\right)$$

The analysis employs **Lyapunov stability** via the **Jacobian matrix eigenvalues** to identify evolutionarily stable strategies (ESS), establishing a structured, dynamic framework well-suited to modelling caregiver regulation systems.

Zhang et al. (2023) conclude that a stable and ideal long-term care system appears when public agencies enforce guardianship, private agencies conform, and elderly persons actively participate. Their evolutionary game model demonstrates that although multiple equilibria exist, effective government regulation, calibrated subsidies and penalties, and smallest enforcement costs provide the greatest likelihood for convergence to a high-quality service environment. Most importantly, the authors caution that if under-the-table profit channels are allowed to exist, institutions would act contrary to standardized care. The removal of such incentives is then paramount to sustain welfare-enhancing results in multi-agent eldercare ecosystems.

Now, let's look at B5, "An evolutionary game-based simulation study of a multi-agent governance system for smart senior care services in China" by Shi et al (2023). The paper models the dynamics of strategic decision making in China's smart senior care sector using a tripartite evolutionary game framework. It considers three rational but bounded agents—the government, smart senior care technology service providers, and older adults—whose strategies evolve over time. Each agent selects from two strategies: the government can opt for strict or relaxed regulation, providers can act in a trustworthy or untrustworthy manner, and older adults can choose to use or abstain from smart senior care

services. The interactions are governed by replicator dynamics, with state variables x, y, $z \in [0, 1]$ representing the probabilities of each agent adopting the more cooperative strategy. The evolution of these strategies is defined by differential equations such as

$$\frac{dx}{dt} = x(1-x)\,(G_1 - \underline{G}),$$

Where G_1 and $\underline{G}$ denote the expected and average payoffs of strict regulation. Similar forms are defined for providers and older adults using payoff functions $C1$, $C2$ and $E1$, $E2$, respectively. These equations incorporate variables such as fines, subsidies, brand effects, and quality-of-life enhancements. The study ultimately uses these replicator dynamics to identify evolutionarily stable strategies (ESS) and to assess how agents adapt

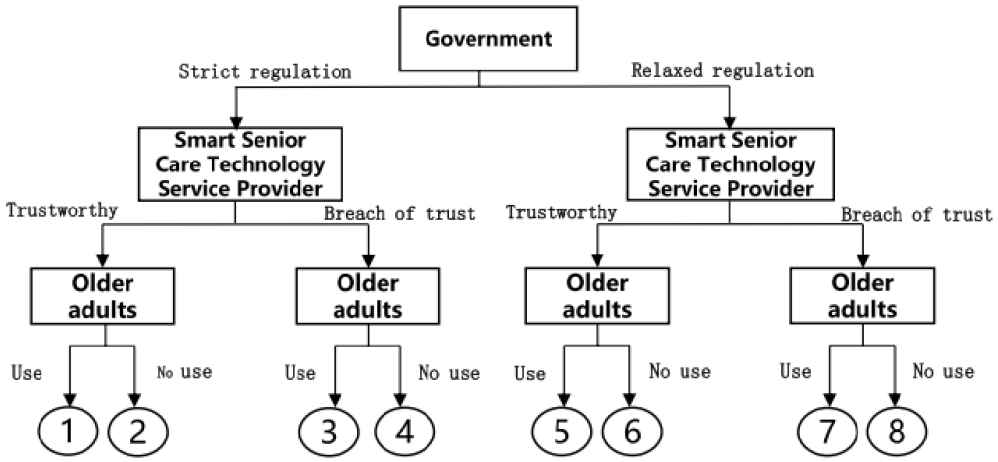

Figure 4. Tree decision of the tripartite evolutionary game agents in Shi et al (2023)

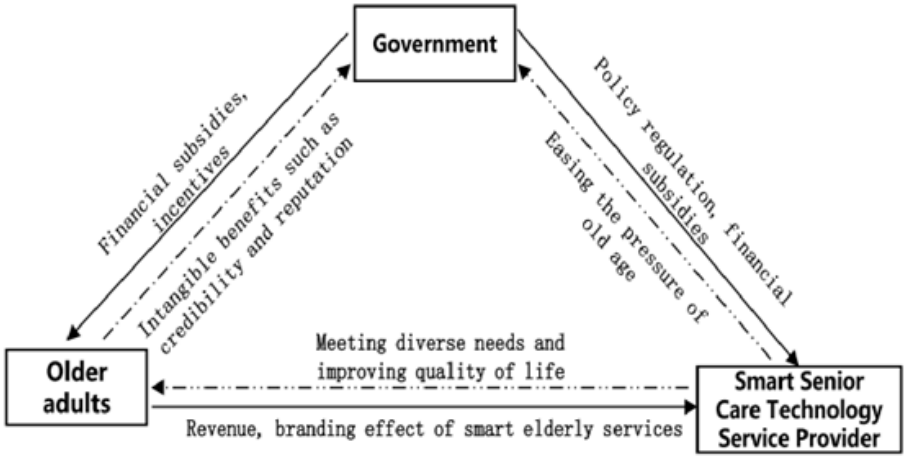

Figure 5. Tree decision of the tripartite evolutionary game agents in Shi et al (2023)

Within a dynamic governance ecosystem. Shi et al. (2023) develop an evolutionary game theory model to study strategic interactions between the government, smart senior care technology providers, and older adults, considering China's rapidly changing care environment. Their analysis shows that

system stability and optimal outcomes—characterized by government monitoring, trustworthy provision of services, and engagement by older adults—are possible if the relevant incentives are aligned. For example, larger fines for noncompliance will motivate providers to offer financial rewards for compliance, hence engaging older adults in the process. On the other hand, too much subsidy or benefit will effectively destabilize such a system leading to undesirable consequences, such as reliance on unethical practices. The role of the government cannot be overemphasized; it becomes a regulatory giant on a parameter change, suggesting the need for stronger adaptive regulation. Findings suggest the concept of dynamic regulation, which changes depending on costs, incentives, and governance effectiveness and recognizes the need for trilateral cooperation to resolve fragmented service delivery. This model thus provides concrete pathways for addressing structural problems in multi-agent caregiving governance.

Moving from B1-B5's analysis of the multi-agent interaction in caregiving, B6 looks at a legal-institutional perspective on care policy. Rana and Singh (2024) discuss the Maintenance and Welfare of Parents and Senior Citizens Act in India in the manner of an examination of legally enforceable duties in altering care obligations and turning elder care from voluntary responsibility to legally mandated duty. The Act addresses issues related to the maintenance of parents and senior citizens, the establishment of old age homes, provisions for medical care, and measures to protect their lives and property. However, by raising several issues in the act, the paper emphasizes the growing need for a more improved and contemporary policy. As Rana and Singh (2024) argue, almost 15 years after this Act's enactment, outdated norms and procedural inefficiencies limit its implementation. Many elderly people in rural and backward areas might remain oblivious to their rights or are faced with institutional roadblocks in seeking justice in this regard. Consequently, the paper calls for more contemporary policies that combine awareness campaigns, fast-track tribunals, and welfare schemes with legal mandates to guarantee holistic yet enforceable eldercare in modern Indian society.

For a more global analysis, we will now move to caregiving policy in Europe. B7, "Assessing Policy Challenges and Strategies Supporting Informal Caregivers in the European Union" by Wieczorek et al. (2022), assesses policy challenges and strategic gaps across EU member states, highlighting the fragmented support for informal caregivers and advocating for coordinated, equity-focused reforms across diverse healthcare systems. In their analysis of informal caregiver support policies of various EU countries, Wieczorek et al. (2022) probe three main themes: financial compensation/recognition; labour market policies; and wellbeing services, i.e., training, counselling, or respite care. Their findings point to certain commonalities in relation to cash benefits and flexible work arrangements, but considerable disparities were revealed in access and application. A primary impediment to access is still traditional social norms about gender and family duty, which militate against any demand for or assumption of need by caregivers. Even when such policies are enacted, they are susceptible to something called "policy drift," whereby their implementation maybe unintentionally altered through shifts in institutional arrangements or in the influence of stakeholders. The authors therefore call for a much more coordinated and equity-biased type of reform with an understanding of cultural impediments to obtain sustainable support for informal caregivers spread across different welfare regimes. Extending B7's cross-national policy perspective, B8,"What seems to matter in public policy and the health of informal caregivers? A cross-sectional study in 12 European countries" by Calvo´-Perxas et al (2018), evaluates what forms of support actually improve caregiver outcomes. This paper synthesizes evidence from 56 studies across nine countries to assess the effectiveness of interventions for informal caregivers of individuals with long-term conditions. This study investigates the link between public policies applied in Favor of informal caregivers and the health of the caregivers across 12 European countries. Drawing on the Survey of Health, Ageing and Retirement in Europe (SHARE) data for model construction, the researchers found that measures of support that are non-financial in nature, such as training, respite, and counselling, are more positively associated with caregiver health than compensation-support measures.

The fact that a country is classified as one that primarily relies on family care, where family members are expected to play the principal role in caregiving, is associated with poorer health among caregivers. Increased caregiving burden, however, correlates negatively with the health of caregivers. The study found no significant gender difference in the relationship between policy and caregiver health. The authors therefore conclude that non-financial policies are superior and that there should be a balance between informal, formal (private, in this case), and government-based care.

2.2.1 Summary

Across the eight studies analysed in Domain B, a consistent theme emerges: caregiving decisions are embedded within complex, multi-agent systems that involve families, government bodies, and private care institutions. These relationships are marked by coordination failures, information asymmetries, and misaligned incentives. Strategic modelling papers (B1–B4) show how government subsidies, tax structures, and regulatory enforcement shape the caregiving behaviours of families and providers. However, they also reveal that excessive intervention can destabilize care ecosystems, while insufficient oversight leads to free-riding or care avoidance. Governments must navigate fine policy thresholds to maintain cooperation. Empirical and legal analyses (B5–B8) reveal that statutory mandates (like India's MWPSC Act) can enforce care duties but often lack accessibility and awareness. Across Europe, fragmented caregiver support and heavy reliance on familial care worsen health outcomes. Non-financial supports—like respite care and training—are more effective than cash transfers, yet remain underused. Together, these findings point to a fundamental systems problem: caregiving is treated as both a private obligation and a public necessity, but institutional frameworks rarely reconcile the two. This tension produces inefficiencies, inequities, and ultimately undermines the sustainability of long-term care systems. A coordinated, incentive-aligned, and user-informed policy architecture is urgently needed.

Table 2. Summary of Key Papers on Government and Policy Mechanisms in Caregiving (Domain B)

Serial No.	Author(s)	Brief Overview	Contribution to Analysis
B1	Barczyk & Kredler (2017)	Constructs a dynamic game between elderly parents and adult children under public LTC policy.	Models caregiving as a multi-stage decision problem. Shows how LTC subsidies shape intra-family bargaining and reduce Medicaid reliance when optimally calibrated.
B2	Zhang, Liu, & Wang (2022)	Models evolutionary strategies between government, care platforms, providers, and elderly users in a smart care ecosystem.	Demonstrates how feedback, penalties, and subsidies drive equilibrium behaviour. Emphasizes the regulatory role of government in coordinating decentralized caregiving systems.
B3	Hu & Zhang (2023)	Uses evolutionary game theory to study interaction between families of the disabled elderly and private care institutions under LTC insurance.	Identifies how government tax and subsidy policy stabilize professional institutional care and home care coexistence. Shows crowd-out and incentive thresholds.
B4	Zhang, Wang, & Zhang (2023)	Analyses strategic behaviour of government, private institutions, and older adults in senior care governance.	Identifies stable outcomes (ESS) and shows that coordinated regulation and compensation strategies reduce provider default and increase user participation.

B5	Shi et al. (2023)	Models China's smart senior care governance as a three-agent evolutionary game.	Shows that strong regulation, balanced incentives, and user compensation stabilize cooperative behaviour. Emphasizes government as a key stabilizing actor in multiagent systems.
B6	Rana & Singh (2024)	Analyses India's Maintenance and Welfare of Parents and Senior Citizens Act as a legal caregiving mandate.	Highlights how enforceable obligations shift caregiving from voluntary to compulsory. Advocates for legal reform to improve access and effectiveness of statutory support.
B7	Wieczorek et al. (2022)	Assesses policy challenges and support mechanisms for informal caregivers across 12 EU countries.	Finds wide disparities in caregiver support. Advocates for equity-based, coordinated reforms, especially around labour flexibility and wellbeing services.
B8	Calvó-Perxas et al. (2018)	Investigates the relationship between caregiver health and policy support across 12 European countries using SHARE data.	Finds non-financial supports (training, respite, counselling) are more positively associated with caregiver health than cash-based support. Countries relying heavily on family care show worse caregiver health. Recommends balanced policy frameworks integrating informal, formal, and government care.

2.3 Implications for Goverments, Private Organizations and Individuals

2.3.1 Governmental Shift from Passive Support to Strategic Contribution

From this review, it becomes evident that governments not only have a role in designing legislation themselves, but also a more important mediatory role in designing the systems that govern these caregiving interactions. In this section, we will provide insights for both these roles. The single most important takeaway is that the government must take a "Goldilocks" approach. They have to ensure that the caregiving load is distributed evenly between governments, private care organizations, and the caregivers themselves. To begin, the government's active contribution in this process is primarily legislative and monetary. As seen by A1-A4, B1-B3, a lack of caregiving incentive is a prominent issue that leads to problems like strategic free-loading. Thus, financial incentives **and** awareness regarding how to access these incentives must be established. From B1 and B3, we learn that moderate subsidies and targeted tax incentives promote cooperative caregiving behaviour within families and institutions. Over-subsidization encourages dependency and crowds out informal care, while under-subsidization exacerbates caregiving burden and service underuse. Policies must be calibrated to balance informal and formal care, as well as promote role-sharing across siblings or family units (A1–A4 in Domain A reinforce this point). However, one major issue about the current landscape of caregiving that must be addressed is that governmental interventions are solely monetary. Non financial incentives must also be established. Governments must invest in respite care, counselling, and skill related projects- creating a more personalized infrastructure for these caregivers. A powerful policy shift is required: from viewing caregiving as a purely economic trade-off to understanding it as a multi-dimensional social role. Since, in this new framework for caregiving interactions, we recommend increased emphasis on private forms of care, strict governmental supervision over these organizations is recommended. Studies B2, B4, and B5 highlight the need for active, dynamic regulation of private providers in care ecosystems. Strategic penalties for non-compliance, performance-based rewards, and transparent quality feedback systems—

especially in tech-enabled care models—can align institutional behaviour with patient welfare. Governments must function not only as funders but as real-time regulators of care quality and accessibility.

Public policy must evolve from fragmented, reactive models to strategic caregiving ecosystems—ones that align financial incentives, legal duties, and behavioural nudges across all stakeholders. The design of these systems must be data-driven, culturally sensitive, and flexible enough to accommodate the complexity of real-world caregiving relationships.

2.3.2 More Accountability and Diversity in Private Care Infrastructure

As the government's role is more managerial and monetary, the core operations of care systems mainly fall to private care organizations. These include, but are not limited to, nursing homes and home caregiving options. These care services, as seen in B2, need to be moderated through user feedback. Stable government intervention incentivizes private care institutions to adapt based on feedback from elderly individuals for better caregiving systems. It is important to re-emphasize that governments should be playing a *moderating*, not an *imposing* role. While government regulation should reward care services that have improved elderly individuals' lives and penalties should be placed on those who don't, B4 and B5 reveal that when penalties for non-compliance are weak or enforcement inconsistent, providers may default to profit-maximizing behaviour, resulting in reduced service quality or even harm to care recipients. To counteract this, regulators and institutional leaders must co-develop trust-based contractual mechanisms, Outcome-linked reimbursements, Tiered licensing or rating systems, Public transparency dashboards for service performance, and these need to be regularly updated and accessible to the public. Such mechanisms create market incentives for quality, not just quantity, of care. The caregiving burden extends beyond the family–provider dyad into the workplace. B6 and B7 point to the need for employers, especially in aging labour markets, to address the invisible costs borne by caregivers of employees. Human resource managers must treat caregiving not as a private inconvenience, Optimizing Caregiving Systems: A Strategic Analysis of Family, Government, and Institutional Interactions but as a structural challenge that affects employee well-being, retention, and productivity. Leading strategies include: Paid caregiving leave or flexible work schedules, Caregiver assistance programs (e.g., referrals, subsidies), Integrating caregiving into DEI (Diversity, Equity, Inclusion) policies (in collaboration with the government, perhaps).

This reframing helps businesses respond not only ethically but also strategically, aligning caregiving sensitivity with broader goals of workforce sustainability. B3 and B4 reveal that fragmentation between public regulators and private providers leads to gaps in oversight and coordination. Care businesses should proactively engage with policy-makers to co-design regulatory standards, data-sharing frameworks, and feedback loops that balance autonomy with accountability. Cross-sector working groups, industry-wide ethical charters, and pilot programs with outcome evaluations can help resolve the trust deficit between business and state.

2.3.3 More Collectivistic Family Caregiving

The most important contributor to care systems is undoubtedly family caregivers. While policy-makers and institutions design the framework for caregiving, individuals—especially family members—are the ones who live its consequences daily. The insights from B1–B8, alongside A1–A8, show that caregiving decisions are not just personal but strategic: shaped by expectations, role asymmetries, financial trade-offs, and institutional gaps.

Of course, this statement is rather idealistic, but families should approach caregiving not reactively, but as a shared, negotiated responsibility. Domain A shows that caregiving often falls disproportionately on a single member—usually a daughter—due to lack of prior role allocation (A2, A7).

Early conversations, clear delegation of tasks, and shared financial/legal planning (e.g., power of attorney, living arrangements) can prevent strategic imbalances and reduce resentment. Formal caregiving contracts within families may even help correct free-riding tendencies. Though bringing in law may be viewed as an extreme measure, it becomes a necessary measure when we factor in the well-being of the burdened caregivers. In addition, caregivers must be familiarized with the governmental policies and private care institutions that are involved. Domain B reveals that many caregivers are unaware of their legal rights, available non-financial supports, or local institutional resources. Caregivers should take active steps to explore: Training or respite care programs (B7–B8), Public caregiver allowances or subsidies (B1, B3), Regulatory mechanisms to report unethical providers (B5). Through these modes, caregivers bear less individual responsibility and use existing organizations for assistance.

For individuals and families, caregiving is not just an emotional or moral act—it is a strategic decision embedded in larger systems. To navigate these systems effectively, families must plan collaboratively, stay informed, use available supports, and participate in shaping care policy. When caregivers move from isolated burden-bearers to engaged co-creators, the entire care ecosystem becomes more sustainable and humane.

3. Proposed Model

The preceding sections in this study have synthesized strategic caregiving systems based on insights from review of 16 research papers across two domains i.e. Caregiver Role Allocations and the Role of Governments and Private Institutions. This section proposes a model based on cooperative game theoretic approach to formalize the coordination challenges in caregiving. It is based on the conceptual framework that has been established in the paper and offers a normative standard to evaluate the efficiency and fairness of caregiving.

The model considers caregiving as a three- agent cooperative game with transferable utility. It captures the interaction between three principal agents: the Family (F), the Government (G), and Institutions (I). Each of these agents contribute to fulfil a fixed caregiving burden which would be denoted by C, in a way that total contribution satisfies the constraint:

$$c_F + c_G + c_I = C$$

Each of the agent would face increasing marginal burden with the increasing caregiving burden which can be modelled using convex cost functions. The three cost functions are given by:

$$\phi_F(c_F) = \alpha_F c^2_F$$

$$\phi_G(c_G) = \alpha_G c^2_G - \beta_G c_G$$

$$\phi_I(c_I) = \alpha_I c^2_I - \beta_I c_I$$

The termα terms represents the cost intensities for the three agents. Cost intensities are considered as physical strain for families (physical and emotional fatigue), fiscal and administrative cost for governments, and operational overheads (staffing, compliance) for institutions. The term β denotes the offsetting benefits, such as welfare improvements or tax revenues, that in a way partially mitigates the cost for governments and institutions. A similar term could have been introduced for families to account for non-monetary cultural or emotional incentives. However, in this model we stick to the offsetting benefits for government and institutions only to align with the papers reviewed in previous sections.

A social planner would always aim to minimize the total societal cost. The cost could be minimized by solving the following constrained optimization problem via the Lagrangian method:

$$\min_{c_F, c_G, c_I} \phi_F(c_F) + \phi_G(c_G) + \phi_I(c_I) \text{ subject to } c_F + c_G + c_I = C$$

This would yield optimal caregiving allocations (c^*_F, c^*_G, c^*_I) that minimize societal burden while reflecting the relative capacities and incentives of each agent. The lagrangian equation can be set up as:

$$L = \alpha_F c_F^2 + \alpha_G c_G^2 - \beta_G c_G + \alpha_I c_I^2 - \beta_I c_I + \lambda(C - c_F - c_G - c_I)$$

Differentiating with respect to each variable and setting equal to 0:

$$\partial L/\partial C_F = 2\alpha_F c_F - \lambda = 0$$

$$\partial L/\partial C_G = 2\alpha_G c_G - \beta_G - \lambda = 0$$

$$\partial L/\partial C_I = 2\alpha_I c_I - \beta_I - \lambda = 0$$

$$\partial L/\partial \lambda = C - c_F - c_G - c_I = 0$$

The equations could further be solved as:

$$\lambda = 2\alpha_F c_F$$

$$\lambda = 2\alpha_G c_G - \beta_G$$

$$\lambda = 2\alpha_I c_I - \beta_I$$

$$c_F + c_G + c_I = C$$

$$2\alpha_F c_F = 2\alpha_G c_G - \beta_G \rightarrow (a)$$

$$2\alpha_F c_F = 2\alpha_I c_I - \beta_I \rightarrow (b)$$

From (a)

$$2\alpha_G c_G = 2\alpha_F c_F + \beta_G \Rightarrow c_G = \frac{2\alpha_F c_F + \beta_G}{2\alpha_G}$$

From (b)

$$2\alpha_I c_I = 2\alpha_F c_F + \beta_I \Rightarrow c_I = \frac{2\alpha_F c_F + \beta_I}{2\alpha_I}$$

Substituting the values of C_G and C_I in $c_F + c_G + c_I = C$

$$c_F + \frac{2\alpha F\ C F + \beta G}{2\alpha G} + \frac{2\alpha F\ C F + \beta I}{2\alpha I} = C$$

$$c_F \left(1 + \frac{2\alpha_F}{2\alpha_G} + \frac{2\alpha_F}{2\alpha_I}\right) + \frac{\beta_G}{2\alpha_G} + \frac{\beta_I}{2\alpha_I} = C$$

$$c_F\left(1+\frac{\alpha_F}{\alpha_G}+\frac{\alpha_F}{\alpha_I}\right)=C-\frac{\beta_G}{2\alpha_G}+\frac{\beta_I}{2\alpha_I}$$

$$c_F=\frac{C-\frac{\beta_G}{2\alpha_G}+\frac{\beta_I}{2\alpha_I}}{1+\frac{\alpha_F}{\alpha_G}+\frac{\alpha_F}{\alpha_I}}$$

$$c_G=\frac{2\alpha_F c_F+\beta_G}{2\alpha_G}$$

$$c_I=\frac{2\alpha_F c_F+\beta_I}{2\alpha_I}$$

Solving the constrained optimization problem using Lagrangian approach has given the optimal caregiving allocations that minimize the societal burden along with reflecting upon the relative capacities and incentives of all the three agents. While this method gives efficient distribution of caregiving burdens, it does not fundamentally address how the burden should be shared in a fair manner. In real life, caregiving agents not only seek to minimize collective cost but also expect that their individual contributions should reflect a sense of fairness and agreement. In order to evaluate these considerations, the model has been extended to include cooperative game theory through the Shapley Value. The Shapley Value helps in allocating the total caregiving burden based on marginal contribution of each agent to different possible coalitions. By comparing the Lagrangian solution (efficiency) with the Shapley allocation (fairness), we can assess whether the efficient burden-sharing outcome aligns with equity principles or whether redistributive adjustments may be justified to ensure stable cooperation among agents. These tools help assess whether caregiving systems are both efficient and equitable, and whether stable coalitions can form under rational self-interest.

The cooperative game can be set up as:

v(S), where $S \subseteq \{F, G, I\}$

v(S) is the minimum cost to meet caregiving burden C using only the players in set S.

We can calculate the total cost for:

One-player coalitions: v({F}), v({G}), v({I})

Two-player coalitions: v ({F, G}), v({F, I}), v({G, I})

Full coalition: v ({F, G, I})

Each value is found by solving the cost minimization problem subject to only those players participating.

The Shapley Value ϕ_j for each player $i \in \{F, G, I\}j$ is given by

$$\phi_i=\sum_{S\subseteq N\setminus\{i\}}\frac{|S|!\ (N-|S|-1)!}{N!}[v(S\cup\{i\})-v(S)]$$

Where:

N={F, G,I} is the set of all agents

|S| is the size of coalition S

v(S) is the cost saving achieved by coalition S

Assuming that cost functions are known and total cost under full cooperation (i.e., solving the Lagrangian) is C_{opt} we define:

$v(S)=C_{sep}(S)-C_{coop}(S)$

Where:

$C_{sep}(S)$ is the cost incurred when only agents in S work alone without help from others,

$C_{coop}(S)$is the cost when agents in S cooperate optimally.

We can compute the marginal contribution of each agent by evaluating v(S) for all subsets (S). If the Shapley allocation significantly varies from the cost shares derived from Lagrangian approach, it may indicate that the efficient outcome is not perceived to be fair. In such cases, redistributive adjustments (e.g., subsidies or service credits) could help realign the system toward a more equitable and stable configuration. If the agent's Shapley cost share of each agent is lower than their actual cost in the current allocation, they might be overburdened. However, if it is higher, they might be over- contributing. Shapley value allows assigning a fair cost and benefit share that reflects role of each agent in achieving cost reductions and independent of how the system was optimized.

The proposed model assesses whether caregiving systems are both efficient and equitable. It also finds out whether stable coalitions in caregiving systems can be formed under rational self interest. The model supports the broader aim of this research paper that caregiving inefficiencies are associated with misaligned incentives and lack of coordination in decision-making. It suggests a practical and normative framework that illustrates how strategic cooperation can improve the outcomes of caregiving at family, government and institutional levels.

4. Conclusion

This paper examined caregiving as a strategic, multi-agent decision-making process. Domain A explored intra-family role allocation, highlighting how unstructured delegation often leads to inefficiencies and burden asymmetries. Domain B analysed the impact of public policies, showing that caregiving behaviour is shaped not only by family dynamics but also by regulation, incentives, and institutional trust. Together, these domains emphasize that caregiving systems function best when incentives are aligned and inter-agent communication is optimized. To extend beyond secondary analysis, this paper also proposed a cooperative game-theoretic model that conceptualizes caregiving as a burden sharing problem among families, governments, and institutions. It combined Lagrangian optimization which focused on efficiency with Shapley Value analysis based on fairness. The model offers a prescriptive framework for how caregiving responsibilities can be distributed more equitably and sustainably. This addition addressed a key gap in the literature by providing a formal mechanism to assess coordination failures and potential remedies in caregiving systems. As aging populations grow, caregiving must be reimagined as a shared societal responsibility—one that demands strategic coordination between families, institutions, and the state. This study contributes to that reimagining by offering both a comprehensive synthesis and a novel model to guide more cooperative, fair, and effective caregiving systems. Future research could be an extension to this framework by empirically validating the model, exploring other caregiving relationships, incorporating intersectional factors under different policy regimes.

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