

The Pennsylvania State University
The Graduate School
School of Public Affairs

**CENTRAL AND LOCAL GOVERNMENT FISCAL BEHAVIOR UNDER
FISCAL FEDERALISM—A THEORETICAL ANALYSIS UNDER
ASYMMETRIC SETTING WITH EMPIRICAL EVIDENCE**

A Thesis in
School of Public Affairs
by
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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

Nov 2023

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Abstract

This dissertation undertakes a comprehensive analysis of the intricate interplay between central and subnational governmental entities within the framework of fiscal federalism. This investigation is structured around the exploration of three distinct inquiries pertinent to both national and subnational administrations. These three inquiries are systematically delineated into two hierarchical levels and subsequently deliberated upon across three dedicated chapters.

At the national level, this study advances existing literature by introducing a novel theoretical framework concerning the decision-making mechanism behind the provision of public goods. This framework is formulated as a dynamic game with complete information involving three distinct actors. By employing a backward induction methodology to solve the game, the outcomes yield distinct theoretical implications, notably diverging from prior investigations due to the model's modified structure. A significant proposition posited in this study asserts that the motivation of subnational governments to augment the supply of public goods is subdued once a specific threshold of public goods provision is achieved. Consequently, supplies from the national level, whether through collaborative provisioning, general transfers, or categorical transfers, garner greater favor from subnational entities than previously hypothesized. Additionally, the influence of political bias emerges as a determinant in decision-making, functioning as a multiplier affecting the perceived ideal policy gap. The conjecture put forth suggests that the national government might be inclined to tolerate a greater policy gap when effectuating transfers to subnational governments that share the same political affiliation. Furthermore, to validate the theoretical assertions made, an empirical analysis is conducted utilizing a fixed effect regression model. This model is applied to longitudinal data obtained from various American states, aiming to establish empirical evidence in support of the theoretical underpinnings outlined in this study.

At the subnational level, a meticulous examination was undertaken to ascertain the impact of intergovernmental transfers on the expenditure patterns and revenue collection strategies of subnational governments. Regarding expenditure behavior, the existing literature concerning the elucidation of the "flypaper effect" was synthesized. I set up a Ramsey planner's problem and generate an analytical solution representation delineating the extent of the flypaper effect under both distortionary and non-distortionary tax regimes. The implications arising from this analysis manifest in two principal dimensions. Firstly, the collection of distortionary taxes exhibits a discernible price effect, thereby

serving as a primary catalyst for the observed flypaper effect phenomenon. Secondly, it is posited that the magnitude of the flypaper effect is amplified when public goods demonstrate a lack of substitutability with private goods. These theoretical inferences are corroborated by the empirical findings from the collection of pertinent literature previously amassed in the course of prior research endeavors.

In contrast to the scrutiny afforded to the impact of intergovernmental transfers on the expenditure facet, the investigation into their effect on the revenue aspect remains a less explored area. Therefore, this study establishes a theoretical framework aimed at elucidating the ramifications of intergovernmental transfers on the tax collection endeavors of subnational governments. The derived conclusions indicate that when governments place a greater emphasis on productive expenditures, an augmentation in general transfers is likely to trigger a downturn in tax effort. Conversely, an increase in categorical transfers is anticipated to correspond with heightened tax collection efforts. Building on these theoretical inferences, empirical substantiation is sought by means of a Difference-in-Difference analysis, employing the paradigm of fuel taxation in the United States as a case study. Through this empirical investigation, the study endeavors to provide tangible evidence supporting the theoretical propositions posited.

To summarize, the thesis is a comprehensive investigation of different level governments' fiscal behavior under fiscal federalism including both theoretical inference and empirical investigation. This thesis advanced some existing model and narrow down the gaps in prior research.

Key words: fiscal federalism, asymmetric game theory analysis, longitudinal study

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List of Symbols

Dynamic Game Theory Model

- F Total production output of jurisdiction i., p. 76
- N National government, p. 15
- S_h State government with better resource endowment, p. 15
- S_l State government with lower resource endowment, p. 15
- σ Preference on equalization of central government, p. 15
- T_0 Benchmark amounts under general transfer game, p. 16
- GT General transfer, p. 15
- CT Categorical transfer, p. 15
- T_p productive categorical grants, p. ??
- T_w Welfare-oriented categorical grants, p. ??
- G Public goods utility compound, p. 18
- P Productive-oriented public goods, p. 18
- W Welfare-oriented public goods, p. 18
- r match ratio matrix, p. 16
- m Matching ratio for productive grants, p. ??
- n Matching ratio for welfare-oriented grants, p. ??
- A_N The action set for national government, p. ??
- A_S The action set for subnational government, p. ??

- c_i The price of public goods in jurisdiction i , p. 20
 e_j Tax collecting efficiency of player $j \in P$, p. 20
 a_j Tax collecting ability of player $j \in P$, p. 20
 f_i Tax collecting effort of player $j \in P$, p. 20
 y_i Actual policy position in jurisdiction i , p. 19
 X_i Ideal policy position for subnational government i , p. 19
 X_N Ideal policy position for national government i , p. 19
 x_i Ideal policy direction on one dimensional line favored by government i , p. ??
 y Actual policy direction on one dimensional line, p. ???

Benchmark Model for Flypaper Effect

- X private good, p. 58
 X public good, p. 58
 y representative resident's income, p. 58
 τ lump-sum tax, p. 58
 f non-matching intergovernmental transfer, p. 58
 α preference on public and private goods of representative resident , p. 58
 λ_{rc} lagrange multiplier for representative citizen, p. 59
 λ_e lagrange multiplier for the economy, p. 59
 λ_{lg} lagrange multiplier for the local governemnt, p. 59

Model for Flypaper Effect with Distortionary Tax

- X_t Private taxable goods, p. 64
 X_{nt} Private non-taxable goods, p. 64
 θ Tax rate on X_t , p. 64

Chapter 1 |

Introduction

1.1 About Fiscal Federalism

Many countries, regardless of their explicit federal system in terms of political structure, face issues related to the hierarchical structure of governments, which results in an unequal distribution of political and economic powers. Fiscal federalism is distinguished by the potential misalignment of expenditure responsibilities and revenue assignments. Fiscal federalism is a form of fiscal decentralization that is widely recognized as a more efficient way to provide public goods and services, particularly in large and complex countries with multiple levels of administrative institutions. Hayek [1] argued that local governments are better positioned to understand local needs and preferences, and therefore to provide appropriate public goods and services. Stigler [2] built on Hayek's insights and argued for the necessity of protecting the funding ability of subnational governments. Tiebout [3] developed a theoretical framework to show that voting with one's feet can ensure that public goods supply matches local needs. He also demonstrated that competition among local governments can lead to improved administrative efficiency. Tiebout's theory seems to get supported by the actual data showed in Table 1.1, which potentially reflects the difference of tax burden preference of different states. These foundational insights form the basis for much of the research on the advantages of fiscal federalism.

Table 1.1: Effective Tax Revenue in America

State	State and Local Taxes (\$ billions)	Personal Income (\$ billions)	Effective Tax Rate
New York	177.8	1,281.10	13.90%
District of Columbia	7.5	55.5	13.40%
North Dakota	5	39.5	12.70%
Hawaii	9.5	75.4	12.60%
Vermont	3.8	32.6	11.70%
United States Total	1,652.80	16,820.30	9.80%
Alabama	16.4	198.9	8.30%
Oklahoma	13.9	174.4	8.00%

Source: U.S. Census Bureau Dataset

In this chapter, I provide an overview of the fiscal federalism structure, focusing on the revenue sources for different levels of government, public service responsibilities, and the financial connection between central and subnational governments, as illustrated in Figure 1.1. Specifically, central and local governments have distinct methods for generating revenue and supplying public goods and services, and the central government joins public goods provision either through transfer payments, known as intergovernmental transfers or joint provision, allowing subnational jurisdictions to maintain necessary public goods and services while governments in two layers expressing their political intentions and concerns in this process.

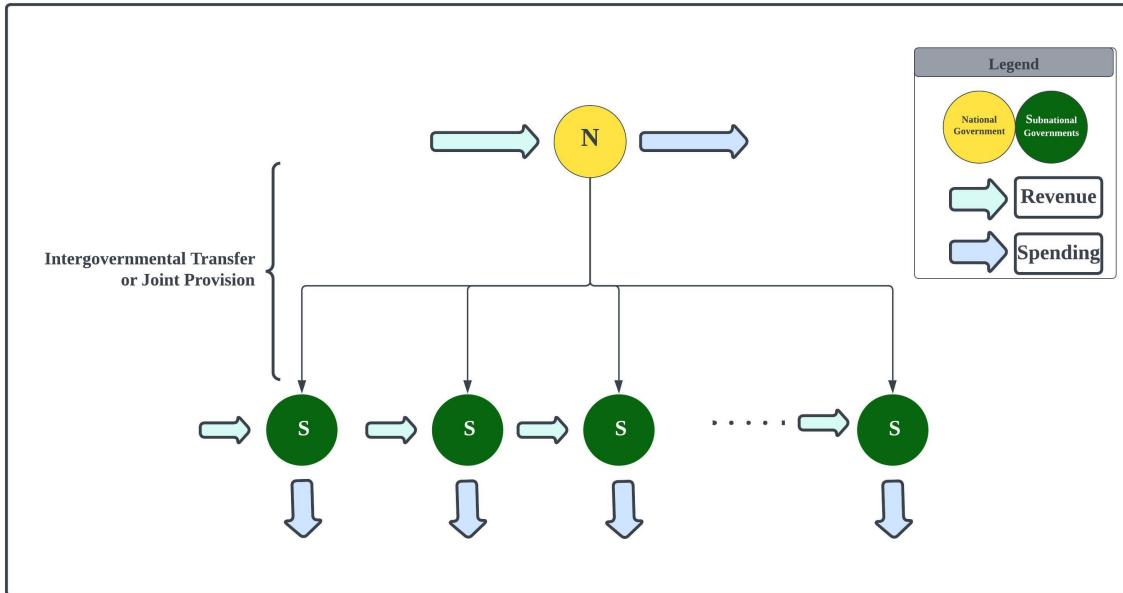


Figure 1.1: Fiscal Federalism Structure

For the following part of this chapter, I'll briefly summarize the literature on the evaluation of fiscal federalism, what are the topics that are commonly mentioned in related research. After that I'll give a basic introduction about the fiscal federalism structure in USA, to be more specific, I'll talk about the revenue and responsibilities of different levels of governments, and fiscal interaction between different levels of governments.

1.1.1 The Evaluation of the Fiscal Federalism System

Even within the topic of fiscal federalism, the fiscal federalism structures in different countries have different content and features, needless to say, they show different impact in public goods and services supplying. Like I mentioned in Chapter 1, it's hard and nearly impossible to find a perfect stick yard criterion to compare fiscal federalism in different countries. I'll try to explain and get a comprehensive way to evaluate fiscal federalism. Literature about fiscal federalism can be roughly divided into two groups. First-generation theory of fiscal federalism concentrate on the fiscal structure itself, focusing on the efficiency of federalism in collecting revenue and offering responsibilities, and whether the revenue-responsibility combination perform well in public goods supply. Coming to second-generation theory of fiscal federalism, scholars get interested in the effect of fiscal federalism on other area such as the effect on economic development.

1.1.1.1 First-Generation Theory of Fiscal Federalism

Evaluating the efficiency of fiscal structures is a common approach to assessing their reasonableness. Pareto efficiency, which requires that resources be allocated in a manner that cannot make anyone better off without making someone else worse off, is widely accepted as a standard for evaluation [4]. Scholars have identified three economic factors useful in evaluating fiscal structures: externalities, information complexity, and incentive compatibility. Oates [5] proposed that governments and residents of a jurisdiction should bear the costs of negative externalities and receive payment for positive externalities. Olson [6] argued that the "free rider" problem could be resolved by making jurisdictions and beneficiary areas identical, achieving an equilibrium in which marginal costs equal marginal benefits. One example of an efficiency consideration in the United States' fiscal federalism structure is the revenue structure for individual taxes, as shown in Table 1.2. To minimize behavioral distortions and improve efficiency, individual income taxes, which are easy to move across jurisdictions, are mainly collected by federal and state governments, allowing individuals to be indifferent about where they live and pay taxes.

Table 1.2: . Percentage Composition of Tax Revenue by Government Level

Type	Federal	State	Local
Individual income	51.80%	37.20%	4.70%
Corporate income	6.90%	4.70%	1.10%
Other taxes	41.20%	58.10%	94.20%

Besides, information complexity is an important consideration in evaluating fiscal federalism structure. Basing their work on the earlier contributions of Hayek and Tiebout, Bseley et al [7] developed a political economy model to simulate the decision-making process in a democratic country. They emphasized the advantage of local government in public goods supplying and introduced insensitivity of central government into their model. Information communication is also important, with local governments having better knowledge of local residents' needs and their behavior being better perceived by local residents. Decentralized fiscal federalism structures put local governments under supervision, as noted by Dethier [8] and based on Tiebout's voting on feet framework. Baicker [9] introduced a horizontal competition structure with multiple local governments and states that enables local residents to evaluate local governments' efficiency in public goods supply under a yardstick competition framework. This information transparency can push local governments to improve their performance.

Finally, a well-designed fiscal structure should satisfy the criterion of incentive compatibility. Incentive compatibility is a game theory concept introduced by Leonid Hurwicz [10] that requires a mechanism to be designed such that each participant can achieve the best outcome for themselves by acting truthfully. In public administration and public economics, incentive compatibility has become an important criterion for evaluating the quality of fiscal federalism. Proper fiscal federalism settings can motivate local governments to efficiently provide public goods. For example, Eckstein [11] argues that the proper combination of funding resources and responsibilities can motivate organizations, including local governments, to work hard and provide public goods efficiently, since working hard with efficiency in public goods supplying is an weakly dominate strategy and could attract more residents and increase more public funding resource. Under the impact of incentive compatibility theory, scholars generally assume that local governments aim to maximize local fiscal revenue in fiscal federalism administration process. (Baretti, Bucovetsky,Dahlby,Jha) [12–15].

The first-generation theory of fiscal federalism focuses on the positive impact of decentralized structures on public goods provision. The main research objective is to assess the effectiveness of fiscal federalism in enhancing public goods efficiency. This period is characterized by theoretical studies.

1.1.1.2 Second-Generation Theory of Fiscal Federalism

The second-generation theories of fiscal federalism expand beyond the efficiency of public goods provision and explore its impact on other social areas, such as economic development [16,17] and local government behavior [18]. Once connect the fiscal federalism with other social areas, scholars in this generation highlight that fiscal federalism may not always function effectively, particularly in developing countries [19–22], while acknowledging the fundamental role of fiscal federalism in public goods provision. The literature can be categorized into three themes: the relationship with economic development, political intentions, and its effect on local government fiscal behavior.

The relationship between fiscal federalism and economic development is inspired by Charls Tiebout's theory [3], which has been supported by ample econometric evidence. However, Tiebout's theory is based on assumptions that are hard to achieve in developing countries, where local governments may not have the ability to supply public goods with proper efficiency. Second-generation theory literature aims to explore the limitations of Tiebout's assumptions and investigate the implications for economic development. The role of production factors such as labor and capital in fiscal federalism has been studied

extensively. Econometric evidence suggesting that even within developed countries like the European Union, residents do not move freely between jurisdictions [23]. Faguet's survey found that even for those who do move, public goods performance is not their primary concern [24]. Except for the population movement, capital is also a interesting factor in fiscal federalism literature. Mckinnon [25] attribute the economic boost in southern United States to the low factor cost including capital, labor and land. He then did a follow up research claims that the compensation and equalization effect of transfer payment in fiscal federalism system may block the flow of production factors. Cai and Treisman [16] proved that with initial difference in resource endowment, the decentralized feature of fiscal federalism may lead to local governments' sturdiness in economic development since the moving of capital seems surely lead to development imbalance, the imbalance between different jurisdictions will destroy the enthusiasm of local governments. Treisman [20] further emphasizes that such governments with lower resource endowments tend to prioritize poverty reduction over economic development efficiency.

Scholars of second-generation theory have noted the impact of fiscal federalism on local government behavior, including the influence of intergovernmental transfers on local tax collection efforts [26], spending structures [27], and debt [28]. These effects will be further analyzed in Chapter 3 under asymmetric conditions.

In addition to economic considerations, political intentions also play a significant role in explaining fiscal federalism design. While economic and efficiency theories are commonly used to explain fiscal federalism, political factors can be a fair supplement in explaining fiscal policy and behavior. In Canada, fiscal federalism is an important tool for equalizing resources across different jurisdictions and serves as a glue for political federalism. Similar econometric evidence is found in Australia as well [29]. However, the transfer payment mechanism from high fiscal revenue areas to low revenue areas in Italy has exacerbated conflicts between different jurisdictions, leading to a different look for fiscal federalism in Italy.

Except for the relationship between revenue and responsibilities within individual jurisdictions, the interaction between governments is a compelling topic for researchers in the field of fiscal federalism. This interaction can be broadly divided into two categories: horizontal interaction, which refers to the interaction among governments at the same level, and vertical interaction, which refers to the interaction between central and subnational governments. In this paper, the focus will be on the vertical interaction between central and subnational governments.

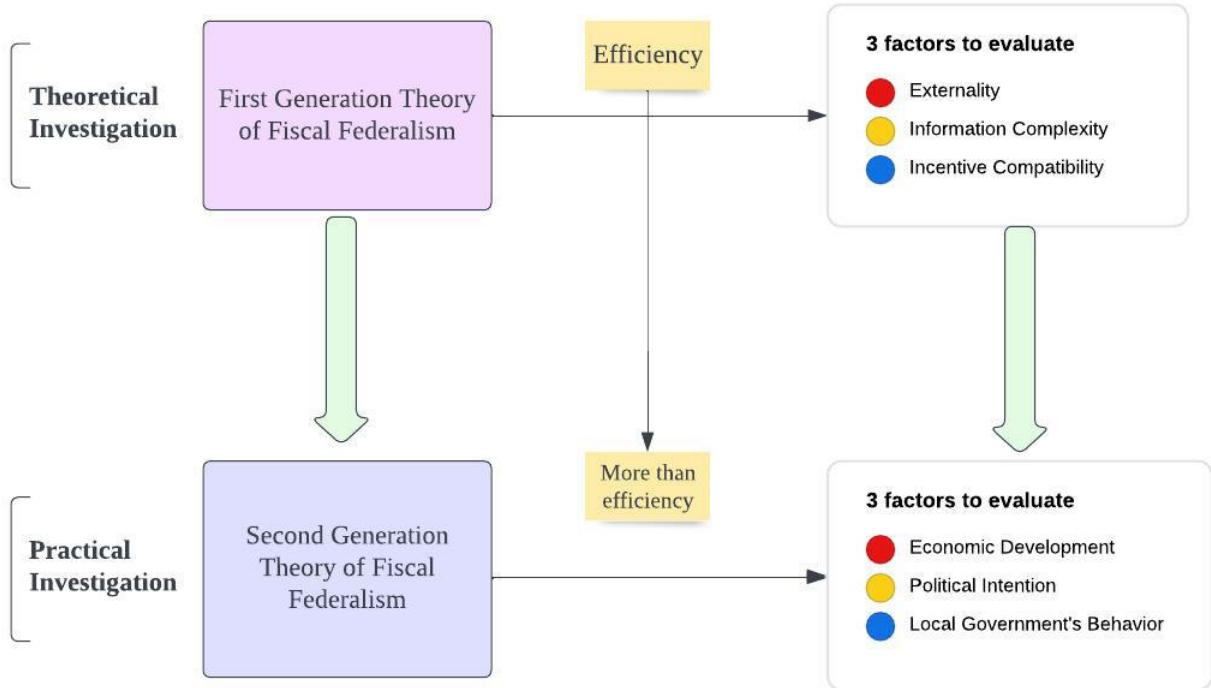


Figure 1.2: How to evaluate the fiscal federalism

In summary, as depicted in Figure 1.2, the original research on fiscal federalism constructed a theoretical framework for efficiently providing public goods. In developed countries, particularly in America, scholars have discovered empirical evidence supporting the advantages of this decentralized fiscal structure. However, in developing countries, fiscal federalism has not worked as effectively, leading to the emergence of second-generation theory. This newer approach focuses on the other side of the coin.

1.2 Fiscal Federalism Structure in America

1.2.1 Revenue and Responsibilities of different levels governments

The United States constitution stipulated that states keep the remaining rights, which means except for the clear defined rights that federal government have, states government keep the undefined rights. Besides, the constitution set no instruction about the responsibilities between state and local governments. This feature combined with the fact that America is a huge country with rich diversity lead to an interesting administrative fact: the responsibilities of state governments in each states are not identical. Within each

states, the local governments form up their responsibilities based on the actual needs, thus the local governments are not identical neither. Thus the follow introduction are not describing the administrative reality precisely, but are introducing the general structure.

Under current fiscal federalism system in America, federal, state and local governments rely on different source of income, have different function in supplying the public good and federal government reimburse the state and local government through intergovernmental transfer. On revenue side, from the breakdown of the source of revenue of fiscal year 2019, 50% of the federal revenue comes from the individual income tax, 7% from corporate income tax, 36% is social insurance or payroll tax. On the other hand, on state and local level, intergovernmental transfer accounts for more than 30 percent on average, followed by sales taxes and property tax.¹

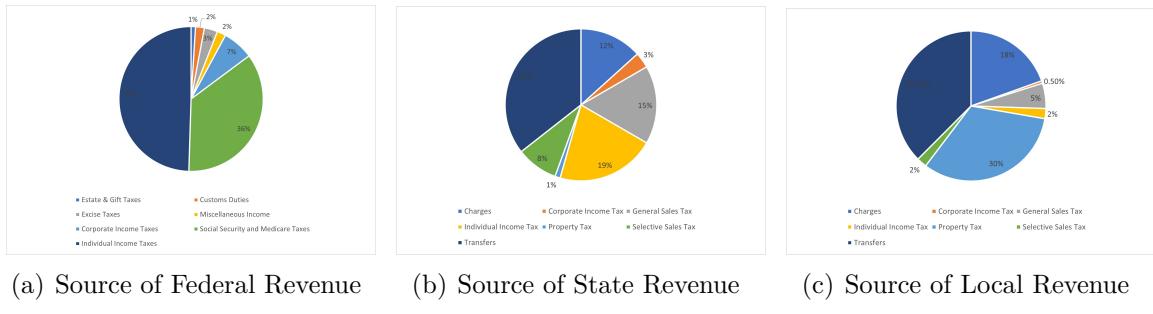


Figure 1.3: Source of Revenue for Multiple Level of Governments

On the expenditure side, federal, state and local government functions differently in supplying public goods and services. Filtered out the public-goods-unrelated expenditure such as interest from debt, federal government is paying for income security, social security, health, national defense, highways and infrastructure, medic care, social services such as education, training and employment. Similarly, if filtered out the expenditure which are unrelated to the public goods and services in state and local governments, the left parts include public welfare, elementary and secondary education, higher education, health and hospitals, highways and roads, police, courts, housing and community development.²

¹Data Source:The Department of the Treasury and the Bureau of the Fiscal Service

²Data Source:The Department of the Treasury and the Bureau of the Fiscal Service

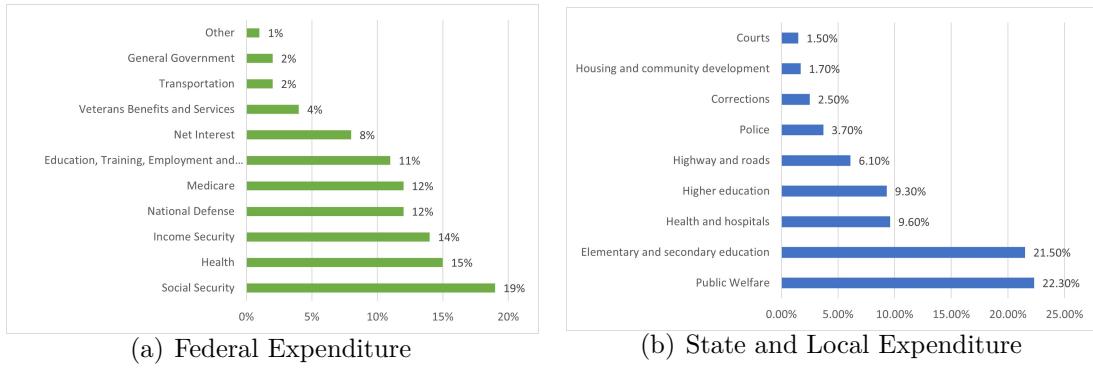


Figure 1.4: Expenditure Structure for Multiple Level of Governments.

Though The revenue and expenditure structure of federal, state and local government are relatively stable. Figure1.4 shows a cross-sectional data of 2019. A time series fluctuation is presented in FigureA.1 attached in Appendix A. Information in FigureA.1 shows that it's not a big deal to capture the revenue structure by just breakdown the data in one year.

Federal, state and local government has their unique function in supplying public goods, for example, the federal government is supplying national defense exclusively, while state and local government is the sole supplier in police, courts, housing and community development. Meanwhile, some of the areas are overlapped by both layers of governments, such as public welfare, education, health, highway and infrastructure construction.

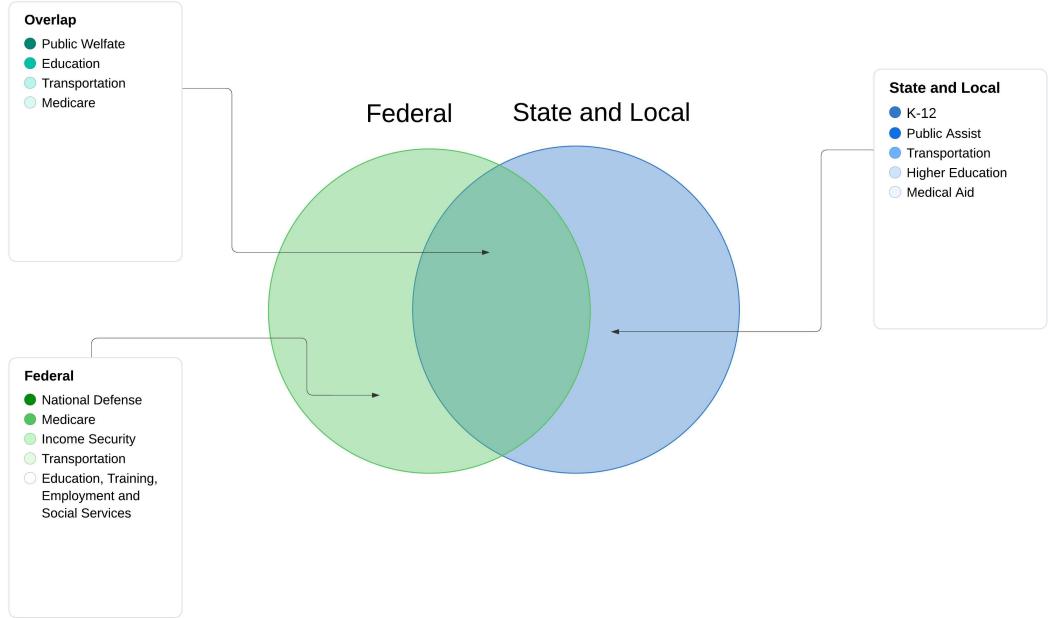


Figure 1.5: Venn graph on public goods and services supplying by federal, states and local government

1.2.2 Interaction between National Government and Subnational Governments

Typically there are two ways for national governments to engage in the public goods provision in subnational governments, which are joint provision and intergovernmental transfers. The difference is whether national government provide the public goods directly. I'm describing these two methods in this sections.

In the US fiscal federal system, the Federal government imposes significant influence on state and local fiscal decision making through various grants-in-aids programs (GIA) or intergovernmental transfer(IGT). Annually, these programs amounts to nearly \$700 billion, or close to 20 percent of overall federal revenues [30]. Grounded in fiscal federalism, these programs, are guided by the idea that the allocation of publicly funded goods and services should be the responsibility of state and local governments, due to their closer proximity to the constituents. The sought for advantages of such division include: reduced costs associated with planning and administration, the ability to account for spatial differences, and increased opportunities for citizens to influence political decision-

making [31]. IGT from federal government help to narrow the gap between revenue and expenditure of state and local government, encourage the supply of specific public goods and promote the horizontal equity among states.

Generally, grants-in-aids programs in the US federal fiscal system, can be categorized across two dimensions including the level of restrictions that are attached to the awards, and the administrative procedures that govern the award process. In terms of restrictions, IGT can be organized into categorical grants, block grants and general revenue sharing grants. Categorical grants include formula categorical grants, open-ended reimbursement categorical grants and project categorical grants. Project categorical grants are awarded with relatively strict set of activities that are attached to a specific purpose. Block grants are awarded to fund specific programs, but carry relatively few restrictions. The main difference is that block grants do not attach a specific purpose to how recipients spend the award. General revenue sharing grants carries the least amount of restrictions. In brief, these awards can be spent for any purpose, as long as it is not prohibited by federal or state law. According to the Congressional Research Service report [30], there are about 600 grant-in-aid programs, and categorical grants account for about 95 percent of the programs and more than 80 percent of total grant outlays.

Table 1.3: Divide Grants by level of Restriction Attached

Level of Restriction		
Low Restriction	Medium Restriction	High Restriction
Formula Categorical Grant	Block Grant	Project Categorical Grant
Open-ended Reimbursement		
General Revenue Sharing		

In terms of the administrative procedures that govern the awards, the grants can be categorized into three kinds including projects grants *or competitive grants*, formula grants, and reimbursement grants. For competitive grants, states should apply by submitting a request and get the grants through a competitive process. They are intended to improve the efficiency of funding allocation by encouraging grantees to seek funds for well-planned and exemplary projects. Formula grants are distributed to states through mathematical formulas decided by social characters within the jurisdiction. Typically the factors in the formula depends on the intention of the grants, and common factors may include population, poverty level, income per capita, unemployment rate,

enrollment in public schools, etc. Finally, reimbursement grants awards state and local governments in the form of a reimbursement for a specific percentage of state and local spending on a program. The reimbursement amount does not carry a specific limit. Reimbursement grants could be divided into open and closed ended reimbursement grants. The matching mechanism in reimbursement grants is a very intriguing consideration in public economic literature when evaluating the distortion effect. For matching grants, federal governments will reimburse a specific ratio for each 1 dollar of state and local expenditure. Based on whether federal government set a cap on the matching grants, matching grants can be divided into open-ended matching grants and closed-ended grants.

Table 1.4: Divide Grants by Form of Administrative Procedure

Form of Administrative Procedure		
Submitting Request	By Formula	Reimbursement
Competitive Grants	Formula grants Formula-project grants	Project Categorical Grant

In the joint provision process, unlike intergovernmental transfers, national government is the direct provider for part of the public goods in subnational jurisdictions. Such cases wildly exist in those projects under Interstate Maintenance Program, the National Highway Program, the Surface Transportation Program, the Highway bridge Replacement and Rehabilitation Program, the Congestion Mitigation and Air Quality Control Program. The mechanism of joint provision is relatively straight forward, national government collect revenue and supply the public goods directly.

1.3 Introduction of the Structure in the Following Chapters

The objective of this paper is to comprehensively analyze the fiscal federalism structure by addressing a series of questions on national and subnational level. Game theory tools are used to provide a theoretical explanation of fiscal behavior of national and subnational governments in the public goods provision process and theories are empirically tested, with a focus on the American context. Since fiscal federalism involves at least two layers of government, the analysis is conducted by separately investigating questions at both central and subnational levels. There are two questions on central level. For one, how national government choose the way to engage in the subnational public goods

provision, which means how national governments decide if it should stay outside, join with intergovernmental transfer or provide the public goods directly. For another, since the intergovernmental transfer is the most influential fiscal tool for national government, the grants distribution mechanism is also an important topic. On subnational level, the main focus is the reactive fiscal behavior of subnational government on national government's decision. To be more specific, the discussion can be divided into two categories, one is the reaction of spending behavior, another on is the revenue collection behavior. The resulting 2×2 table gives a comprehensive overview of the content of the following chapters, as is shown in Table 1.5.

Table 1.5: General Setting of the Questions in Fiscal Federalism Analysis

		Layers of Governments	
		National	Subnational
Spending Side	1.How national government's engaging way is decided?	3.What's the spending reaction of subnational government on IGT?	
	2.How IGT distribution decision is made in national government ?	4.What is the revenue collection reaction of subnational government on IGT?	
Revenue Side			

Questions about central government, which are questions on the left side in Table 1.5 will be investigated in two chapters, in which I will talk about the decision making process about engaging method on central level, and how a intergovernmental transfer decision is made in reality. Questions about local government on the right side are included in other chapters. In chapter 4, I'll analyze and describe the spending behavior of subnational governments once they received the intergovernmental transfer from national level. In chapter 4, I'll investigate the revenue collection behavior when subnational governments got the IGT support. For each questions, both theoretical inference and empirical evidence is supplied.

Chapter 2 | Questions on the Central Level

2.1 National Government's Choice

As mentioned in Chapter 1, broadly there are three choices available for national government when dealing with the provision of sublevel jurisdictions' public goods, which are no provision, joint provision and intergovernmental transfer. Based on Volden's [32] dynamic game setting, I expand his setting in three aspects to better investigate governments' behavior. Firstly, I differentiate the intergovernmental transfer into transfer with bare restriction-general transfer and transfer with restriction attached-categorical transfer. Secondly, I assume different kinds of players on subnational level in terms of the resource endowment. Besides, I modified the utility preference for the players in this game compared to Volden's setting. I'm listing my game setting in detail specifically in following sections.

2.2 A Dynamic Game Analysis with Complete Information

The Figure 2.1 demonstrates the extensive form of central and subnational interaction, which is developed based on Volden's game theory model [32]. But this paper presents a modified version of the game. Departing from Volden's model, I consider two types of players differentiating in the tax base (or resource endowment) instead of assuming identical subnational governments. Moreover, the paper defines different types of grants and specifies varying restrictions attached to grants. Additionally, the game in this paper incorporates a different form about the utility of subnational governments by considering the free rider risk. The game model in this paper can be described in terms of three aspects: player set, behavior set, and utility set. The nuance of the difference between the

modal in this paper and Volden's model will be explained in detail in following sections. Besides, the game is set as a dynamic game with complete information, which means the utility for all players in this game is a common knowledge for all players. In summary, the modified game in this paper offers a more nuanced understanding of the interactions between central and subnational governments.

- **Player Set**

Three players take actions in this intergovernmental transfer game: the central government N , state governments with higher resource endowment S_h , and state governments with lower resource endowment S_l . The assumption of identical subnational governments in Volden's paper is relaxed. Since governments with differing resource endowments may have varying fiscal preferences, leading to differing reactions to intergovernmental fiscal policy. The player set can be listed as $P = \{N, S_h, S_l\}$. For convenience, I defined $i \in \{l, h\}$. The difference between S_h and S_l is that the states with higher resource endowment is more productive, possess higher tax bases (GDP), thus I have $F_h > F_l$.

- **Action Set**

For central or national government, one available choice for national government is to stay out of the subnational jurisdictions' public goods provision. I call this subgame as no provision game. Otherwise, once the national government decide to join the provision, next question is to decide how to join, the available choices are joint provision game, general transfer game or categorical transfer game. Joint provision game is to provide the goods directly. In this case, citizens in a specific state enjoy the public goods offered by both national and subnational governments combined. In joint provision game, the national government is the direct provider of the goods and decide the amount of public goods provided to S_i , which are G_{Ni} .

Another subgame is to offer intergovernmental transfer. In Volden's setting, national government can offer grants only through general transfer, which is a lump-sum subsidy. I assume there are two kinds of intergovernmental transfer. Transfer to lower level governments are either general transfer GT or categorical transfer CT which is more restricted during administrative process and subnational governments cannot use the grants freely as they want to. Volden didn't distinguish different kinds of grants in his dynamic game setting. However the restriction may play a role in affecting both national and subnational governments' behavior, thus I differentiate the intergovernmental transfer in terms of the restriction level following

Table 1.3.

The main goal of the national government to join the general transfer subgame is to narrow the utility gap of S_i and equalize the original resource endowment difference. The effect of general transfer has been wildly mentioned in fiscal federalism literatures [33, 34]. I adopted Buettner's design about the amount of general transfer, in which general transfer amount T received by government i can be captured as:

$$T_i = T_0 - \sigma F_i$$

where σ captures the central government's intention to equalize the resource in different jurisdictions. A higher σ means national government prefer to equalize the resource. For example, compared to US government, OECD central government prefer to set a higher σ . T_0 is the benchmark grants amounts when S_i got zero F_i . F_i is the total production output which is also the tax base of S_i .

Compare with the general transfer, the equity is not a main concern in categorical transfer game. The role for categorical grants is to affect the policy direction in subnational jurisdictions. By encouraging the spending in specific area, central government could achieve the policy output in a national-favored direction. The categorical transfer are typically matching transfer, which means national government pay for specific percentage of the expenditure in specific area and subnational governments pay for the rest. I assume there are two kinds of public goods on subnational level which are productive goods P like roads, railways, and other kinds of infrastructure. Another kind of public good is welfare public goods W like social welfare, salaries for public servants.

For categorical transfer game, I assume matching ratio for productive grants is m and matching ratio for welfare-oriented grants is n . Thus the productive and welfare-oriented grants received by subnational government i is:

$$\begin{cases} T_p^i = m P_i \\ T_w^i = n W_i \end{cases}$$

To summary, the available action for national government is

$$A_N = \{NP, (JP, G_{Ni}), (GT, T_0, \sigma), (CT, m, n)\}$$

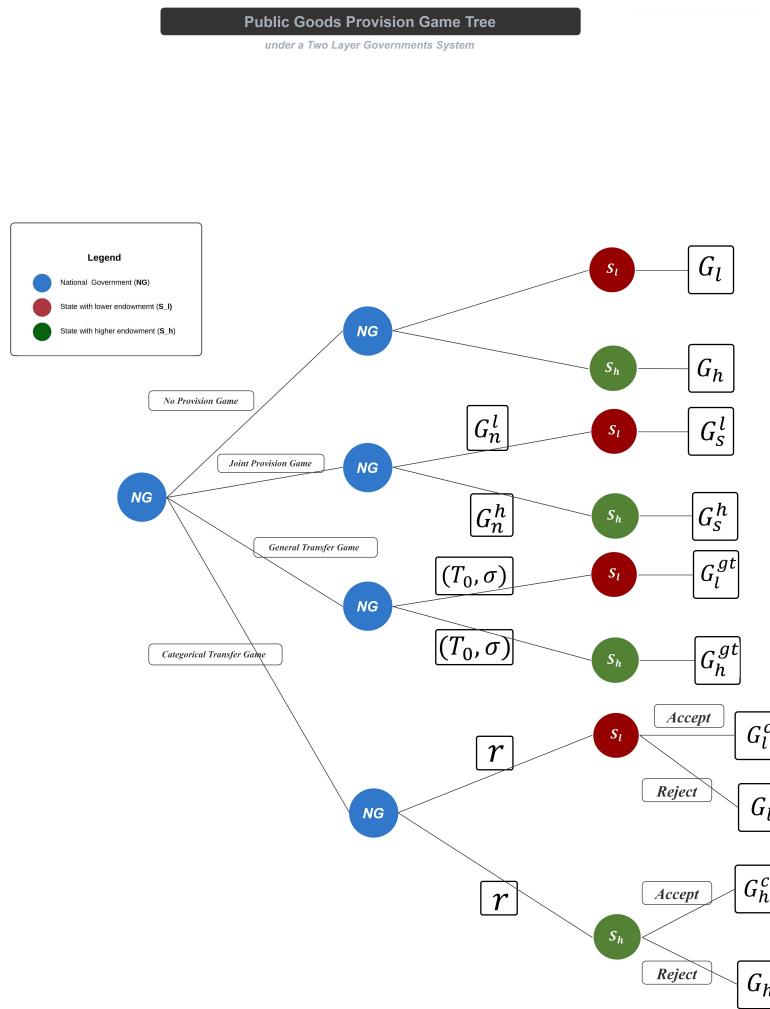


Figure 2.1: Dynamic Game Tree between Central and Subnational Governments

For subnational governments, they need to decide the public goods G_i they need to provide under no provision game, the public goods G_s^i under joint provision game and public goods G_i^{gt} under general transfer game. I assume subnational government cannot reject the joint provision or general transfer since joint provision and general transfer are lump-sum supplement. For categorical grants, I assume subnational governments may choose to reject based on their utility consideration. If subnational governments choose to reject the grants, then the national government is out of the game and the game became a no provision game. If subnational governments decide to accept the grants, then they need to decide the amount of public goods they provide G_i^{ct} based on the matching ratio m and n offered by national government. To summarize, the action set for subnational governments A_i is

$$A_i = \{(G_i|NP), (G_s^i|JP), (G_i^{gt}|GT), (Accept, G_i^{ct}|CT), (Reject, G_i|NP)\}$$

- **Utility Set**

I followed the design of Volden's design but with multiple new considerations.

For subnational governments, the utility function can be listed as:

$$U_i = \alpha_i G_i - t_i^2 \cdot f_i - \gamma_i |y_i - X_i|$$

I set G as Cobb-Douglas form public goods utility compound affected by the amount of P and W .

$$G_i = P^{\beta_i} W^{\epsilon_i}$$

α_i is the marginal utility of G_i , which could be explained as the demand of the public goods in place i . β_i and ϵ_i are elasticity of productive public goods and welfare public goods and I assume $\beta_i + \epsilon_i < 1$ since part of the utility also comes from private goods consumption.

The utility for subnational governments comes from three parts. The first part is the utility from G . The second part is the tax burden t_i imposed by both national and subnational governments. The square of the tax burden represents the risk averse attitude of the citizens. f_i is a fraction factor representing the ratio of blame taken by subnational government for rasing tax, thus $f_i = \frac{t_i}{t_i + t_N}$. One thing to

emphasize is there is no fraction factor for the credit by supplying public goods. Nicholson and Theobald [35] observe that citizens typically do not care about whether national or subnational governments are offering the public goods as long as the the public goods surpass a specific threshold. However citizens are very sensitive about which side is rasing the tax, thus the fraction of the tax burden between two levels of governments is clearly divided while the public goods credit is not.

The third part captures the policy direction. I compress the policy direction to a 1 dimension line with X_N and X_i on two sides. The actual policy outcome lies in somewhere between X_N and X_i . Each government has an ideal policy outcome point on a one dimensional line. y is the actual policy outcome and X_i means the ideal policy outcome for jurisdiction i . $|y_i - X_i|$ captures the distance between the actual policy outcome and the ideal policy outcome of S_i . The logic of this term is that the policy direction is typically an outcome of both national and subnational impact. For example, central government prefer the policy direction with less negative externality while subnational government focus merely on their own benefits. While $|y - X_i|$ expresses the policy distance. Besides, I add a $0 < \gamma_i \leq 1$ and let $\gamma_i |X_N - X_i| = |y_i - X_i|$ to capture the possible "alliance effect". For example, for specific policy gap between national and subnational governments, national governments may have preference on a specific jurisdiction S_i , or subnational government may take a lower threshold to accept the restriction if national government and a specific subnational government are alligned. γ_i may take a minimal value when national government and subnational government share similar ideas. If federal and state governments stand in polarized opposite position, then $\gamma_i = 1$.

Basically, subnational governments prefer to maximize the utility of the public goods while control the tax burden blame from citizens and control the policy outcome based on their policy preference.

For national government, the utility function can be listed as

$$U_N = \sum_i \alpha_i G_i - \sum_i (t_{Ni} + t_{si})^2 \cdot \frac{t_{Ni}}{t_{Ni} + t_{si}} - \sum_i \gamma_i |y_i - X_N|$$

The utility for national government comes from three parts as well. For one, the national government cares about the utility from increasing public goods in all subnational jurisdictions combined. The second term still capture the tax burden

under national government's name. The third term still express the utility from policy direction favor.

I made balanced budget assumption for both national and subnational governments, which means all tax income is all invested into the public goods provision. Suppose the price for public goods in i is c_i , and e_j is tax collecting efficiency of player $j \in P$. e_j is decided by multiple factors such as number of administrators, level of salaries in tax administration system, and IT expenditure on equipment [36–39]. e_j is also affected by subjective attitude, for example, government can decide how much effort they put in tax collection. Based on the balanced budget assumption, I have $\frac{c_i G_s^i}{e_i F_i} = t_i$ on subnational level.

The modification I made to Volden's dynamic game setting can be summarized in three aspects. Except for the heterogeneous players setting and different transfer setting. One most significant modification is I added fiscal illusion effect and bias factor into the utility function. One fundamental assumption in Volden's assumption is that citizens or voters have full information regarding spending at the national and subnational level and they accurately assign credit for goods provision based on those criteria. In another word, governments would consider they can only receive credit for the proportion they supplied. What's more, when national government's role is accomplished through IGT, then "the credit for good provision is divided in proportion to the size of the grant and the total spending by the subnational government" [40]. An extensive assumption is that voters also have full information about the which government should be responsible for the tax raising. Based on these two assumptions, the voters have full information about the merit and fault assignment about the public goods provision. The assertion that voters accurately ascribe electoral credit and blame is based primarily on a federalist perspective on vote-choice [41], and some earlier empirical literature do support this setting [42]. There are empirical evidence, however, that at least in America, voters ascribe credit and blame for public goods provision inaccurately. For example, Carpini and Keeter shows that only 14% of the interviewees knows about the unemployment rates and 25% knew about the proportion of the federal spending in terms of the education resource supply [43]. Besides, Gilens indicates that only 12% of the respondents got correct answer whether the crime rate has risen or declined during last decade [44]. Needless to say, a bunch of literature on fiscal illusion talking about voter's inaccurate sense about the price of public goods is also an strong side evidence of the voters' insufficient information [45–47].

Compared with Volden's assumption, I added fiscal illusion consideration into the utility setting. I kept Volden's assumption about the clear assignment on tax burden but I loosen the assumption about credit assignment, which means the voters are clear about the which government is collecting the tax while unclear about which government is providing public goods. Thus the utility from the public goods G is a function of the total amounts of public goods in $i G_i$ which equals national provided amounts to $i G_n^i$ and subnational governments provided amounts G_s^i , thus $G_n^i + G_s^i = G_i$. Mathematically, the implication is that the subnational governments have the motivation to welcome the national resource and prefer to be a free rider, which contradict implications in Volden's model—subnational governments have the intention to impede national government resource inflow and increase subnational governments' public goods provision to get more credit. In this thesis, I solve this game through backward induction.

2.2.1 No Provision Game

Under no provision game, subnational government is the only public goods provider. In this game, utility is decided by the amounts supplied by subnational government. Also, subnational government take all the blame of raising the necessary tax. Finally, in this game, the subnational government decide the policy outcome exclusively, thus $y = X_i$. In this case, subnational governments' utility is written as:

$$U_i = \alpha_i G_i - \left(\frac{c_i}{e_i F_i} G_i \right)^2 \quad (2.1)$$

where c_i is the price for the public goods compound.

Equation 2.1 can also be written in P and W as:

$$U_i = \alpha_i P_i^{\beta_i} W_i^{\epsilon_i} - \frac{(c_{p_i} P_i + c_{w_i} W_i)^2}{e_i^2 F_i^2} \quad (2.2)$$

Subnational government would maximize U_i by deciding optimal P_i and W_i .

$$\begin{cases} \frac{dU_i}{dP_i} = \alpha_i \beta_i P_i^{\beta_i-1} W_i^{\epsilon_i} - \frac{2c_{p_i}(c_{p_i} P_i + c_{w_i} W_i)}{e_i^2 F_i^2} \\ \frac{dU_i}{dW_i} = \alpha_i \epsilon_i P_i^{\beta_i} W_i^{\epsilon_i-1} - \frac{2c_{w_i}(c_{p_i} P_i + c_{w_i} W_i)}{e_i^2 F_i^2} \end{cases}$$

Thus I have

$$\frac{W_i}{P_i} = \frac{\epsilon_i c_{pi}}{\beta_i c_{wi}} \quad (2.3)$$

So, the question for subnational governments under no provision subgame is to maximize the utility by adjusting G , with the price of the compound G can be calculated as $\frac{c_{pi}P_i + c_{wi}W_i}{P_i + W_i}$.¹

Together with equation 2.3 I have:

$$c_i|_{NP} = \frac{c_{pi}c_{wi}(\epsilon_i + \beta_i)}{\epsilon_i c_{pi} + \beta_i c_{wi}} \quad (2.4)$$

Subnational governments are deciding the optimal G such that utility U_i could reach maximum. So the first order condition is: $\frac{dU_i}{dG_i} = 0$, combined with equation 2.1, optimal solution of G for subnational government can be written as:

$$G_i^*|_{NP} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2} \quad (2.5)$$

Plug equation 2.5 into equation 2.1, the maximum utility under no provision game is:

$$U_i^*|_{NP} = \frac{\alpha_i^2 e_i^2 F_i^2}{4c_i^2} \quad (2.6)$$

For national government, they care about the utility from all subnational jurisdictions combined since they can still get the utility from voter's public goods consumption due to citizen's fiscal illusion on the public goods provision. What's more, national government do not take the criticism for tax raising. As trade off, national government has to accept the policy inutility due to the inability to affect the policy direction. To summarize, the utility for national government under no provision game is:

$$U_N = \sum_i \alpha_i G_i - \sum_i \gamma_i |X_N - X_i|$$

2.2.2 Joint Provision Game

For joint provision game, both national and subnational government would contribute to the public goods provision directly. For subnational government i , they

¹This is not an accurate value of the price of the compound G since G is a Cobb-Douglas compound. But this price function can be proven as bijective function of the real G price.

would observe the amount of goods provided by national government G_n^i then decide the amount of goods they would like to provide G_s^i . Subnational governments' tax only need to cover G_s^i , and I follow Volden's setting that in joint provision game, subnational government decide the policy outcome.² Under joint provision game and general transfer game, I assume national government do not change the optimal proportion. For tax burden part, the total tax burden is $t_{si} + t_N$ and the fraction for state i is $\frac{t_s}{t_s + t_N}$. The tax from national government and subnational government can be listed as:

$$\begin{cases} t_{si} = \frac{G_s^i c_i}{e_i F_i} \\ t_N = \frac{\sum c_N G_{Ni}}{\sum F_i} \end{cases}$$

With these three aspects considered, the utility for subnational governments is:

$$U_i = \alpha_i(G_{si} + G_{Ni}) - \left(\frac{c_i G_{si}}{e_i F_i} + \frac{c_N \sum G_{Ni}}{(F_l + F_h)e_N} \right) \cdot \frac{c_i G_{si}}{e_i F_i}$$

The first oder condition $\frac{dU_i}{dG_i} = 0$ can generate:

$$G_i^{s*}|_{JP} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2} - \frac{1}{2} \cdot \frac{c_N}{c_i} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \sum G_{Ni} \quad (2.7)$$

National government get the utility from public goods supply and afford the tax to cover the public goods spending offered by national government in all subnational jurisdictions while not able to impact the policy outcome in i . The utility for national government in joint provision game is:

$$U_N = \sum_i \alpha_i G_i - \sum_i (t_{si} + t_{Ni})^2 \cdot \frac{t_{Ni}}{t_{si} + t_{Ni}} - \sum_i \gamma_i |X_N - X_i| \quad (2.8)$$

where $G_i = G_s^i + G_{Ni}$.

2.2.3 General Transfer Game

General transfer game means that the subnational government is the direct provider of the public goods with the lump-sum transfer payment from national government.

²To maximize the utility, subnational government need to provide G at a specific P-W structure, which means P and W should keep the optimal proportion $\frac{W_i}{P_i} = \frac{\epsilon_i c_{p_i}}{\beta_i c_{w_i}}$.

National government shares no ability to intervene subnational jurisdictions' policy direction. Subnational governments in this game need to decide the public goods supply and policy direction while needless to worry about the full tax burden, thus the utility for subnational government is:

$$U_i = \alpha_i G_i - (t_{si} + t_{Ni}) \cdot t_{si}$$

where

$$\begin{cases} t_{si} = \frac{G_i c_i - T_i}{e_i F_i} \\ t_{Ni} = \frac{\sum T_i}{\sum F_i e_N} \end{cases}$$

Thus I have:

$$U_i|_{GT}(G_i) = \alpha_i G_i - \frac{(G_i c_i - T_i)^2}{e_i^2 F_i^2} - \frac{(c_i G_i - T_i) \cdot \sum T_i}{e_i F_i e_N \sum F_i} \quad (2.9)$$

The first order condition based on equation 2.9 is:

$$G_i^*|_{GT} = \frac{\alpha_i e_i^2 F_i^2}{2 c_i^2} + \frac{T_i}{c_i} - \frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i} \quad (2.10)$$

For national government, the utility comes from the public goods from all jurisdictions combined, while need to take the necessary burden and cannot achieve any impact on subnational jurisdictions policy direction. This setting may be counterintuitive at first—national government seems take the tax burden with no benefits in exchange. The reason lies in the fact that national government cares about the utility of all jurisdiction combined and the marginal effect of one unit product increase in a low endowment subnational jurisdiction should be higher than the marginal effect of same amount product increase in high endowed place, which means national government should be motivated to equalize the public goods provision in different places. The utility for national government in this game is:

$$U_N = \sum_i \alpha_i (G_i) - \sum_i \left(\frac{G_i c_i - T_i}{e_i F_i} + \frac{\sum_i T_i}{\sum_i F_i e_N} \right) \cdot \frac{\sum_i T_i}{\sum_i F_i e_N} - \sum_i \gamma_i |X_N - X_i| \quad (2.11)$$

2.2.4 Categorical Transfer Game

Under categorical transfer game, subnational governments decide the level of public goods provision level conditional on the matching ratio m and n . Meanwhile, They need to collect tax to partly supply the goods. Also, in this game, subnational governments cannot set the policy position arbitrarily as they want to. National government can affect policy directions by attaching restrictions to the grants.

I set a pair of matching ratio $0 < m < 1$ and $0 < n < 1$, which means national government have matching ration m for subnational's productive spending and ratio n for welfare-oriented spending.

One obvious distinction between categorical transfer subgame and other subgames is that the categorical transfer changed S_i 's public goods price. Under new price system, I have:

$$\frac{P_i}{W_i} = \frac{\beta_i c_{wi}(1 - n)}{\epsilon_i c_{pi}(1 - m)}$$

and

$$c_i|_{CT} = \frac{(1 - m)(1 - n)c_{pi}c_{wi}(\epsilon_i + \beta_i)}{(1 - m)\epsilon_i c_{pi} + (1 - n)\beta_i c_{wi}} \quad (2.12)$$

Another important distinction of categorical transfer is that I assume national government do not collect tax to support the categorical transfer, thus N do not take criticism for rasing tax in categorical transfer game, instead, national government can only issue bonds to support categorical transfer while cannot use bonds to support any other programs. For example, one common way to finance support categorical transfer is to issue special bonds. This means, under categorical transfer, the subnational governments undertake all the criticism for tax raising, and national government endure the inutility for issuing bonds. The subnational governments' utility under new price system is:

$$U_i|_{CT} = \alpha_i G_i|_{CT} - \frac{c_i|_{CT}^2 G_i^2|_{CT}}{e_i^2 F_i^2} - \gamma_i |X_N - X_i|$$

The first order condition for subnational governments is: $\frac{dU_i|_{CT}}{dG_i|_{CT}} = 0$

thus I have:

$$G_i^*|_{CT} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2|_{CT}} \quad (2.13)$$

One obvious observation is categorical transfer is not an intergovernmental transfer with equity consideration. S_h , with greater amount of resource and tax base, can achieve greater public goods increase with same matching ratio m and n .

The utility of the subnational government under categorical transfer with new price became:

$$U_i^*|_{CT} = \frac{\alpha_i^2 e_i^2 F_i^2}{4c_i|_{CT}^2} - \gamma_i |y_i - X_i| \quad (2.14)$$

National government care about the public goods provision condition in all subnational area including S_i and S_h , and need to collect revenue to afford part of the public goods. The setting in this game is that the national government can only issue bonds to support the categorical transfer while the subnational governments are not authorized to issue bonds.

The good thing for national government in this game is that it can affect the policy direction by adjusting the matching ratio m and n . One important issue here is how to evaluate the inutility for national governments to issue bonds. This question related to the controversies in economic theory concerns the shifting of the burden of the national debt. One side of the argument claims that the burden of the debt is borne at the time the debt is issued; the other says that the burden of the debt is shifted forward in time [48, 49]. Though this thesis evaluate the one-time game, but generally scholar tend to attribute the bonds burden to the future generations, which means it actually shifted forward. Representative topics include the discussion between national debt and inflation, money supply, currency value, and economic growth [50–54]. This thesis does not focus on these discussions in detail. I just abstractly simplify the inutility from two aspects which are the size of the bonds and time to mature [48, 55, 56].

Thus I set up a term δD to capture the future burden that national government may undertake, where δ express the time factor and D is the size of the burden. The idea is: the inutility for national government depends on two sides, firstly, for how long the national government needs to payback the bonds burden. National government doesn't worry too much about the long-term bond thus have a small δ ; on the other side, the size of the burden also matters for national government's evaluation.

The utility of national government in this game can be listed as:

$$U_N = \sum_i \alpha_i G_i^*|_{CT} - \delta D - \sum_i \gamma_i |X_N - y_i| \quad (2.15)$$

One thing to notice here is the policy outcome direction is not fully decided by subnational government, thus $y_i \neq X_i$.

So the utility for players in player set P based on their actions under different games can be summarized in Table 2.1³.

Table 2.1: Utility or Goods Provision of Players in Each Subgame

Game	Player	Utility
No Provision Game	NG	$U_N = \sum_i \alpha_i G_i - \sum_i \gamma_i X_N - X_i $
	Si	$U_i^* _{NP} = \frac{\alpha_i^2 e_i^2 F_i^2}{4c_i^2}$
Joint Provision Game	NG	$U_N = \sum_i \alpha_i G_i - \sum_i \left(\frac{G_{si} c_i}{e_i F_i} + \frac{\sum c_N G_{Ni}}{e_N \sum F_i} \right) \cdot \frac{\sum c_N G_{Ni}}{e_N \sum F_i} - \sum_i \gamma_i X_N - X_i $
	Si	$G_{si}^s _{JP} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2} - \frac{1}{2} \cdot \frac{c_N}{c_i} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \sum G_{Ni}$
General Transfer Game	NG	$U_N = \sum_i \alpha_i (G_i) - \sum_i \left(\frac{G_i c_i - T_i}{e_i F_i} + \frac{\sum_i T_i}{\sum_i F_i e_N} \right) \cdot \frac{\sum_i T_i}{\sum_i F_i e_N} - \sum_i \gamma_i X_N - X_i $
	Si	$G_i^* _{GT} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2} + \frac{T_i}{c_i} - \frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i}$
Categorical Transfer Game	NG	$U_N = \sum_i \alpha_i G_i^* _{CT} - \delta D - \sum_i \gamma_i X_N - y_i $
	Si	$U_i^* _{CT} = \frac{\alpha_i^2 e_i^2 F_i^2}{4c_i^2 _{CT}} - \gamma_i y_i - X_i $

Before conduction the backward induction and infer the policy outcome, here are some propositions that we can get by analyzing the optimal choice for subnational government under each kind of game.

Proposition 1: Under no provision game, public goods provision and utility are determined by the demand, tax collection efficiency, tax base and cost.

Subnational government's behavior under no provision game is like a benchmark condition and proposition 1 is straight forward. The subnational jurisdictions with

³Since subnational governments have no motivation to reject national government's joint provision and general transfer decision, subnational governments' utility in joint provision and general transfer subgame doesn't matter anyway, thus are not listed in the table.

greater demand, higher tax collection efficiency, greater tax base and lower public goods cost tend to supply greater amount of public goods and enjoy higher utility.

Proposition 2: Under joint provision game, the public goods supplied by national government is a pure squeeze out for subnational government's public goods supply.

This is contradictory with Volden's statement. In Volden's suggestion, national government's provision would potentially stimulate subnational governments' provision, since the subnational government and national government would compete in public goods provision to get more credit from public goods provision. In this model however, the inflow of national government's public goods lead to pure squeeze out effect. This could be partly explained by the fiscal illusion in the utility function. The voters or citizens are not clear about how the tax is used and who is supplying the public goods, as long as the public goods meet the specific threshold, the voters don't care either national or subnational government is making contribution. However citizens are rather more sensitive about the tax burden. This mechanism in my model lead to a different implication.

Besides, the size of the squeeze out effect are infected by a $\sum G_{Ni}$ and a bunch of ratios including $\frac{c_N}{c_i}$, $\frac{e_i}{e_N}$, $\frac{F_i}{\sum F_i}$, which are shown in equation 2.7. It's straight forward to understand greater $\sum G_{Ni}$ leads to greater squeeze out—national tax to afford $\sum G_{Ni}$ is undertaken by whole nation, thus a greater $\sum G_{Ni}$ means subnational government needs to be cautious about any further tax increase. This squeeze out would be affected by the parameters $\frac{c_N}{c_i}$ and $\frac{e_i}{e_N}$, thus subnational jurisdictions with greater advantage in tax raising efficiency and public goods cost compared with national government would suffer greater local public goods provision outflow. One thing need to emphasize here is that S_h would be affected heavier in terms of the squeeze out size.

Proposition 3: Subnational governments may increase or decrease the public goods provision depends on the size of the income effect and squeeze out effect in general transfer game.

The first term of equation 2.10 representing subnational government public goods provision under no provision game. The second term $\frac{T_i}{c_i}$ is the income effect of the general transfer since S_i would increase the supply following the $P - W$ structure in equation 2.3 due to the lump-sum subsidy. The third term in equation 2.10 express the squeeze out effect due to the national tax undertaken by the citizens in

S_i .

What equation 2.10 tells us is then: whether the public goods in S_i increase or decrease depends on the comparison between $\frac{T_i}{c_i}$ and $\frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i}$, which equals to:

$$\frac{1}{c_i} \cdot (T_i - \frac{1}{2} \sum T_i \cdot \frac{F_i}{\sum F_i} \cdot \frac{e_i}{e_N}) \quad (2.16)$$

We have $T_i = T_0 - \sigma F_i$, thus $T_l > \frac{1}{2} \sum T_i > T_h$. For S_l , equation 2.10 should be normally be positive. The exception is when $\frac{e_i}{e_N}$ is great enough to make equation 2.14 become negative since $\frac{F_i}{\sum F_i} < 1$. The condition becomes just the opposite when it comes to S_h . Normally the squeeze out effect should be greater than income effect for S_h unless the tax collection efficiency for S_h is extremely low compared to national government.

2.3 Backward Induction Solution of the Policy Outcome

The extensive game about national government's engaging method is solved through backward induction. The national government would take the first movement to decide which engaging method to join the public goods provision, then subnational governments decide if they accept or reject national government's decision. Once subnational governments rejected, the game turns into no provision game, which means national government has no role in public goods provision.

As I have mentioned before, the joint provision and general transfer are free lump-sum subsidy, thus subnational government has no motivation to reject national government's *NP* and *JP* decisions. The first step to conduct the backward induction is to compare the utility of subnational government under categorical transfer game and no provision game.

2.3.1 Utility Evaluation of Subnational Governments

The first step of the backward induction is to evaluate the utility of S_i and S_h , which is the tail part of the extensive tree in Figure 2.1. For subnational government, the backward induction analysis gives us that both S_l and S_h won't accept

the categorical transfer unless $U_i|_{CT} > U_i|_{NP}$ otherwise subnational governments would just turn down the grants and supply the public goods without national government's assistance. National governments knows subnational governments' potential motivation to reject the grants. If national government want to make sure that the grants could be accepted, the matching ratio m and n should be set at a level that could guarantee $U_i|_{CT} > U_i|_{NP}$. Thus I have proposition 4.

Proposition 4: One necessary but insufficient condition for national government to choose categorical transfer is $U_i|_{CT} > U_i|_{NP}$

Since we have equation 2.6 and equation 2.13, the inequation $U_i|_{CT} > U_i|_{NP}$ can be rewritten as:

$$\frac{\alpha_i^2 e_i^2 F_i^2}{4c_i|_{CT}^2} - \frac{\alpha_i^2 e_i^2 F_i^2}{4c_i|_{NP}^2} > \gamma_i |X_N - X_i| \quad (2.17)$$

From equation 2.4, I can calculate:

$$\frac{dc_i}{dc_{pi}} = \frac{(\epsilon_i + \beta_i)\beta_i c_{wi}^2}{(\epsilon_i c_{pi} + \beta_i c_{wi})^2} \quad (2.18)$$

which is a positive value. In categorical transfer subgame, a lower productive price $c_{pi}|_{CT}$ leads to a lower $c_i|_{CT}$.

$$c_i|_{CT} < c_i|_{NP} \quad (2.19)$$

and $c_i|_{CT} = \frac{(1-m)(1-n)c_{pi}c_{wi}(\epsilon_i + \beta_i)}{(1-m)\epsilon_i c_{pi} + (1-n)\beta_i c_{wi}}$ thus:

$$\frac{dc_i}{dm} = \frac{-c_{pi}c_{wi}^2(1-n)^2\beta_i(\epsilon_i + \beta_i)}{(\epsilon_i c_{pi}(1-m) + \beta_i(1-n)c_{wi})^2} \quad (2.20)$$

Equation 2.3.1 means the left side of equation 2.3.1 is greater than zero. The evaluation for subnational government about if they should accept the categorical transfer then became: whether the utility increase from more public goods provision under categorical transfer game can surpass the inutility of policy direction change. The implication of equation 2.3.1 and 2.3.1 for this question can be summarized from two aspects. For one, higher m and n would always make it easier for subnational

governments to accept the categorical grants, which is an intuitive conclusion. For another, equation 2.3.1 can be rewritten as:

$$\frac{dc_i}{dm} = \frac{-c_{pi}\left(\frac{\epsilon_i}{\beta_i} + 1\right)}{\left(\frac{\epsilon_i c_{pi}(1-m)}{\beta_i c_{wi}(1-n)} + 1\right)^2} \quad (2.21)$$

This tells us that for S_i with higher welfare-oriented goods price, the effect of categorical transfer on productive goods leads to greater price effect thus brings greater utility from public goods increase. For S_i with higher productive public goods price, the marginal effect of the c_{pi} adjustment is less significant. To summary, if the national government decide to supply matching ratio categorical transfer to P , then S_i with higher price of W is easier to accept the categorical transfer with all the other conditions holding equal. Mutual conclusion can be made if we calculate $\frac{dc_i}{dc_n}$.

Proposition 5: The subnational governments aligned with national government are more likely to accept the categorical transfer.

Aligned governments means national and subnational governments share similar ideas in policy direction thus subnational government tolerate less policy inutility in categorical transfer game. In extreme circumstances, when national government have exact the same ideal policy point with subnational governments, $X_N = X_i$ and policy inutility became 0. In addition to the gap between national and subnational governments' ideology, subnational governments allied with national governments may be favored by national government during the grants distribution decision making.

2.3.2 Utility Evaluation of National Governments

The evaluation of national government's utility is on the root part of Figure 2.1. Since the game is set as a complete information game, national government is perfectly clear about subnational governments' optimal provision amount G^* and optimal utility U^* under each game. Based on the U^* of subnational governments in each game, national government can expect subnational governments' action about whether accept the grants or not. For example, if national government is too eager about the actual policy output and too stingy about the grants matching ratio, subnational governments would turn down the categorical transfer and the

subgame degenerate to no provision subgame since $U_i^*|_{CT} < U_i^*|_{NP}$. With this expectation, national government would not make the categorical transfer proposal at first place if it already knows the subnational governments would turn it down.

Based on national government's expectation on subnational government's action, national government would make decision based on the utility of national government U_N . National government has two dimensions in utility evaluation in this game—policy direction and cost to provide the goods. The consideration of policy output is explicit. The cost to provide the goods could be affected by two aspects which are collection efficiency e_N and e_i and price of the goods c_N and c_i . From these two aspects, I can have proposition 6.

Proposition 6: One necessary but insufficient condition for national government to make categorical transfer proposal is $U_N|_{CT} > U_N|_{NP}$.

This proposition is a naturally conclusion by backward induction. Except for the necessary condition on the subnational governments side, the national government should have the motivation to choose categorical transfer over no provision.

Comparing $U_N|_{NP}$ and $U_N|_{CT}$ in Table 2.1, the condition $U_N|_{CT} > U_N|_{NP}$ can be rewritten as:

$$\sum_i \left(\frac{\alpha_i^2 e_i^2 F_i^2}{2c_i^2|_{CT}} - \frac{\alpha_i^2 e_i^2 F_i^2}{2c_i^2|_{NP}} \right) + \sum_i \gamma_i |X_i - y_i| > \delta D \quad (2.22)$$

This equation implies that national government's motivation to implement categorical transfer comes from the public goods increase stimulated by intergovernmental transfer and a preferred policy output compared to no provision subgame. Public goods increase under categorical transfer comes from the price drop. Matching ratio m and n is obviously a factor affecting the size of the public goods increase. Except for matching ratio, public goods demand, collecting efficiency and the size of the tax base also matter. Utility increase from policy outcome shift is affected by γ_i and the distance between actual policy outcome and subnational governments' ideal policy point. When making decision between categorical transfer subgame and no provision game, national government would adjust m and n such that the goods increase and policy favor worth the cost to issue bonds.

Due to the utility function setting, it's hard to have a arithmetic expression when comparing the utility of national government in categorical transfer subgame and

general transfer game. However it's natural to have that $U_N|_{CT} > U_N|_{GT}$ is another necessary but insufficient condition.

Proposition 7: The national government prefer general transfer subgame compared to joint provision subgame when the price of public goods provided by national government c_N is greater than the one by subnational governments c_i .

Mechanism of joint provision subgame parallels that of general transfer subgame since national government's behavior doesn't change the price of G_i . The difference is that national government provide goods directly in joint provision game while extend subnational government's budget constraint in general transfer game. The evaluation of $U_N|_{GT} - U_N|_{JP}$ is actually evaluating⁴:

$$\frac{c_l \cdot G_{Nl} + c_h \cdot G_{Nh}}{c_N \cdot (G_{Nl} + G_{Nh})} \quad (2.23)$$

In both game, national governments needs to collect tax and undertake tax burden blame, thus the tax collection efficiency e_N is not a consideration when comparing these two games.

The difference between these two for national government is the compare between c_N and c_i . If $\frac{c_l \cdot G_{Nl} + c_h \cdot G_{Nh}}{c_N \cdot (G_{Nl} + G_{Nh})} > 1$, national government would choose to provide public goods directly rather than offer general transfer. One implication from equation 2.3.2 is that, national government equalize the public goods between subnational jurisdictions with minimal tax burden, thus national government care about both c_l and c_h . In some circumstances when the gap between c_l and c_h are extremely large, national government would step in and take over part of the public goods provision.

2.4 Review and Summary

In this chapter, I try to shed light on how the fiscal policy in public goods provision is decided with the interaction of national government and subnational governments. In this process, whether the joint of national governments in public goods provision

⁴The calculation process is offered in Appendix C

lead to the squeeze in or squeeze out effect for the amounts of public goods in subnational jurisdiction S_i is affected by a bunch of parameters.

To summarize, the question on the subnational government is: whether to accept the categorical transfer once the categorical transfer method is chosen and the matching ratio is decided by national government. This decision by subnational government is decided by the compare between the utility for subnational government in no provision game and categorical transfer game. This evaluation for subnational government is about the trade off between policy inutility and lower price. The decision on categorical transfer is the only decision jointly made by national and subnational government. Though turning down the joint provision or general transfer is not against the rule, but subnational government has no motivation to do that. The reason is, no matter subnational if government deny the categorical transfer or joint provision offer, the tax from national government is imposed to the whole nation, thus taking the general transfer or joint provision offer would at least avoid paying tax in vein.

The choice for national government is to evaluate the utility based on subnational government's public goods provision level G_i^* . The adoption of categorical transfer is a joint decision by both national and subnational governments. If subnational government is satisfied about the categorical transfer offer and categorical transfer is the optimal option for national government compared to the other three subgames.

Compared with Volden's setting, I changed the utility setting and added the categorical transfer into discussion. However, to investigate the effect of categorical transfer, the compare between different games cannot get a clear arithmetic solution, which is a flaw compared to Volden's original setting.

Another disputable issue here is national government's resource to support the categorical transfer. Unlike general transfer and joint provision, in this game, national government issue bonds to support the categorical grants, not through tax. This change makes the evaluation between categorical transfer and other games for national government became ambiguous. Though the drawback is obvious, this setting is still reasonable in two aspects. For one, most of the categorical transfer programs are supported by bonds, especially in American and OECD countries [57–59]. For another, categorical transfer and general transfer are designed to have different purpose for national government. Categorical transfer is to stimulate spending in specific area while general transfer and joint provision

is to equalize the public goods spending in different jurisdictions. Thus putting categorical transfer and general transfer under same framework to compare is an unreasonable competition.

Chapter 3 |

National Governments' Administration on Intergovernmental Transfer

3.1 Literature on Game Theory Modeling of Bargaining Process

In the United States, approximately \$700 billion, which constitutes almost 20% of the federal revenues, is annually disbursed across various state and local government grant programs. As a result, the mechanism by which intergovernmental transfers are distributed has long been a captivating subject in public finance.

The distribution of grants in democratic countries is considered a bargaining game among decision-making groups such as committees, congress, or houses, depending on which group is the decisive institution. Four assumptions are crucial in simulating the grants distribution bargaining using bargaining models: recognition rule, voting rule, amendment rule, and money-distribution rule. The recognition rule determines how to select an agenda setter to make the initial proposal, with most literature assuming the random recognition rule [60–63], which means n members among the decision making institution have equal probabilities to be chosen to make the initial proposal. The voting rule establishes the standard for passing the proposal, with the majority rule and unanimous voting rule being common. The amendment rule places constraints on making amendments, ranging from the closed rule, which allows no amendments, to the open rule, which allows any and all

(germane) amendments. Finally, the grants-type rule determines how grants could be manipulated by decision-making institutions, with some scholars assuming direct decisions on the number of receivers, referred to as "earmarks" or "pork barrel" spending model. The mechanism of intergovernmental transfer distribution, which accounts for nearly 20 percent of overall federal revenues, is a compelling topic in the public finance area, particularly in democratic countries like the United States.

Baron and Ferejohn's work [64] laid the foundation for subsequent analyses of bargaining models. They made several important assumptions, such as random recognition, majority voting rule, and earmarks rule. Their work, as well as the generalization by Banks and Duggan [65], demonstrates that legislators with agenda-setting power tend to receive a disproportionate share of funding. In addition, the equilibrium is characterized by funds flowing only to legislators in the winning coalition, with no funds allocated to those outside of it. Furthermore, they found that when proposals are brought up under a closed rule, the winning coalition is minimized, leading to the maximization of benefits for the members of the winning coalition.

Although Baron and Ferejohn's work [64] is pioneering in the field of grants distribution, the heavy reliance on the "earmarks" assumption limits its explanatory power in the actual political environment. Martin [66] addresses this issue by modifying the assumptions of the model. Specifically, he restricts the power of decision-making members to only determine the factors in the formula rather than the specific numbers. This modification is a significant step towards reflecting the realities of political and administrative life. Martin's model generates different conclusions compared to Baron and Ferejohn's work. In contrast to the latter, Martin predicts oversized winning coalitions and the emergence of persistent winning blocs. Additionally, he demonstrates that when bargaining over a low-dimensional formula, legislators have limited ability to target funds to specific districts, a prediction supported by empirical evidence. For instance, Martin analyzed existing formula grants and found that 95% of the formula have less than 5 variables, which means members have limited bargaining dimensions. As a result, jurisdictions with similar features can be free-riders, even if they are not part of the winning coalition. Martin predicts positive distribution outside the winning coalition as a consequence.

3.2 Some Empirical Evidence for the Grants Distribution

Apart from the introductory remarks on intergovernmental transfers in Chapter 1, one of the primary challenges with their distribution is the political environment in which it occurs. The allocation of intergovernmental transfers is often susceptible to the influence of individual political agendas that may undermine the intended structure of the distribution procedures. This challenge has been addressed through classic game theory analyses of Congress. Given the significant role of intergovernmental transfers in the US federal system, the influence of politics on their allocation can be prohibitively expensive. Several anecdotal examples illustrate this, such as Robert Carlyle Byrd's efforts to direct federal spending to his home state, West Virginia, over two decades. One example of Robert Byrd's influence is seen in the creation of a new formula for distributing a trust fund surplus proposed by him during the 1992-1997 authorization negotiation. This new formula primarily benefited states such as West Virginia with high state gasoline tax rates and low per capita income.

Markusen, Saxenian and Weiss's [67] conducted a descriptive study to analyze three distinct swings in the distribution of federal grants to cities during the 1960s and 1970s. They found that federal grants increased substantially during this period, with northeastern and midwestern cities benefiting the most from 1965-1972, southern and western cities benefiting the most from 1972-1975, and a slight swing back in favor of the first group from 1975-1978. These swings can be partially explained by the political background, as noted in their article. Stegarescu [68] explains that the degree of IGT decentralization is a result of population, unemployment, trade-openness, presidential regimes and electoral systems based on the test result of the panel data of 17 nations. Kasdin [69] conducted an empirical test and found that the complexity of state or local government networks influences the amount of federal transfer and federal control. Higher-level governments tend to relinquish control when the lower governmental network is highly complicated, but the amount of transfer is negatively related to complexity. The complexity can be a barrier that hinders politicians from claiming political credit, and thus, they are less motivated to secure fiscal revenue for their jurisdiction. Larcinese, Rizzo, Testa [70] tested the impact of the president on the amount of federal transfer

to state government and found that states that heavily supported the incumbent president in past presidential elections tend to receive more funds. Wallis [71] also emphasizes the political effect on the amount of intergovernmental transfer. He claims that states with the high volatility of presidential vote receive significantly more federal support based on his study on the longitudinal data of all states in the U.S. Markusen, Saxenian and Weiss [67] defined the supply side and demand side when investigating the mechanism of the IGTs decision-making process, even though they don't point out the specific factors, they emphasize that the IGT is the result of the political, economic and social characteristics of both demand and supply side.

The existing literature suggests that political factors, including potentially biased factors, can significantly impact the distribution of intergovernmental transfers. Based on the aforementioned studies, it can be inferred that the determinants of intergovernmental transfers are not limited to legislative decision-making institutions, but also include administrative branches. Furthermore, the political stance of local jurisdictions appears to play a notable role in intergovernmental distribution.

3.3 An Empirical Investigation on IGT Distribution Mechanism

Combined with Martin's [66] conclusion introduced in section 2.2.1 and all the literature implying the political impact mentioned above, I design and conduct an longitudinal empirical test to statistically investigate the intergovernmental transfer mechanism. Specifically, I try to solve two questions in this empirical design, for one, following Martin's inference, how much extent does states share similar characteristics so the IGT benefits goes outside of the winning coalition. Another questions I wonder is, following Markusen, Saxenian and Weiss's framework, if we got the social and economic characteristics control, how much can political factors affect the IGT. The reason I focus on the political factors is that, contradictory to what we discussed in section 2.1, the political factor seems unrelated to efficiency, thus may cause more distortion and waste of resources. Besides, examination on political factors could be important because of the sharp rise in hostility between democratic and republican parties. The potential effects of political party control may impact the IGT grants distribution significantly.

3.3.1 Sample and Characteristic Selection

I focus on the direct IGT from federal government to state governments in America. To incorporate the political impact into the data framework, I did a stratified sampling to collect states sample from traditional republican states, traditional democratic states and swing states. The state grouping method are based on two criterion, the historical presidential election result and the winning rate following Beachler,Donald,Bergbower,Matthew etc.'s work [72]. The democratic states and republican states are those chose same party in the president election since 1984 with wining rate over 58%. The swing states are those have chosen president from two parties and the winning rates are less than 58%.

The states collected into my sample can be listed as Table 3.1

Table 3.1: States Sample and Grouping

States	Group	Code
Wyoming		
Idaho		
Kansas	Red States	1
Nebraska		
North Dakota		
Maryland		
Massachusetts		
Rhode Island	Blue States	2
New York State		
Washington		
Pennsylvania		
Nevada		
Wisconsin	Swing States	3
Ohio		

The social and economic characteristics that commonly included in the formula when doing the intergovernmental transfer are population, working age population weight, median household income, unemployment rate, road mileage and gdp [30]. I collected all factors mentioned in Dilger's service [30] of the sample states,

besides, I also take reference from some major intergovernmental transfer programs such as Medicaid, the Title I-A education program, Temporary Assistance for Needy Families (TANF), Section 8 Housing Choice Vouchers, and the Community Development Block Grant (CDBG) to collect factors comprehensively. I also did proper operation for data regression convenience and better data visualization. The characteristics I collected and source of data can be listed as Table 3.2.

Table 3.2: Social characteristics for Sample States

Variables	Definition	Operation	Source	Time Period
gdp	Real GDP	Log transformation	FRED	2000-2019 annually collected
lgp	Population	Log transformation	Census of bureau	2000-2019 annually collected
wapw	Working age population weight	No operation	Census of bureau	2000-2019 annually collected
mhi	State median household income	Log transformation	Census of bureau	2000-2019 annually collected
ur	unemployment rate	No operation	FRED	2000-2019 annually collected
prm	public road mileage	Log transformation	Bureau of transportation statistics	2000-2019 annually collected

3.3.2 Principle Components Analysis of Social and Economic Characteristics

As mentioned previously, the formula for distributing grants may involve numerous factors. Furthermore, issues of multicollinearity can be intuitively identified within

the variables that have been collected. For instance, the weight of the working-age population and the unemployment rate are highly interdependent variables, where higher population levels inevitably correspond to increased utilization of public roads. This observation is further supported by the correlation heatmap, which indicates a certain degree of correlation among the variables.

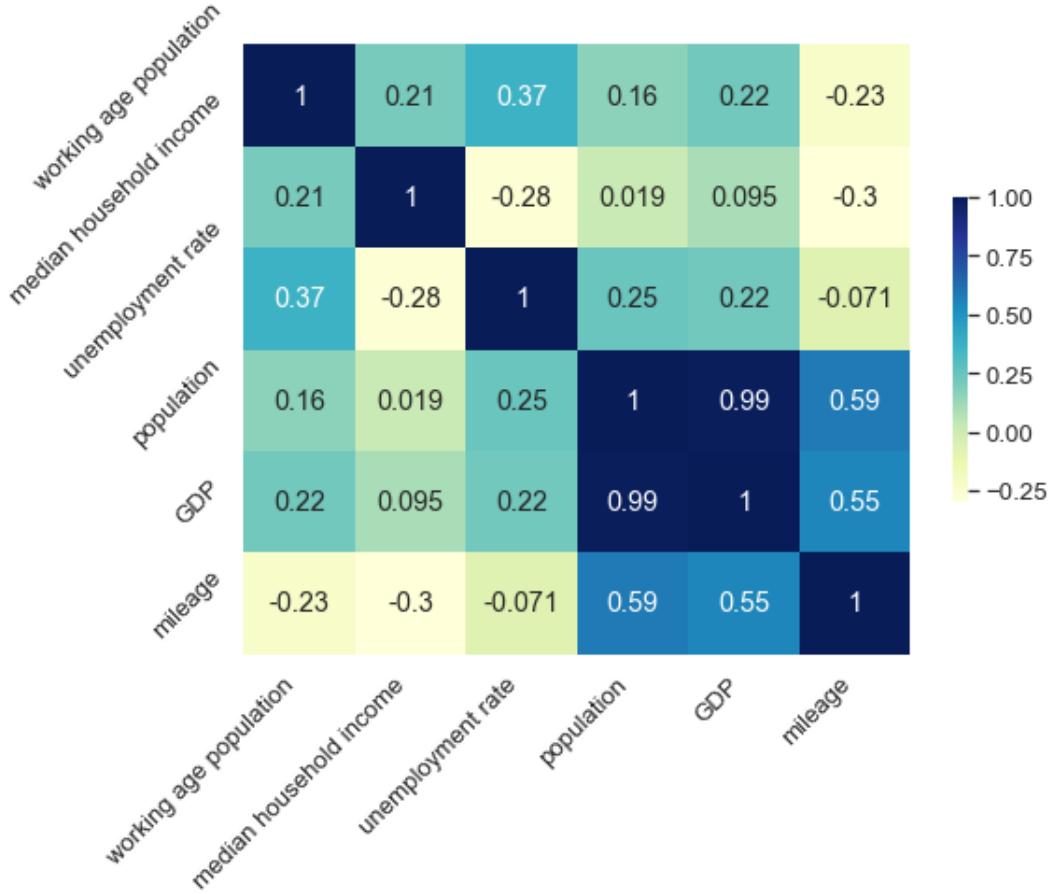


Figure 3.1: Heatmap of the Social Characteristics

To answer the first question, these two problems are obvious hinder thus it's hard to judge how similar jurisdictions could be in social and economic characteristics directly. So I conduct a primary components analysis to reduce the data dimension and overcome multicollinearity problem to check if the reduced-dimension data are cluster distributed or scattered distributed.

According to the primary components variance analysis result shown in the figure, the first two dimensions express 67% of the information. The first three dimensions include 87% of the information.

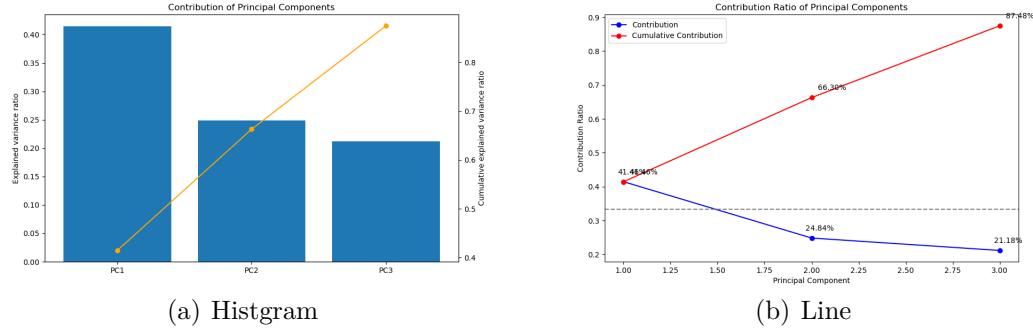


Figure 3.2: Principle Components Contribution

Thus I did principle components analysis by compress the data into two and three dimensions separately. By keeping these two and three principle components with most information, comparing the characteristics between jurisdictions became a possible procedure. The scatter plot after data dimension reduction is shown as Figure 3.3

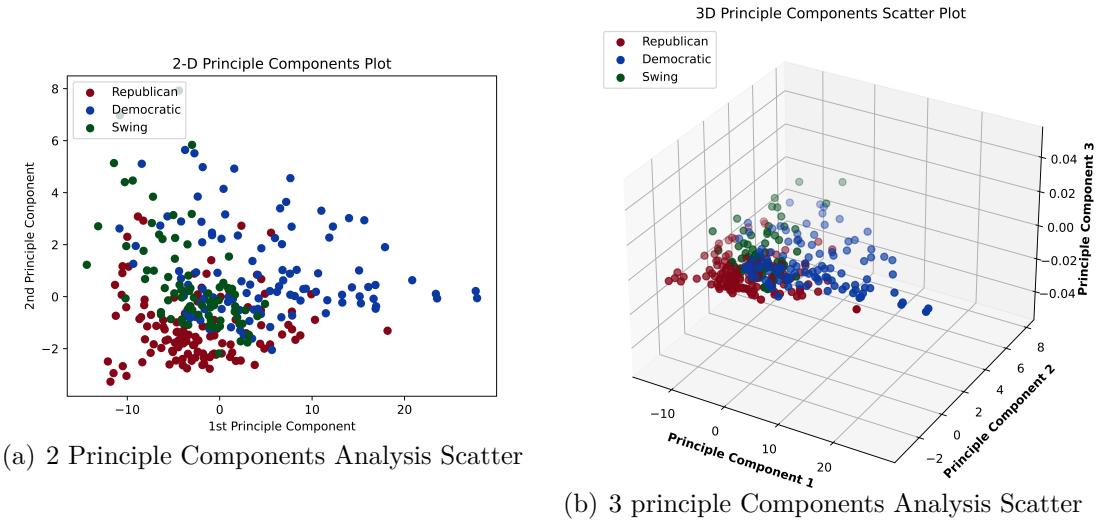


Figure 3.3: Social Characteristics Principle Components Analysis Scatter Plot

Though reduced dimensions do not have specific economic meaning, but one clear information shown in Figure 3.3 is that a lot of states characteristics are cluster distributed, which means plenty jurisdiction features in my data are quite similar. This implication is a side evidence for Martin's [66] deduction that some jurisdiction with similar features can be a free riders, this also predicts the funds outflow of the winning coalition.

Another potential implication is that, the distribution is obviously hierarchical in terms political parties. Republican states, democratic states and swing states are clearly cluster distributed in their own area. In 2d plot shown in Figure 3.3 (a) , Red dots and blue dots distributes on two sides while swing states in the middle. This means any modification on the grants formula that benefits one party is a huge damage to another. This may explain why in the legislative bargaining process, two parties are sharply opposed and swing states are relatively indifferent. What makes Swing states different from the other parties is implied in the 3-D plot shown in Figure 3.3 (b), the green dots are not in the same level in the third dimension. This is not counterintuitive, since traditional republican states are highly likely to share similar social characteristics, but this figure may offer a different view on any fiscal collective behavior of the party. When a member in the bargaining process take any behavior, are they doing that due to their political status or arguing benefits for their represented jurisdiction? It seems that any collective political behavior within a party should find a micro-foundation. In other words, when analyze the motivation, one should focus on the motivation of particular member rather than the motivation of a whole group.

3.3.3 Political Impact Investigation

The goal of this section is to develope and test a theoretical framework that seeks to further advance the understanding of how the above factor outside of the bargaining institution can affect the spatial distribution of IGT. I still focus on the intergovernmental transfer from federal to state governments. Toward this end, based on the literature implication I collected in section 2.2.1 and 2.2.2, I explore how combination of political party control across legislative and administrative branches affects the distribution of IGT. The factor I'm interested includes whether legislative and administrative branches is unified, whether Democratic or Republican party has different preferences, and whether party control is aligned across the federal and state governments. The distribution of IGT is affected by (1) political party distribution across the federal and state government, and by (2) political party affiliation (i.e., Republican or Democratic party). I also examine how the perceived importance of a state in the federal political process affects the distribution of IGT. In addition, to gain insight into the role of swing state,I also examine the relationship between the IGT and whether a particular state is considered a battle

ground state.

3.3.3.1 Variable and Data

The variables I collected can be listed as Table 3.3, the data is annually collected from 20000 to 2019, and the source of the data and other detail is attached in Appendix TableA.1.

One variable I need to explain here is the dummy variable c , which represents the party distribution combination in administrative and legislative branch across federal and state levels.

Table 3.3: Variables and Operation

Variables		Definition	Operation
Dependent Variable	lg(igt)	IGT from federal to state i	Log
Independent Variables	c	Combinations of levels, branches and parties.	No operation
	p	Dummies to identify i is democratic, republican or swing.	
	log(gdp)	Real GDP	
	log(pl)	Population	
Control Variables	wapw	Working age population weight	Log
	mhi	State median household income	
	ur	unemployment rate	No operation
	prm	public road mileage	Log

Three aspects decide the type of " c ", which are the governmental level, branches and different parties. 2 Branches and 2 levels formulate a 2×2 Table shown in Table 3.4, which are four sectors. For each sector, u_1, u_2, s_1, s_2 , two possible parties may get control, which are the democratic party " d " and the republican party " r ". For example, $c_1 = (u_1 = r, u_2 = r, s_1 = r, s_2 = r)$, where 'r' means republican party and 'd' means democratic party. Here, I just use abbreviation (r, r, r, r) to express c_1 , which means combination one. In this research, I use the majority of

the House of Representatives to define the partyism of the legislative branch since the House plays a leading role in the budget making process. The partyism of the administrative branch is decided by the partyism of the administrative leader, which could be the president or governor. There are 16 types of combination, which are:

$$(r, r, r, r), (r, r, r, d), (r, r, d, r), (r, r, d, d), (r, d, r, r), (r, d, r, d), (r, d, d, r), (r, d, d, d)$$

$$(d, r, r, r), (d, r, r, d), (d, r, d, r), (d, r, d, d), (d, d, r, r), (d, d, r, d), (d, d, d, r), (d, d, d, d)$$

I use c_1, c_2, \dots, c_{16} to express these 16 different combinations. In the regression, only fifteen combinations are saved, the first combination $c_1 = (r, r, r, r)$ is omitted in regression to avoid the multicollinear problem and c_1 acts as a benchmark.

Table 3.4: Branches and Levels Combination

Branches		
	administrative	house
Levels	federal	u_1
	state level	s_1

As for dummy variable p , I collected the longitudinal data of three different types of states based on whether the states are traditional democratic states, republic states, or swing states, Fifteen states are divided into 3 groups. The first group is the traditional republican states group, or what are called "red wall states", and we code $p = 1$ for the first group. Second group is traditional democratic state group, also known as "blue wall states", and we define $p = 2$ for second group. The third group is the swing state group, also known as the "battle ground states", $p = 3$ for the third group. The sample states in this research is same as the sample in principle components analysis collected in Table 3.1.

I selected some variables and generate some relationship scatter plots to get a intuitive description about the relationship. The figure is shown in Figure 3.4. I hide the legend of different party. One thing that should be noticed is that, except

for the lower left subfigure, which shows the relationship between relationship and igt, shows a clear linear trend, other figures show obvious hierarchical distribution. The linear relationship between population and intergovernmental transfer amount is not surprising, but the hierarchical plot is kind of intriguing, hold x axis constant, we still get different igt amounts. Even for the relationship between the partisan of states and IGT amounts, especially for those democratic states, the points falls on both upper and lower sides. The hierarchical distribution implies that the social and economic characteristics cannot fully explains the IGT distribution, and the rest of the black box may potentially be explained by political impact and the influence out of the legislative branch.

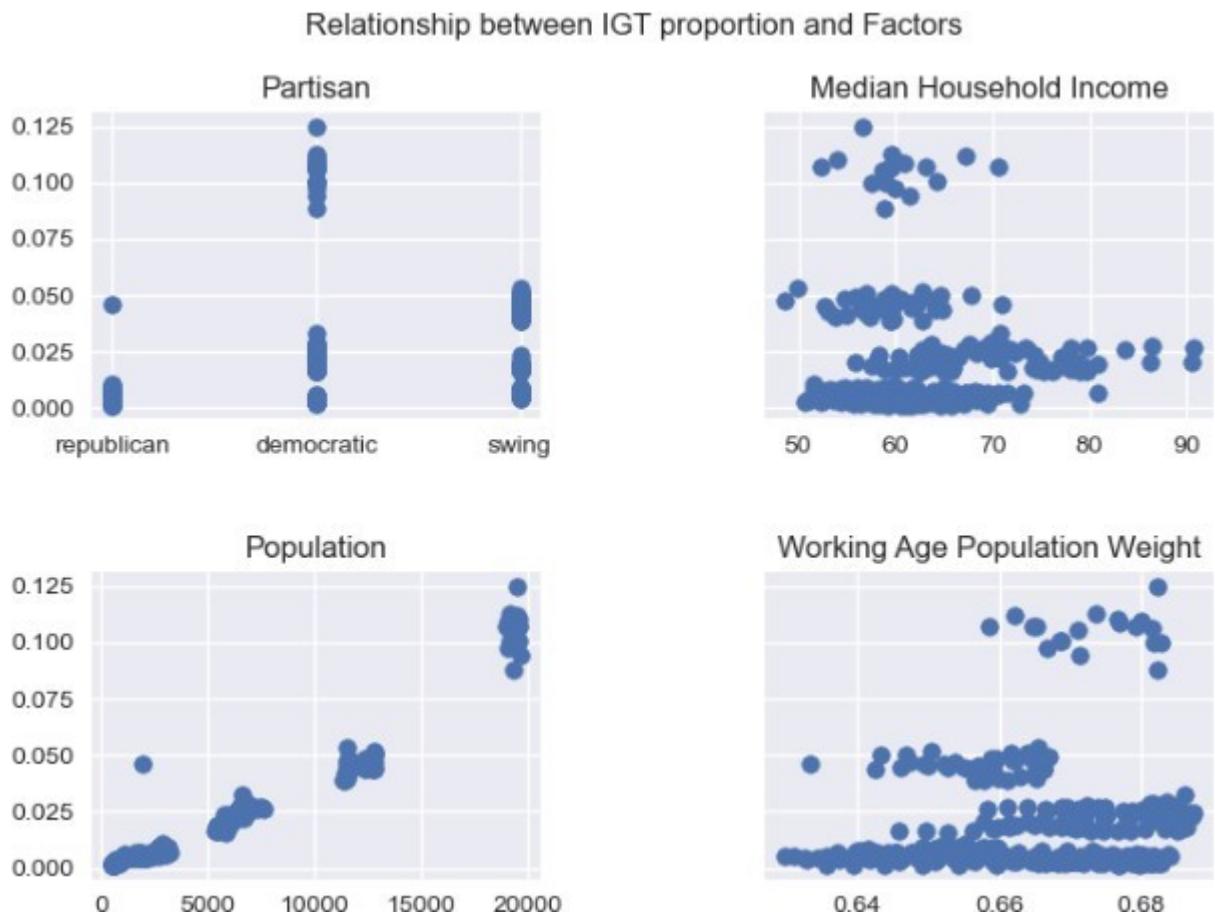


Figure 3.4: Factor and IGT Scatter Plot

3.3.3.2 Model Setting

Though I did a relatively comprehensive literature investigation in grants distribution formula issue, and the sample data includes the most important concerns in intergovernmental transfer distribution, it still possible that some variables may be omitted from the equation, especially given this is a longitudinal data with 19 years time span. So one crucial problem for this investigation is how to deal with the potential omitted variable issue and avoid the following heteroscedasticity and endogeneity problem. To make sure I can get an unbiased estimate, I adopt two factor fixed effect model in the regression. In the following research, I display 3 regression models. The benchmark model is OLS regression. Besides, since the fiscal behavior happens on state level, which is a relatively big and stable jurisdiction, it's totally possible some factors are time-invariant. So, the second model in my display is fixed model with time variable fixed. Though, state is a relatively stable jurisdiction, the time span is relatively long, thus some omitted variables could be time-variant as well. To get all these omitted variables controlled as much as possible, the third model I adopt is two factor fixed effect model, with both time factor and individual effect controlled.

The equation for OLS regression can be displayed as follow.

$$\begin{aligned} \log(igt_{i,t}) = & \alpha + \beta_1 c_{i,t} + \beta_2 p_{i,t} + \beta_3 \log(gdp) + \beta_4 \log(pl) + \beta_5 \log(mhi_{i,t}) \\ & + \beta_6 wapw_{i,t} + \beta_7 ur_{i,t} + \beta_8 \log(prm_{i,t}) + \epsilon_{i,t} \end{aligned} \quad (3.1)$$

For $t = 1, 2, 3 \dots T$ and $i = 1, 2, 3 \dots N$

The second model, which is the fixed effect model with time effect fixed is:

$$\begin{aligned} \log(igt_{i,t}) = & \alpha_i + \beta_1 c_{i,t} + \beta_2 p_{i,t} + \beta_3 \log(gdp) + \beta_4 \log(pl) + \beta_5 \log(mhi_{i,t}) \\ & + \beta_6 wapw_{i,t} + \beta_7 ur_{i,t} + \beta_8 \log(prm_{i,t}) + \epsilon_{i,t} \end{aligned} \quad (3.2)$$

For $t = 1, 2, 3 \dots T$ and $i = 1, 2, 3 \dots N$

Finally, the third model, which is two factor fixed effect model with time effect and individual effect controlled is:

$$\begin{aligned} \log(igt_{i,t}) = & \alpha_i + \theta_t + \beta_1 c_{i,t} + \beta_2 p_{i,t} + \beta_3 \log(gdp) + \beta_4 \log(pl) + \beta_5 \log(mhi_{i,t}) \\ & + \beta_6 wapw_{i,t} + \beta_7 ur_{i,t} + \beta_8 \log(prm_{i,t}) + \epsilon_{i,t} \end{aligned} \quad (3.3)$$

For $t = 1, 2, 3 \dots T$ and $i = 1, 2, 3 \dots N$

There are four hypothesis in this investigation, which can be listed as follow.

Hypothesis 1—The unified Government Hypothesis

Unified government means the administrative branch and legislative branch on federal level coming from same party. Unified government is likely to spend a higher overall spending scale since the financial powers are less limited.

Hypothesis 2—Party Specific Hypothesis

Democratic and republican parties have different preferences on the IGT scale. The preference on IGT of different parties is fuzzy here, since two possible inference may be reasonable here. In terms of the scale of government, the democratic party prefers a big government, which would lead to a higher-scale IGT, and the republican party holds the opposite idea. In terms of the administrative structure, democratic government tends to establish a centralized government, whereas republican government prefers a decentralized structure. In this way, we can get a opposite conclusion

Hypothesis 3—Alignment Hypothesis

The allocation of the IGT are affected by the political ideology. The federal government is likely to allocate more IGT to states that are controlled by same party.

Hypothesis 4—Battle Ground States Hypothesis

The competition level between two parties in state would affect the IGT received by that state government. The federal government is motivated to get elected or reelected; thus, the federal government is willing to put resources and supply more public goods to states that matter a lot for their election to get political credits.

The regression results can be summarized as Table 3.5

Table 3.5: Regression Results Display

	Model-1 Log(igt)	Model-2 Log(igt)	Model-3 Log(igt)
c2	-0.0161 -0.43	-0.0534 -1.99	-0.0954 -1.83
c3	-0.0467 -1.4	-0.0352 -1.4	0.0282 -1.09
c4	0.00886 -0.19	-0.0751 -2.21	-0.101 -2.67
c5	-0.127 -3.31	-0.122 -3.12	0. -0768 -2.87
c6	0.0792 -1.33	0.0203 -0.47	0.0351 -0.73
c7	-0.0125 -0.32	0.00947 -0.27	0.0149 -0.51
c8	0.0578 -1.3	0 0	0.0767 -2.15
c9	0.0314 -1.32	0.0368 -1.21	0.00131 -0.08
c10	-0.0601 -1.27	-0.0392 -1.2	-0.0318 -0.76
c11	0.144 -1.6	0.127 -1.87	0.0973 -1.5
c12	0.0561 -1.26	0 0	0.0692 -1.94
c13	0.0963 -1.96	0.078 -1.78	0.0371 -1.07
c14	0.0653 -0.81	0.021 -0.4	-0.00931 -0.15
c15	0.000495 -0.01	-0.0173 -0.33	0.00997 -0.21
c16	0.0466 1.94	0 0	0.0512 2.44

Table 3.6: Regression Results Display (follow up)

	Model-1 Log(igt)	Model-2 Log(igt)	Model-3 Log(igt)
Democratic States	0.259	0.217	0
	-4.88	-5.51	0
Swing States	0.0899	0.0189	0
	-2.7	-1.94	0
Log(population)	0.106	1.087	0.457
	-0.92	-10.67	-1
working age population weight	-5.362	2.199	-4.768
	-6.93	-2.72	-5.43
Log(median household income)	-0.753	-1.407	-0.348
	-3.51	-8.68	-1.26
unemployment rate	0.0136	-0.0151	0.0234
	-1.97	-2.27	-4.51
Log(GDP)	0.807	-0.0855	1.346
	-6.85	-0.86	-7.43
Log(mileage)	0.143	0.0576	1.222
	-2.91	-1.59	-3.21
Constant	9.057	7.078	-1.473
	-15.21	-14.32	-0.73
Observations	309	309	309
Adjusted R2	0.942	0.969	0.68

3.3.3.3 Result Analysis

The first information in the display is that all three models show high adjusted R^2 , especially the first two models. The high adjusted R^2 could be explained by the high explanatory power in the control variables I selected. The adjusted R^2 of the third model, in which both time and individual effect controlled, is relatively lower. Given that the state variable is controlled and one of the criterion of the sample selection is that the partisan of the states has not changed in the past 19 years, the deduction process in the fixed effect regression would delete the partisan

variable that's the reason why coefficients of partisan variables are 0. Thus the lower adjusted R^2 can be explained by the loss of partisan variables. So for the rest of analysis, I'll adopt the coefficients of partisan variables in model 2 and all other coefficients in model 3.

From model 3, $c_4(r, r, d, d)$, $c_5(r, d, r, r)$, $c_{16}(d, d, d, d)$ are statistically significant on 5% significant level. From model 2, the partisan variables, "Democratic States" and "Swing States", are significant as well. If we loosen the 5% significant level to 10%, $c_2(r, r, r, r)$, $c_{12}(d, r, d, d)$ is also significant.

The first hypothesis about the unified government is supported by the regression result. By comparing the coefficient of $c_5(r, d, r, r)$ and $c_1(r, r, r, r)$, we can tell that a traditional republican state, with both administrative and legislative branch controlled by republican party, receives 7.78% lower of intergovernmental transfer under bipartisan control on federal level compared to a unified republican controlled federal. When the federal level is not uniformly controlled by the republican party, the ability to distribute grants to state level is significantly constrained.

The second hypothesis about party preference is also supported by the significant coefficients. Comparing the coefficient of $c_{16}(d, d, d, d)$ and $c_1(r, r, r, r)$, I can tell that states receive 5.12% higher intergovernmental transfer when both federal and state level are controlled by democratic party compared to when both federal and state are controlled by republican party. This means that democratic party prefer to transfer more to state government, the first inference in my hypothesis dominates. The understanding of this result needs more investigation though. For example, does this conclusion still holds when it comes to the intergovernmental transfer to local level?

Alignment effect is also significant in intergovernmental transfer distribution, compared aligned combination $c_1(r, r, r, r)$ and $c_{16}(d, d, d, d)$, coefficients for all other unaligned combinations, including $c_4(r, r, d, d)$, $c_5(r, d, r, r)$, $c_{16}(d, d, d, d)$ are negative.

Finally, about the effect of partisan, the coefficient of swing states in model 2 doesn't support my hypothesis about battle ground state. One possible explanation is that we do not have a factor to control the effect of election period. My theoretical analysis and the supporting literature about the benefits swing states have is achieved by the election process, however this investigation is a longitudinal study with 19-years time span, thus for those years when politicians do not care about

elective pressure and political credit, the benefits of swing states may be neglected.

3.3.3.4 Deficiencies and Rethinking on Related Topics

I have to admit that our investigation is limited and deficient. The most obvious defect is the time span of the data. This defect may be even more serious given that elections happens every 2 even 4 years, not annually. One may claim that our model is not convincing since our conclusion may not hold when put our investigation in a longer time span.

Given all the deficiencies we talked about, this paper could be an extension and may get some insight in related area. The investigation on IGT is embed in the framework of fiscal federalism. Given all the benefits of fiscal federalism as Musgrave [73] mentioned, it also introduces several challenges. Our investigation may supply some implication for those challenges. For one, The involvement of multiple jurisdictions in the funding and execution of public programs introduces loss aversion behavior between the national and the subnational governments [74–76] and asymmetric information [77–79]. The former problem arises because the subnational are less accountable for the local government separation of funding and spending responsibilities. Information and potential loss aversion creates the risk that agency problems compromises the allocative efficiency of federal spending, including conflict of interest and moral hazard problems. For example, the presence of moral hazard problems act to discourage the subnational government from delivering services cost effectively [80](i.e., a shirking).

Moreover, the delegation of program implementation from a central government to a subnational government, increases information asymmetry, which may further exacerbate the above incentive problem. They may also increase the risk that agents within a subnational government engage in behaviors that are inconsistent with program goals (i.e., conflicts of interest problems). Our analysis suggests some potential explanation. Our investigation confirmed the effect of political party bias in grants distribution. This effect may be a common knowledge for both federal and state governments. Once the state government know the grants they received is guaranteed, the state government won't be motivated enough to implement the policy dedicatedly. So the incentive problem may be partly explained by the biased grants distribution process.

Finally, this research may be a supplementary material for the flypaper effect,

which I will discuss in detail in the following chapter. The fly paper effect means that increase in grants-in-aid leads to significantly higher public spending than the same increase of private income, so money sticks where it hits [81]. Scholars ascribe this fact to many causes. Hamilton tried to explain fly paper effect as improper data distinction or improper empirical method [82]. Some identify flypaper effect happen due to fiscal illusion [83]. Our research may offer some new angle to understand the flypaper effect. The confirmed biased effect in grants distribution means for some of the states, getting grants from federal governments is effortless compared to getting revenue from other methods. This relative price effect may explain the fact that state government prefer to raise funds from IGT rather than raising tax.

Chapter 4 |

Effect of Intergovernmental Transfer on Local Governments' Spending Behavior

The following two chapter talks about the reaction of subnational governments with different intergovernmental transfer. I did a comprehensive literature review for the current literature. Generally, I divided the literature into 3 categories, based on the fiscal behavior and whether the topic is across or within the border of the jurisdiction. The investigation directions of the literature can be summarized as Figure4.1. The first category focus on the impact on local governments' spending behavior. The second category talks about the impact on local governments' revenue collection behavior, such as the investigation on local governments' tax effort, debt expansion tendency and issue and soft budget constrain behavior. The third category is about the effect of intergovernmental transfer across jurisdictions, such as the role of intergovernmental transfer in equalization.

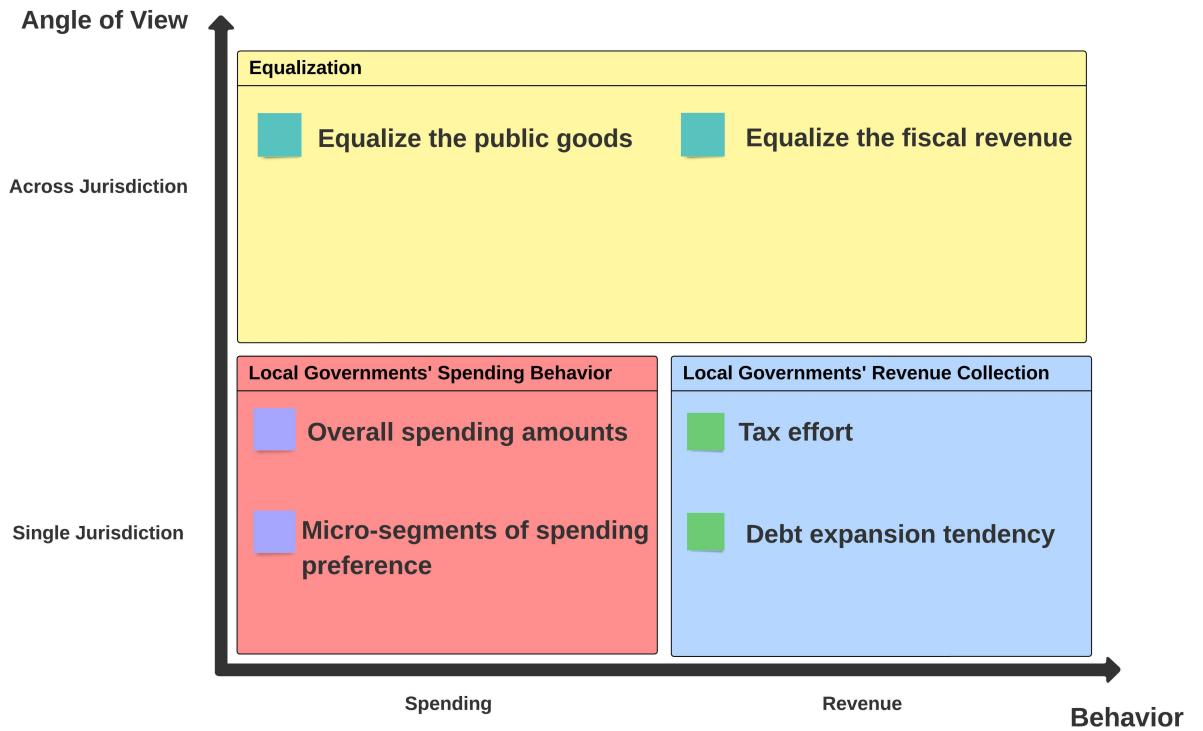


Figure 4.1: Effect of Intergovernmental Transfer

The lower two sectors talk about subnational governments' reaction in spending and revenue behavior. Those behavior focus on the behavior within the jurisdiction. The literature about the red sector in Figure 4.1 is discussed in this chapter and the discussion about the blue sector will be talked in Chapter 5.

4.1 Effect of IGT on Local Governments' Spending

4.1.1 Effect of IGT on Local Governments' Total Spending Amounts

One intuitive philosophy about the effect of IGT on subnational government spending is called "fungibility" [84], which means the intergovernmental transfer received by local government would substitute the local government's revenue.

Recipients assimilate federal funds into general revenue and reduce the spending on public goods through a reduction of local taxes within the jurisdiction. However, supportive empirical evidence are quite limited. On the contrary, evidence on flypaper effect is widespread everywhere.

The flypaper effect is widely regarded as the most influential phenomenon in the fiscal federalism literature regarding the vertical transfer of funds from the federal to the state or local level [27, 85]. According to Bradford and Oates' model, a lump sum grant to the state or local level should have the same effect as an increase in individual revenue within the jurisdiction in terms of stimulating public expenditure [86]. This conclusion is known as the equivalence theorem, which is based on two fundamental assumptions: the median voter theorem and lump-sum tax collection by federal, state, and local governments. However, empirical evidence does not support this theorem. Specifically, some researchers have found that a \$1 increase in individual revenue leads to an increase in public expenditure of only \$0.02 to \$0.05, while a \$1 increase in intergovernmental transfers can lead to an increase in public expenditure of \$0.25 to even \$1 [85, 87, 88]. This phenomenon is known as the flypaper effect. According to Inman's statistics, over 3,500 research papers have investigated the flypaper effect, both theoretically and empirically [81].

In this section, I'm summarizing how scholars in different stages explain the flypaper effect. The understanding of flypaper effect went through a incremental progress, though may not be chronologically. This progress can be identified as three phrases. In the first stage, the conventional analysis, scholars believe the matching grants have both price effect and income effects while the non-matching grants is analogous to the lump-sum subsidy, which means only income effects exists. In second stage, some scholars start to realize that non-matching grants has price effects as well, but that's due to the impact of fiscal federalism setting and fiscal illusion. Federal government collecting revenue then redistributing to state and local generates fiscal illusion since this process is too complicated for consumers to perceive. In third stage, scholars start to realize the effect of distortionary tax that collect by grants recipient. The distortionary tax policy together with the low administrative efficiency in state and local leads to a higher marginal cost of the tax collection. Hence no matter the grants is matching or non-matching, the state or local government trend to use the grants rather than the tax revenue to cover the expenditure.

I set up a very simple Ramsey model to better summarize the literature discussing the flypaper effect.

Benchmark model

The Benchmark model is similar to Carlos and Guillermo's [89] benchmark model with small modification.

To make the benchmark model as straight forward as possible while capture the IGT mechanism. I assume that:

1. Economy is static.
2. Only one local government and representative citizen in this economy.
3. Two kinds of goods in the economy which are public good G and private good X .
4. Resident spend all there income y , which is given, on either private goods X or tax τ .
5. The tax is lump-sum tax with no dissertation.
6. Source of government revenue: tax τ and transfer f .
7. Type of transfer: Nonmatching grants,like lump-sum subsidy.

The representative citizen's budget constraint is:

$$y = X + \tau \quad (4.1)$$

The local government's budget constraint is:

$$f + \tau = G \quad (4.2)$$

Combine equation 4.1 and 4.2, I get a budget constraint for the economy:

$$y + f = X + G \quad (4.3)$$

The utility for representative resident comes from the utility of X and G . I assume the utility function is the Cobb-Douglas form thus it's a concave utility:

$$U(X, G) = AX^\alpha G^{1-\alpha}, 0 < \alpha < 1 \quad (4.4)$$

For the representative resident, the problem is to choose proper level of X to maximize the utility in equation 4.4 subject to equation 4.1. The Lagrangian equation can be set up as:

$$L(X) = AX^\alpha G^{1-\alpha} + \lambda_{rc}(y - X - \tau) \quad (4.5)$$

Solving the equation 4.5 will get first order condition(foc):

$$\alpha A \left(\frac{X}{G} \right)^{\alpha-1} = \lambda_{rc} \quad (4.6)$$

$$y = X + \tau \quad (4.7)$$

To solve the Ramsey problem, the Ramsey planner needs to decide the level of X, G to maximize the utility subject to equation 4.3 and equation 4.2. The Lagrangian can be set as:

$$L(X, G) = AX^\alpha G^{1-\alpha} + \lambda_e(y + f - X - G) + \lambda_{lg}(f + \tau - G) \quad (4.8)$$

Solving the equation 4.8 will generate:

$$\alpha A \left(\frac{X}{G} \right)^{\alpha-1} = \lambda_e + \lambda_{lg} \quad (4.9)$$

$$(1 - \alpha)A \left(\frac{X}{G} \right)^\alpha = \lambda_e + \lambda_{lg} \quad (4.10)$$

$$y + f = X + G \quad (4.11)$$

$$f + \tau = G \quad (4.12)$$

Combining equation 4.9, 4.10, 4.11 will generate:

$$(1 - \alpha)y + (1 - \alpha)f = G \quad (4.13)$$

The flypaper effect definition can be mathematically expressed as $\frac{dG}{df} - \frac{dG}{dy}$. Given equation 4.13, the flypaper effect $fe = 0$, which means, under this setting, theoretically there should be no flypaper effect.

The investigation on flypaper effect in my view can be divided into 3 phrase from the shallower to the deeper. I'm conducting a summary systematically with the combination of the benchmark Ramsey model.

4.1.1.1 Phrase One

Except for the introduction of intergovernmental transfer in Chapter 1, one important concern about IGT in economic analysis is the matching mechanism. For matching grants, federal governments will reimburse a specific ratio for each 1 dollar of state and local expenditure. Based on whether federal government set a cap on the matching grants, matching grants can be divided into open-ended matching grants and closed-ended grants.

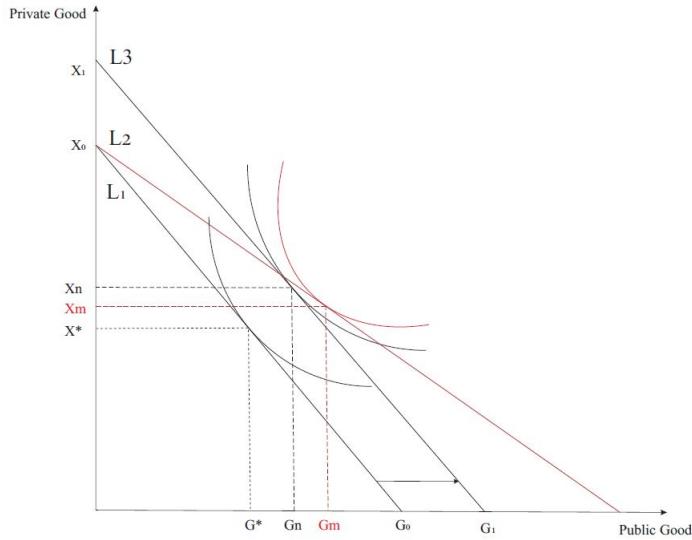


Figure 4.2: Income Effect and Price Effect of Matching and Non-matching Grants

As is shown in figure 4.2, the two parallel lines L_1 and L_2 are budget constraint of the economy before and after the non-matching grants and L_3 is the budget constraint with matching grants which is the red line. The difference between G_m and G^* is the combination of price effect and income effect of matching grants.

The matching grants model explains why scholars in first stage explain the fly paper effect by misspecification or omitted variable. Misspecification refers to instances where researchers may conflate matching grants with lump-sum grants, leading to a mix-up of price effects and subsequently resulting in increased public goods spending [90, 91]. Matching grants reduce the marginal price of public services, thus mix-up with lump-sum grants would lead to an increase in public goods spending [92]. Some scholars attribute the flypaper effect to omitted variables or pre-selection issues. Knight [93] developed a two-level bargaining model to

demonstrate that the federal government distributes intergovernmental transfers to states and local governments with a higher propensity to spend, indicating that the flypaper effect is not a result of intergovernmental transfers. However, prior studies and investigations have encountered endogeneity issues. To address this, Knight conducted an empirical test where he employed an instrumental variable to control for the endogeneity problem. His results indicate that once the pre-selection issue is filtered out, the flypaper effect is not evident, at least for the data he collected regarding interstate highway programs. To summarize, the understanding under this view is that the flypaper effect may not actually exist, but may instead be a result of misspecification or omitted variables.

4.1.1.2 Phrase two

The literature on the flypaper effect has also been approached from a second perspective, whereby scholars recognize the importance of lump-sum grants and their potential price effects. While scholars in the first stage focused on the price effects of matching grants, it was realized that this may not be sufficient to explain the large gap in the flypaper effect. As such, the second stage of literature argues that non-matching grants also have price effects, which can be attributed to fiscal illusions. McCulloch [94] argued that taxpayers often misperceive the costs of governmental activities, a concept later summarized as fiscal illusions. The theory of fiscal illusion was first developed by Italian economist Amilcare Puviani in his 1903 book *Teoria della illusione finanziaria* [95]. Wagner [96] introduced this concept in America and identified the effect of fiscal illusions on local government spending. Oates and Borge [45, 46] also recognized the potential price effect of non-matching grants and attempted to explain it using the concept of fiscal illusions. The lower-estimated public good price generates an even flatter slope of the budget constraint compared to the L_3 in figure 4.2.

The existence of fiscal illusion can be attributed to administrative factors and institutional intention. The fiscal federalism framework is complex and difficult for residents to comprehend, while administrative processes are often opaque and lack transparency, preventing residents from understanding the nuances of intergovernmental grants and their own contributions to these grants. Empirical research by Turnbull [47] supports this view, demonstrating that imperfect information generates a broader fiscal illusion based on municipal data. Additionally, the

budget-maximizing tendencies of bureaucratic systems are supported by both empirical evidence and theoretical inference [97, 98]. This tendency is sometimes referred to as "Leviathan government," in which governments seek to maximize their budgets rather than prioritize residents' utility [99]. The combination of budget-maximizing bureaucrats and lower perceived prices of public goods leads to increased expenditure on public goods.

4.1.1.3 Phrase Three

In stage three, Scholars have also examined the effect of the cost of tax collection within a jurisdiction. This cost can arise from two aspects, one being the distortionary tax, another one comes from the revenue collection ability of the sunational government. Assuming that tax revenue collection does not cause any distortion for the recipient is a strong assumption. In reality, changes in state and local government tax policies can significantly alter residents' behavior. For instance, if residents are dissatisfied with tax and public goods policies, they may choose to work less and spend more time on leisure. Alternatively, they may move to another jurisdiction, which itself incurs costs due to the tax increase. Hamilton [82] was the first to observe that the cost of tax collection within a jurisdiction leads to a curved budget constraint, rather than a straight line. However, his idea was not widely accepted at the time, and he neglected to consider administrative ability as a source of cost, focusing only on deadweight loss as the source of tax collecting cost.

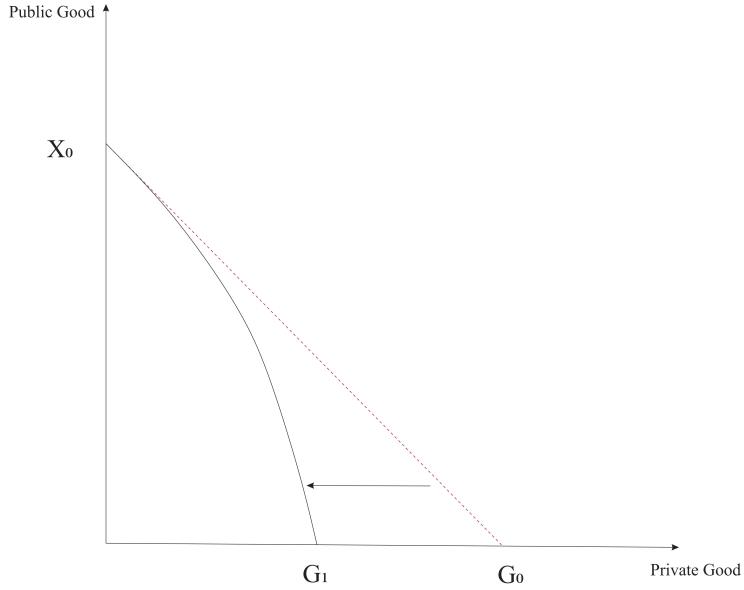


Figure 4.3: Hamilton's Curved Budget Constraint

In reality, the cost of tax collection comes from various sources, including the different levels of administrative ability between federal and state governments. Volden [32] developed a game theory model to simulate the interaction between the federal government and lower-level governments and showed that the different costs of collecting revenue for federal and state governments partially explains the flypaper effect. Dahlby and Ferede [100] argued that the price effect of non-matching grants exists even without fiscal illusion due to subnational governments face information and ability disadvantages, meanwhile Vegh and Vuletin [89] came to a similar conclusion. In summary, these researchers suggest that the collection of tax revenue is costly for state and local governments due to factors such as administrative inefficiency and distortion, leading to a preference for using "cheaper" resources such as intergovernmental transfers. Therefore, even non-matching grants or lump-sum grants can have price effects.

Some horizontal government interaction explains this distortion as well, Brueckner [101] develops a strategic model to analyze the state and local fiscal behavior, he concludes that the lower-level governments are quite sensitive to other competitors. This sensitivity may explain why state and local government don't want tax increase revenue to cover the public goods. Other horizontal interaction theory such as yardstick competition or tax competition also explains the sensitivity.

I expand the benchmark model by introducing the distortion of tax collection into

it.

Ramsey Model with Distortionary Tax Collection

To capture the distortion effect of the tax, I loosen the 3rd and 5th assumption of the benchmark model. I follow the setting by Carlos and Vuletin [89] by adding a taxable private goods X_t to differentiate with the non-taxable private goods X_{nt} and capture the distortion effect of proportional tax. In reality, X_{nt} could express any behavior that representative resident take to avoid the taxation, such as more time on leisure or The assumption on taxation and representative resident's spending behavior are:

1. Three kinds of goods in the economy which are public good G and taxable private good X_t and non-taxable private good X_{nt} .
2. Resident spend all there income y , which is given, on either taxable private goods X_t , non-taxable private goods X_{nt} or tax.
3. The tax is proportionary tax on X_t , with tax rate θ .

So the budget constrain for resident, local government and the whole economy could be separately list as:

$$y = X_t(1 + \theta) + X_{nt} \quad (4.14)$$

$$f + \theta X_t = G \quad (4.15)$$

$$y + f = x_t + x_{nt} + G \quad (4.16)$$

Different from Carlos' setting who accept a more general setting on residents' and governments' utility, I set Cobb-Douglas form on utility to get a arithmetic solution. Unlike the benchmark model in Carlos' research, in which he set the linear utility, the Cobb-Douglas setting means the imperfect substitute between private and public goods, which is a more reasonable setting. The distribution on X_t , X_{nt} and G should maximize representative resident's utility and government's utility.

$$\begin{cases} U = AX^\alpha G^{1-\alpha} \\ X = BX_t^\beta X_{nt}^{1-\beta} \end{cases} \quad (4.17)$$

Where X represent a compound private good. For resident, they need to decide X_t , X_{nt} to maximize U subject to equation 4.14. For local government, the problem

is to decide the distribute of X and G to maximize U , thus the Ramsey problem is to maximize both resident and local governments' utility, which is listed as equation 4.17 subject to equation 4.14 and 4.15. For resident, the first order conditions on $X_t, X_{nt}, \lambda_{rc}$ can be listed as:

$$\frac{\partial U}{\partial X} \frac{\partial X}{\partial X_t} = (1 + \theta) \lambda_{rc} \quad (4.18)$$

$$\frac{\partial U}{\partial X} \frac{\partial X}{\partial X_{nt}} = \lambda_{rc} \quad (4.19)$$

$$y = X_t(1 + \theta) + X_{nt} \quad (4.20)$$

Solving equation 4.18, 4.19 will generate the relationship between X_t and X_{nt} in equilibrium and the level of θ :

$$X_{nt} = \frac{(1 - \beta)(1 + \theta)}{\beta} X_t \quad (4.21)$$

$$\theta = \frac{\beta X_{nt}}{(1 - \beta) X_t} - 1 \quad (4.22)$$

For local government and Ramsey Planner, they need to decide G, X_t, X_{nt} subject to equation 4.15 and 4.16, the FOCs on $X_t, X_{nt}, G, \lambda_e, \lambda_{lg}$ are:

$$\frac{\partial U}{\partial X} \frac{\partial X}{\partial X_t} = \lambda_e + \lambda_{lg} \quad (4.23)$$

$$\frac{\partial U}{\partial X} \frac{\partial X}{\partial X_{nt}} = \lambda_e + \frac{\beta}{1 - \beta} \lambda_{lg} \quad (4.24)$$

$$\frac{\partial U}{\partial G} = \lambda_e + \lambda_{lg} \quad (4.25)$$

$$y + f = x_t + x_{nt} + G \quad (4.26)$$

$$f + \theta X_t = G \quad (4.27)$$

Solving equation from 4.23 to 4.27, I can get the arithmetic solution of X_t, X_{nt}, G as:

$$x_t = \frac{\beta y + f}{\alpha \beta + 1 - \alpha} \cdot \alpha \beta \quad (4.28)$$

$$G = \frac{(\beta y + f)(1 - \alpha)}{\alpha \beta + 1 - \alpha} \quad (4.29)$$

Follow the definition of fe in benchmark model , the flypaper effect under distortionary taxation can be calculated as:

$$\frac{dG}{df} - \frac{dG}{dy} = \frac{(1-\alpha)(1-\beta)}{\alpha\beta + 1 - \alpha} \quad (4.30)$$

To get a visual impression about the size of flypaper effect under distortion, I generated a 3-D figure based on equation 4.30 through Mathematica.

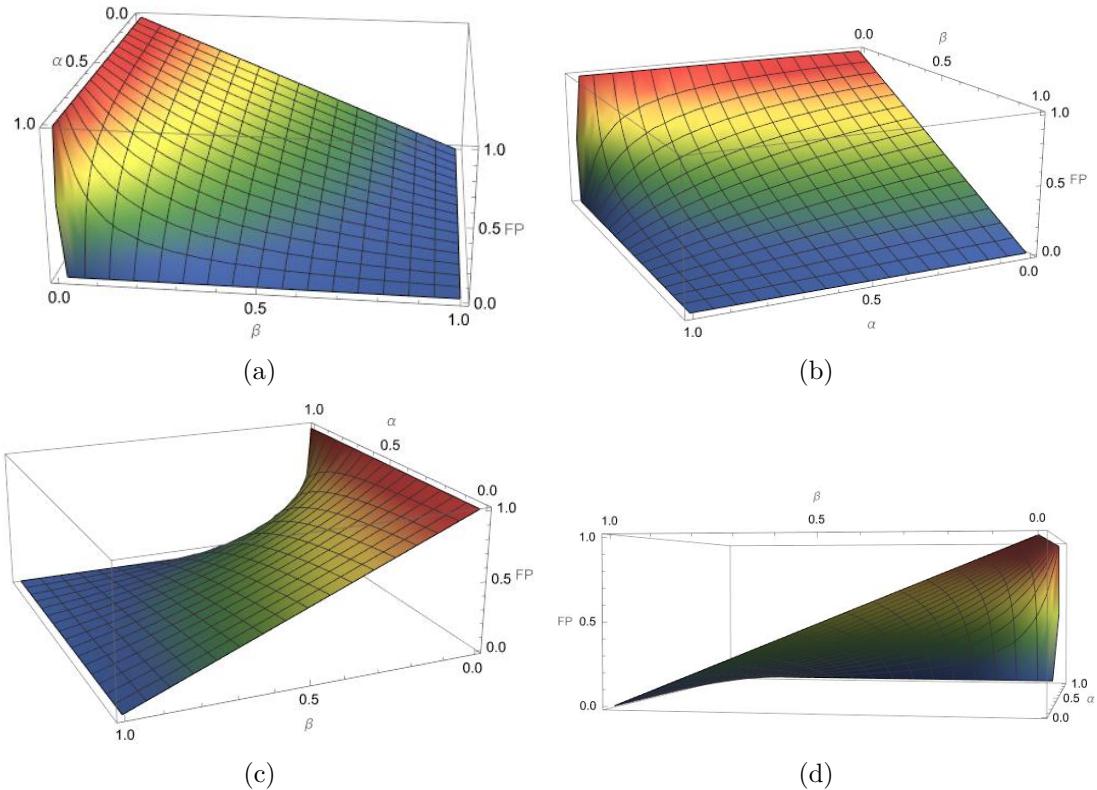


Figure 4.4: 3-Dimensions Plot of the Fluctuation of Flypaper Effect under Distortion

From figure 4.4, one obvious fact to be noticed is that the flypaper effect under distortion is always positive, no matter what the value of α and β is. More implication can be found when we pin down one of α and β and evaluate the fluctuation of flypaper effect on the other.

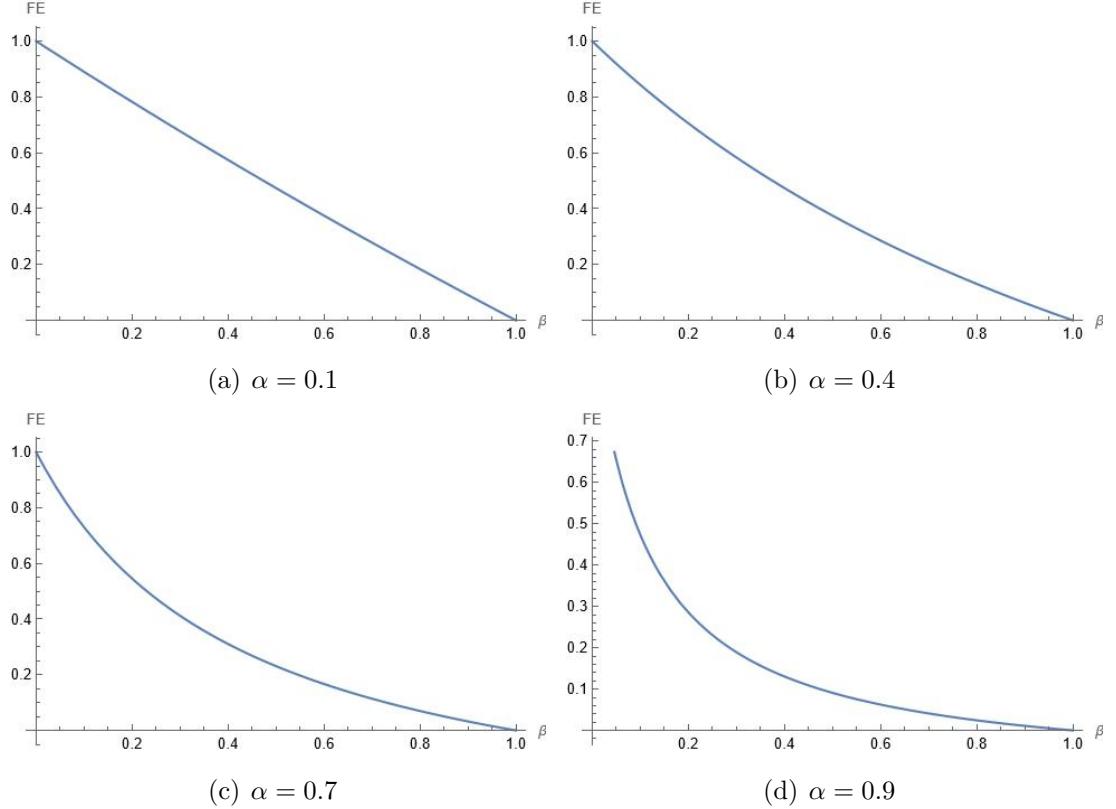


Figure 4.5: 2-Dimensions Plot of the Fluctuation of Flypaper Effect on β

Figure 4.5 are cross sections of Figure 4.4 when $\alpha = 0.1, 0.4, 0.7, 0.9$ separately. It can be explained from two aspects. For one, the size of flypaper effect is negatively related with β for given *alpha*. In other words, the more citizens value private goods, the greater fly paper effect should be. Potential explain behind is that, higher *beta* means citizens attach great importance to the taxable private goods, thus the tax on X_t doesn't change citizen's allocation on X_t and X_{nt} . In this circumstances, collecting tax to support public goods is not that "expensive" compared to general transfer. So the stimulative effect gap between *IGT* transfer and private income increase is trivial.

Besides, the elasticity of *FE* on β is affect by α . As α gets higher, the relationship between *FE* and β shifts from a linear relationship to a convex relationship.

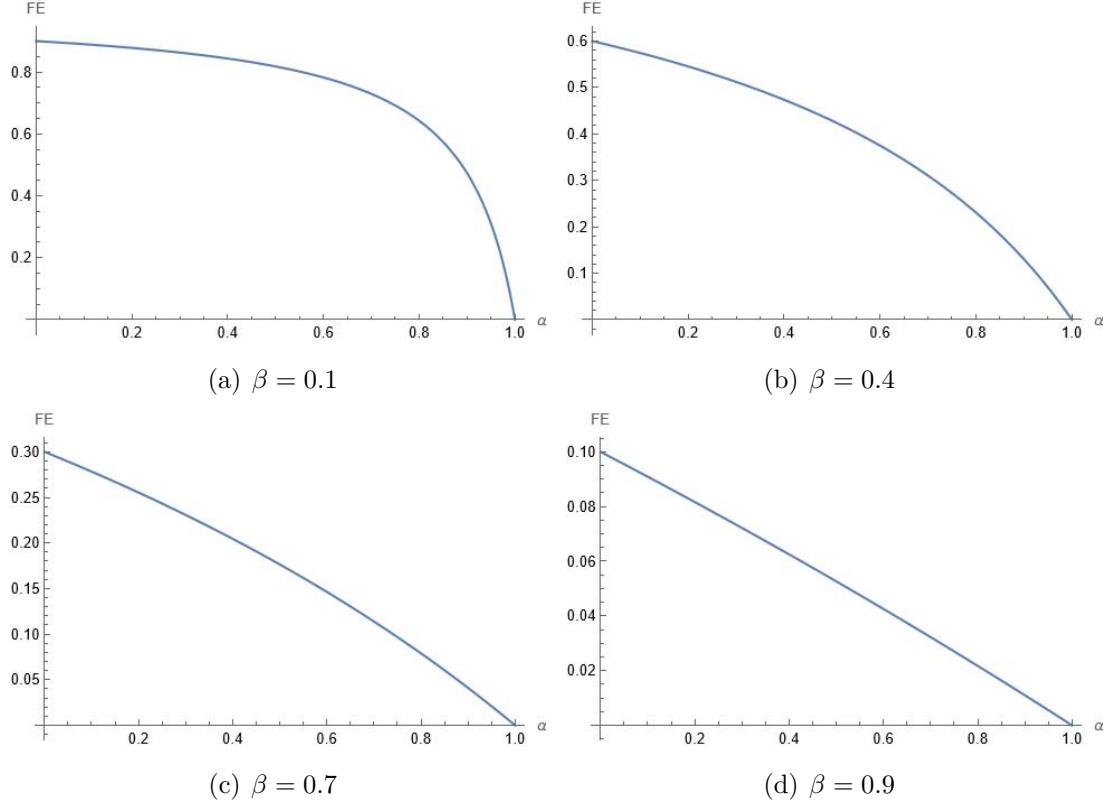


Figure 4.6: 2-Dimensions Plot of the Fluctuation of Flypaper Effect on α

α is also negatively related to FE . A greater α means the greater marginal utility on private goods. In short, when citizens care more about private goods rather than public goods, the fly paper phenomenon is relatively less significant. One explanation is, when citizens gain more utility from private goods, government should alleviate the tax burden since less public goods is necessary, thus lead to less distortion. Another obvious suggestion is as β gets higher, the function of FE on α gradually evolve into a linear function from a concave function.

4.1.2 Effect of IGT on Local Governments' Spending Segments

Compared to investigations on overall spending amounts, the understanding of the impact of intergovernmental transfers on micro-segmented spending varies. Scholars focus not only on the effect of matching mechanism but also on the effect of restrictions when analyzing the impact of IGT on spending preferences. Specifically, general transfers, such as general revenue sharing in Table 1.1, and transfers with special purposes, such as block grants and project categorical grants in Table 1.1 have

different effects on local governments' spending preferences. Some empirical evidence still implies the flypaper effect, meaning that intergovernmental transfers stimulate local governments' spending in specific areas. Feldstein observed that categorical grants in the education field from the Massachusetts state government to local governments lead to higher local government spending on education [102]. Karnik and Lalvani [103] incorporated the spatial effect into their model when analyzing data from Maharashtra in India. They found that an increase in intergovernmental grants results in urban local governments spending more on specific expenditure categories than they would have with an equivalent increase in incomes.

Another widely discussed phenomenon related to government spending preference is fungibility [84]. Fungibility refers to the fact that intergovernmental transfers received by local governments may substitute their own revenue, which can result in changes to the spending structure based on local government preference, rather than being tied to the strings attached to the intergovernmental transfer. Evidence of this phenomenon can be seen in Latin America, where subnational governments have been found to prefer using transfer funds to cover administrative expenses [104]. Similarly, research in China has shown that local governments crowd out revenue that should have been invested in public services and instead direct it to productive spending once they receive intergovernmental transfers, even though these transfers are restricted to specific categories [105, 106].

4.2 Summary on Flypaper Effect

Together with the proposition I get in Chapter 2 about the effect of IGT on subnational government's public goods provision, I can make a comprehensive summary about subnational governments' spending behavior under IGT. This summary answers two questions. Why researchers find empirical evidence support for contradictory theory—flypaper effect and fungibility effect? Second question is what is affecting the size of flypaper effect such that measurement for flypaper effect varies in different regions and different public goods.

As I mentioned in Section 4.1.1, the categorical transfer's flypaper effect is wildly accepted by scholars intuitively since it lower down the price, thus the The vital part is to explain the flypaper effect of general transfer. In the perfect information dynamic game mode, the contradiction of general transfer can be explained by

equation 2.2.3.

$$G_i^*|_{GT} = \frac{\alpha_i e_i^2 F_i^2}{2c_i^2} + \frac{T_i}{c_i} - \frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i}$$

Why empirical evidence support both flypaper effect and fungibility effect? The explain lies in the compare between $\frac{T_i}{c_i}$ and $\frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i}$. The first term $\frac{\alpha_i e_i^2 F_i^2}{2c_i^2}$ express the local public goods provision with no disturbance. $\frac{T_i}{c_i}$ express the flypaper effect—provision increase due to the general transfer and $\frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \frac{\sum T_i}{c_i}$ represents the fungibility effect—(provision decrease due to general transfer). The compare of flypaper effect term and fungibility effect term can be rewritten as:

$$T_i - \frac{1}{2} \cdot \frac{e_i}{e_N} \cdot \frac{F_i}{\sum F_i} \cdot \sum T_i \quad (4.31)$$

From equation 4.31, I can have proposition 8.

Proposition 8: One potential reason for the flypaper effect empirical evidence in S_l is the lower percentage compared to the whole output.

In this argument, general transfer doesn't affect price, thus whether the empirical evidence shows flypaper effect or fungibility depends on the size of general transfer received and the tax burden they have to afford. The amount S_i received is easy to calculate, while the tax burden is adjusted by two factors $\frac{F_i}{\sum_i F_i}$ and $\frac{e_i}{e_N}$. For S_l , $\frac{F_l}{\sum_i F_i}$ could be a extremely small value, which may lead to $T_l - \frac{1}{2} \cdot \frac{e_l}{e_N} \cdot \frac{F_l}{\sum F_i} \cdot \sum T_i > 0$.

Proposition 9: One potential reason for the flypaper effect empirical evidence in S_l is the relatively disadvantage in tax collection efficiency compared to national government.

Literature on tax collection efficiency generally share a consent that tax collection efficiency positively related with the economic development level [39, 107]. A region with low economic output S_l typically leads to lower tax collection efficiency, which enlarge the gap between T_l and $\frac{1}{2} \cdot \frac{e_l}{e_N} \cdot \frac{F_l}{\sum F_i} \cdot \sum T_i$, which leads to greater size of flypaper effect. Combined proposition 8 with proposition 9, one deduction is: for those economy entity with imbalanced regional development, those underdeveloped regions may show greater spending tendency when receiving general transfer. In Bowman's research conducted in 1974, he use federal education grants to West Virginia as example to measure flypaper effect scale [108]. His conclusion is that one dollar increase in governmental transfer to school districts would lead to 1.06 more

spending compared to the same increase in tax revenue. As a contrast, Weicher also evaluates the size of flypaper effect and conclude that the states grants to school districts in America would lead to 0.4 more spending on average [109]. These two investigation were generated in roughly same time and discuss same topics: scale of flypaper effect in school districts. However the scale differ greatly. One explanation is: West Virginia ranks 48th in GDP.

Proposition 10: One potential reason for the flypaper effect empirical evidence in S_h is citizen's tax aversion.

One natural following question after proposition 8 and 9 is: how could flypaper effect evidence is also wildly found in high economic output region, such as some empirical research conducted in California, New York and some developed states in India [110–112]. The explain is the constant parameter in $\frac{1}{2} \cdot \frac{e_l}{e_N} \cdot \frac{F_l}{\sum F_i} \cdot \sum T_i$, which is 1 and $\frac{1}{2}$ here. The difference between the parameter is due to citizen's concave or linear utility on public goods increase and convex tax burden increase.¹ In other words, citizen gets inertia as public goods increase and sensitive as tax burden increase. So, the general transfer naturally stimulate local governments' spending.

Under what circumstances would regional's choice on public spending shows fungibility? From equation 4.31, we can have a basic image about the jurisdiction that shows fungibility effect to intergovernmental transfer: a region with higher output percentage in total output, higher tax collection efficiency compared to national government, lacking feeling about tax increase.

Proposition 8,9 and 10 compose the answer for the first question—how to explain the contradictory two theories about spending reaction. Second question in this summary is how to explain the wildly difference in the size of flypaper effect. According to Hines and Thaler's measurement, change in spending as grant changes vary from 0.25 to 1.06 [27]. This range is summarized based on a bunch of empirical research conducted in different regions in America. Besides, this range varies at one time with another [110].

Except for the difference in e_i and F_i , explanation for the flypaper effect variation also drives from different preference and distribution on different goods, including taxable private goods, non-taxable private goods and public goods. This property differs in different regions, thus it's not surprised to observe a wide range about

¹In my utility setting, the utility for public goods is set as linear to get arithmetic expression, the actual utility maybe concave but this won't change the conclusion here.

the size of flypaper effect.

Chapter 5 |

Effect on Subnational Governments' Revenue Collection Behavior

5.1 Problem Introduction

Once received transfer payment from national government, subnational government should react in terms of both spending and revenue collection behavior. Chapter 4 is about the reaction in spending. In this chapter, I'll discuss the effect of IGT on subnational's revenue collection. Specifically, I focus on the reaction in tax collection effort.

In most of the countries, administrative institution has no allowance to change the legal tax rate arbitrarily, while the intergovernmental transfer fluctuate frequently at a yearly base. For example, in America, it's senate and house of representatives' job to alter the legal tax rate. This discordance means administrative branch would change the tax collection effort to control the actual tax burden. Subnational governments has many methods to alter the actual tax burden without changing the legal tax rate such as tax deduction, tax relief etc. To summarize, in this chapter, the problem is to investigate subnational governments' reaction on tax collection effort by solving subnational governments' Ramsey problem.

5.2 Former Theory and Bibliography

Inherent to the nature of general transfer is that transfer would lead to tax fungibility effect, which means transfer would substitute local governments' revenue collection efforts. This phenomenon is also referred to as the crowding out effect on tax effort and has been supported by bunch of evidences [113–115]. Empirical evidence in both developed and developing countries has further confirmed this theoretical inference. For example, Nicholson [116] discovered the fungibility effect of intergovernmental transfer on tax effort at the state level in Germany and the United States. Similarly, Baretti [117], Aragon and Gayoso [118], Panda [119], Mogues [26], and Bravo [120] found similar evidence in developing countries such as Peru, India, Ghana, and Chile. In short, the fungibility of intergovernmental transfer on tax revenue could lead to a decrease in the efforts of governments to collect tax revenue once they receive sufficient funds from transfer payments.

The fungibility effect seems natural when the range of study is constrained in one specific jurisdictions. Once multiple jurisdictions and horizontal competition are introduced into the consideration, one opposite impact also seems to be reasonable. Some theoretical research contend that the local jurisdictions should be motivated to lower the tax burden since they are facing the tax competition. The lower tax burden may attract capital, citizen or enterprise into the area, thus the local governments may actively give up the tax benefits they could have collected. In another word, the tax competition may encourage the local governments to expand the tax base rather than increase the tax effort. The revenue from intergovernmental transfer may neutralize this subjective intention, thus the tax effort would be positively affected. Bucovetsky and Smart [121], Buettner [122] describe this guess in their analysis of fiscal equalization. Liu [123] found some empirical evidence in China. However, compared to the study on fungibility, the investigation on this effect are seldom systematically investigated in theoretical level, limited literature are empirical analysis.

To synthesize the literature, two potential gaps arise. Firstly, akin to the research on the impact of intergovernmental transfers on local governments' spending preferences, the focus of is mainly on general transfers, with little emphasis on categorical transfers. Even in some literatures that try to discuss the effect of strings attached on the grants and points out the potential effect of the strings,

they do not conduct a rigorous theoretical discussion, thus they got different conclusions [124–126]. Nicholson [116] did a fixed regression and assert that the general grants-in-aid exert downward pressure on state tax effort. Dash and Raja [127] get opposite evidence and find stimulative effect on tax collect efficiency.

The second issue is that most of the literature in investigating the effect of grants with restriction are theoretical conjecture rather than empirical investigation. Empirical evidence is surprisingly limited. Brunt and Khidari's [128] research on the effect of categorical grants in Morocco failed to yield a conclusive result, which they attribute to political influence, leaving ample room for local governments to negotiate.

To address the identified gaps in the literature, I set up a one-period Ramsey problem in this study to analyze the tax collection behavior of subnational governments when received categorical transfer. To further validate the theoretical inferences, empirical investigation was conducted in Chapter 6. Compared to the research in this area, my investigation get implication on both general transfer and categorical transfer. The utilization of both qualitative and quantitative methods in this study allowed for a solid understanding of the research topic.

5.3 A Ramsey Problem for Subnational Government

The Ramsey problem for subnational government is to maximize the utility under specific budget constraint, thus the model is constructed from budget constraint aspect and utility aspect.

5.3.1 Budget Constraint for Subnational Government

The budget of subnational government comes from two parts—transfer from national government and tax collection. To address the underemphasized categorical transfer, I assume national government make both general transfer and categorical transfer to subnational government.

I follow the setting in Chapter 2 on general transfer that general transfer to region i is related to the total output in i , which I represents as F_i . The allocation function for general transfer amount is $T_0 - \sigma F_i$, where T_0 is the benchmark amount when

the tax base in i is 0 and σ is the "equalization parameter". A greater σ typically means national government prefer to a equalized development in different regions¹.

In terms of categorical transfer, I still follow the matching mechanism in Chapter 2. The national government can decide the categorical transfer be spent either on productive public goods P or welfare public goods W . Besides, the matching ration in different sectors $0 < m < 1$ and $0 < n < 1$ are also decided by national government, thus the transfer flow direction and matching ration is also exogenous for subnational government. In this logic, the total amount of categorical transfer can be written as:

$$m_i P_i + n_i E_i \quad (5.1)$$

Revenue source of the subnational government comes from intergovernmental transfer, including general transfer and categorical transfer, and tax revenue. Total revenue is spent on either productive public goods or welfare-oriented public goods, thus the budget constraint for subnational government is:

$$p_i + w_i = \tau_i F_i + (T^0 - \sigma F_i) + (mp_i + nw_i) \quad (5.2)$$

5.3.2 Utility Construction

I assume there is a representative company and the production function in region i is:

$$F_i = A_i K_i^\alpha P_i^\beta \quad (5.3)$$

where K is the capital amount and P is the productive, α and β is the elasticity of K and P . I assume that $\alpha + \beta < 1$, since the the capital and productive spending are marginal decline.

Subnational government care about both welfare utility and after tax output, thus the utility function for subnational government can be expressed as:

$$U_i = (1 - \tau_i)F_i + \lambda_i W_i \quad (5.4)$$

¹One this to notice, in this chapter, the amount of general transfer and categorical transfer is exogenous for subnational government.

where τ_i is actual tax rate, which may affected by government's subjective collection willing and ability. The λ_i is the demand of welfare utility. A greater λ_i means subnational government prefer welfare utility and make light of productive utility, vice versa.

5.4 Model Inference

Based on the construction I set above, the subnational government solve the Ramsey problem. The total revenue is spent on either P_i and W_i . The budget constraint can be list as:

$$P_i + W_i = \tau_i F_i + T_i \quad (5.5)$$

where T_i is the total amount of transfer payment, which equals to

$$(T^0 - \sigma F_i) + (mp_i + nw_i) \quad (5.6)$$

Under the assumption of free capital flow, the economic competition would lead to a final equilibrium and achieve same capital return. The equilibrium condition is

$$(1 - \tau_i) \frac{\partial F_i}{K_i} = r \quad (5.7)$$

where r is capital return. With equation 5.3 and 5.7, I can express capital as a function of P, r and A_i

$$K_i(P_i, r, A_i) = \left[\frac{1}{r} (1 - \tau_i) A_i \alpha P_i^\beta \right]^{\frac{1}{1-\alpha}} \quad (5.8)$$

For given r , subnational government choose P_i to maximize the utility, thus I have:

$$\frac{\partial F_i}{\partial P_i} + \frac{\partial F_i}{\partial K_i} \frac{\partial K_i}{\partial P_i} = \frac{\lambda_i (1 - m_i)}{(1 - \tau_i) (1 - n_i) + \lambda_i (\tau_i - \sigma_i)} \quad (5.9)$$

which means the marginal utility for productive goods should equals to the marginal cost. With equation 5.3, 5.8, 5.9, the optimal amount of P can be expressed as function:

$$P_i = \left\{ r^{-\alpha} A_i \alpha^\alpha (1 - \alpha)^{\alpha-1} \beta^{1-\alpha} (1 - \tau_i)^\alpha \left[\frac{(1 - \tau_i) (1 - n_i) + \lambda_i (\tau_i - \sigma_i)}{\lambda_i (1 - m_i)} \right]^{1-\alpha} \right\}^{\frac{1}{1-\alpha-\beta}} \quad (5.10)$$

Plug equation 5.10 into equation 5.3, the output in region i F_i can be represented as

function:

$$F_i = A_i^{\frac{1}{1-\alpha-\beta}} \left(\frac{1-\tau_i}{r} \right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{\beta}{1-\alpha} \right)^{\frac{\beta}{1-\alpha-\beta}} \alpha^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{(1-\tau_i)(1-n_i) + \lambda_i(\tau_i - \sigma_i)}{\lambda_i(1-m_i)} \right]^{\frac{\beta}{1-\alpha-\beta}} \quad (5.11)$$

Combined with equation 5.5 and 5.6, the welfare oriented spending in region i is:

$$W_i = \frac{[(\tau_i - \sigma_i)F_i - (1 - m_i)P_i + T^0]}{1 - n_i} \quad (5.12)$$

Based on equation 5.4, 5.10, 5.11 and 5.4, the utility for subnational government is:

$$U_i = A_i^\theta \frac{\alpha^{\alpha\theta} \beta^{\beta\theta}}{\theta(1-\alpha)^{(1-\alpha)\theta} r^{\alpha\theta}} \frac{(1-\tau_i)^{\alpha\theta} [(1-\tau_i)(1-n_i) + \lambda_i(\tau_i - \sigma_i)]^{(1-\alpha)\theta}}{[\lambda_i(1-m_i)]^{\beta\theta} (1-n_i)} + \frac{\lambda_i T^0}{1-n_i} \quad (5.13)$$

where $\theta = \frac{1}{1-\alpha-\beta}$.

The question I want to make suggestion on is the effect of transfer payment on the actual tax collection efficiency. From equation 5.13, one obvious implication is that both parameters in general transfer and categorical transfer is affecting actual tax efficiency. With equation 5.13, we can shed light on $\frac{d\tau_i}{d\sigma_i}$, $\frac{d\tau_i}{m_i}$ and $\frac{d\tau_i}{n_i}$.

5.5 Affecting Mechanism

I'll start with the affecting mechanism of general transfer. From equation 5.13, changing of σ_i would change τ . Solved by implicit function theorem, I have:

$$\frac{d\tau_i}{d\sigma_i} = -\frac{\lambda_i}{\frac{\alpha}{1-\alpha} \frac{(1-\tau_i)(1-n_i)+\lambda_i(\tau_i-\sigma_i)}{1-\tau_i} + (1-n_i-\lambda_i)} \quad (5.14)$$

From equation 5.11, $\frac{\partial F_i}{P_i} + \frac{\partial F_i}{K_i} \frac{\partial K_i}{\partial P_i} > 0$, thus I have $(1-\tau_i)(1-n_i) + \lambda_i(\tau_i - \sigma_i) > 0$.

This means equation 5.14 gives two implications:

- When $n_i + \lambda_i \leq 1$, $\frac{d\tau_i}{d\sigma_i} < 0$
- When $n_i + \lambda_i > 1 + \frac{\alpha\lambda_i(1-\sigma_i)}{1-\tau_i}$, $\frac{d\tau_i}{d\sigma_i} > 0$

A greater n_i means national government concentrate on the welfare spending and a greater λ_i means local government care more about welfare effect. Based on these two implications, we have proposition 11.

Proposition 11: When both national and subnational government care more about productive utility, more general transfer would make subnational government lower down actual efficiency, vice versa.

The explain is, when both levels government care more about productive utility, local government would treat general transfer as a free subsidy. A lower actual tax burden would stimulate capital inflow and boost the economy output. In this circumstance, the tax fungibility effect is in the dominate position. However when both levels of government cares more about welfare utility, the tax competition effect would be weaken. In this condition, the general transfer would lead to a greater actual tax burden τ_i . Besides, when we say care more or care less, 1 and $1 + \frac{\alpha\lambda_i(1-\sigma_i)}{1-\tau_i}$ working as the threshold.

Proposition 11 is about the effect of general transfer on actual tax rate. From equation 5.13, we can also got some implication on the effect of categorical transfer. The effect of productive matching ration can be calculated as:

$$\frac{d\tau_i}{dm_i} = \frac{\beta(1-m_i)^{-1}}{\alpha \frac{(1-\tau_i)(1-n_i)+\lambda_i(\tau_i-\sigma_i)}{1-\tau_i} + (1-\alpha)(1-\lambda_i-n_i)} \quad (5.15)$$

Since $0 < m < 1$, whether equation 5.15 is positive or not is decided by denominator. Similarly, 1 and $1 + \frac{\alpha\lambda_i(1-\sigma_i)}{1-\tau_i}$ also act as two thresholds. From the calculation, we have:

- When $n_i + \lambda_i \leq 1$, $\frac{d\tau_i}{dm_i} > 0$
- When $1 < n_i + \lambda_i < 1 + \frac{\alpha\lambda_i(1-\sigma_i)}{1-\tau_i}$, $\frac{d\tau_i}{dm_i} > 0$
- When $n_i + \lambda_i > 1 + \frac{\alpha\lambda_i(1-\sigma_i)}{1-\tau_i}$, $\frac{d\tau_i}{dm_i} < 0$

Thus I have proposition 12.

Proposition 12: When both national and subnational governments care more about productive spending, more categorical transfer on productive public goods would stimulate a higher actual tax rate, vice versa.

The potential explain is: higher taxation income can both restrain and stimulate economy output when subnational government care more on productive utility, since more spending on P is also a fiscal stimulus for F_i . In the condition with no transfer, subnational governments would control the τ_i such that marginal suppression effect equals marginal stimulate effect such as the peak of Laffer Curve [129]. When national government make categorical transfer directed to P , tax collection would stimulate the economy output since marginal stimulate effect would surpass marginal suppression effect. For subnational governments preferring productive utility, this would lead them to collect

more tax and invest into the productive spending. However if subnational governments care more about welfare public goods, categorical transfer on P would not encourage subnational governments to collect more tax.

Except for the effect of categorical transfer on productive public goods, transfer on welfare public goods may also affect subnational governments' tax collection. The marginal effect of n_i can be calculated by implicit function theorem and envelop theorem as:

$$\frac{d\tau_i}{n_i} = \frac{(1 - n_i)^{-1} [-\beta\theta(1 - \tau_i)(1 - n_i) - \lambda(\tau_i - \sigma_i)]}{\alpha\theta \frac{(1-\tau_i)(1-n_i)+\lambda_i(\tau_i-\sigma_i)}{1-\tau_i} + \theta(1 - \alpha)(1 - \lambda_i - n_i)} \quad (5.16)$$

The sign of equation 5.16 is undecided however. Unlike equatin 5.14 and 5.15, we cannot get a clear distinction about the sign of $\frac{d\tau_i}{n_i}$. This means the understanding of the welfare categorical transfer on tax collection is unclear.

5.6 Review and Summary

Through a theoretical analysis, this chapter shed light on how intergovernmental transfer affects subnational governments' tax collection behavior. Compared to former investigation on related topics, this chapter add categorical transfer and different spending preferences into the Ramsey model.

Further review and modification is also necessary though. For example, the utility function is set as a compound of a Cobb-Douglas form and a linear form to get some arithmetic expression (such as the value of threshold, etc). This setting may not reflect the true tradeoff in real world. However this is a necessary compromise.

Chapter 6 | Summary, Thoughts and Rethink

Though fiscal system is a very big topic, one can always capture the key points by analyzing two vital sectors—resource collection and reallocation. The reallocation process is a public goods provision process. All the other research questions are somewhat pertained to this main stream. One key word that no one can avoid when trying to understand the resource reallocate and public goods provision process is "tradeoff". Basically all fiscal system mechanism design is a compromise of different aspects. Fiscal federalism is one particular system that wildly adopted by both developed and developing countries. In this chapter, I want to extract some thoughts that spread all over the fiscal system investigation, which also accounts to a summary of this thesis.

6.1 Overall Interests and Partial Interests

One contradiction that any fiscal system cannot avoid is the overall interests and partial interests. This tradeoff is an widespread concern in fiscal federalism investigation. For example, this tradeoff is In fiscal federalism system, at least two layers of government exists—national government and multiple layers of subnational governments. National government care about the benefits for all regions while subnational governments focus merely on their own region. Due to this inconsistency, national government would adjust the public provision condition by intergovernmental transfer to better suits the overall interests. I try to reflect this inconsistency in the dynamic complete game model in Chapter 2. The equilibrium result shows the necessity of general transfer and joint provision. In short, national governments adopt general transfer and joint provision to better serve the overall interests, even though this may not be a goods news for all subnational regions.

Besides, the tradeoff between overall and partial interests is also reflected in the

consideration of externality. The whole is more than the sum of its parts. Externality is also an very important concern. Though I didn't express the externality factor in the utility function in this thesis, the national government conflict local regions's interests due to externality is so common that can be found in both developed and developing countries, involving all kinds of public goods such as environment pollution, inter-state highway construction and public education [130–132].

Except for the utility discordance between national and local governments, another example for the overall and partial interests tradeoff is the

6.2 Efficiency and Equity

6.3 Long Term Interest and Short Term Interest

Appendix A | Supportive Data and Figures

A.1 Data

Table A.1: Data Source and operation for the empirical test in Section 2.3.3

Variables	Source	Time Period
Dependent Variable	lg(igt)	State CAFR
Independent Variables	c p	Ballotpedia
	gdp	FRED
	lgp	2000-2019 annually collected
Control Variables	wapw mhi	Census of bureau
	ur	
	prm	Bureau of transportation statistics

A.2 Figures

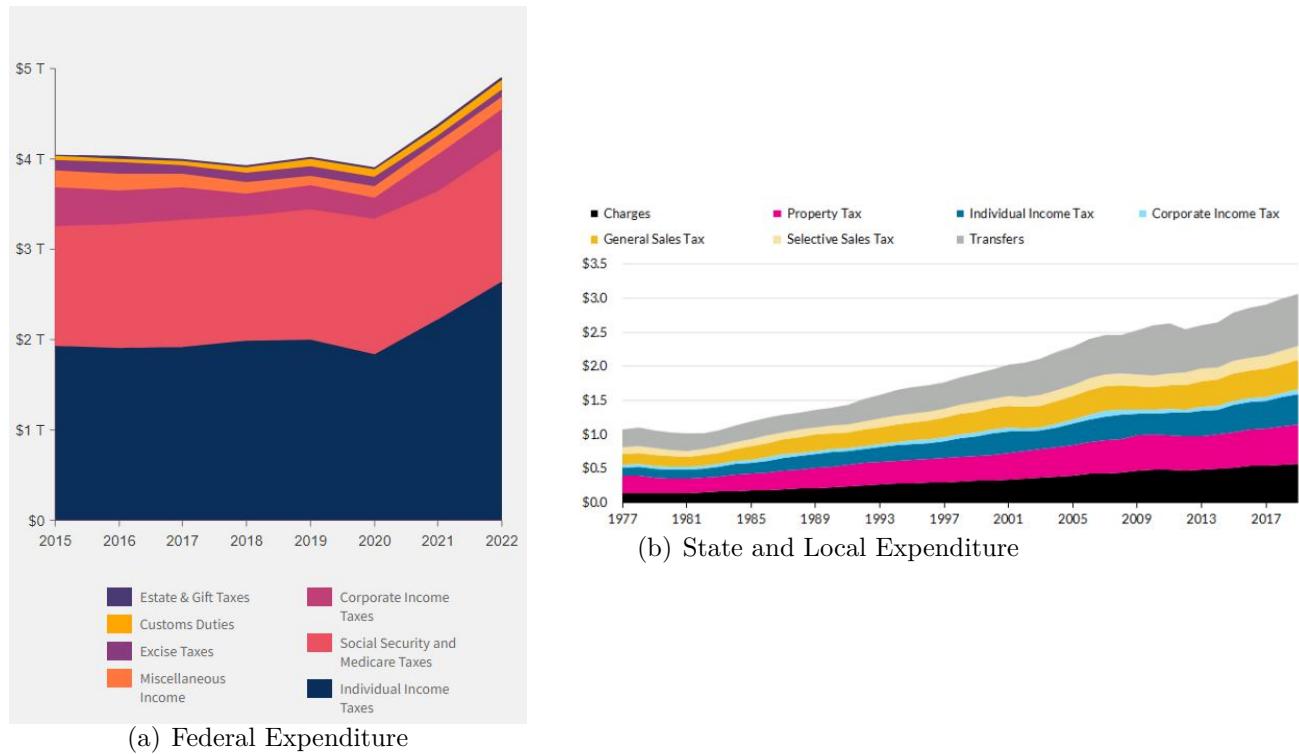


Figure A.1: Fluctuation of Revenue Structure of three level governments. Data Source: US Urban Institute Dataset

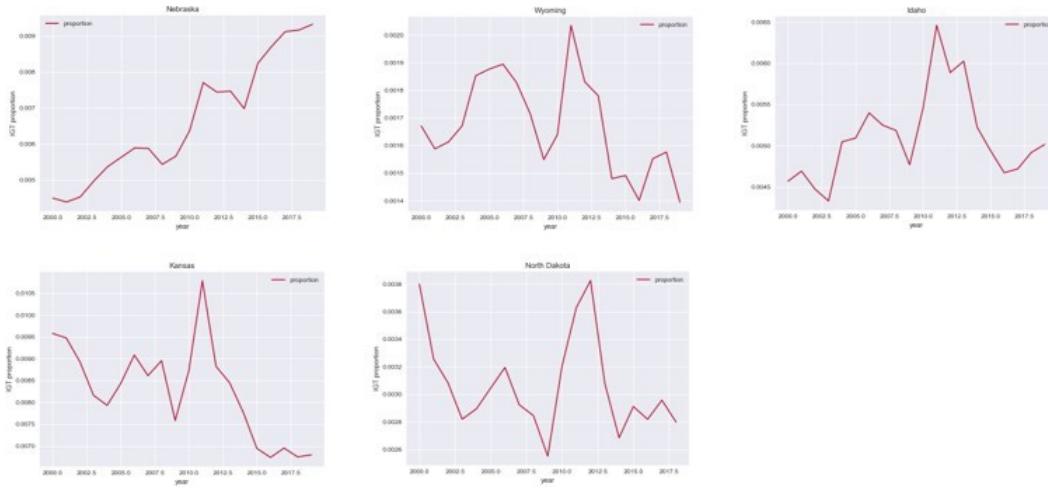


Figure A.2: Time Series Graph of Republican States IGT (2000-2019)

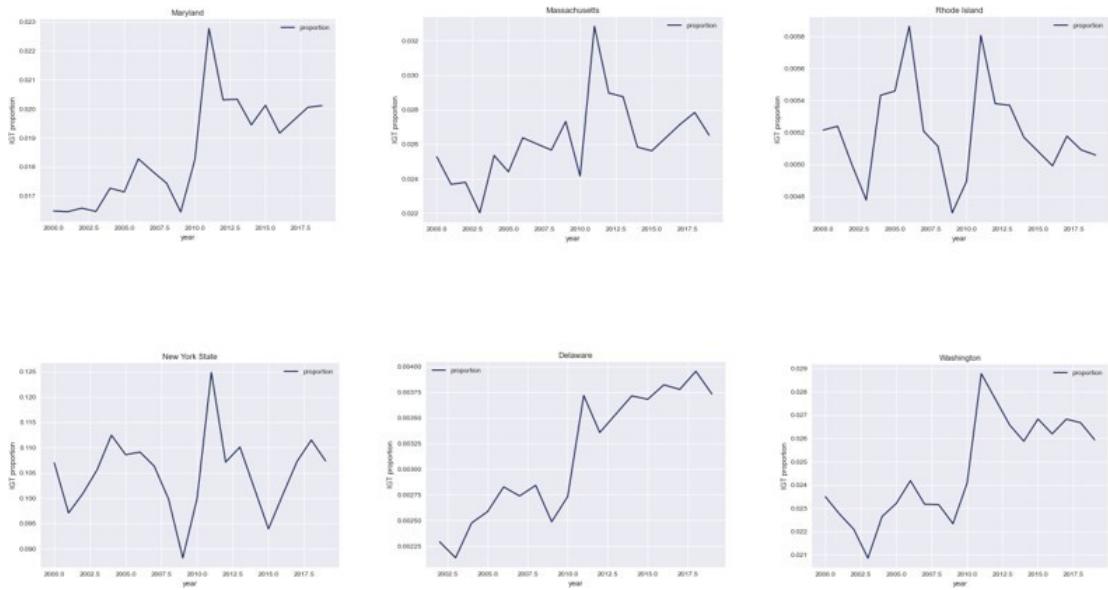


Figure A.3: Time Series Graph of Democratic States IGT (2000-2019)

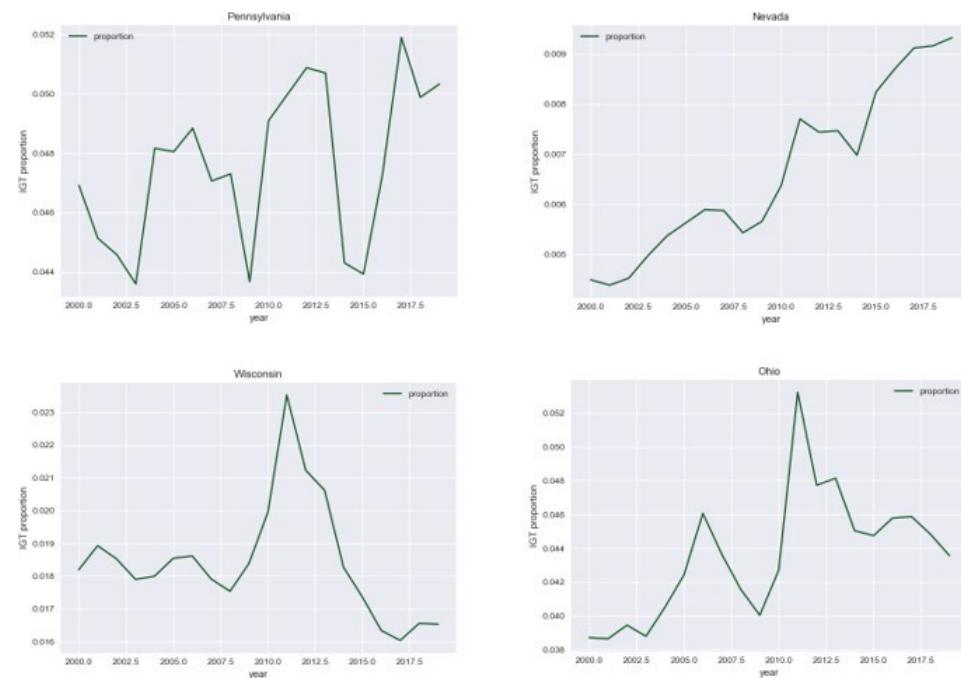


Figure A.4: Time Series Graph of Swing States IGT (2000-2019)

Appendix B |

Results

*Declaration is offered in the separate file.

B.1 More Declaration

Appendix C|

Appendix for the proof

*The proof is supplied in separate file.

C.1 Proof of the Equalization Effect of General Transfer

C.2 Proof of the Free Rider Effect under Inaccurate Ascribe

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Vita

Yan Hao

I remember it was an afternoon during exam week. Typically, I would take a nap in the afternoon, but since coming to the United States two years ago, this habit has been sporadic. Coupled with the fact that it was exam week in the winter semester, I, like anyone striving for a decent GPA, spent the entire day in the Sheridan library in Johns Hopkins DC campus, preparing for exams in microeconometrics and Bayesian econometrics.

The view outside the window is so stunning that it's mesmerizing. The streets of DC are clean, yet covered in fallen leaves, flanked by buildings that are several decades, even centuries old. Each building has a stone plaque at its entrance, detailing the stories behind them. The fall season in the Eastern United States already carries a chill, and looking through the window, with raindrops patterning against the glass, I can imagine the cold outside, making the warmth of the fourth floor of the library especially precious.

Lunchtime sandwiches arrived promptly, but within 30 minutes, drowsiness started creeping in. Surrounded by disheveled students slumped over their desks, I realized my brain was in no condition to delve into the intricacies of exogenous identification or any kind of math at that moment. So, I turned to the supplementary reading the professor had recommended. I randomly picked an article and planned to skim through the abstract, just for the sake of it. I can't recall the exact title of that article, but I vaguely remember it was about the theoretical analysis and VAR testing of the effects of fiscal stimulus on economic growth. Surprisingly, I found myself completely engrossed in the article's summary of related literature and its presentation of various perspectives and logical arguments. What's more, out of sheer interest, I ended up tracking down the original articles referenced. Consequently, what was initially meant to be an afternoon dedicated to revising for final exams irrepressibly transformed into several hours of diving into academic literature.

At that time, understanding academic articles was quite challenging for me as a non-native English-speaking graduate student. I struggled through reading three or four articles with only partial comprehension, and before I knew it, the day turned into night. I realized that continuing in this manner would seriously jeopardize my performance in the final exams. It was at that moment, as I looked at the half-darkened sky outside the window, that a thought popped into my mind for the first time: What is the actual explain of this problem? Should I pursue a Ph.D.?

It's been four years now, and I've long forgotten what that initial question was that sparked my interest in pursuing a Ph.D. The research topics during my doctoral studies have also evolved. At this moment, I am in the process of writing the acknowledgments section of my thesis, marking the nearing conclusion of my Ph.D. journey. Looking back over these past four years, I dare not claim any significant scholarly achievements as a researcher, but I have indeed persevered through each challenging yet fulfilling day. Certainly, apart from the academic endeavors during these four years in Pennsylvania, there have been occasional moments of joy, along with the enjoyment of life, whether

through small breakthroughs or savoring moments with a few close friends, especially Yulin Xu and Tiangeng Lu in the wilderness of Pennsylvania, occasionally finding ways to improve life by enjoying good food once upon a time, typically handmade BBQ or that Vietnamese noodle house named "Little Saigon". During the year-long period of staying at home to avoid the COVID-19 pandemic, the rice noodles from Little Saigon were a rare delight for me.

I am deeply grateful to Dr. Odd Stalebrink, from whom I've learned a great deal, not only in academic guidance but also in navigating the challenges of a strenuous doctoral journey. Also, to Dr. Kim Younhee, who was my professor in Public Administration, a lovely and amiable lady. I am grateful to Dr. Mallinson, a member of my dissertation committee. Additionally, my professor in Macroeconomics, Dr. David Argente, who later moved to Yale University for teaching. I appreciate his dedication and wish him all the best.

Additionally, I am deeply grateful to my mom and dad for providing me with all the support, both material and emotional that parents can offer. They've been doing this for thirty years, especially during my doctoral studies, where it felt like they were going through the degree alongside me. And to my girlfriend, thank you for your support, especially given the distance of over ten thousand kilometers that separates us on opposite ends of this planet.

The four years at Pennsylvania State University may not be long in the grand scheme of life, but they are moments I will forever cherish. In the days and nights of my future, I fear I will often find myself reminiscing about the snowy nights where I furrowed my brow in contemplation. Each of these moments will serve as a driving force for my future endeavors and will shape me. There's a Chinese saying, 'at thirty, one stands firm.' In two days, I will turn thirty. In this section of gratitude, aside from expressing my thanks, I also consider it as my own wish list. I hope that in the forthcoming phase of my life, I can have a happy and fulfilling family and pursue a career that I am passionate about and dedicated to.

One should strive continuously to strengthen himself.

Yan Hao
11/07/2023
Two days before my 30th birthday
Chengdu, Sichuan, China.