SPATIAL COMPETITION, CONFLICT AND COOPERATION

DISSErTATION

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By

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* * * * *

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ABSTRACT

This dissertation contributes to the study of the economics of strategic interactions through the examination of four distinct but thematically related investigations of spatial competition, conflict and cooperation. A spatial accounting, whether conceptualized as local interactions, neighborhood effects, externalities, or other locally defined phenomena, increases the detail used to examine the decisions of economic agents.

The first essay examines the theoretical conditions in which spheres of influence form in games of spatial conflict. The term sphere of influence is defined for nation-state competition. Spheres of influence form in non-cooperative games of strategic complements if the contact between the rivals is repeated in both spatial and temporal contexts. The constraints on global cooperation are eased by the ability to form spheres, which allow the nation-states to avoid exhaustive conflict within individual spatial competitions.

Employing this sphere of influence model, the second essay develops a theory of cooperative tax strategies to reexamine the problem of local tax competition. Cooperative tax polices assume the form of either uniform or differentiated taxation on local capital. Contrary to previous findings, differentiated taxation of capital may generate higher community welfare, as well as increased resistance to defection from cooperative policy regimes. A spatial econometric examination of state-level local taxation is consistent with these theoretical propositions.

The third essay examines another form of spatial competition: defense spending by nation-states. Two theoretical models are developed in this paper: a two-period dyadic rivalry model and an alliance and hegemonic defense provision model. Spatial econometric testing of the model indicates evidence for U.S. hegemonic behavior, but an underlying rivalry in defense expenditure and armed forces for all other nation-states.
The final essay also employs the sphere of influence model to study the lack of competitive elections for the U.S. Congress. So-called sweetheart gerrymandering is demonstrated to be the result of bipartisan efforts to allocate voters by political preferences in order to reduce electoral competition within congressional districts. The adoption of these strategies increases the number of party loyalists, reduces bipartisan legislative coalitions, increases the risk associated with the legislative process, but does not change the expected legislative output of Congress.
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This dissertation contributes to the study of the economics of strategic interactions through the examination of four distinct but thematically related investigations of spatial competition, conflict and cooperation. A spatial accounting of economic agents, whether conceptualized as local interactions, neighborhood effects, externalities, or other locally defined phenomena, increases the detail used to examine strategic decisions. In theoretical models, this spatial detail helps determine the nature of conflict and cooperation. Spatial differences due to position or other geographic factors create heterogeneity across the competitive environment. This heterogeneity defines zones of relative strength and weakness for the agents. Similar to models of comparative advantage, these differences enable forms of cooperation that are superior to globally uniform or across-the-board cooperation. In this dissertation, the establishment of spheres of influence is the most important use of spatial heterogeneity.

Econometrically, a spatial accounting of strategic interactions provides additional information in the same manner as time-series methodology that may be used to improve estimates and explicitly define the nature of the strategic interaction among rivals.

The first essay of this dissertation examines the strategic conditions under which spheres of influence arise. The term sphere of influence is defined for nation-state competition, although the model can be used to examine other types of multicontextual institutional conflict. Spheres of influence form in non-cooperative games of strategic complements if the contact between players is repeated in both spatial and temporal contexts. The spatial interaction must occur in
strategically heterogeneous settings, in which the players possess regions of relative strength and relative weakness. The constraints on cooperation are eased by the ability to form spheres, which allow the players to avoid exhaustive conflict within individual spatial competitions. Three proposals are examined that an incentive compatible player may employ to induce a rival to adhere to a sphere of influence regime. Issues concerning hegemony, side payments, and localized conflict that eases global cooperation are also addressed.

Employing this sphere of influence model, the second essay develops a theory of cooperative tax strategies to reexamine the problem of local tax competition. A reexamination of interjurisdictional tax competition, this chapter explores the conditions under which cooperative local government tax policies are sustainable in repeated games. Employing several specifications of local production, the results of the paper indicate that preferred public finance outcomes are sustainable for feasible values of intertemporal social discounting. Cooperative tax polices assume the form of either uniform or differentiated taxation on local capital. Contrary to previous findings, differentiated taxation of capital may generate higher community welfare, as well as increased resistance to defection from cooperative policy regimes. This differentiated taxation of capital, in which one jurisdiction assess a high tax rate for some business sector while its neighbors assess low rates and vice versa for other business sectors, is an application of the sphere of influence model. Notice that contrary to standard narratives of tax competition, in which sets of differentiated tax rates are implicitly a priori evidence of tax competition, sphere of influence behavior enables sustainable forms of cooperation among the competitive local governments. A spatial econometric examination of state-level local taxation is consistent with these theoretical propositions. Local jurisdictions employing sphere of influence behavior in tax policy space are able to achieve higher rates of taxation on business.

Another form of spatial conflict among public institutions is the defense expenditure decision among nation-states. The role of space is a surprisingly neglected aspect in studies of military expenditure. This chapter develops a theoretical analysis and conducts a spatial econometric investigation of the determinants of military expenditures to improve the
understanding of the global security structure. Two theoretical models are developed in this paper: a two-period dyadic rivalry model and an alliance and hegemonic defense provision model. The impact of proximity is highlighted in each. Together, these models generate distinct hypotheses concerning defense expenditures. These hypotheses are tested and evaluated with spatial econometric models that define several sets of strategic interactions. The results indicate evidence for U.S. hegemonic behavior, but an underlying rivalry in defense expenditure and armed forces for all other nation-states. In particular, the theoretical models and the empirical results suggest that in the modern global security structure, dominance has been yielded to the U.S. in the arena of military quality, as defined by capital expenditure. However, spatial competition remains in a form of military supply that is important among contiguous nation-states, but is not threatening to the U.S. as hegemon. This competition assumes the form of manpower provision for military forces. Hence, competition and cooperation exist for military provision.

Finally, a form of cooperation for political parties competing within congressional jurisdiction is examined using the sphere of influence model. Social scientists have noted the increasing lack of competitive elections for Congress. So-called sweetheart gerrymandering has been identified as a source of this outcome by some commentators and political participants, but this strategic phenomenon has not been studied in the academic literature. Sweetheart gerrymandering is the result of bipartisan efforts to allocate voters by political preferences in order to reduce electoral competition within congressional districts. This chapter explores the theoretical objectives of the major political parties in their pursuit of an implicitly cooperative strategy in an explicitly competitive process. The resulting model suggests that the political parties benefit via the election of representatives with greater flexibility to pursue party-defined objectives. These benefits are positively correlated with the segregation of voters into ideological spheres of influence. The adoption of these strategies increases the number of party loyalists, reduces bipartisan legislative coalitions, increases the risk associated with the legislative process, but does not change the expected legislative output of Congress. Sweetheart gerrymandering transfers political conflict from the jurisdictional-level to the legislative floor.
Taken together, these essays demonstrate how location and other spatial characteristics influence conflict or shape cooperation among rival public institutions. The three forms of competition examined in this dissertation among local governments, nation-states and political parties are not the only types of organizations that may be studied using this approach. The study of spillovers among neighborhoods, whether through the provision of local public goods or externalities such as the social benefits to homeownership or the existence of negative externalities such as crime, may be enhanced using the methods in this dissertation. The results of these studies may suggest policies regarding the location of economic assets or the assignment of political power within a governmental hierarchy. Potential future projects may include: the designation of neighborhoods by organized crime into spheres of influence, the provision of public goods by U.S. states in Antebellum America (an age of weaker federal authority), the location of competitive economic activities (such as fast food or other retail services), and the strategies of political parties within presidential campaigns. The theoretical and empirical results of this dissertation demonstrate the potential of this spatial approach to refine existing results and alter policy recommendations.
2.1 Introduction

In 1493 Pope Alexander VI established the Line of Demarcation. “The Line” defined spheres of influence in the New World for Spain and Portugal. This convention was modified and formalized in 1494 by the Treaty of Tordesillas. Although these spheres of influence were generally not recognized by the other powers of Europe, a question remains. Why did Spain and Portugal, who were engaged in global competition, agree to refrain from conflict in certain areas of the New World? Similarly, in the aftermath of World War II statesmen such as Winston Churchill recognized that the United States and the United Kingdom would face global competition from the Soviet Union. Yet even in this explicitly competitive environment, Churchill proposed to Stalin a set of influence percentages for the states of Eastern Europe. This informal arrangement in fact reflected the spheres of influence in Europe for the next half century (Resis 1981). Given the expectation of conflict or competition elsewhere in the world, what motivated such an arrangement? The model in this paper presents several game theoretic answers.

The term “sphere of influence” has never been precisely defined in the international relations literature. Spheres of influence often refer to areas or domains for which costly competition is suspended. This cooperative agreement typically occurs in an explicitly
competitive global environment. Thus, although the United States and its allies engaged the Soviet Union and its satellite states in a global competition for influence throughout the Cold War, this competition was not witnessed in every region at every time.

These historical cases pose two questions for formal theory in international relations. First, is it possible to generate models of strategic competition in which the players are simultaneously cooperating and competing? Second, why would rational actors adhere to such an arrangement? The results of this chapter demonstrate that states may enter into sphere of influence regimes in order to achieve a limited form of global cooperation in iterated games.

In general, existing studies examine the cooperate/conflict decision as a global response because only a single Prisoner's Dilemma game is considered. Employing the Folk Theorem, these models find that the decision to adhere to a cooperative strategy profile is dependent upon a player's discount factor. If the player places enough value on future benefits, the payoffs generated by deviation from cooperation are less than the discounted flow of cooperative payoffs (Fudenberg and Tirole 1998). However, the required discount factor may exceed the player's actual discount factor. In this case, deviation is a best response to the rival's cooperative strategy and subsequent punishment. Thus, if either player fails to meet the required discount factor, the repeated Nash equilibrium of the game becomes the single-stage Nash equilibrium.

However, the players may alter their strategies in order to produce at least a limited cooperative arrangement. To examine this, two modeling details not often found in studies of cooperation and conflict are required. First, the model developed in this chapter involves multiple games. This is an important change. Competition between players occurs in geographic space. As such, power projection capabilities by the powers may differ region by region. Thus, one player may naturally have a competitive advantage in some regions. Unlike an aggregation of homogenous games, representation of this heterogeneous strategic environment by a single Prisoner's Dilemma game ignores the possibility of local or individual game behavior.

Second, the payoffs in these regional games are generated by explicit cost and benefit functions. This specification is critical in order to ensure the robustness of this paper's results.
2x2 Prisoner’s Dilemma games are hampered by their simplicity. Too often, the payoffs are exogenously defined to satisfy certain game criteria. Little effort is spent examining the first principles that generate these values. More importantly, the players are most often only given the ability to cooperate or defect. In contrast, the players in this paper choose over a continuous range of strategies. Thus, cooperation or conflict occurs as a matter of degree depending upon the realized strategies of the players.

Additionally, by employing explicit cost and benefit functions the best response strategies of the players can be examined in more detail. This chapter examines a model of strategic complements. In this type of game, the best response to an increase in the intervention of a rival is an increase in own intervention. In contrast, the best response functions in a game of strategic substitutes are negatively sloped. In such games, incomplete dominance is possible. Both players can intervene in a region and both may earn positive payoffs. This strategic setting will not be consistent with the conjectures in this chapter. In fact, in a game of strategic substitutes spheres of influence will not form. Optimal cooperation assumes the form of intra-regional cooperation or zones of control. These arrangements can be thought of as a type of partitioning. For example, the partitioning of Poland from 1772-1795 by Prussia, Russia, and Austria was enacted to maintain the peace (Wight 1979). Similarly, the Munich partitioning of Czechoslovakia in 1938 by Germany with the agreement of the United Kingdom and France occurred to maintain the peace at the global level of affairs. In contrast, optimal cooperation in the game of strategic complements developed in this chapter assumes the form of spheres of influence.

Examined together, a continuous strategy space and multiple games enrich the strategic environment of the model in this chapter. In this setting, not only do the players have the option of cooperating within each game, but they also have the option of refraining from engagement within any region. Such an action is tantamount to recognition of a sphere of influence for its rival. I define a sphere of influence as a spatial region or areal unit, which is dominated by a
single player with the tacit agreement of a rival Great Power. This definition implies that the rival player undertakes no serious strategic challenge for dominance in that region. In return, the rival expects cooperative behavior from its rival in other contestable regions.

The results of this chapter demonstrate that sphere of influence formation increases the ability of the players to cooperate by lowering the required discount factor. Pooling the individual games' incentive compatibility constraints mathematically generates this result. Slackness in one region's constraint, perhaps generated by a sphere of influence, spills over into the global decision constraint. Pooling always enhances the ability to cooperate. Formal theory in the international relations literature has overlooked this important aspect of cooperation and conflict models. The exception is the set of work concerning issue linkage (Keohane 1984, McGinnis 1986). However, these authors only examined the effect of bundling together payoffs from repeated Prisoner's Dilemma games. The model developed in this paper advances this literature by noting the local nature of cooperation and conflict.

The model presented in this chapter allows the characterization of the strategic settings in which spheres of influence arise. The model is well suited for describing imperialistic Great Power competition. But it is also useful for examining other types of institutional conflict. This chapter explicitly examines the case of two Great Powers, but the game can be modified to study $n$ player competition. The game assumes a fixed set of capabilities for the players. Therefore it is not a complete description of imperialistic competition. A more complete setting requires situating the present model as subgame in a larger iterated guns-butter game.

The plan of this chapter is as follows. First, relevant studies analyzing cooperation and conflict are examined. Although there is no literature on spheres of influence, these studies comprise a survey of the kinds of strategic interaction that constitute sphere of influence formation. The distinction between vertical interactions vis-à-vis regions and powers and horizontal interactions vis-à-vis competing powers is noted. Additionally, several methodological sources are identified. Next, the primary objectives of this chapter are explored through a series of theoretical conjectures. Then these objectives are examined through the development of a
game of strategic complements. Finally, the results of the model are discussed. Theoretical weaknesses and testable implications are noted. Particular attention is given to possible extensions of this model, including two conjectures concerning the discount factor and international cooperation.

2.2 Spheres of Influence

The term sphere of influence is common in both academic publications and the popular press. Given its common employment, it is curious that the term has never been rigorously defined. The concept of a sphere of influence is most closely associated with imperialism. A sphere of influence can refer to a region of the world in which a Great Power alone exercises military dominance. Alternatively, a sphere can characterize a region in which a Great Power exercises commercial or economic dominance, with the acceptance of rival Great Powers. Note that this is different then dominance exercised due to an overwhelming advantage in costs or capabilities. There is no cooperative behavior in such a strategic setting. As stated earlier, I define a sphere of influence as a spatial region or areal unit that is dominated by a single Great Power with the tacit agreement of a rival Great Power. The definition possesses two aspects. First, the formation of spheres involves a vertical strategic interaction between a Great Power and a regional power. Second, the formation of spheres requires a horizontal strategic interaction between the Great Powers.

The vertical aspect has been examined in both the international relations and economics literature. Lake (1996) discusses the nature of Great Power interaction with minor powers. Employing relational contract theory from economics, he demonstrates that the spectrum of contractual relationships of security dyads is dependent on opportunism costs and governance costs. The intervention variable in this paper is similar to the equilibrium solution for

1 A Great Power is a nation-state with global interests. This is a tautology but a useful one for this study. In international studies, few nation-states are capable of significant international interaction. Most nation-states are passive or reactive players at best. These smaller powers are modeled as passive regions in this chapter. On the other end of the spectrum, a hegemon is defined as a Great Power that is dominant in every region of the world. This is a simplistic definition of a hegemon. This type of power is explored in more detail in Chapter 4 of this dissertation.
the security relationship found in Lake’s model. A weakness of the study, as noted by Lake, is that the security threat faced by the states is exogenous. This security threat is a horizontal interaction. The model in this paper endogenizes this threat by detailing the conditions under which a rival Great Power may withhold a strategic challenge for a given region.

One type of vertical security relationship between a Great Power and minor power is the status of satellite states. Satellite states, such as the Soviet occupied states of Eastern Europe, are a clear example of the creation of a sphere of influence. Wight (1979) defines a satellite as a state whose “foreign policy is controlled by another power.” Similarly, Murphy (1961) defines a satellite as a state controlled by elites whose policies are influenced by another, more powerful state. Satellite state formation is captured in this paper by high levels of intervention within a region.

Buffer state formation is another example of the vertical component of sphere of influence formation. Buffer states, as defined by Wight (1979) are “weak powers between two or more stronger ones, maintained or even created with the purposes of reducing conflict between them.” As will be seen, the model in this paper demonstrates that it may be rational for two Great Powers to insure that neither dominates a region. This behavior mirrors buffer state formation when the region is spatially contiguous to the Great Powers. Wight (1979) further distinguishes trimmer states, which are minor powers that play off their mightier neighbors. Wight cites the Duchy of Savoy as an historical example. This situation is not actively modeled within the game in this chapter because the regions are passive players.

The horizontal nature of sphere of influence creation is the strategic interaction between the competing Great Powers. There is of course a large literature examining cooperation and conflict in international relations. Well known examples include Schelling (1960), Jervis (1978), Axelrod (1984), and Oye (1986). These studies have primarily focused on single round and infinitely repeated Prisoner’s Dilemma games. Cooperation and conflict are therefore global, as opposed to local or regional, strategies. A number of papers have examined interdependent or linked games. McGinnis (1986), discussed below, is the most important for this paper. Other
examples include Lohman (1997), Huelshoff (1994), and Dixon (1986). Lohman and Huelshoff separately examine issue linkage in the context of domestic politics and foreign policy decision-making. Dixon attempts to find empirical evidence of issue linkage in United States-Soviet foreign relations. Unlike these papers, the model in this chapter employs issue linkage to examine Great Power competition region by region.

The ability to refrain from a strategic challenge is crucial to the generation of spheres. An example of a study that examines the absence of a strategic challenge is Powell (1996b). Using a simple timing game with uncertainty from economics, Powell demonstrates that changes in relative power produce a tradeoff for a declining state. By standing firm to a specific security threat, a state may initiate an unnecessary war, but it will do so while relatively stronger. In contrast, the abilities of the players in the present model are fixed. The players abandon an aggressive strategic posture in order to exploit the spatial nature of the game. As such, some of the actions in this game constitute appeasement. A power may not challenge its rival in a region in order to guarantee cooperative behavior elsewhere. Like Powell’s model, appeasement as a policy ceases to be effective at a defined concession threshold. Powell characterizes this level in terms of payoffs. In this chapter, the threshold is determined by the discount factor of the incentive compatible Great Power.

The game of strategic complements in this paper is best conceptualized as a bargaining problem. Examples of this type of game include Powell (1996a) and Fearon (1998). In the present model, two Great Powers determine influence in a number of regions. Each power announces levels of proposed intervention in each region. The power announcing the highest level for a given region wins and must enact its announced level. The announcement is irreversible for each time period. As in other studies of conflict and cooperation, the ability to cooperate is linked to the discount factor of the players. The local game explored in this paper is simpler than those developed by Powell and Fearon. However, these studies do not develop the strategic possibilities that arise through the consideration of multiple games.
The methodology of this chapter employs previous analyses of linked or interdependent games. McGinnis (1986) examines the effect of issue linkage on the prospects for cooperation in international relations. The article is a technical exploration of the 2x2 Prisoner’s Dilemma, but the payoffs are not derived from cost and benefit functions. The author’s results, that the prospects for cooperation may or may not be improved by explicit issue linkage, are due to this black box payoff definition.

Bernheim and Whinston (1990) examine the topic of issue linkage with respect to markets and firms’ ability to collude in price formation. The game developed in the present chapter borrows from their framework. Bernheim and Whinston formally establish the conditions under which collusion is possible in an iterated price game of multimarket contact. Among their findings, they conclude that multimarket contact only increases the ability to collude when strategic differences are present in the linked markets. They also examine the conditions under which the firms will establish spheres of influence, that is markets where other firms respect the primacy of some firm’s interests.

Spagnolo (1999) proves that multimarket or multicontext interaction always eases cooperation between agents in games with strictly concave objective functions. Consistent with the model in this chapter, Spagnolo demonstrates that linking markets can create cooperation, even if such cooperation is impossible within individual markets. With these results in mind, the importance of defining payoffs from meaningful objective functions is highlighted.

2.3 Theoretical Conjectures

The model developed in this chapter demonstrates why spheres of influence form in non-cooperative games. The following conjectures constitute the primary theoretical propositions concerning sphere of influence formation.

Conjecture 1: *Sphere of influence formation reduces the required discount factor for cooperation in an iterated spatial game.*
In the typical cooperative strategy profile of a Prisoner’s Dilemma game, both players reduce their level of competition. The resulting strategies, unsustainable in a single shot game, produce higher payoffs for both players. As is well known, the cooperative outcome may be sustainable in an infinitely repeated game. The Folk Theorem defines the minimum discount factor necessary to prevent defection by either player in any round. Conjecture 1 implies that this required discount factor is decreased through the establishment of spheres of influence, thereby improving the prospects for sustaining a cooperate regime. To establish spheres, each player completely disengages from some of the local games. If the games are indeed Prisoner’s Dilemmas, then single round global payoffs increase for both players. However, the reduction of competitive activity in these regions increases the incentive for each player to cheat in its rival’s sphere. Therefore, the increase in payoffs from the cooperative regime in tandem with a punishment strategy for deviation must be large enough to sustain the cooperative arrangement.

Conjecture 2: *Sphere of influence formation requires a heterogeneous strategic environment.*

A game of strategic complements defines a contest in which the best response to escalation by a rival is own escalation. In this setting, competition is typically exhaustive. Net benefits are eroded to zero by the costs of victory. Thus, sphere of influence formation not only involves total strategic disengagement from some regions, but also a reduction of intervention within a power’s own sphere. As a result, if the players are symmetric in abilities within the local games, no feasible discount rate sustains a sphere of influence regime. The incentive to cheat is simply too compelling. However, if one player possesses a strategic advantage, then the potential spoils for the deviating player diminish. In this paper, the strategic asymmetry manifests itself in the costs of intervention. Assuming both players possess a strategic advantage in at least one local game, a sphere of influence regime is feasible for some admissible discount factors.
Conjecture 3: *Localized conflict can sustain cooperation globally.*

Although counterintuitive, this conjecture is consistent with the sphere of influence theory. If two powers outline spheres of influence, it may be the case that certain regions are not subject to this arrangement. In fact, the global arrangement may depend upon a grudging acceptance of competition within one or several regions. By accepting strategic conflict in these regions, the possibility of deviation is eliminated. This reduces the incentive to cheat for one or both of the players. Thus, localized conflict may reduce the required discount factor sufficiently that a non-incentive compatible player may now adhere to a sphere of influence agreement globally.

This conflict amidst cooperation prevents exhaustive conflict in other regions or the implementation of a globally imposed trigger punishment. Regions in which the benefits for cheating are very high are more likely to be held in this status. For example, the Cold War was witness to series of regional engagements between the Superpowers as relative abilities changed. But these intense local competitions did not result in conflict in every region of the world.

Conjecture 4: *Hegemons, a Great Power with a relative strategic advantage in every region, may posses an incentive to create spheres of influence with a weaker rival in order to reduce exhaustive competition.*

Although a hegemonic power wields more influence and is capable of dominating any context, this does not imply that it is in its best interests to do so. Indeed, if its rival is capable of exerting a strategic challenge in several regions, then the hegemon’s total discounted payoff may increase by allocating a sphere of influence to its rival. In return, the rival refrains from challenging the hegemon elsewhere.
2.4 The Model

The game examined is a contest of strategic complements. The game is winner-take-all and thus represents an intense mode of competition. The players of the game are two Great Powers. Each player is a unitary, payoff maximizing, risk neutral agent. Cost and benefit functions are common knowledge. The game is an absolute-gains model of non-cooperative behavior. The competition occurs in a number of passive regions. These regional games are independently solved. Each Great Power announces a non-negative intervention level for every region. Wight (1979) defines intervention as forcible actions, “short of declaring war, by one or more powers in the affairs of another power.” Intervention thus includes diplomatic, economic, and military actions designed to increase the strategic standing of a Great Power within a region. Diplomatic communication is an example of a refrained style of intervention. Military intervention in support of regional opposition forces constitutes the most aggressive type.

Each region possesses a benefit multiplier. This multiplier reflects the underlying strategic value of the region. Benefits include economic factors, security needs, domestic political requirements, and prestige possibilities. Total benefits are a linear function of the regional benefit multiplier and the level of intervention of the winning Great Power. Equation (1) defines the benefit level of region $k$ for the level of intervention $i$ by Great Power $a$.

$$\text{Benefits} = \beta_k i^a$$

---

2 This model can be generalized as an $n$ player game. Models of cooperation and conflict typically examine the two-player case because of its simplicity. An example of an $n$ player game, in a non-cooperative setting, is Niou and Ordeshook (1990). Their model demonstrates that an $n$ player game is associated with a significant increase in complexity. This is not true in this simple game because of the winner-take-all format.

3 Because the regional game is winner-take-all, the players choose strategies as if the game is modeled as one of relative-gains. This model reinforces the notion that the debate between relative and absolute gains is partly an artifact of treating payoffs as infinitely divisible commodities. This is often an implicit assumption of cooperation and conflict studies that examine a global contest only. For technical treatment of the repeated Prisoner’s Dilemma in absolute and relative-gains formats, see Snidal (1991). For a debate on related issues, see Grieco (1993) and rebuttals by Snidal (1993) and Powell (1993).

4 Wight (1979) distinguishes between offensive and defensive interventions. Intervention that supports the incumbent regime is defensive. Intervention in support of opposition forces is offensive. For the purposes of this model, the distinction is not strategically relevant because intervention is primarily defined by its ability to confer benefits on the enacting Great Power.

5 Prestige is less easily defined than the other types of benefits. Wight (1979) defines prestige as, “influence derived from power.”
Intervention is a costly activity. Costs are convex to reflect increasing opportunity costs. As a simplifying assumption, let this convexity assume the form a quadratic function of the level of intervention. Every region possesses Great Power specific cost multipliers. The relative difference of the multipliers defines the strategic heterogeneity of the model. These differences arise in three ways. The Great Powers may possess differing technology with respect to intervention. The relative level of all cost multipliers captures such effects. Differences in regional cost multipliers may also be due to spatial proximity. The closer a Great Power is to a region, the easier it is to project power into that region. Finally, relative differences may be due to pre-positioned regional assets, thereby reflecting a previously played guns-butter game.

Equation (2) defines costs for an enacted intervention level \(i\) in region \(k\) by Great Power \(a\).

\[
\text{Costs} = c_a^k \left( \frac{\bar{i}_k}{i_k} \right)^2
\]  

(2)

With costs and benefits defined, the strategic rules of the game yield payoff values for the Great Powers. The game is Bertrand. In a Bertrand market game, the firm announcing the lowest price serves the entire market. For the Bertrand power game modeled here, the Great Power announcing the highest level of intervention wins the region. Intervention levels are announced simultaneously. Winning Great Power \(a\)'s payoff is defined by equation (3).

\[
\Pi_{\text{winner}}^a = \beta_k i_k^a - c_k^a \left( \frac{i_k^a}{\bar{i}_k} \right)^2
\]  

(3)

In the case of a tie, the regional benefits are split evenly between the Great Powers, but each Great Power must still pay the entire cost for its announced level of intervention.

---

6 Alternatively, the degree of convexity could be a parameter. Setting this parameter equal to two allows a clearer examination of the strategic issues of the game, while still capturing the effect of increasing marginal costs.

7 McGinnis (1986) indicates that simultaneous announcement in a multisuper game is unrealistic. In fact, the opposite may be true. Even if the game possesses a priori defined first-movers, any noise, not matter how slight, in the information process concerning the Stackleberg leader’s actions results in a game yielding the simultaneous Nash equilibria. For a proof of this remarkable result, see Bagwell (1995).
The payoff for the losing Great Power is zero. Although the losing power announces an intervention level, it does not actually enact that level if its announcement is less than its rival’s. Instead the losing Great Power enacts an intervention level of zero. However, its announcement of some other level of intervention stands as a credible threat to dominate the region. It is important to note that this model does not represent on-the-ground competition between the Great Powers. Such a scenario is better modeled as a quantity game with respect to intervention levels. Intervention is a strategic substitute in this setting. Spheres of influence will not form in these games due to differences in best response functions, incentives to cheat, and punishment strategies. Cooperation in this type of game occurs within the regions, perhaps as zones of control. However, consistent with the results of this paper, pooling across heterogeneous regions improves the prospects for cooperation.

Unlike a quantity game, the exhaustion of net payoffs in the present model occurs because the players wish to signal their intent to dominate a region through costly intervention. No disincentive for either player exists to commit to an extremely larger intervention level because the player must incur the costs of this irreversible announcement. Because spheres of influence typically arise through long run negotiation and bargaining, this specification is appropriate. In fact, it is the only specification in which spheres form and are the preferred form of cooperation.

In order to examine sphere of influence formation in this game, it is necessary to develop the model with a series of variants. These variations include length of the game, the number of regions, and the cost differences among the players. Proofs of these solutions are presented in the appendix. First, examine the single-stage game within a single region. Assume cost functions, and therefore cost multipliers, are equal for each Great Power. In this case, the benefit multiplier subscript and the cost multiplier subscripts and superscripts are suppressed. If a Great Power is unopposed, its preferred level of intervention is found by maximizing equation (3). \( i^* \) is the solution of this optimization problem.
The payoff, \( \Pi \), for the unopposed Great Power is

\[
\Pi = \frac{\beta^2}{4c}
\]  

With two competing Great Powers, Bertrand competition in the bargaining game ensues.

**Proposition 1:** If a single-stage game consists of two Great Powers, one region, and symmetric costs, then both Great Powers earn zero payoffs in the Bertrand Nash equilibrium.

Proposition 1 is a direct result of Bertrand competition. The winner-take-all nature of the regional games drives the Great Powers to increase their intervention levels. The winner plays \( \frac{\beta}{c} \) and the loser plays \( \frac{\beta}{c} - \epsilon \), where epsilon is some small non-negative number.\(^8\) Each of these announcements is larger than the preferred level found in equation (4). This escalation has two effects. Higher intervention levels produce larger benefits for the occupying Great Power, but higher intervention levels also incur larger costs. Because costs increase exponentially in intervention levels, net benefits are ultimately exhausted. Also note that the winner and loser of the regional game are in identical payoff states in the Bertrand Nash equilibrium, although one Great Power is the incumbent power in the region.

\(^8\) Notice in the Bertrand equilibrium that the nation-states do not select equivalent effort levels. The equilibrium is defined by the equivalency in payoffs. If both nation-states played the winning effort level, then the nation-states would tie, split the regional payoff, and earn negative payoffs. Hence, this is not a valid Nash equilibrium.
Collusion or cooperation that yields positive payoffs for the Great Powers requires each Great Power to choose the same level of intervention. As with all Prisoner’s Dilemma games, an incentive exists for either power to cheat on this arrangement in the single-stage game. Theorem 1 states this formally.

Theorem 1: Cooperation among the Great Powers is impossible in a single-stage, single region game with symmetric costs.

The cooperative solution requires the players to solve

$$\max_i \frac{1}{2} \beta i - c i^2$$

(6)

Evaluating (6) produces

$$i = \frac{\beta}{4c}$$

(7)

Although both players increase their payoffs from zero to $\frac{\beta^2}{16c}$ by cooperating, an unambiguous incentive to defect on this arrangement exists. If this occurs, the defector earns $\frac{\beta^2}{4c}$ in payoffs. Because this incentive exists for both players, the only valid Nash equilibrium for the single shot game is the equilibrium identified in Proposition 1.

---

9 Collusion and cooperation are loaded words because of welfare connotations. Cooperation is used in this chapter to describe Great Power behavior that is not Bertrand competitive, but the issue of welfare effects for the regions with respect to Great Power actions is not addressed. If the intervention in pursuit of regional dominance takes the form of investment or political patronage of local regimes, the game may be beneficial to regional welfare. If the intervention is military in nature, increased intervention levels may be costly. For example, trimmer states, as defined by Wight (1979), characterize those situations in which regional welfare increases from Bertrand competition between the two Great Powers. An extension of this model could examine different kinds of intervention and the resulting welfare effects on the regions.
The introduction of asymmetric costs changes the Nash equilibrium of the game. Let a Great Power with a cost advantage within a particular region be the dominant power. Let a Great Power with a cost disadvantage in that same region be the challenging power. Not surprisingly, the dominant power wins the region, but its payoff will not always be dependent on the actions of its rival. Proposition 2 establishes the relevant cases.

Proposition 2: *If a game consists of a single region and the challenging Great Power’s cost multiplier is no more than twice the dominant Great Power’s cost multiplier, then the payoffs of the winning Great Power are reduced due to strategic interaction.*

Equation (4) defines the preferred level of intervention for a Great power with a cost multiplier of $c$. Let $\theta c$ be the cost multiplier of the challenging Great Power. By definition, $\theta$ is greater than one. Proposition 2 states that if the preferred intervention level of the dominant power exceeds the zero payoff intervention level of the challenging power, then no strategic challenge can occur. This is true when $\theta$ is greater than two. Any challenge that forces the dominant power to increase its intervention level yields negative payoffs for the challenging power. Thus, it is not a credible threat due to a standard rationality constraint.

Define those regions for which a challenge is not credible as uncontested. Such regions are not part of the sphere of influence game. There is no rational way for the challenging power to alter the payoffs of the dominant power, thus costly strategic competition does not occur. As will be examined later, challenging powers cannot offer uncontested regions to their rivals because it is simply not in their power to affect the result.\(^{10}\) Such an offer is strategically equivalent to offering nothing.

\(^{10}\) Hitler’s offer of British India to the Soviet Union as a means of obtaining a tripartite alliance is an example. Germany did not have the means to project power in the region, so its offer to the Soviets had little strategic effect. For a detailed analysis of this event, see Schweller (1998).
Theorem 2: *Cooperation among the Great Powers is impossible in the single-stage, single region game with asymmetric costs.*

Cooperation is of course never possible in a single shot game, provided an incentive to deviate exists. Regardless, given the rules of this game, it is never in the dominant power’s interest to share the region with its rival. If the region is uncontested, no strategic interaction occurs. If the region is contested, then the cooperative payoff is smaller than the Bertrand payoff of \( \frac{(\theta - 1) \beta^2}{\theta^2 c} \).

Introducing additional regions into the single-stage game does not increase Great Power cooperation. On first inspection, it may appear that a spatial game allows the Great Powers to designate regions where they win and regions where they will not enact a strategic challenge.\(^{11}\) In other words, the Great Powers divide the set of regions into spheres of influence. But no cooperative regimes are sustainable in a single-stage, spatial game, in accordance with the well-known results of single-stage Prisoner’s Dilemma games. Deviation is never punished and cooperation is not rewarded in the single-stage, spatial game. This fact implies Proposition 3.

**Proposition 3:** *If the Great Powers compete in multiple regions, then the Nash equilibrium of the spatial game is equivalent to the set of Nash equilibria of the individual regional games.*

All the preceding conclusions generate Theorems 3 and 4, which are included for completeness.

**Theorem 3:** *Cooperation among the Great Powers is impossible in the single-stage, spatial game.*

---

\(^{11}\) The term *spatial game* is used in this paper to describe a game of multiple regions. Multiple games are also referred to as interdependent games (Spagnolo 1999). But spillover effects between the games typically characterize interdependent games. McGinnis (1986) refers to the repeated spatial game as a multisupergame. Spatial games in the economics literature typically refer to games of price and location determination. Spatial game in the present model refers to the fact that the Great Powers compete within spatial or areal units. The cost multipliers in this model indicate how the regions are spatially oriented in power-projection space, thereby reflecting physical distance and power projection capabilities. This is consistent with the types of distance definitions geographers employ.
Theorem 4: Great Power cooperation is impossible in all single-stage games.

Because the game is a Prisoner’s Dilemma, both Powers possess an incentive to escalate their level of regional intervention, provided the region is defined as strategically contestable. Competition exhausts payoffs fully in the symmetric case and partially for the dominant power in the asymmetric case. Cooperation, whereby the Great Powers adhere to a regime in which they share the spoils of a region, is impossible due to both the manner in which payoffs are defined and the single-stage nature of the game.

As is well known, the strategic setting changes when games are repeated. In all types of games, repeated interaction fosters an environment in which punishments and rewards can be issued for previous behavior. For example, the Folk Theorem indicates the set of equilibria that are sustainable against deviation given an exogenous discount factor (Mas Colell et al. 1995).

In Prisoner’s Dilemma games, cooperative outcomes are resistant to deviation under a variety of repeated game strategies. Similar to Bernheim and Whinston (1990) and Powell (1996a), I focus on trigger strategies. If a Great Power deviates, its rival will adopt Bertrand competition strategies in all regions in future rounds. This implies that if a Great Power cheats, it does so in all possible regions. Both Great Powers anticipate that cheating on regional arrangements is met with global punishments in the next time period. The trigger strategy, if modeled as a two-stage game, is not subgame perfect. But similar to arguments associated with the Chain Store paradox, the trigger strategy is an effective technique to enforce cooperation in infinitely repeated games (Kreps 1990). Tit-for-tat strategies can also be used.

A rational Great Power will not cheat on a cooperative arrangement in any round, if the discounted flow of cooperative payoffs is greater than or equal to the single round deviation.

---

12 The trigger may also be employed in a limited number of regions. However, no player prefers to use this limited response trigger. The only effect would be to increase the required rival’s discount factor and thereby decrease the possibility of cooperation.

13 The cooperation can be implicit or explicit. Sphere of influences can arise through explicit planning between the Great Powers or such arrangements can arise from the rational recognition of the Great Powers of the strategic setting and the optimal means to improve their own payoff. Because the game is repeated, it is also valid to imagine the regime arising due to a trial and error process, although this is not consistent with the trigger strategy examined in this paper.
payoff plus discounted payoffs from all future punishment rounds. This requirement is called the incentive constraint and is provided in relations (8) and (9). Let $\delta$ be the exogenous discount factor of future payoffs.\textsuperscript{14} The discount factor is less than one and greater than zero by definition. Rounds are denoted by $t$. The game is infinitely repeated.\textsuperscript{15}

\[
\Pi_{\text{deviation}} + \sum_{t=0}^{\infty} \delta^{t+1} \Pi_{\text{punishment}} \leq \sum_{t=0}^{\infty} \delta^t \Pi_{\text{cooperative}}
\]  

(8)

Solving the infinite series yields

\[
\Pi_{\text{deviation}} + \frac{\delta}{1-\delta} \Pi_{\text{punishment}} \leq \frac{1}{1-\delta} \Pi_{\text{cooperative}}
\]

(9)

For the spatial game, the constraint is the pooled set of incentive constraints for all regions in the game. As will be seen, this pooling is responsible for the primary results in this paper.

Theorem 5: If a repeated game consists of a single region and the Great Powers have symmetric costs, then cooperation is possible, provided the future discount factor is greater than $\frac{3}{4}$.

In the cooperative regime each power plays $\frac{\beta}{4\epsilon}$, as identified in equation (7). Of course, each power has an incentive to defect. However, solving equation (9) for this case demonstrates that cooperation is sustained provided each player’s discount factor is greater than $\frac{3}{4}$. Therefore evenly matched Great Powers, as defined by costs, may sustain cooperative regimes in a single

\textsuperscript{14} Although not established in this paper, $\delta$ may be Great Power specific. In fact given differences in Great Power political institutions, $\delta$ is almost certainly different for each power.

\textsuperscript{15} Wight (1979) notes that, “the members of international society are, on the whole, immortals.” States and regimes rise and fall, but the institutions behave as time discounting, infinitely lived agents. Therefore, the game is framed as infinitely repeated.
region if their interaction is repeated. But given the winner-take-all environment of the regional games, Great Powers cannot sustain cooperation, regardless of the discount factor, if one Great Power possesses a structural advantage in costs.

Theorem 6: Cooperation among Great Powers is impossible in the repeated game with one region and asymmetric costs.

Consistent with Theorem 2, it is never in the interest of the dominant power in a single region game to cooperate. The cooperation of this power provides nothing in its favor from the challenging power. The repeated nature of the interaction has no effect. The result of this particular game contrasts with many existing studies of bargaining and conflict. These models often assume that payoffs are an infinitely divisible good. Recall that benefits in this game are derived from political control of a region. Power is different than revenue or profits. It is not easily divisible and the rules of this game reflect this aspect.

The theorem also casts doubt on the ability of rivals to cooperate when only one context or region is under competition. The iterated spatial game provides greater prospects for the powers to cooperate, but only under certain conditions. Indeed, issue linkage has been suggested as a means of achieving cooperation. However, some authors imply that issue linkage always fosters cooperation. Alternatively, McGinnis (1986) states that forced issue linkage can frustrate cooperation. In this game, competition in multiple regions or contexts never frustrates the ability of Great Powers to cooperate, but it is possible that the inclusion of additional regions has no effect. To prove this, first note that cooperation in multiple regions in the repeated game must assume a specific form, namely the intra-regional cooperative solution as solved in equation (7).

Proposition 5: If a repeated game consists of multiple regions, each with symmetric costs, then Great Power cooperation is never possible by allocating entire regions into spheres of influence.
By allocating the regions into spheres of influence, each Great Power must choose an intervention level of zero within some regions. The rival accordingly plays the optimal level of intervention in these regions. Payoffs increase for both players, but so does the incentive to cheat. Indeed, this incentive is so strong that the required discount factor for at least one player exceeds one. Therefore, no feasible discount factor sustains this sort of cooperative outcome.

Proposition 5 also confirms the second theoretical conjecture of this paper. Sphere of influence formation is simply not possible in a spatial game of strategic complements with symmetric costs. Cooperation in this setting requires intra-regional cooperation, which is not sphere of influence behavior. Theorem 7 addresses this form of cooperation.

Theorem 7: *If a repeated game consists of multiple regions, each with symmetric costs, then Great Power cooperation is possible provided that the discount factor is greater than $\frac{3}{4}$.*

The proof is similar to Theorem 5, except now the game occurs in multiple regions. Because no player possesses a cost advantage, the incentive compatibility constraint is equivalent to the single region game. The required discount factor in both cases is $\frac{3}{4}$. Therefore, Great Power interaction in multiple regional contexts neither frustrates nor eases cooperation over the single region case with symmetric costs.

This result echoes the primary finding of Bernheim and Whinston (1990) with regards to multimarket contact. Inclusion of strategically neutral contexts has no effect on the ability of Great Powers to cooperate. Note also that disaggregation of a region, from an analytical perspective, into many regions has no effect on the game, provided that no cost advantages are generated. Likewise, regions with symmetric costs can be aggregated with no strategic effect on the results of this model.
To demonstrate Conjecture 1, the asymmetric cost case must be explored. There are several variants of this game. In the first variant, a region becomes a part of a Great Power’s sphere of influence if that Great Power is the dominant power in the region. For this regime to be resistant against deviation, both Great Powers must meet incentive constraints with respect to the future discount factor.

If the incentive constraint fails for either power, then adjustments are made to the definition of the spheres of influence. Regions may be assigned to a challenging Great Power’s sphere of influence. Alternatively, regions may be excluded from a sphere of influence agreement. In this case, the Great Powers effectively agree to Bertrand compete in these regions. If the incentive to cheat is large, this is a rational arrangement. This situation is a test of Conjecture 3. Finally, it may be the case that the dominant power is the same Great Power in all regions with asymmetric costs. This globally dominant power is a hegemon. As specified in Conjecture 4, the hegemon may find it profitable to cede one or more regions to its rival to prevent strategic challenges in its own sphere of influence. The general case generates the following important theorem.

The Sphere of Influence Theorem: Subject to the future discount factor, spheres of influence arise if a repeated game of Great Power competition contains multiple regions, asymmetric costs, and each Great Power is a dominant power in at least one region.

The proof of the Sphere of Influence Theorem demonstrates that for some feasible future discount factors, sphere of influence formation is possible and beneficial to both players. However, all three strategic conditions are required to insure the required discount factor is less than or equal to one. The inclusion of multiple regions allows the players to designate whole regions to each player. Allowing each player to be the dominant power in at least one region insures that some sphere of influence package is acceptable to both players. And finally, if costs are asymmetric, then the incentive to cheat is smaller than in the symmetric cost case. However,
provided the regions are contested, there is a certain benefit in restraining the strategic challenge of a rival. Of course, final acceptance of the sphere of influence regime is dependent upon the actual discount factors of the Great Powers.

For example, assume the game consists of two regions. In one region, Great Power \( a \) is dominant and has a cost multiplier of \( c \). The rival of \( a \) has a cost multiplier of \( \tilde{c} \). As in Proposition 2, \( c \theta = \tilde{c} \), where \( \theta \in (1,2) \). Costs are reversed in the second region. Let \( \beta \) be the benefit multiplier in both regions. Theorem 6 proves that intra-regional cooperation is impossible, even in a repeated game. According to Proposition 2, both Great Powers win the region for which they are dominant, yet suffer reduced payoffs due to the necessity of checking a potential strategic challenge. Therefore the only means of cooperation available is to establish spheres of influence.

The cooperative regime consists of each Great Power playing \( \frac{\beta}{4c} \) in its sphere of influence. Additionally, each Great Power refrains from enacting a strategic challenge in its rival's sphere of influence. The incentive constraint for this strategy profile is

\[
\frac{\beta^2}{4c} + \frac{(2-\theta)\beta^2}{4c} + \left( \delta - \frac{\theta}{1-\delta} \right) \left[ 0 + \frac{(\theta-1)^2}{\theta^2} \right] \beta^2 \leq \left( 1 - \frac{1}{1-\delta} \right) \frac{\beta^2}{4c} \tag{10}
\]

Solving (10) for \( \delta \) yields

\[
\delta \geq (2-\theta) \left( 3 - \frac{4(\theta-1)^2}{\theta^2} \right)^{-1} \tag{11}
\]

For \( \theta \in (1,2) \), the right hand side is bounded above by \( \frac{1}{2} \). Therefore Great Power cooperation,
that is sphere of influence formation, always occurs if \( \delta \geq \frac{1}{2} \). For values of \( \theta \) greater than two, \( \delta \) must be greater than some negative number. This is due to the fact that for these values of \( \theta \) no strategic challenges are possible, therefore cooperation is trivially enforced.

Notice that for \( \theta \in (1,2) \) the cooperation requirement on the discount factor is eased slightly. As \( \theta \) increases, the payoff for deviating in the rival’s sphere of influence falls because a Great Power’s own costs are higher. Therefore a larger \( \theta \) initially reduces the incentive to cheat, thereby requiring a lower \( \delta \). But \( \theta \) also affects the flow of discounted payoffs due to Bertrand competition punishment. As \( \theta \) increases, this payoff increases because the challenging Great Power is less able to mount a strategic challenge. Because the punishment payoff is larger, the incentive to cheat is higher. Thus, incentive compatibility requires a larger \( \delta \). The tradeoff between these two effects is responsible for the quadratic relationship present in (11).

With respect to a game of strategic complements, the Sphere of Influence Theorem vindicates Conjecture 1. The ability to form spheres reduces the required discount factor for a cooperative strategy profile. If the regions possess asymmetric costs, then the intra-regional cooperative outcomes are not desirable from the perspective of the dominant power. Formation of spheres, or whole region allocation with concomitant strategic restraint in the rival’s sphere, is the only way to achieve an iterated cooperative outcome. Furthermore, the discount factor requirement of \( \frac{3}{4} \) for the symmetric cost case is always greater than the required discount factor for the sphere of influence scenario when costs are asymmetric. Therefore, the ability to form spheres eases the ability of players in a game of strategic complements to improve their discounted payoff through cooperation.

The mathematical engine of this result is the ability to pool incentive constraints, as noted by Bernheim and Whinston (1990). If each region is considered separately, then slackness in one region’s incentive constraint cannot be used to ease cooperation at the spatial game level.
But if all incentive constraints are pooled, slackness in individual constraints can be used to sustain a sphere of influence agreement. This is particularly true if cooperation within a single region is impossible before pooling, a result noted by Spagnolo (1999).

Contrary to suggestions made by some authors, including McGinnis (1986), pooling of incentive constraints never makes cooperation more difficult. If the inclusion of a region increases the required discount factor beyond a Great Power’s incentive compatibility requirement, then that region is discarded from the sphere of influence regime. Rational Great Powers agree to Bertrand compete in that region. The worst payoff case is realized if all regions are discarded as such because the prevailing discount factor will not sustain any cooperative agreement. Even in this case, cooperation is not frustrated by consideration of the spatial game. It must be the case that cooperation is not possible in the individual games due to discount constraints, so consideration of the iterated spatial game simply has no effect.

Stylized comparative statics of the discount factor can be examined by rewriting inequality (9) as

\[ \delta \geq \frac{\Pi_{\text{dev-r}}}{\Pi_{\text{dev-r}} + \Pi_{\text{coop-SOI}} - \Pi_{BC}} \]  

(12)

Single round payoffs from Great Power deviation in a rival’s spheres of influence are captured by \( \Pi_{\text{dev-r}} \). Single round payoffs in a Great Power’s own spheres of influence in the cooperative regime are measured by \( \Pi_{\text{coop-SOI}} \). And \( \Pi_{BC} \) indicates single round payoffs from Bertrand competition under the punishment enforcement.

As \( \Pi_{\text{dev-r}} \) increases, the future discount factor must be larger to maintain this Great Power’s adherence to the cooperative regime. If (12) is set at equality, the effect on \( \delta \) is proved by noting
In the same manner, it can be shown that an exogenous increase in the cooperative payoff or a
decrease in the Bertrand competition payoff reduces the required future discount factor.

This last point has an interesting application. The ability to punish deviation increases
sphere of influence formation and cooperation more generally. This is especially true if the
punishment includes costs beyond reduced regional payoffs due to Bertrand competition. For
example, if deviation from the sphere of influence arrangement is met by home territory
punishment, then the ability to sustain cooperative behavior is increased. Nuclear deterrence is
an obvious example.

If incentive compatibility fails for one of the Great Powers, the other Great Power can
expect its rival to cheat on the candidate cooperative regime. For a payoff-maximizing player, it is
clearly in its interest to fashion a cooperative proposal, provided it improves the discounted flow
of payoffs. The incentive compatible Great Power has two, possibly three, options.

Type I Proposal: An incentive compatible Great Power can encourage cooperation by removing
regions from its sphere of influence, thereby returning the regions to a state of Bertrand
competition.

This counterintuitive result, that increased, localized competition can foster global
cooperation, is easily explained. Under the cooperative regime, the regionally dominant Great
Power reduces its intervention level to increase its net benefits. In so doing, the incentive for its
rival to increase its own intervention level is increased. The incentive compatible Great Power is
therefore presented with a tradeoff. By accepting Bertrand competition in some regions, it
reduces its payoffs, but it may induce its rival to adhere to a previously unacceptable sphere of
influence arrangement. Note that the incentive compatible Great Power is the dominant power in
the region in question. Thus, it still secures positive payoffs when the region returns to Bertrand competition. The proof of the Type I proposal validates the third conjecture of this paper.

Type II Proposal: *An incentive compatible Great Power can encourage cooperation by ceding regions from its own sphere of influence to its rival sphere of influence.*

Unlike a Type I Proposal, a Type II Proposal is an example of appeasement. A region, which previously provided benefits to one Great Power, is yielded to another Great Power in the interest of sustainability with respect to the modified sphere of influence arrangement. The incentive compatible Great Power strictly prefers the Type I Proposal to the Type II Proposal because of the effect on its own payoffs. If the incentive compatible power removes a region from its sphere in which it was dominant, the power will still capture a reduced payoff in Bertrand competition. If it is given to its rival’s sphere, it loses the entire payoff.

Type III Proposal: *An incentive compatible Great Power can encourage cooperation by ceding regions with symmetric costs to its rival’s sphere of influence.*

Of course, Type III proposals assume the presence of symmetric cost regions. As with the Type II proposal, this course of action requires the ceding Great Power to sacrifice payoffs in the cooperative regime. This is a real loss because even if all proposed cooperation fails to be resistant against deviation, it may still be possible to cooperate within symmetric cost regions, provided the discount factor condition is met. But such an act is rational if it allows cooperation within other regions that faced strategic challenges in the absence of a Type III proposal. Type III proposals also constitute appeasement as typically defined.
In any case, the incentive compatible Great Power will choose the least costly combination of these actions in order to appease its rival and sustain cooperation. The specifics of this interaction are dependent on exact magnitudes of regional benefits and costs, as well as the prevailing future discount factors.

There exists a special case of the use of Type II and Type III proposals to create or sustain cooperative outcomes. A hegemon, as defined in this game, is a Great Power, which is the dominant power in all regions with asymmetric costs. Recall that costs measure not only accounting costs, but also reflect power projection capabilities. To analyze this case, first note that the hegemon’s rival will never earn positive payoffs under Bertrand competition. But ceding one region to the challenging power is not sufficient to sustain cooperation within all contestable regions. The hegemon must provide enough benefits to the challenging power to insure it does not cheat against the cooperative regime in any round. Without loss of generality, let Great Power a be the hegemon. Assume that no symmetric cost regions are present. The incentive constraint for the challenging power, \( b \), is

\[
\sum_{l=1}^{c} \frac{\beta_i^2}{4 c_i^b} + \sum_{j=1}^{m-c} \left( 2 - \theta_j \right) \frac{\theta_j \beta_j^2}{4 c_j^b} + \left( \frac{\delta}{1 - \delta} \right) 0 \leq \left( \frac{1}{1 - \delta} \right) \sum_{l=1}^{c} \frac{\beta_i^2}{4 c_i^b}
\]  

(14)

As before, there are \( m \) regions \( j \) in which Great Power \( b \) is the challenging power. The hegemon allows \( b \) to form a sphere of influence in \( c \) regions \( l \). Solving (14) for \( \delta \) yields

\[
\delta \geq \frac{\sum_{j=1}^{m-c} \left( 2 - \theta_j \right) \theta_j \beta_j^2}{\sum_{j=1}^{m-c} \frac{\left( 2 - \theta_j \right) \theta_j \beta_j^2}{4 c_j^b} + \sum_{l=1}^{c} \frac{\beta_i^2}{4 c_i^b}}
\]  

(15)

The required discount factor in (15) is clearly less than one. Therefore, it is possible to create a
sphere of influence set for the challenging power, such that the challenger does not cheat on the

global cooperative arrangement. The concomitant incentive constraint for the hegemon to adhere
to the cooperative regime is

\[
\sum_{k=1}^{n} \frac{\beta_k^2}{4 c_k^a} + \sum_{i=1}^{c} \frac{\theta_i (2 - \theta_i) \beta_i^2}{4 \theta_i c_i^a} + \left( \frac{\delta}{1 - \delta} \right) \sum_{k=1}^{n} \frac{(\theta_k - 1) \beta_k^2}{\theta_k^2 c_k^a} \leq \left( \frac{1}{1 - \delta} \right) \sum_{k=1}^{n} \frac{\beta_k^2}{4 c_k^a}
\]  

(16)

Solving for \( \delta \) provides

\[
\delta \geq \frac{\sum_{i=1}^{c} \frac{\theta_i (2 - \theta_i) \beta_i^2}{4 \theta_i c_i^a}}{\sum_{i=1}^{c} \frac{\theta_i (2 - \theta_i) \beta_i^2}{4 \theta_i c_i^a} + \sum_{k=1}^{n} \frac{\beta_k^2}{4 c_k^a} - \sum_{k=1}^{n} \frac{(\theta_k - 1) \beta_k^2}{\theta_k^2 c_k^a}}
\]  

(17)

Again, clearly the discount factor requirement in condition (17) is less than one. The

hegemon must decide how many regions \( l \) to yield. Increasing \( c \) through the use of Type II

Proposals lowers the required future discount factor. Of course, the hegemon will cede only the

minimum number of regions required to maintain the cooperation of its rival. If there are no

symmetric cost regions, then at least one region must be ceded to the challenging Great Power in

order to generate a flow of payoffs. If symmetric cost regions exist, some mix of Type II and Type

III Proposals are used by the hegemon to prevent strategic challenges by its rival. There is no

guarantee that both the hegemon and the strategic challenger will adhere to any sphere of

influence arrangement. However, the solutions in conditions (15) and (17) when examined jointly

confirm Conjecture 5. Hegemons possess an incentive to form spheres of influence.

Side payments may also further sphere of influence creation. Great Powers may offer
direct concessions to each other to create or sustain spheres of influence. Such concessions are
similar to the definition of compensation, as given by Wight (1979). In this game, side payments can be used to lower the required discount factor, but it is not possible to create and sustain spheres of influence with side payments alone.

Proposition 6: For a single region with asymmetric costs such that \( \theta \in (1,2) \), there does not exist a side payment that fosters cooperative behavior in the single-stage or repeated game.

Given the rules of this game, the cost of insuring that the challenging power never cheats on the dominant power always exceeds the benefits of removing the strategic challenge. Therefore a dominant power will never offer such a side payment. However, *ex post* side payments can be used to increase \( \Pi_{\text{coop-SO}} \) as reward for cooperative behavior. This will decrease the required future discount factor. Thus side payments constitute a Type IV Proposal that can be employed by an incentive compatible Great Power to lower the required discount factor for its rival.

2.5 Conclusion

The primary finding of this study is that the prospects for Great Power cooperation are significantly improved when the competition occurs in a strategically heterogeneous spatial game. As such, this chapter offers a new perspective of the iterated Prisoner’s Dilemma and its implications for international conflict and cooperation. Cooperation in the iterated spatial game assumes the form of spheres of influence. These sets of regions or contexts are characterized by the lack of an active strategic challenge by rival Great Powers. This absence occurs in the expectation that other Great Powers will possess regions in their own spheres of influence. As a result, the flow of future payoffs is increased provided future discounting is not too large. This global strategy allows the Great Powers to escape the trap of engaging in exhaustive and ultimately wasteful competition within the regions of the game.

Spheres of influence arise only under certain strategic conditions. First, the interaction must be repeated. Second, the interaction must occur in multiple contexts or games. Third,
these regional games must be strategically heterogeneous. These exogenous characteristics act as a guide in the creation of spheres of influence. Competition in multiple regions, each with symmetric costs or strategic neutrality, does not ease cooperation relative to the single region case. The actual delineation of the spheres is dependent on the realized values of costs and benefits.

This chapter also explored a number of specific issues regarding the spatial game. In some situations, regional Bertrand competition fosters global cooperation. This conflict amidst cooperation reduces the incentive to cheat on a global cooperative regime. Side payments alone are not sufficient to sustain a sphere of influence arrangement. Hegemons, although they possess strategic dominance, also have an incentive to engage in sphere of influence behavior with strategically inferior rivals.

There are many theoretical extensions possible for the basic framework developed in this paper. For example, the game has been reexamined in a preliminary manner for the case of Cournot competition or games of strategic substitutes. Cournot games are more appropriate for games of incomplete dominance, such as certain military or commercial competitions. The game could also be expanded to examine imperfect information. For example, the model could be recast as a game of hidden action, whereby own payoffs are known, but not the rivals’ multipliers, actions, or discount factors. A significant complication could be undertaken if the regional games were remodeled as interdependent, that is if the outcomes in some regions affect outcomes in other regions. If prestige is the primary payoff such a complication is worthwhile. As noted earlier, the game could be placed in a larger guns-butter game. In this setting, the multipliers become endogenous to reflect choices made regarding military and diplomatic capabilities.

The discount factor could also be treated as an endogenous variable. The discount factor is function of the social discount rate (Romer 1996). As the social discount rate increases, the discount factor falls. Suppose the social discount rate is equal to the domestic interest rate of a Great Power. One benefit of imperialism for the Great Powers was the flow of cheap natural resources. As a component of land in a conventional neoclassical production function, the influx...
of natural resources increases the marginal product of capital and labor. As such, wages and the interest rate increase. Thus, the discount factor falls. In the present model, this decrease threatens incentive compatibility and makes cooperation less likely. This chain of events suggests a hypothesis concerning the flow of benefits and imperialistic overstretch.

Additionally, different types of political regimes likely possess differing discount factors. Lake (1992) is an example of a study that examines the effects of regime type on regime behavior. Lake demonstrates that democracies are less likely to fight wars and more likely to cooperate. But suppose that democracies, which are more sensitive to the immediate needs of a mass constituency, possess larger discount factors. That is, democracies may be more impatient than other forms of government. If this is the case, this paper suggests that democracies are less likely to enter into agreements concerning spheres of influence, not because of a moral disinclination, but rather because of a disregard for future returns.

More importantly, this model offers opportunities to reexamine historical cases. The issue of the domestic interest rate and periods of international cooperation is an example. Cases of cooperation and conflict could also be examined with respect to the number of contexts in which the competing institutions interacted. The model in this paper suggests that those conflicts involving multiple contexts with clear strategic differences offer the best conditions for cooperation. Those conflicts with one region or issue offer the least.

Finally, empirical studies could be conducted that seek evidence of the kind of strategic cooperation examined in this paper. O'Sullivan (1995) offers a method from the geography literature on plotting spheres of influence based on military or other power projection capabilities. O'Sullivan's method is not game theoretic, so the technique only reflects what has been defined as strategic dominance in this paper. Thus a hegemon would possess a vast, if not all encompassing, sphere of influence if O'Sullivan's method were employed. As this chapter has demonstrated, this is unlikely to be the case because payoffs to the hegemon would likely be reduced due to the need to fend off strategic challenges in most regions. Thus if regions or contexts were classified into spheres by some other measure, perhaps actual military presence or
commercial activity, then a comparison could be made. Differences between O’Sullivan’s classification and the alternative classification would serve as evidence for the type of strategic behavior explored in this chapter.

2.6 Proofs

Proposition 1: If a single-stage game consists of two Great Powers, one region, and symmetric costs, then both Great Powers earn zero payoffs in the Bertrand Nash equilibrium.

Proof: Without loss of generality, let Great Power a select the intervention level defined by equation (4). Great Power b, a’s rival, earns zero payoffs if its intervention is less than \( i^* \). Great Power b’s preferred level of intervention is also \( i^* \). Therefore, to win the region with the highest possible payoffs, given a’s current strategy, b should play \( i^* + \varepsilon \), where \( \varepsilon \) is some small positive number. Given b’s new strategy, a possesses an incentive to marginally increase its announced intervention level. By induction, this incentive exists for the non-winning power until payoffs for the winner are exhausted due to increasing marginal costs. In the Bertrand Nash Equilibrium, \( i \) equal to \( \frac{\alpha}{\varepsilon} \) is the winner’s announced and enacted intervention level. The loser plays \( \frac{\alpha}{\varepsilon} - \varepsilon \), thereby mounting an announced strategic challenge. Both Great Powers earn zero payoffs. QED.

Theorem 1: Cooperation among the Great Powers is impossible in a single-stage, single region game with symmetric costs.

Proof: Cooperation under the rules of the game requires the Great Powers to choose equal intervention levels within the region. Both players solve the following optimization problem.

\[
\max_i \frac{1}{2} \beta i - c i^2 \quad \text{(A1)}
\]
The solution of this problem is

\[ i = \frac{\beta}{4c} \]  

(A2)

Both Great Powers earn \( \frac{\beta^2}{16c} \) in payoffs. However, both Great Powers have an incentive to increase their intervention levels to \( \frac{\beta}{2c} \). A deviator increases its payoff to \( \frac{\beta^2}{4c} \). Due to this incentive, the resulting single-stage equilibrium is the Bertrand Nash equilibrium identified in Proposition (1). QED.

Proposition 2: If a game consists of a single region and the challenging Great Power’s cost multiplier is no more than twice the dominant Great Power’s cost multiplier, then the payoffs of the winning Great Power are reduced due to strategic interaction.

Proof: Let \( c \) be the cost multiplier of the dominant Great Power. Let \( \theta c \) be the cost multiplier of the challenging Great Power. Note that \( \theta \) is greater than one by definition. From equation (4), the dominant power’s preferred level of intervention within the region is \( \frac{\beta}{2c} \). If the challenging power can select a level of intervention above \( \frac{\beta}{2c} \) and earn non-negative payoffs, then the dominant power must increase its own intervention to insure regional victory. The challenging power’s effective strategic threat disappears at the level of intervention at which its payoff equals zero. This level occurs at

\[ i = \frac{\beta}{\theta c} \]  

(A3)

If \( \frac{\beta}{\theta c} \) is greater than \( \frac{\beta}{2c} \), then a strategic challenge against the dominant power’s preferred level of \( i \) is possible. This is true when \( \theta < 2 \). In this case, the dominant power must play \( \frac{\beta}{\theta c} \) to secure the region. Because this level of intervention is larger than the dominant Great Power’s
preferred level of exertion and due to the strict concavity of the net benefit function, the payoff for the dominant Great Power is reduced.  \textit{QED.}

\textbf{Theorem 2:} \textit{Cooperation among the Great Powers is impossible in the single-stage, single region game with asymmetric costs.}

\textit{Proof:} There are two cases due to relative cost structures. If the region is uncontested, cooperation is trivially eliminated. The dominant Great Power never desires to reduce its level of intervention. The challenging Great Power has no means to entice cooperation. If the region is contested, there are no feasible arrangements that improve the payoff of the dominant power. Indeed, under Bertrand competition the dominant Great power earns a payoff of \( \frac{(n-1)\theta^2}{\theta^2} \). If the dominant power designs a cooperative regime according to its preferences, both powers play \( \frac{\beta}{4\theta} \) and the dominant Great Power earns \( \frac{\beta^2}{16\theta} \). For all \( \theta \in (1, 2) \), the Bertrand competition payoff is larger. Therefore, without even considering single-stage game implications, there exists no incentive for a dominant Great Power to cooperate in the single-stage, single region game. \textit{QED.}

\textbf{Proposition 3:} \textit{If the Great Powers compete in multiple regions, then the Nash equilibrium of the spatial game is equivalent to the set of Nash equilibria of the individual regional games.}

\textit{Proof:} Suppose not. If a candidate Nash equilibrium of the spatial game is not equivalent to the set of Nash equilibria of the individual regional games, then either a dominant Great Power is not a winner or a challenging Great Power possesses a feasible incentive to escalate and win a region. In either case, a Great Power has an incentive to deviate in strategy. Therefore any candidate equilibrium for the spatial game, which includes a regional equilibrium that is not equivalent to a single region Nash equilibrium, is not a valid Nash equilibrium for the spatial game. \textit{QED.}
Theorem 3: Cooperation among the Great Powers is impossible in the single-stage, spatial game.

Proof: Theorem 1 and Theorem 2 prove the impossibility of Great Power cooperation in single-stage, single region games, regardless of cost structures. Proposition 3 indicates that the inclusion of multiple regions does not alter the Nash equilibrium of the spatial game. Therefore, cooperation is impossible in all single-stage games with more than one region. QED.

Theorem 4: Great Power cooperation is impossible in all single-stage games.

Proof: Previous theorems and propositions indicate that for all combinations of regional competition and cost structures, Great Power cooperation is impossible in the single-stage game. QED.

Theorem 5: If a repeated game consists of a single region and the Great Powers have symmetric costs, then cooperation is possible, provided the future discount factor is greater than \( \frac{3}{4} \).

In the cooperative regime each power plays \( \frac{\beta}{4\epsilon} \), as identified in equation (7). Of course, each power has an incentive to defect. However, solving equation (9) for this case demonstrates that cooperation is sustained, provided each player’s discount factor is greater than \( \frac{3}{4} \).

Proof: First note that each Great Power plays \( \frac{\beta}{4\epsilon} \), as identified in equation (7). As seen in Theorem 1, in every round each Great Power has an incentive to deviate to \( \frac{\beta}{2\epsilon} \). If deviation by a single Great Power occurs, its rival invokes its trigger. In the next and all subsequent rounds, the
rival plays $\frac{\beta}{c}$, thereby exhausting all payoffs to both Great Powers. Thus, employing relation (9), cooperation is resistant to deviation provided

$$\frac{\beta^2}{4c} + 0 \leq \left( \frac{1}{1-\delta} \right) \frac{\beta^2}{16c}$$

(A4)

The discount factor is the only exogenous variable upon which cooperation depends. Solving (A4) for $\delta$ yields

$$\delta \geq \frac{3}{4}$$

(A5)

Thus, provided condition (A5) is satisfied, the Great Powers can sustain a cooperative arrangement within a single region. QED.

Theorem 6: Cooperation among Great Powers is impossible in the repeated game with one region and asymmetric costs.

Proof: If the region is strategically uncontested, the challenging Great Power cannot reduce the payoffs of the dominant Great Power, in accordance with Proposition 2. In a contested region, a dominant Great Power plays $\frac{\beta}{\theta}$ and earns a payoff of $\frac{(\theta-1)\beta^2}{\theta c^2}$ under Bertrand competition. Recall that the cooperative regime, as preferred by the dominant Great Power, involves an intervention level of $\frac{\beta}{4c}$, producing a payoff of $\frac{\beta^2}{16c}$. As in Theorem 2, payoffs under the cooperative agreement are always lower for the dominant Great Power for all $\theta \in (1,2)$. Thus it is never in the interest of the dominant Great Power to propose a cooperative regime in the single region repeated game. QED.

Proposition 5: If a repeated game consists of multiple regions, each with symmetric costs, then Great Power cooperation is never possible by allocating entire regions into spheres of influence.
Proof: Assume two regions, \( j \) and \( k \), are in competition between Great Powers \( a \) and \( b \). Without loss of generality, let region \( j \) be \( a \)'s sphere of influence and region \( k \) be \( b \)'s sphere of influence.

The incentive constraint for Great Power \( a \) is

\[
\frac{\beta_j^2}{4c_j} + \frac{\beta_k^2}{4c_k} + \left( \frac{\delta}{1+\delta} \right)(0) \leq \left( \frac{1}{1+\delta} \right) \left( \frac{\beta_k^2}{4c_j} \right) \tag{A6}
\]

Rearranging terms provides

\[
\left(1 + \delta \right) \left( \frac{\beta_j^2}{4c_j} + \frac{\beta_k^2}{4c_k} \right) \leq \frac{\beta_j^2}{4c_j} \tag{A7}
\]

Clearly, condition (A7) is never satisfied for valid values of the discount factor. QED.

Theorem 7: If a repeated game consists of multiple regions, each with symmetric costs, then Great Power cooperation is possible provided that the discount factor is greater than \( \frac{3}{4} \).

Proof: The proof is similar to the proof of Theorem 5, except competition now occurs in \( n \) regions \( k \). Generalizing equations (4) and (7) for the spatial game provides the incentive constraint to sustain cooperation.

\[
\sum_{k=1}^{n} \frac{\beta_k^2}{4c_k} + 0 \leq \left( \frac{1}{1-\delta} \right) \sum_{k=1}^{n} \frac{\beta_k^2}{16c_k} \tag{A8}
\]

Solving for \( \delta \) produces

\[
\delta \geq \frac{3}{4} \tag{A9}
\]

QED.

The Sphere of Influence Theorem: Subject to the future discount factor, spheres of influence arise if a repeated game of Great Power competition contains multiple regions, asymmetric costs, and each Great Power is a dominant power in at least one region.
Proof: Without loss of generality, let there be \( n \) regions \( k \) in which Great Power \( a \) is the dominant power. Likewise, let there be \( m \) regions \( j \) in which \( a \) is the challenging power. Cost and benefit multipliers are region specific. Due to the definitions of dominating and challenging powers it is also the case that

\[
c^k_a \theta_k = c^k_b \quad \text{(A10)}
\]

\[
c^j_b \theta_j = c^j_a \quad \text{(A11)}
\]

Additionally, all \( \theta \in (1,2) \). Under the proposed regime, a region enters a Great Power's sphere of influence, if that Great Power is the dominant power in the region. Employing relation (9) provides the general incentive constraint for Great Power \( a \).

\[
\sum_{k=1}^{n} \frac{\beta_k^2}{4 c^k_a} + \sum_{j=1}^{m} \frac{(2 - \theta_j) \beta_j^2}{4 c^j_a} + \left( \frac{\delta}{1 - \delta} \right) \sum_{k=1}^{n} \frac{(\theta_k - 1)^2 \beta_k^2}{\theta_k^2 c^k_a} \leq \left( \frac{1}{1 - \delta} \right) \sum_{k=1}^{n} \frac{\beta_k^2}{4 c^k_a} \quad \text{(A12)}
\]

Solving (A12) for \( \delta \) and rearranging terms produces

\[
\delta \geq \frac{\sum_{j=1}^{m} (2 - \theta_j) \beta_j^2}{\sum_{j=1}^{m} 4 c^j_a} + \frac{\sum_{k=1}^{n} \theta_k^2 \beta_k^2 - 4 (\theta_k - 1)^2 \beta_k^2}{\sum_{k=1}^{n} \frac{\beta_k^2}{4 c^k_a}} \quad \text{(A13)}
\]

For this sphere of influence regime to exist, the right-hand side of (A13) must always be less than or equal to one. The is true if \( \forall \ k \)

\[
\frac{\theta_k^2}{(\theta_k - 1)^2} \geq 4 \quad \text{(A14)}
\]

It is clear that for \( \theta \in (1,2) \), condition (A12) is satisfied. QED.

Type I Proposal: An incentive compatible Great Power can encourage cooperation by removing regions from its sphere of influence, thereby returning the regions to a state of Bertrand competition.

Proof: Inequality (A15) holds for the non-incentive compatible Great Power by definition.
If the incentive compatible Great Power removes one or more regions from its sphere of influence and returns these regions to a state of Bertrand competition, then $\Pi_{dev-r}$ decreases for the non-incentive compatible Great Power. According to equation (13), the required future discount factor decreases. \textit{QED.}

Type II Proposal: \textit{An incentive compatible Great Power can encourage cooperation by ceding regions from its own sphere of influence to its rival sphere of influence.}

\textit{Proof:} This course of action has two effects on inequality (A15). As in the proof of Proposal Type I, $\Pi_{dev-r}$ decreases because those regions that are ceded are no longer eligible for future deviation. The proposal also increases $\Pi_{coop-SOI}$, which further decreases the required discount factor. \textit{QED.}

Type III Proposal: \textit{An incentive compatible Great Power can encourage cooperation by ceding regions with symmetric costs to its rival’s sphere of influence.}

\textit{Proof:} If the region is ceded, $\Pi_{coop-SOI}$ increases for the non-incentive compatible Great Power. Clearly, the required future discount factor decreases. \textit{QED.}

Proposition 6: \textit{For a single region with asymmetric costs such that $\theta \in (1,2)$, there does not exist a side payment that fosters cooperative behavior in the single-stage or repeated game.}
Proof: First, it must be determined if it is possible for the dominant Great Power to pay the challenging Great Power the amount it would receive if it challenged the dominant Great Power’s ideal level of intervention, as defined by equation (4). If cooperation is possible, it must also be the case that the dominant Great Power’s payoff, net of the side payment, is larger than its payoff under Bertrand competition. Recall that a dominant Great Power earns a payoff of \( \frac{\theta^2}{4\varepsilon} \) if not faced with a strategic challenge. If the challenging Great Power knows that the dominant power is playing \( \frac{\theta}{2\varepsilon} \), then it can win the region and earn a positive payoff by playing \( \varepsilon \) more in intervention. Its payoff in this situation is \( \frac{\theta^2 (2 - \theta)}{4\varepsilon} \). This is the minimum side payment necessary to keep the challenging power from mounting a strategic challenge. Thus the dominant power’s payoff in the side payment game is \( \frac{\theta^2 - \theta^2 (2 - \theta)}{4\varepsilon} \). Under Bertrand competition, the dominant power earns \( \frac{(\theta - 1)\theta^2}{\theta\varepsilon} \). Proposition 6 requires that the Bertrand payoff is always larger than the side payment game payoff. Rearranging the implied inequality produces condition (A16).

\[
\frac{-\theta^2 (\theta + 1)}{\theta - 1} < 4
\]

(A16)

Clearly, the numerator is negative and the denominator positive \( \forall \theta \in (1,2) \). QED.
2.7 Works Cited


CHAPTER 3

A THEORY OF COOPERATIVE TAX STRATEGIES

3.1 Cooperative Tax Strategies

A commonly cited challenge to the U.S. system of decentralized local and state public finance is the problem of costly tax competition. With the exception of anecdotal evidence, few studies of tax competition provide empirical support for the standard set of theoretical conclusions. Indeed, descriptive statistics presented in this chapter contradict key elements of the standard tax competition narrative. At the aggregate economic scale, these statistics indicate taxation among local jurisdictions is relatively uniform. However, analysis of taxation behavior at a more narrowly defined industry scale indicates a heterogeneous spatial pattern. Furthermore, the evidence concerning the impact of tax policies on gross state product is weak or contradictory. Consequently, the existing tax competition model may be too strategically simple or coarsely defined to describe the actions of local and state tax authorities. As a result, these facts cast doubt on the assertion that the U.S. system of decentralized public finance is responsible for an inefficiently low level of public revenues.

The observed behavior of state and local governments may in fact represent an optimal set of cooperative tax policies. This chapter demonstrates this proposition through the development of a theoretical model of strategically sophisticated local governments and confirms this model with a spatial econometric test. The results indicate that local and state governments
implement cooperative tax policies by employing spatially differentiated tax policies. Hence, empirical evidence that might be inferred as evidence of costly tax competition is in actuality the manifestation of strategic cooperation of local and state governments.

State and local tax competition is of considerable importance to issues of regional and urban economic development, fiscal federalism, and the role of government in society. Local government revenue constitutes a significant portion of total U.S. government revenue. For example, in 1990 state and local revenues amounted to $849 billion, while federal revenues equaled $1200 billion (Hy and Waugh 1995). Furthermore, local revenue is the primary source of funding for many public goods. Examples include education, police, fire, public health, and transportation services. These public goods constitute issues of curbside importance. That is, they are issues that can generate the most vocal complaints from the public if inefficiently provided. This chapter seeks to clarify the strategic issues associated with the taxation aspects of these local issues.

The standard stylized narrative of tax competition examines a number of jurisdictions and the tradeoff they confront between local capital investment and tax-financed public good provision. Investment in a locality of mobile capital generates land rent, which is the source of local income for private consumption. Local government is the sole provider of local public goods. Local taxation is therefore required to finance these goods. Head taxation for each jurisdiction is typically assumed impossible for a number of reasons, most notably political constraints. Thus, the jurisdiction must impose a tax on mobile capital. However, taxation of capital reduces the after-tax return to the owners of capital. Consequently, capital flees the locality for jurisdictions with higher after-tax returns, thereby reducing local private income.

Of course, every community exists within this strategic setting. The incentive of each community to reduce its tax on mobile capital results in a Prisoner’s Dilemma (PD) if the resulting Nash Equilibrium results in lower social welfare for each jurisdiction. In this case, public goods are inefficiently provided due to low tax revenue. Furthermore, private income is not increased
because each community eliminates potential competitive advantages with respect to capital allocation. Critics of fragmented local governance often refer to this dilemma as a "race to the bottom".

Almost all of the existing research is consistent with this pessimistic result. For example, the basic tax competition model, as developed by Zodrow and Mieszkowski (1986) and Wilson (1986), demonstrates the conditions in which political jurisdictions produce an inefficient bundle of private and public goods. In later work, other authors examine variants of the interjurisdictional tax competition model. These variants include restricted capital mobility, restricted and unrestricted labor mobility, factor augmenting public goods, congested public goods, multiple capital types, spatial aspects and multiple tax instruments. Although these models differ structurally, the inefficiency result concerning interjurisdictional tax competition typically remains.

In contrast, the models developed in this chapter demonstrate that the strategic possibilities present in the existing system of decentralized public finance inspire greater confidence in the ability of local governments to rationally achieve a relatively more efficient provision of public goods than the tax competition models suggest. Unlike previous analyses, the models in this chapter incorporate repeated interactions, multiple tax instruments and spatial heterogeneity. Similar to studies of price collusion among firms, a Folk Theorem result defines the potential for cooperation as a function of social discounting. The models in this chapter define the form of this cooperation in terms of taxation policies for distinct economic sectors.

Interestingly, the presence of spatial heterogeneity and multiple tax instruments enhances the potential for cooperation. Cooperative behavior in these cases assumes the form of spheres of influence; that is, differentiated tax rates among jurisdictions across production sectors. This is a counterintuitive result because conventional wisdom indicates that differentiated tax rates on mobile assets are symptoms of costly tax competition. However, the results produced in this chapter indicate that jurisdictional tax breaks for specific production

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16 Spatial heterogeneity, as defined later in the chapter, captures both the effect of the fixed location of the jurisdictions and relative differences in productive abilities for varying types of economic activity.
sectors may not only increase private income for communities, but may also improve the ability of the communities to deter cheating against a cooperative arrangement that provides for efficient funding of public services among jurisdictions. Spheres of influence are strategically preferred because they reduce the required discount factor needed to maintain cooperative behavior. Computationally, this is due to a pooling of incentive compatibility constraints for individual economic sectors or industries.

The results of this model cast a decidedly more positive perspective on the tax competition problem. With multiple production sectors and constant returns to scale in local production, jurisdictions may achieve cooperative outcomes through the use of a set of uniform or differentiated tax rates. Differentiated taxes on capital, that is defining spheres of influence, are strategically preferred. For increasing returns to scale in local production, the use of differentiated tax rates is crucial to the prospects of cooperation. Because capital is most productive when it spatially clusters, perhaps as a result of agglomeration economies, cooperation in the repeated game is impossible with only one economic sector. However, with the presence of multiple production sectors, cooperation in the repeated game is feasible, provided the jurisdictions tacitly assign spheres of influence. For the case of decreasing returns to scale, differentiated taxation of capital produces higher local income and in some cases generates a small discount factor requirement for cooperation. Therefore observed heterogeneity of tax rates across sectors and among jurisdictions cannot be interpreted as *prima facie* evidence of tax competition. Indeed, such observed behavior most likely represents a concerted attempt to generate cooperation with respect to tax policies.

The empirical results of this chapter are consistent with this theoretical model. State and local governments with increased differentiation, relative to their neighbors, in the sources of business taxation maintain overall higher levels of aggregate business taxation. States with more uniform sources of business taxation are less effective at taxation. In particular, the estimates indicate a one standard deviation increase in sphere of influence behavior generates a 7.47% increase in average aggregate tax revenue. Furthermore, those states with high taxes but low
sphere of influence behavior are clustered, indicating these regions are pursuing cooperative policies in the form of uniform taxation. Both of these strategies are consistent with the local tax policies identified in the theoretical model of this chapter. More importantly, these results indicate that government efforts to regulate or realign state and local tax policies, due to a perceived tax competition problem, lack research support. In these cases, such efforts are likely pursued to accomplish other political objectives.

The next section of this chapter presents descriptive statistics concerning tax policies, and then contrasts this evidence with the standard tax competition model. The third section contains a review of the existing tax competition literature. In addition, material concerning repeated games and sphere of influence formation is identified to establish the tools used to derive the results of this chapter. The theoretical model is then developed in which three cases of local production are analyzed. In the final section, the theoretical conclusions of this chapter are tested with state and local data. An appendix of tables of empirical results and figures of theoretical computations and maps of state and local behavior is found at the end of the chapter.

3.2 Tax Competition or Tax Cooperation?

Few studies of tax competition utilize data to generate theoretical conjectures or evaluate constructed models. To provide a basis for reevaluation of the existing theoretical tax competition framework, the following spatial statistical analysis is conducted. Data are drawn from Bureau of Economic Analysis (BEA) state and local economic data from 1999. The political unit or tax jurisdiction under investigation is the state. The state serves two roles in this analysis. It is a tax authority itself. Moreover, it is accounting unit for all local tax authorities that reside within its borders. As such, state and local authorities create a set of tax policies that are used to generate state level characteristics in this analysis. The focus here is therefore on the state as a tax environment, as opposed to the state as a political authority of local tax rates.

Gross state product (GSP) data are used as an indication of the size of both state and local economic sector activity within a given state. In particular, 1999 two-digit Standard
Industrial Classification (SIC) codes for private industries define nine distinct economic sectors within each state. The BEA also provides a measure of business taxation by state and by industry. Utilizing these data, a consolidated tax rate (CTR) is constructed for each industry at the state level. This CTR is equal to the amount of annual business taxation divided by the amount of annual output. The CTR is constructed for each state’s economy as a whole, as well as for all nine industries. It should be noted that the measure of business taxation provided by the BEA includes federal taxes. In the following statistical analysis, the constant reflects these generally uniform federal tax policies. State and local government variation in tax policies, which is observable in these data, is the primary concern of the present analysis. Table 1 presents descriptive statistics of the data used throughout this chapter.

The standard tax competition narrative indicates that state and local tax authorities have an incentive to reduce their tax rates in order to attract mobile capital. As a consequence, observers should find relatively uniform levels of tax among neighboring, and therefore competing, jurisdictions. To test this proposition, first order spatial autoregressions were estimated with state-level consolidated tax rates as the dependent variable. This specification is

\[ y = \rho Wy + \epsilon \]  

(1)

where \( y \) is a vector of the dependent variable, \( \rho \) is the spatial lag parameter, \( W \) is a spatial weight matrix, and \( \epsilon \) is a normally distributed error term (Anselin 1988). For each autoregression, the spatial weight is a simple, contiguity matrix for U.S. states. Given this definition, only the continental U.S. is included in this analysis. Note that this analysis includes the District of Columbia as a “state.”

Ten different autoregressions were estimated: one for each economic sector and one for all private industries.\(^\text{17}\) For each spatial estimate, the spatial weight matrix is row-normalized, so that the sum of each row is equal to one. The estimated spatial lag parameter indicates the

\(^{17}\) The spatial autoregressions were estimated with a maximum likelihood method using Matlab. The codes for this estimation are generously available in the Econometrics Toolbox for Matlab from James LeSage. They are available for download from the University of Toledo Department of Economics webpage.
degree of spatial association exhibited in the data. In general, this estimated value is a member of the set \([-1,1]\). Values near one suggest a spatial process similar to that of strategic complements; specifically, decreases or increases in tax rates induce similar actions by neighbors. The tax competition model suggests that the estimated spatial lag parameter should be approximately one.

Table 2 contains the results of this analysis. All the estimated values of the spatial lag parameter possessed z-probabilities of .001 or lower. The results contain consistent and inconsistent elements with respect to the existing tax competition narrative. First, all the estimated parameters are positive. Moreover, with the exception of the construction industry, parameters are close to one. This suggests that there is indeed positive, spatial association in the determination of consolidated tax rates. However, this analysis alone is not sufficient to determine whether these tax policies are inefficiently low, as the tax competition model concludes. Furthermore, the largest estimated spatial lag parameter is for the all-industries category. Hence, the greatest spatially defined strategic complementarity is found for the aggregate measure of local taxation. All of the narrowly defined industry categories exhibit less, although still significantly positive, spatial association. Maps of these data are provided in Figures 1 through 10. Figure 1 notes the relative uniformity of the aggregate case, a result that may be interpreted as evidence of tax competition, or at least policy interdependency. However, this view of tax policy is misleading, as Figures 2 through 10 demonstrate. Each of these maps displays the tax policies of state and local governments for individual industries or economic sectors. As reflected in the statistics presented above, there is much more heterogeneity present at this level of examination.

The tax competition narrative also suggests that those jurisdictions that announce tax rates lower than their neighbors should gain an economic advantage in output. Constructing a variable that indicates how a given state contrasts relative to its neighbors with respect to tax policy tests this proposition. A spatial mean is computed for each state, which indicates the average CTR for its contiguous neighbors. The deviation from the spatial mean is then calculated
by subtracting the spatial mean from the observed CTR for each state. A positive spatial deviation indicates that a state possesses a relatively higher level of taxation than its neighbors possess. Nine OLS regressions were then estimated with this constructed variable included as an independent variable. For each estimation, the dependent variable is the 1999 GSP component that accounts for the economic sector under investigation. The estimates are reported in Table 2.

The results indicate that, perhaps surprisingly, the consolidated tax rate is in general not a significant explaining factor of the size of any state-level industry. The exception is that of the wholesale sector, which is negatively impacted by high tax rates. This is an intuitive result given the relative freedom of location with respect to the location of wholesale firms. However, for the rest of the economic sectors, it appears that the consolidated tax rates are not particularly relevant in explaining the health of any given state’s sector. This result seems to contradict the underlying assumption of the tax competition literature, that capital is sensitive to local tax rate, especially relative to a jurisdiction’s rivals.

Although this evidence seems to contradict the existing models of tax competition, this chapter provides an alternative explanation. Indeed, I argue that these descriptive statistics are consistent with a model of tacit strategic cooperation among the local jurisdictions. This cooperation assumes the form of policy regimes that use differentiated and sometimes uniform taxation of specific industries or capital types. I argue that this type of strategic behavior is consistent with the observed behavior noted here: deviation from spatial means generating statistically insignificant impacts on GSP component size and less strategic complementarity at the sector level than the aggregate level. Before analyzing this proposed model of tax competition, it is important to note the existing literature on the subject.
3.3 Tax Competition Research

3.3.1 Relevant Research

Zodrow and Mieszkowski (1986) and Wilson (1986) are important foundation elements of research on the topic of tax competition. Simultaneously published, the authors argue that jurisdictions that compete for taxable, mobile capital decrease the supply of public goods below the efficient quantity. However, the notion that fractionalized local governance leads to an inefficient provision of public goods is older. As Zodrow and Mieszkowski (Z+M) note, there are three distinct conjectures concerning local government production of public goods. Williams (1966) and Brainard and Dolbear (1967) examine spillover issues with respect to local public goods. These authors demonstrate the quantity produced may be inefficient because benefits to individuals outside the jurisdiction are ignored. The second conjecture examines the problem of fiscal externalities due to population mobility. This issue is closely connected to the Tiebout hypothesis. Buchanan and Goetz (1972), Flatters et al (1974) and Stiglitz (1977, 1983) show that population mobility may result in an inefficient supply of public goods because of the resorting of the population and its concomitant effect on community preferences. Starrett (1980) and Boadway (1980) note that the exact nature of the supply inefficiency is dependent on the mode of local taxation. The final conjecture develops this point in more detail. Pigou (1947) develops the classic result that taxation is less efficient when generated by distortionary taxes, as opposed to lump sum or head taxes.\footnote{In a related vein, several authors demonstrate that if sorting of households and firms results in homogenous communities, perhaps through finely tuned zoning laws, then potentially distortionary taxation of real estate or capital achieves the efficiency of a lump sum tax. This set of articles includes Hamilton (1975), Fischel (1975) and White (1975).}

Tax competition between local jurisdictions comprises a fourth conjecture concerning the efficiency of the supply of local public goods. Oates (1972) frames this issue by stating, “the result of tax competition may well be a tendency toward less than efficient levels of output of public services. In an attempt to keep tax rates low to attract business investment, local officials may hold spending below levels for which marginal benefits equal marginal costs, particularly for
programs that do not offer direct benefits to local business.” Zodrow and Mieszkowski (1986) and Wilson (1986) offer theoretical models that examine the scenario described by Oates; namely the tradeoff between private land income and tax revenue levied on taxable capital. Z+M establish what is now the benchmark model of tax competition. The authors prove that public goods are undersupplied if a number of local jurisdictions compete for mobile capital and are required to generate revenue by taxing this asset.\(^{19}\) Of course, such taxation is distortionary because of the ability of the capital to flee from the jurisdiction if the after-tax rate of return is lower than any other jurisdiction’s rate of return.

Wilson (1986) generates a similar result, albeit in a more algebraically complicated manner. However, Wilson’s general equilibrium model proves the undersupply of public goods result through an analysis of capital to labor ratios within each jurisdiction. In particular, he finds that firms substitute labor for capital when mobile capital is taxed to fund local public services. In addition, Wilson characterizes the tax competition inefficiency as a form of fiscal externality. Wildasin (1989) characterizes this fiscal externality in more detail. He notes that the externality arises because a jurisdiction that cuts its tax rate does not account for the decrease in the tax base, the capital stock, in other jurisdictions. As an alternative explanation for tax competition, DePater and Myers (1994) identify a pecuniary externality. They show that in a setting with asymmetric jurisdictions, if a jurisdiction decreases its tax on capital, then it increases the after-tax price of capital, thereby altering the terms of trade for capital in all regions.

In response to these two foundational models of tax competition, a series of variants have explored the effects of relaxing the assumptions of or adding local markets to tax competition environment. The Z+M model, due to its relative simplicity, serves as a useful benchmark. Adopting an approach similar to studies in industrial organization that examine the effect of the number of firms on market power, Hoyt (1991a) proves that the extent of the underprovision of the public increases as the number of regions increases. In a variant

\(^{19}\) The Z+M model also allows overprovision of the public good. However, Matsumoto (1998) shows in a model of firm- and factor-augmenting public goods, that if firms are mobile, then the Z+M overprovision result is eliminated.
examining differing population sizes for the regions, Bucovetsky (1991) employs a quadratic production function to show that the residents of the smaller region is able to obtain higher utility. Wilson (1991) formalizes this result for the general case. The author's result is due to elasticities of supply with respect to capital for each region. Because of its larger labor force, the supply of capital for the larger region is relatively more inelastic. As a result, the larger region is less motivated to cut tax rates to attract additional capital. Hence, smaller regions possess a strategic advantage, enabling them to cut their tax rate, attract capital from the larger region and obtain a utility level higher than the Pareto equilibrium, as defined for both regions.

Hwang and Choe (1995) examine the effect of heterogeneous factor endowment of capital on local tax competition. The authors find that if income effect of the public good is zero, then a poorly endowed, larger region adopts a high tax rate and gains less utility than its smaller rival jurisdiction. However, if the public good is defined as a normal good, then a poor large region may retain the high tax rate, but gain a higher utility than its rival, provided the region is not too large in population.

Lee (1997) develops a two-stage model of imperfect capital mobility. In the first stage, capital is perfectly mobile. However, in the second stage, capital relocation requires a transaction cost. Contrary to other studies of tax competition, Lee finds that this variant may result in the overprovision of the public good in the second period. In addition, the author proves that the competition for capital in the first period is more aggressive due to the constrained mobility of capital in the second period. This finding is consistent with earlier work by Coates (1993). Coates employs a repeated game, as does the model in this chapter, to study tax competition. He finds that if head taxation is available, then the competition for capital leads to negative property tax rates or subsidies to attract mobile capital. Although the instruments are different, the Coates model is the extreme case of the Lee framework with respect to competition for future capital return. Furthermore, Coates finds that collusion by local governments on tax rate choice is
welfare enhancing, although he models this as imposed by a federal authority. In contrast, the models in this chapter show that local governments can achieve and sustain with greater confidence collusive tax rate assignments.

Smith (2000) examines a single shot model in which distinct types of capital are present. She finds that it may be welfare enhancing to tax the types of capital with different rates. However, she notes that the underprovision of public goods result is still present. Indeed, this result is due to the single shot nature of Smith’s model. Regardless, the concept that differentiated taxation of capital can be welfare enhancing is crucial for the results of the models derived below.

Burbidge and Myers (1994) examine the impact of imperfect population mobility. In their model, individuals gain utility from living in their home or preferred jurisdictions but are capable of relocating. The authors find that in this setting, the resulting Nash equilibrium is inefficient. However, they note that the efficient Nash equilibrium solution can be achieved if a resource transfer occurs between the jurisdictions to reduce population mobility. Hoyt (1993) is also an examination of population mobility and tax competition.

Richter and Wellisch (1996) study a model of mobile labor and firms in a model of tax competition. In their model, local governments can provide local public goods, for residents, and local public factors, for firms. They find that an efficient provision is achieved if no rents flow out of the jurisdictions to absentee firm owners. On the other hand, if rents flow out only local public goods are supplied efficiently. The ability to tax efficiently arises in the authors’ model because rents accrue to mobile firms who possess immobile factors of productions, which are responsible for the rent. The inefficiency associated with public factors is a result of the jurisdictions’ attempt to tax rents that leave the jurisdiction. Duranton and Deo (1999) examine the financing of public services that possess only a productive effect; that is, the public services do not increase residential utility directly. In the authors’ model, capital and labor are perfectly mobile. Their results indicate that inefficient provision occurs in an environment of multiple jurisdictions.
Matsumoto (2000) develops a model with congestible public inputs that are financed by a profit tax on mobile firms. Consistent with existing studies, he finds that interjurisdictional competition results in an underprovision of such public inputs.

Wilson (1995) constructs a model with mobile labor and multiple tax instruments. In his model, the jurisdictions are able to tax capital and labor. Wilson demonstrates that scale economies in the production of the public good entice the jurisdiction to adopt a property or capital tax. However, there are no increased incentives to reduce the public good provision further. Wilson also shows that the use of the labor or head tax, which is distortionary due to population mobility, also generates underprovision of the public good.

Other analyses of multiple tax instrument availability exist. Bucovetsky and Wilson (1991) prove that in the case of labor immobility, a wage tax or head tax on labor is preferred over a distortionary tax on mobile capital. Wildasin (1991) outlines a more general problem of local government behavior in which a number of strategic variables are available. His theoretical model, called duopolity theory, consists of two stages. In the first, the governments announce which variables or policy instruments will be employed. In the second stage, the policies are announced. Braid (1996) examines a hierarchical model of tax competition with multiple tax instruments. His model consists of a number of jurisdictions located within metropolitan areas, which in turn are located in a world economy. Due to the complementarity between labor and capital in local production, Braid finds that if jurisdictions can tax both metropolitan-mobile labor and world-mobile capital, it is optimal in the Nash Equilibrium to tax both. However, consistent with earlier models, the equilibrium is not efficient relative to a centralized approach. Additionally, Braid states that if local production is weakly separable in labor, then property taxation dominates wage taxation. Furthermore, similar to Hoyt’s (1991a) analysis, Braid notes that as the number of jurisdictions increases, the use of wage taxation decreases in favor of property taxation.

In further work, Braid (2000) develops an explicitly spatial model in which workers can commute to one of two employment jurisdictions within a metropolitan area. If the jurisdictions can choose between a wage tax and tax on mobile capital, then both jurisdictions choose the
wage tax. This result is due to costless mobility of capital and costly relocation of workers, modeled as commuter costs. Oshawa (1999) also develops an explicitly spatial model of tax competition, albeit taxes on retail sales. Consistent with Hwang and Choe (1995), in Oshawa’s model, small governments are able to set lower tax rates and capture a disproportionately large quantity of government revenue in the Nash Equilibrium. Also, Oshawa demonstrates that jurisdictions located in advantages, namely central, locations are able to set lower tax rates in equilibrium. His results confirm the importance of spatial effects in tax competition models.

A different variant of the spatial approach is the metropolitan model. These tax competition models are constructed around an urban model of residential location and worker commuting to a central business district. Pioneering examples include Epple and Zelenitz (1981) and Henderson (1985). Unlike other models of tax competition, in which property taxation is typically modeled as a tax on mobile capital, property taxation in a metropolitan model is modeled as a tax on housing consumption. Studies of metropolitan models with tax competition include Hoyt (1991b), Hoyt (1992), Krelove (1993) and Noiset and Oakland (1995). For example, Krelove’s model indicates that tax rate choice and public good provision is inefficient due to the fractionalized nature of governance in the metropolitan area. However, unlike most other models of tax competition, Krelove notes that underprovision and overprovision of the public good are possible.

Noiset and Oakland’s model represents the most sophisticated model of the metropolitan type. Their model consists of a central city that is both an employment center and a taxing and spending authority. The rest of the metropolitan area consists of an outer suburb. The suburb has no political authority and thus acts only as a bedroom community for the workers in the metropolitan area. Because the suburb does not tax property, the model is not strategic in tax choice. However, the results offer insights into the spatial/urban implications of tax rate choice. The authors find that the central city, which desires to maximize land rents, inefficiently taxes and provides public goods. Similar to Krelove, Noiset and Oakland note that an underprovision or overprovision is possible. Furthermore, the authors note that the source of the externality is the
ability of the central city to export a part of the tax burden to the suburb; that is, the cost of taxation, diminished land rent, also falls on the suburb because of the construction of the metropolitan model. This reduction of land rent in the suburb is not taken into account by the central city, so its decision is not Pareto optimal. The nature of this externality is responsible for the outcome in which property taxation may in fact be too high.

Several papers examine the effect of the incentives of other governments in a hierarchical or federal system of governance. Hoyt and Jensen (1996) demonstrate that state governments, through the use of grants, mandates and subsidies, can overcome the tax competition problem. In particular, the state government is able to accomplish this by precommitting to a set of policies that alter the incentives of the competing local governments. However, the assumption that state governments are not subject to political pressure that may result in a change in policy is unfounded. In fact, Bensen (1990) provides evidence that the Federal government creates incentives for tax collusion that results in too much taxation. These incentives manifest in the federal tax code in the form of state and local tax deductions. However, Bensen notes that remaining non-tax competition, such as tax exemption or other types of local spending to attract business, dissipates the reduced cost of tax competition.

Bucovetsky et al. (1998) also note that problems exist in the ability of the federal government to effectively deal with tax competition if information asymmetries exist within the levels of government. Dhillon et al. (1999) also examine information issues, but for the case of tax coordination among local governments. The authors examine the case of an output tax. Interestingly, the authors find that differentiated tax rates across jurisdictions may be required to sustain collusion in the presence of imperfect information. The authors’ approach is different than the analysis in this chapter because the authors do not consider a repeated interaction.

Konrad and Schjelderup (1999) examine a case that focuses on international capital allocation but is relevant for urban tax competition. The authors wish to study the ability of a group of jurisdictions to harmonize their tax rates. They call this process “fortress building.” The goal of this effort is to simultaneously increase their tax rates to more efficiently finance a public
good. However, the model is weaker than the analysis in this chapter because the coalition is assumed and defection is not considered. Although labeled a non-cooperative game theoretic model, it is actually a cooperative game theoretic model. Thus, unsurprisingly, the authors find that the cooperating countries realize gains in utility through tax harmonization, provided the underlying strategic interdependence in tax rates is a game of strategic complements.

Rauscher (1998) pursues an alternative line of reasoning. Although his model employs a user charge or benefit tax on public services, Rauscher shows that tax competition may in fact increase the efficiency of public services if a Leviathan, or corruptible, form of government is in place. Because each jurisdiction must attract capital, the ability of local jurisdictions to tax and waste local assets is accordingly reduced. Thus, benefit tax competition acts to tame the Leviathan.

Use of data in studies of tax competition is limited. Nechyba (1997) and Buettner (2000) are notable exceptions. Nechbya employs a computable general equilibrium of New Jersey data to examine the use of local property and income taxes. He finds that city officials have a dominant strategy to set a zero tax rate for income taxation due to population mobility potential and voter anger. His results arise because his public choice mechanism differs from other studies. In Nechyba’s model, the residents of a jurisdiction determine the property tax rate and local politicians determine the local income tax rate. He notes that collusion among local governments to establish an income tax is only enforceable with the help of state or federal government, perhaps through the introduction of grants.

Buettner (2000) tests a version of the standard tax competition model using panel data from Germany. Employing a spatial instrumental variables technique (Kelejian and Prucha 1998), Buettner’s results confirm a number of conclusions from existing models. First, he finds that neighbors’ tax rates are strategically interdependent. In particular, he notes that this is a relationship of strategic complements. Furthermore, consistent with existing theoretical findings, he shows that smaller jurisdictions enact smaller tax rates if involved in interjurisdictional competition.
3.3.2 Summary

A large and rich literature on local government tax competition exists within the urban and public economics fields. Zodrow and Mieszkowski (1986) and Wilson (1986) establish the benchmark result: jurisdictions that tax mobile capital enact inefficient tax rates and inefficiently supply local public services. A number of variants are worth noting. Labor mobility does not significantly alter this result. For example, Lee (1997) finds that the presence of labor mobility does not change the inefficiency result. The size of the jurisdictions apparently does have an impact on the equilibrium tax rates. Wilson (1991) and Hwang and Choe (1995) show that smaller regions, as defined by population, are able to set smaller tax rates and capture disproportionately large amounts of government revenue. The spatial location affects tax rate choice as well. Braid (1996, 2000) notes the effect of commuting costs and overlapping labor markets on property and wage tax choice. Oshawa (1999) notes that jurisdictions with the exogenous strategic advantage of a centralized location are able to enact lower tax rates and raise a disproportionately larger amount of government revenue. Although almost all studies find that public services are undersupplied, some studies indicate that public services may be oversupplied. For example, Noiset and Oakland (1995) find that central cities disregard the costs of taxation on neighboring jurisdictions within a metropolitan model, and thus, raise too much revenue. Finally, differentiated types of capital may result in differentiated tax rates for each (Smith 2000).

Existing solutions to the tax competition problem hinge on action by state or the federal government that creates incentives to correct the fiscal externality. Examples include Hoyt and Jensen (1996), Bucovetsky et al. (1998) and Dhillon et al. (1999). Coates (1993) also suggests that a federal authority is required to correct tax competition. As the models developed in this chapter will demonstrate, this is surprising given Coates’ use of a repeated game. Konrad and Schjelderup (1999) show that colluding jurisdictions can increase their welfare by raising their taxes; however, the authors’ results require assuming that the jurisdictions do not defect. The present chapter will consider the possibility of defection.
As a set, the existing literature is quite pessimistic. The published theoretical studies indicate that the existence of decentralized jurisdictions responsible for financing local public goods results in an inefficient result. This conclusion appears to hold for a wide array of tax instruments, jurisdictional definitions and modeling frameworks. I believe that an important element of tax competition has not been examined. This element, the strategic aspect of public choice, requires a review of a few studies of repeated strategic interaction.

3.3.3 Repeated Games

A consequence of local jurisdictional interaction is the fixed spatial nature of the strategic interdependency. Moreover, Buettner (2000) indicates that the strategic interaction between local governments spatially decays; that is, the intensity of competition declines as distance between jurisdictions increases. Thus, the rivals of any given jurisdiction with respect to a tax competition game are known and almost constant. As such, the tax competition game of local jurisdictional tax assignment is an iterated spatial game.

Coates (1993) develops a repeated game to examine tax competition. However, Coates' model is not a useful strategic analysis of the tax competition problem. First, his model examines the use of head taxation, often eliminated from discussions of tax competition due to its non-distortionary characteristics in most models. Second, Coates does not attempt to determine a Pareto improving coordinating iterated equilibrium or a policy regime in which the competing jurisdictions achieve a more efficient provision of local public services. For these reasons, I believe the strategic issues surrounding the iterated nature of tax competition have been ignored.

Studies of repeated interactions follow a standard approach. First, the single round Nash Equilibrium is identified. For interesting cases, this single stage game Nash equilibrium is consistent with a Prisoner’s Dilemma (PD). The race-to-the-bottom is an excellent description of a PD policy environment in which the players, the jurisdictions, pursue inefficient policies due to a

\[\text{PD}\]

\[\text{Situations in which the rivals change include the development of new communities and the redrawing of political boundaries.}\]
strategic interaction. Next, a study of a repeated game characterizes the collusive or preferred policy profile. For example, for a study of collusive firm behavior, the cartel solution characterizes the collusive strategy profile for the firms (Tirole 1995). For a game of tax competition, the preferred strategy profile defines a set of tax rates that enable efficient provision of public services.

The test of feasibility of a collusive strategy is the potential for defection in any given round. Each jurisdiction knows that it can find an optimal defection tax rate, given that its rival or rivals adopt a collusive strategy in some round. Because the game is a PD, the payoff for the defector is increased. However, a preannounced punishment follows. One such punishment strategy is the trigger strategy, which requires the cheated jurisdiction to cut its tax rate to zero, thus generating a state of extreme tax competition.

With the punishment strategy, a Folk Theorem result can be derived (Tirole 1995, Fudenberg and Tirole 1998). The Folk Theorem describes the potential for cooperation, or tax coordination in this case, as a function of social discounting. Recall that punishment occurs in rounds after cheating. However, this punishment stream is discounted because it occurs in the future. So, if the payoff from cheating is greater than the punishment cost, then defection occurs and consequently the cooperative regime is not feasible.

Bernheim and Whinston (1990) examine the prospect of price collusion among firms. The game developed in the present chapter furthers their framework. Bernheim and Whinston formally establish the conditions under which collusion is possible in an iterated price game of multimarket contact. Among their findings, they conclude that multimarket contact only increases the ability to collude when strategic differences are present in the linked markets. One such scenario involves what the authors call spheres of influence, or markets in which a single firm acts as a monopoly. Spagnolo (1999) proves that multimarket or multicontext interaction always eases cooperation between agents in games with strictly concave objective functions. Consistent with the model in this chapter, Spagnolo demonstrates that linking markets can create cooperation, even if such cooperation is impossible within individual markets. In chapter 1 of this
dissertation, I develop a sphere of influence game for Great Power competition in international relations. The game developed in that chapter is similar to the approach taken in examining the prospects for cooperation in a game of tax cooperation.

This linkage of issues or markets drives the results in this chapter. Formally, a game with linked policy issue enables the jurisdictions to use slackness in their ability to cooperate on one issue to cooperate on another. Recall that the typical Folk Theorem result is determined by examining whether the discounted gains from cheating exceed the discounted flow of cooperative benefits. As such, the result is primarily a function of the discount factor. This constraint is called the incentive compatibility constraint. For a multicontextual strategic interaction, the gains from cheating and the benefits from cooperating from every issue or context are pooled into a single incentive compatibility constraint. Thus, slackness in a previously independent incentive compatibility constraint can be used to enable cooperation for the entire bundle of contested issues. In certain contexts, games of strategic complements, this aggregate cooperation takes the form of spheres of influence; or segregation of interests to enable increased benefits, increased ability to punish and consequently a lower required discount factor. In games of strategic substitutes, cooperation across contexts assumes the form of what I have termed zones of control, or an entwining of actions within contexts. The next section of the chapter employs these concepts in a series of models of interjurisdictional tax competition.

3.4 A Model of Cooperative Tax Strategies

The models developed in this chapter contrast with existing theories of tax competition. For the case of constant returns to scale in local production, a cooperative outcome is feasible when there is a single economic sector. If the sector is not symmetric with respect to jurisdictional productivity, it is more difficult to sustain cooperation. The benefit for cheating is higher and the cost of punishment is lower for the relatively efficient jurisdiction. However, this relative inefficiency only manifests itself if it is not perfectly reflected in local land rent. With multiple production sectors, the jurisdictions may achieve cooperative outcomes through the use
of a set of uniform or differentiated tax rates. The required social discount factor is the same for each, if the production sectors are of identical size. Otherwise, the differentiated tax rates require lower social discounting to achieve cooperation. These differentiated taxes delineate the production sectors in spheres of influence and offer a different conclusion when observing tax rate differences. In this model, such differences reflect a determined attempt to achieve cooperation.

This conclusion about the use of differentiated tax rates is more important for the prospects of cooperation in the case of increasing returns to scale in local production. Because capital is most productive when it clusters, perhaps as a result of agglomeration economies, cooperation in the repeated game is impossible with only one economic sector. However, with the presence of multiple production sectors, cooperation in the repeated game is feasible, provided the jurisdictions assign sphere of influence. In this setting a jurisdiction announces some tax rate for all economic activities. However, for its sphere of influence, the jurisdiction announces a rate lower than its rivals, thereby attracting capital for local income and as a source of public taxation. As in the CRS case, this may appear to be a situation of costly tax competition. In actuality, this strategic option represents the best possibility for achieving a cooperative outcome with respect to taxation of a mobile asset.

The case of decreasing returns to scale in local production is computationally more complex. Cooperation is clearly feasible if there is only production sector, whether symmetric or asymmetric with respect to local productivity. Evaluation of which case is more difficult to sustain against defection is dependent on the realized values of the parameters. With multiple capital types, cooperation is again shown to be feasible. Dependent on the realized values of the structural parameters, the uniform set of tax rates or the differentiated, sphere of influence set of tax rates may be preferred. Because of the local land rent benefits from agglomeration of one capital type, the sphere of influence tax strategy is typically preferred. The uniform set of tax rates is only strategically preferred in the case in which one or more jurisdictions does not
maintain the incentive capability constraint on social discounting for the differentiated set of taxes. It is thus a second-best strategic option for cooperation in settings in which one jurisdiction does not possess the patience for the sphere of influence option.

3.4.1 The Model

The players of the tax competition game are local political jurisdictions. Each is modeled as a representative agent of its community.\textsuperscript{21} Social welfare for the community is determined by a utility function for this agent. Utility is defined in jurisdictional consumption of a private and a public good. The goods are imperfect substitutes. This is an important assumption. If the goods are complements, then a tax competition problem does not exist because of the need for a public good. Alternatively, if the goods are perfect substitutes, then the jurisdictions simply seek the highest quantity of both goods. As imperfect substitutes, diminishing marginal returns for consumption of both goods motivates the demand for quantities of both goods. Jurisdiction $i$'s preferences are modeled as

\begin{equation}
U_i = \ln(c_i) + \eta \ln(p_i)
\end{equation}

where $c_i$ is total private consumption, $p_i$ is total public good consumption and $\eta$ is a preference parameter governing the desired mix of private and public consumption. Normalize the price of the private consumption good equal to one. Land rent generates income for jurisdictional private consumption. The jurisdiction earns land rent either as a residual claimant or as a factor payment.\textsuperscript{22} For example, suppose $r_i$ is the amount of land rent charged for each unit of capital located in jurisdiction $i$. In this case, the budget constraint for private consumption for jurisdiction $i$ is

\begin{equation}
\text{land rent}\end{equation}

\textsuperscript{21} One implication of the representative agent specification is that a labor market is not explicitly modeled in this paper. The existing theoretical research indicates that the inclusion of mobile labor does not significantly alter the tax competition problem. The focus of this research is the ability of communities to differentially tax distinct production sectors. Inclusion of a labor market creates a taxable source that affects all sectors. As such, it has no direct importance here. However, differentiated taxation of different types of workers may be captured in this model as an application of a tax on a particular section. In particular, this taxation would be levied on labor intensive sectors.

\textsuperscript{22} In the decreasing returns to scale model, land rent is the residual. For the constant and increasing returns to scale models, land rent is a factor payment.
The regional supply of capital is fixed. Define \( \bar{K} \) as this quantity. As in other models of tax competition, this is only assumed to improve tractability.\(^{23}\) Capital is allocated among jurisdictions to maximize profit for capital owners. Capital is perfectly mobile and may relocate without cost in any round. The models explored in this chapter involve two players or jurisdictions.\(^{24}\) Thus,

\[
\sum_{i=1}^{2} K_i = \bar{K}
\]

Some variants of the models in this chapter examine distinct types of capital. In this case, a superscripted letter notes the capital type.

Each jurisdiction assesses a tax on capital. Let \( t_i \) be the per unit tax on capital in jurisdiction \( i \). Land rent and capital taxation comprise the relevant costs for capitalists.

Production of a private good, with a price of one, defines revenue for capitalists. Production is monotonically increasing in jurisdictional capital, as defined by \( F(K_i) \).\(^{25}\) Accordingly, the profit function, \( \Pi_i \), for capital owners in jurisdiction \( i \) is

\[
\Pi_i = F(K_i) - r_i K_i - t_i K_i
\]

For computational simplicity, no capital is owned by regional landlords. Consistent with other models of tax competition, head taxation or taxation of immobile assets is prohibited.

Jurisdictions are the only institutions capable of producing the local public good. Every unit of public production requires a dollar of jurisdictional tax revenue. Therefore, the public budget constraint for jurisdiction \( i \) is

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\(^{23}\) The existence of a supply function for regional capital that is not completely inelastic emphasizes the distortionary nature of a tax on capital, as opposed to a non-distortionary head tax. However, the focus of this paper is the fiscal externality that is a result of jurisdictional competition.

\(^{24}\) Although not demonstrated in this paper, the game may be generalized for \( n \) players. In general, this would serve to strengthen the results of the paper. Cheating in \( n \)-player games would not increase benefits significantly over cheating in a two-player game. However, punishment would be more severe. Hence, as in other Folk Theorem style models, the requirements for adhering to a cooperative regime are relaxed.

\(^{25}\) The exact nature of the production function is specified by three cases concerning returns to scale. Each is examined later in the paper.
To examine stable Nash Equilibria, the public good takes a discrete form. Thus, jurisdictions choose from a menu of public sector projects of fixed size. Furthermore, the communities possess the option to finance no public projects. In the following models, two levels of public expenditure are considered: high ($p_h$) and low ($p_l$).

Within this context, a set of games is examined. Each variation presents a different type of production returns to scale. The constant returns to scale (CRS) case is developed first because it is the simplest. The techniques for solving the model and proving the results of this model are consequently considered with more detail. The increasing return to scale (IRS) case is the most extreme case. It highlights the use of a sphere of influence result for tax assignment. Finally, the decreasing returns to scale (DRS) case is examined. This case is the most relevant vis-a-vis the existing tax competition literature.

3.4.2 Constant Returns to Scale

Suppose the local production function is characterized by constant returns to scale. Define local production as

$$F(K_i) = \alpha K_i$$  \hspace{1cm} (7)

In this setting, capital locates en masse to the jurisdiction with the highest after-tax marginal product. In the case of equal jurisdictional marginal products, the capital stock is evenly divided between the two localities.

The first step in analyzing this case is to determine if a Prisoner's Dilemma exists in the single-stage game. Each jurisdiction desires to finance the large public good. However, if either jurisdiction possesses an incentive to cut its tax rate to a level sufficient to finance the smaller public good, while simultaneously increasing private income, then a PD may exist. The PD exists if the following inequality is satisfied.
\[
\ln \left( r, \frac{K}{2} \right) + \eta \ln (\rho_n) \leq \ln (r, K) + \eta \ln (\rho_n)
\]  

(8)

The first term of (8) measures private consumption in a regime in which each jurisdiction finances the larger public good. The second term captures the utility gained from this public good consumption. The right-hand-side defines the alternative: to defect. In the case of defection, the jurisdiction gains the entire capital stock and is able to finance the large public good. Simplifying (8) demonstrates that the PD always exists.

However, as is the case with any PD, the players involved in the strategic interaction may be able to rationally sustain a cooperative solution. As noted earlier, cooperation is sustainable provided that the discounted flow of a single round of cheating followed by punishment is less than the discounted flow of benefits under cooperation. Inequality (9) provides this condition for an infinitely repeated game.

\[
\Pi_{\text{cheat}} + \sum_{t=0}^{\infty} \delta^{t+1} \Pi_{\text{punish}} \leq \sum_{t=0}^{\infty} \delta^t \Pi_{\text{coop}}
\]  

(9)

For the models in this chapter, the variable \( \Pi \) measures the utility realized by a given jurisdiction under the following outcomes: cheating, punished and cooperating. The parameter \( \delta \), the social discount factor, is a number between one and zero. The larger \( \delta \) is, the greater the weight the jurisdiction places on future benefits and costs. If the discount factor is zero, the jurisdiction only gains utility from the present time period. It receives no welfare from the future. This represents a situation in which the jurisdiction is completely impatient. On the other hand, a discount factor of one indicates a jurisdiction that is completely patient. Benefits in future periods are just as valuable as benefits in the current period. Let the discount factor be exogenously determined. Solving the infinite series of (9) generates

\[
\Pi_{\text{cheat}} + \left( \frac{\delta}{1-\delta} \right) \Pi_{\text{punish}} \leq \left( \frac{1}{1-\delta} \right) \Pi_{\text{coop}}
\]  

(10)
To sustain cooperation, each jurisdiction must choose and announce a punishment strategy. A trigger strategy is often used for its modeling simplicity. If a rival jurisdiction deviates from the cooperative strategy profile, the cheated jurisdiction reduces its tax rate to zero for the remainder of the game. It should be noted, that ceteris paribus, if it rational for both jurisdictions to adhere to the cooperative regime of strategies, then no cheating occurs. As such, the trigger is not employed. Instead, the trigger is analytic tool used to measure the feasibility of sustained cooperation for a repeated strategic interaction. Tit-for-tat could also be employed by the jurisdictions.

Solving (10) for $\delta$ provides a condition on the potential for cooperative behavior. This condition is known as the incentive compatibility constraint for cooperative behavior in the iterated game. If both players possess a discount factor large enough to rationally adhere to a cooperative regime of actions, then the cooperative strategy profile is adopted. However, if either jurisdiction fails this qualifying condition, then cooperation is not sustainable. Therefore, the required discount factor is used in this chapter as the focus of the potential for sustained cooperative outcomes.

The next step in determining the potential for a cooperative solution is to solve for the required discount factor. To do so, each of the terms of (10) must be defined. In the cooperative regime, both jurisdictions finance the large public good. Because the jurisdictions are symmetric, after assessing the appropriate tax rate, the jurisdictions possess an equal after-tax marginal profit. Thus, the regional capital stock is divided between the jurisdictions. Hence, if the jurisdictions cooperate, they each gain land rent from half the capital stock. Additionally, they each finance the large public good. The utility earned from this arrangement is found on the right-hand-side of (11). Alternatively, the jurisdiction may choose to defect from this cooperative

\[26\text{ Alternatively, an off-equilibrium path exists. In this situation the players engage in the cooperative solution, and cheating does occur. Punishment in this setting is infinite. It is not rational for the cheated jurisdiction to "restart" the game because it has learned that its rival will cheat. The only manner in which the game could restart is if some common-knowledge signal existed that credibly indicated that the cheating jurisdiction's social discount factor increased. Then it is rational for the game to restart and a new cooperative path may emerge.}\]

\[27\text{ A tit-for-tat game is less conceptually restrictive than the trigger game. In tit-for-tat, a round of cheating is followed by a round of punishment. It is thus a game of imitation where cooperation is sustained because it is ultimately more valuable to both parties. Punishment is a less effective threat in this game. For more information on repeated games and punishments, consult Fudenberg and Tirole (1998).}\]
To accomplish this task, it marginally reduces its tax rate. Consequently, the entire capital stock allocates into that jurisdiction for the defection round. The defecting jurisdiction is also able to finance the large public good because its capital stock doubles, while its tax rate has only decreased marginally. The first two terms of the left-hand-side represent the benefit from a single round of defection. Finally, if defection occurs, the aggrieved rival invokes its trigger strategy. As a consequence, the defecting jurisdiction only obtains a punishment payoff for remaining rounds. In the CRS game, the punishment results in no public good financing, but an equal division of the capital stock. The punishing player adopts a zero tax rate. Substituting these values into (10) produces

\[
\ln(r, \bar{K}) + \eta \ln(p_n) + \left( \frac{\delta}{1 - \delta} \right) \ln \left( r, \frac{\bar{K}}{2} \right) \leq \left( \frac{1}{1 - \delta} \right) \left( \ln \left( r, \frac{\bar{K}}{2} \right) + \eta \ln(p_n) \right) \tag{11}
\]

Solving for \( \delta \) finds

\[
\delta \geq \frac{\ln(2)}{\ln(2) + \eta \ln(p_n)} \tag{12}
\]

If the required discount factor is greater than one, then the incentive to cheat is always too strong, and no cooperation is feasible. Clearly, the required discount factor for this strategic setting is less than one, so the cooperative solution is feasible. However, this is not a guarantee that cooperation occurs. Rather, (12) identifies the lower bound for realized discount factors of jurisdictions.

Interestingly, it is more difficult, in required discount factor terms, to achieve cooperation with the smaller level of public expenditure. To find the requirement for the policy regime, a condition similar to (11) is constructed, except the cooperative payoff includes the smaller public good, while defection again involves no financing of a public good. After solving, the requirement for sustaining cooperation involving the financing of the smaller public good is

\[
\delta \geq \frac{\ln(2) + \eta \ln(p_n) - \eta \ln(p_i)}{\ln(2) + \eta \ln(p_n)} \tag{13}
\]
Clearly this requirement is always less than one. However, it is also always larger than the requirement found in (12). The reason for this result is that under the smaller public project, the flow of benefits under cooperation is smaller. Hence, the attractiveness of cheating increases. Thus, it is actually more difficult to obtain cooperation for the smaller project. Note the contrast of this result with the existing literature. Cooperation is more likely in the repeated game with higher, not lower, levels of taxation.

3.4.3 CRS Model with Asymmetric Productivity

The preceding analysis assumed that each jurisdiction possessed an equivalent rent for land. Given that each jurisdiction possessed equivalent production possibilities, this is not an unwarranted assertion. Instead, suppose that although the communities retain identical preferences, they differ in exogenous productive efficiency. These localized differences may be the result of natural resource differences, weather or relatively immobile population characteristics. Another source of such efficiency effects is the possible difference in transport costs due to the spatial array of the jurisdictions. As such, suppose the efficiency difference assumes the form of a Samuelson iceberg transport cost. Let the relatively inefficient jurisdiction $j$ possess a production function of

$$F(K_j) = \alpha c K_j$$

(14)

where $c$, the spatial or efficiency parameter, is less than one but greater than zero.

As is standard in the urban economics literature, such exogenous relative location attributes are capitalized into local land prices. To attain the set of land rents, suppose the existence of a reserve land rent, $r$. This is the rent of the inefficient jurisdiction. Using the differences in the marginal products of the jurisdictions, the efficient community’s land rent is

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28 A Samuelson iceberg transport cost is a convenient modeling technique to account for lost profits or decreased consumption due to transport. Typically, a model with such costs assumes a stock of a good and a distant consumption location. To capture the effect of transport costs, the stock of the good undergoes a limited “melt,” or a decrease in the overall stock of the good. In the model presented here, this cost is represented by a fractionalized production function.
easily found. Equation (15) states that the marginal productivity of capital in each jurisdiction must be equal after exogenous efficiency effects and endogenous land rent are determined.

\[
\alpha - r_e = \alpha c - r \tag{15}
\]

\[
r_e = r + \alpha (1 - c) \tag{16}
\]

where \( r_e \) is the land rent of the efficient jurisdiction.

Interestingly, differentiated land rent in this setting has no effect on the game. Provided there are no remaining differences in the marginal product of capital, the jurisdictions compete for capital on equal terms. More surprisingly, the increase in income for landowners in the efficient jurisdictions has no effect on its discount factor requirement in the repeated game. This is verified by noting the discount requirement in the symmetric game does not include the rent parameter. This is curious because the increase in private consumption increases the disparity between the marginal utility of private and public consumption. However, the constraints of the game, most notably the capital market itself, are the determinants of this result. Differences in marginal products are correspondingly eliminated due to the trade-off between defecting and being punished.

However, suppose that the production disparity is not perfectly capitalized into land rent. Given that land prices are a product of the interaction of multiple real estate markets, this is a likely scenario for an individual economic sector. Let \( r \) equal the unit land rent in each jurisdiction. In this setting, the production asymmetry alters the potential for cooperative outcomes. For each jurisdiction to possess some positive amount of the regional capital stock, the following capital market condition must hold.

\[
\alpha c - r - t_w = \alpha - r - t_e \tag{17}
\]

The variables \( t_w \) and \( t_e \) are the tax rates of the inefficient and efficient jurisdictions respectively. Because the disadvantaged jurisdiction must offer a discount on its own tax rate to attract capital, the first priority of the community is to attract capital to generate land rent. Thus, suppose this community chooses a zero tax rate. Three cases arise.
1) $\alpha(1 - c) > \frac{p_n}{K}$  

In this case, the after-tax marginal product of capital of the efficient jurisdiction always exceeds the marginal product of the inefficient jurisdiction. Therefore, there is no strategic interaction between the communities. All capital flows to the more efficient jurisdiction, which finances the large public-sector project.

2) $\alpha(1 - c) > \frac{p_l}{K}$  

If the first condition fails but this conditions holds, then the smaller public project can be financed without fear of capital flight. The efficient community must decide whether to pursue a low level of taxation or raise its tax rate to the high level and in so doing lose half the regional capital stock.

3) If neither is possible, the game reverts to zero financing in the single round Nash equilibrium.

The repeated game of case 1 is trivial. The efficient jurisdiction finances the large public good and gains the entire capital stock. Accordingly, the inefficient community gains no capital. For case 3, the cooperative solution allows both jurisdictions to finance the smaller public project. However, due to the extreme nature of the competition for capital and the discrete nature of the public projects, the market requires that the after-tax marginal products of capital must be equal. Thus, the efficient jurisdiction must set a higher tax than the inefficient jurisdiction. It also has remaining public funds after financing the small public good. The inefficient jurisdiction possesses a binding public budget constraint.

Now examine case 2. The first item of interest is the decision of the efficient jurisdiction regarding its intertemporal strategy. It may choose to finance the smaller public project without strategic interference. Alternatively, it may be the case that it receives a larger payoff when it chooses to finance the larger project. This is true when
\[ \ln(rK) + \eta \ln(p_i) \leq \ln\left( r \frac{K}{2} \right) + \eta \ln(p_n) \]  

(18)

Note that in the second case, financing the larger project entails placing half the capital stock in jeopardy due to the ability of the inefficient jurisdiction to attract capital free of taxation. This can be seen in (18) on the right-hand-side. However, the tax rate required for the large public project may also allow the inefficient jurisdiction to attract half the capital stock and finance the smaller public project. The after-tax capital market condition for sharing the capital stock is

\[ t_i = t_n - \alpha(1 - c) \]  

(19)

The budget constraint of the efficient jurisdiction requires

\[ t_n \frac{K}{2} = p_n \]  

(20)

Substituting generates a condition on the relative sizes of the possible public projects in order for the efficient and inefficient jurisdictions to finance the large and small projects respectively.

\[ p_i < p_n - \frac{K}{2} \alpha(1 - c) \]  

(21)

If this condition fails, then the inefficient jurisdiction adopts a zero tax rate. Mindful of this, the efficient jurisdiction chooses to finance the smaller project. However, if the above condition is true, then the discount factor requirements for both jurisdictions can be found for the following scenario. The efficient jurisdiction finances the large project, and the inefficient jurisdiction finances the small public project. The requirement for adherence of the efficient jurisdiction to this cooperative regime is

\[ \ln(rK) + \eta \ln(p_n) + \left( \frac{\delta}{1-\delta} \right) \left[ \ln(rK) + \eta \ln(p_i) \right] \leq \left( \frac{1}{1-\delta} \right) \left[ \ln(r \frac{K}{2}) + \eta \ln(p_n) \right] \]  

(22)

Note in the left-hand-side of (22), the first two terms account for the defection strategy of the efficient jurisdiction. It is the same as previous defections in the case of a cooperative policy.
involving the large public good. Also note, given that case 2 is being examined, the cooperative regime involves only half the capital stock for both jurisdictions. This is seen on the right-hand-side of (22). Solving yields

\[ \delta \geq \frac{\ln(2)}{\eta(\ln(\rho_n) - \ln(\rho_i))} \]  

(23)

Note that the initial assumption regarding the payoff of the efficient player insures that this ratio is less than one. More importantly, inspection of this value proves it to be larger than the requirement in the symmetric case, as seen in (12). The benefit for cheating is higher and the punishment is lower for the efficient jurisdiction due to the productivity difference. Hence, cooperation is less feasible. The corresponding condition for cooperation for the inefficient jurisdiction is less stringent because of the inefficient jurisdiction’s desire to attract capital and provide public expenditures; actions that are impossible in the single round Nash Equilibrium. Thus, if both jurisdictions possess identical social discount factors, it is the efficient jurisdiction’s incentive compatibility requirement that is binding.

3.4.4 CRS Model with Multiple Production Sectors

The introduction of multiple private production sectors generates strategic flexibility in the taxation decisions of the local governments. As noted earlier, suppose each production function represents the use of a distinct type of capital. This reflects a short- or medium-run imperfection in the capital market. Although investment capital may flow to the industry offering the highest rate of return, there are some elements of institutional capital that are not as mobile. These elements of institutional capital, associated with both workers and management, are reflected in this model as distinct capital types. As with the single sector model, the stock of each capital type is fixed. Capital type is identified by superscripts, \( A \) and \( B \). The capital stock constraint is

\[ \overline{K}_j^i = \sum_{i=1}^{2} K_i^j \quad \forall j \]  

(24)
Land rent is generated within each sector. Assume the price per unit of land is equal across sectors. The budget constraint for private consumption is now

\[ c_i = r K_i^A + r K_i^B \]  

(25)

The jurisdictions may also assess a tax on each type of capital. The size of the tax may differ across capital types. The sum of the tax revenue from all sectors is the new local government budget constraint.

\[ \rho_i = t_i^A K_i^A + t_i^B K_i^B \]  

(26)

Because the benefits from each sector enter the utility function linearly, the inclusion of multiple symmetric sectors in the constant returns to scale game has no conceptual effect on the game. The most efficient set of tax instruments requires symmetric tax rates across jurisdiction, or a uniform tax assessment. This strategy insures an equal division of the capital stock. Segregation of capital, through the use of differentiated tax rates, is not desired due to the increased ability to cheat. For uniform tax assessment, the required discount factor for the cooperative strategy is similar to the single market case, except for differences in scale. This is not surprising given the characteristics of the constant returns to scale production function.

On the other hand, the game is fundamentally altered by the presence of multiple asymmetric production sectors. Suppose the following strategic environment. Each jurisdiction possesses an efficient and an inefficient production sector. As a technical assumption, let the inefficiency be smaller than the tax requirement for single factor financing of the small public project. This assumption insures that both jurisdictions are considered competitive options for each capital market. As before, the jurisdictions can choose to finance a large, small or no public project. Consider two strategy profiles. First, the jurisdictions agree to charge uniform tax rates across sectors to finance the large project. The case is trivial due to the ease of capital mobility in the constant returns to scale production model. Each jurisdiction captures all of the available capital in its efficient sector. If either jurisdiction chooses to defect, it can reduce its tax rates
marginally, and capture the entire stock of each type of capital. Clearly, it can continue to finance the large public good due to the inflow of new taxable capital. The punishment strategy consists of announcing no taxation for either capital market. The discount factor requirement for this set of policies is

\[
\ln(r \bar{K}_e + r \bar{K}_i) + \eta \ln(p_n) + \left( \delta \frac{\delta}{1-\delta} \right) \left( \ln \left( \frac{\bar{K}_e}{2} + r \frac{\bar{K}_i}{2} \right) \right) \leq \left( \frac{1}{1-\delta} \right) \left( \ln(r \bar{K}_e) + \eta \ln(p_n) \right)
\]

(27)

where \( K_e \) and \( K_i \) are the capital types for which the jurisdiction is respectively the efficient and inefficient producer. The discount requirement for cooperative behavior is

\[
\delta \geq \frac{\ln \left( \frac{\bar{K}_e + \bar{K}_i}{\bar{K}_e} \right)}{\eta \ln(p_n) + \ln(2)}
\]

(28)

Unless the inefficient capital stock is more than twice as large as the efficient capital stock, this ratio is always less than one. Therefore uniform taxation is generally feasible, albeit with a resulting segregation of capital.

Alternatively, the jurisdictions may assess differentiated tax rates. The differential accounts for the underlying productive differences of the sectors. Thus, the budget constraints for both jurisdictions are

\[
t_e \frac{\bar{K}_e}{2} + t_i \frac{\bar{K}_i}{2} = p_n
\]

(29)

Any set of rates is feasible provided the after-tax return on capital is equal across jurisdictions. Clearly, capital allocates symmetrically in the jurisdictions. In my previous research, this result is known as a zone of control result, a specific type of sphere of influence in which the players
engage within each sector. Zones tend to form when cheating is relatively easy.\textsuperscript{29} They also form in games of strategic substitutes, which this game resembles if there are efficiency differences that are not capitalized in land rent.\textsuperscript{30}

Thus, each player in the differentiated tax profile splits the capital of each sector and is able to finance the large public good. As such, the uniform and differentiated tax options both possess the same type of required discount factors and generate identical community benefits; however the differentiated tax rates are strategically preferred. If the sizes of the two production sectors are different, the jurisdiction whose efficient sector is smaller requires a larger discount factor. Under the differentiated tax rate policy, both jurisdictions face identical discount factor requirements. The underlying efficiency difference is in effect capitalized into the communities’ tax policies. More importantly, this indicates a case for which differential taxation of economic sectors does not indicate tax competition. Indeed, just the opposite is true. The differentiated tax rates are the best mechanism for insuring tax cooperation.

It is also interesting to note the difference between the required discount factors of the symmetric and asymmetric games with multiple production sectors. Suppose the two capital types are equal in regional quantity. Provided that the smallest public good exceeds a quantity of two, the cooperative discount requirement for the asymmetric game is larger than its counterpart for the symmetric game. The reason is simple. The ability to punish is reduced in the game with production differences.

3.4.5 Increasing Returns to Scale

The primary areal unit of focus in the tax competition literature is the city. Some models of urban economics postulate the existence of agglomeration economies to explain the existence of cities. Typically, these concentrations take the form of an increasing returns to scale (IRS)

\textsuperscript{29} See chapter 1 for more details.
\textsuperscript{30} In a game of strategic substitutes, the active engagement of one player acts to reduce to the activity of its rival. In a game of strategic complements, increased activity of one player is met by increased activity by another. The game with efficiency differences resembles a game of strategic substitutes because the efficient player can dominate its efficient sector.
production function. To represent this environment, suppose the production function of each jurisdiction takes the form

\[ F(K) = \alpha K^\beta \]  

(30)

where \( \beta > 1 \)

As in the CRS case, the aggregate after-tax return on capital is

\[ F(K) - t_i K_i - r_i K_i \]  

(31)

Let the return on each unit of capital equal the average after-tax rate of return on capital in that unit's jurisdiction of residence. If marginal product factor payment were used, as in the CRS model, then after-tax profits are exhausted before all factor payments are made. This is an unfortunate feature of increasing returns to scale production models, and is why economists typically use the decreasing returns to scale model for general equilibrium models (Varian 1992).

With a single production sector, the single stage and repeated game result in similar outcomes. The entire capital stock accumulates in only one jurisdiction. If neither jurisdiction charges any tax, then each jurisdiction has an \( \text{ex ante} \frac{1}{2} \) probability of obtaining the capital stock. If either jurisdiction charges a tax to finance the public good and the other does not, then the capital stock flees to the other jurisdiction \textit{en masse}.

Unlike the constant returns to scale game, the repeated version of the single sector IRS game offers no feasible cooperative regime. If the jurisdictions announce equal tax rates, only one gains the capital because of the IRS specification. The winner is randomly selected with a probability of \( \frac{1}{2} \). The loser is thus confronted with a dominant strategy of reducing his tax rate. Indeed, such an option is a dominant strategy because the losing jurisdiction effectively receives the punishment payoff. Thus no cooperation is ever sustainable because cheating always occurs.

The inclusion of two increasing returns to scale production sectors considerably improves the possibility of cooperation. First, suppose each jurisdiction possesses two sectors of
equivalent production efficiency. The single stage game Nash equilibrium consists of no taxes in either jurisdiction. Each jurisdiction ex ante expects to receive the entire stock of one type of capital.\textsuperscript{31} Consequently, no public good financing occurs.

The repeated game offers the possibility of sustained cooperation and public good provision. This cooperative policy regime assumes the form of a deliberate sphere of influence (soi) policy. Again, suppose the existence of two production sectors of equivalent efficiency. Also suppose the jurisdictions are symmetric. If a jurisdiction wins the capital stock of one sector, the tax required for financing the large public good is

\[ t_{soi} = \frac{p_n}{K} \]  \hspace{1cm} (32)

If this is announced, it must be the case that the rival jurisdiction announces some higher rate of taxation for that capital type. Let \( \varepsilon \) be some number greater than zero.

\[ t_{rival} = \frac{p_n}{K} + \varepsilon \]  \hspace{1cm} (33)

In this setting, it appears that the winning jurisdiction in each sector has provided a tax break for that industry. Indeed, any observation of this type behavior may be interpreted as evidence of harmful tax competition. The analysis here suggests that this conclusion is unwarranted. Although the jurisdictions have divided the production sectors into spheres of influence by providing tax privileges, this activity increases social welfare by increasing the potential for iterated cooperation.

However, cooperation is not assured. The potential for deviation from the cooperative regime must be computed. The required discount factor for the cooperative regime detailed above is

\textsuperscript{31} Similar to the single jurisdiction game, each capital stock type does not divide and accumulate in both jurisdictions. The reason for this en masse agglomeration is the increasing returns to scale production and its associated profit function. Profits are higher for capitalists if capital of agglomerates in one place for each type, as is consistent with increasing returns to scale. It is possible that one jurisdiction gains the full stock of both types of capital, but it is the expectation that matters for economic decision-making.
where \( A \) is this jurisdiction's production sphere by policy construction and the superscript \( j \) notes that in the punishment profile each jurisdiction attains the capital for one economic sector. By defecting, each jurisdiction may capture the entire stock of both types of capital and continue to finance the large public good. Assume that the capital stocks are equal in size. The required discount factor is

\[
\delta \geq \frac{\ln(2)}{\ln(2) + \eta \ln(p_n)}
\]  

(35)

Clearly, this ratio is less than one, which indicates that for some realized values of the discount factor cooperation is sustainable against deviation. Also, again note that the larger the size of the public project, and hence the larger the tax required, the greater the potential for cooperation. Hence, the more dependent each jurisdiction is on a single production sector for public finance, the less likely they are to engage in truly harmful tax competition.

Sphere of influence formation, which may be misinterpreted as tax competition, is clearly beneficial and desired in the increasing returns to scale case. Cooperation is sustained and public provision is achieved. The reason for the formation of spheres is that the IRS case represents the most extreme form of a tax competition game of strategic complements. Without intertemporal cooperation, a decrease in the tax rate of either jurisdiction in any capital stock is met with a concomitant decrease in tax rate of its rival. Spheres of influence in this setting allow both jurisdictions to benefit and establish a regime where the costs of cheating are strong enough that cooperating appears to be a favorable outcome. However, in contrast to much of the existing
tax competition literature, the form of cooperation in the IRS model manifests as a set of
differentiated set of tax rates, which may appear as tax competition. Instead, this tax assignment
is the rational strategic response to the constraints of the capital market for this type of industry.

3.4.6 Decreasing Returns to Scale

The decreasing returns to scale (DRS) case is the more examined with respect to
existing tax competition models. This is due to the DRS case’s compatibility with microeconomic
theory in respect to firm entry, factor payment and the observed phenomena of a spatial dispersal
of economic activity. Suppose production for the DRS model assumes the form of quadratic
equation found in (36).

\[ F(K_i) = \alpha K_i - \gamma K_i^2 \]  
\[ (36) \]

As in the CRS model, an examination of inefficient jurisdictions is included. Again, these
inefficiencies may be the result of exogenous place characteristics, such as natural resources or
location. Let the inefficient production function assume the form

\[ G(K_i) = \alpha c K_i - \gamma K_i^2 \]  
\[ (37) \]

Because the production function is DRS, factor payments differ in this model with those
presented earlier in this chapter. Consistent with the existing tax competition literature, the pre-
tax return on capital is equal to its marginal product. Land, as the fixed factor in the DRS model,
now secures the residual payment. The after-tax return on capital is thus

\[ F_p(K_i) - t_i = \alpha - \gamma K_i - t_i \]  
\[ (38) \]

As the residual claimants, the return to jurisdictional landowners is

\[ F(K_i) - K_i F_p(K_i) = \gamma K_i^2 \]  
\[ (39) \]

To illustrate this model, consider the case of a single production sector. Let sector
production be efficient for both jurisdictions. If the jurisdictions desire to finance the large public
project, then their tax rates are equal. Capital evenly divides between the two jurisdictions due to diminishing marginal returns. Consequently, each jurisdiction enacts a tax of \( \frac{2p_h}{K} \). A PD exists if either jurisdiction possesses an incentive to cut its tax rate to attract additional capital, while financing the small public good. The condition for this situation is

\[
\ln(c_{\text{cheat}}) + \eta \ln(p_i) \geq \ln(c_{\text{coop}}) + \eta \ln(p_h)
\]  

(40)

The capital market and the difference in public sector projects determine this inequality. First, the level of capital attracted by a defection from the cooperative regime is determined. A potential defector faces the following market constraint

\[
\alpha - \gamma K_{\text{rival}} - \frac{2p_h}{K} = \alpha - \gamma K_{\text{defect}} - \frac{p_i}{K_{\text{defect}}}
\]  

(41)

where \( K_{\text{rival}} \) is the capital allocated to the rival’s jurisdiction and \( K_{\text{defect}} \) is the capital that the defecting jurisdiction captures. Of course, \( K_{\text{rival}} \) and \( K_{\text{defect}} \) sum to \( K \). Of the resulting quadratic solution for the candidate capital stock of the defecting jurisdiction, the larger root is evaluated in order to maximize land revenue. Thus

\[
K_{\text{defect}} = \frac{\gamma K^2 + 2p_h + \sqrt{\gamma^2 K^4 + 4 \gamma K^2 p_h + 4p_h^2 - 8 \gamma K^2 p_i}}{4 \gamma K}
\]  

(42)

Therefore, the condition for strategic interaction set out in (40) is

\[
\ln(\gamma K_{\text{defect}}^2) + \eta \ln(p_i) \geq \ln\left(\gamma \left(\frac{K}{2}\right)^2\right) + \eta \ln(p_h)
\]  

(43)

If this condition fails, tax competition is not a concern. Each jurisdiction may finance the public good without fear of capital flight. Note that this is a different strategic effect than those examined earlier. Unlike the CRS and IRS models, capital desires to allocate in both jurisdictions because of its own diminishing marginal return in production. This effect is distorted by the introduction of taxes. If (43) holds, a cooperative, repeated game solution is required to avoid costly tax
competition. Each jurisdiction assigns an identical tax and attracts half the capital stock. To cheat, a jurisdiction accepts lower public good provision in order to attract more capital, thereby increasing local income. This setting is consistent with existing tax competition models. The condition for the repeated game cooperative solution is

\[
\delta \geq \frac{\ln(\gamma K_{\text{detect}}^2) - \ln(\frac{K}{2})^2 + \eta \ln(p)}{\ln(\gamma K_{\text{detect}}^2) - \ln(\frac{K}{2})^2 + \eta \ln(p)}
\]  

(44)

Because this ratio is less than one, the cooperative regime is sustainable for feasible values of the discount factor. Also, note that the inclusion of multiple symmetric production sectors has no effect on the required discount factor other than scale. As noted before, this is due to the additive characteristic of land income in this model.

3.4.7 DRS Model with Asymmetric Productivity

If the game consists of a single asymmetric production sector, the strategic setting is different. As noted in earlier models, if the difference in the marginal products of capital is sufficiently large to allow for the efficient jurisdiction to finance a public project, no strategic conflict exists. However, if a PD exists, then the form of cooperation to sustain public good expenditures is somewhat different than in the symmetric case.

Employing the efficient and inefficient production functions defined earlier, if both jurisdictions enact no tax on capital, then the market generates the following quantities, where \( K_e \) is the capital allocated in an efficient jurisdiction and \( K_i \) is the capital allocated in an inefficient jurisdiction.

\[
K_e = \frac{1}{2} \bar{K} + \frac{\alpha - \alpha c}{4 \gamma}
\]  

(45)

\[
K_i = \frac{1}{2} \bar{K} - \frac{\alpha - \alpha c}{4 \gamma}
\]  

(46)
Suppose that the jurisdictions impose an equal tax rate on their capital stocks. Because production exhibits DRS, there is no change in the resulting stock of capital. Without loss of generality, suppose that this tax rate satisfies the following conditions.

\[ tK_e = p_h \]  \hspace{1cm} (47)

\[ tK_i = p_i \]  \hspace{1cm} (48)

Although it is mathematically possible that the inefficient jurisdiction may finance the large public sector project, it is costly in terms of land income. Enacting this policy requires an extremely high tax rate. For the purposes of the current analysis, suppose that \( \eta \) is small enough such that this option always produces lower utility relative to financing the smaller public good. Indeed, recall that if \( \eta \) is large enough, no tax competition occurs.

Given this strategic environment, the conditions for sustainable cooperation are determined. The discount factor requirement for the inefficient jurisdiction is first found by solving for the capital stock it gains when cheating on the candidate cooperative regime.

\[ \alpha - 2\gamma K_{cheat} = \alpha - \gamma K_{coop} - \frac{p_h}{K_e} \]  \hspace{1cm} (49)

Solving provides

\[ K_{cheat} = \frac{-\alpha c \bar{K} \gamma - 2 \alpha^2 c + \alpha^2 c^2 + \alpha \bar{K} \gamma + \alpha^2 - 2 \bar{K}^2 \gamma^2 - 4 p_k \gamma}{2 \gamma (-2 \bar{K} \gamma - \alpha + \alpha c)} \]  \hspace{1cm} (50)

Using the same methods as employed earlier, the discount factor requirement is

\[ \delta \geq \frac{\ln(\gamma K_{cheat}^2) - \ln(\gamma K_e^2) - \eta \ln(p_i)}{\ln(\gamma K_{cheat}^2) - \ln(\gamma K_i^2)} \]  \hspace{1cm} (51)

The required factor is less than one so cooperation is feasible for some admissible values of \( \delta \). Comparison of this requirement with the requirement of the symmetric case is difficult. In general, this requirement should be less stringent than the symmetric case requirement because
the inefficient jurisdiction has more to lose. However, the ability to punish is also reduced, so it is also possible that the requirement could be larger. The actual requirement is dependent on the realized values of the structural parameters. The capital quantity for a defector that is an efficient jurisdiction is considerably more complex due its ability to choose the smaller public sector project. However, it is also larger, so is of less analytic concern for the present analysis.

3.4.8 DRS Model with Multiple Production Sectors

The character of the game is changed by the inclusion of multiple production sectors. Suppose the game consists of two production sectors. Each jurisdiction is the efficient producer in one sector. As explored earlier, the possibility of a more strategically intricate cooperative solution becomes possible with multiple sectors. The jurisdictions may adopt a uniform or differentiated tax rate cooperative policy.

First, examine the situation in which both jurisdictions assess a uniform tax across sectors. Suppose the tax rate is sufficient to finance the large public sector project. Of course, because there are productive differences in the two jurisdictions, the available capital stock does not allocate evenly. However, due to the fact that each jurisdiction possesses an efficient and an inefficient sector, each jurisdiction possesses an equivalent total capital stock. Therefore, the uniform tax charged by the two jurisdictions is equal. The capital market requirement within each sector is

\[ \alpha - 2 \gamma K_e - t_u = \alpha c - 2 K_i - t_u \]  

(52)

where \( K_e \) and \( K_i \) are the capital allocations of the efficient and inefficient jurisdictions in a given sector. The variable \( t_u \) is the uniform tax. To finance the large public good, the uniform tax must satisfy the following public budget constraint.

\[ (K_e + K_i) t_u = p_n \]  

(53)

Solving the capital market, it is the case that each jurisdiction gains the following quantities of capital for its efficient and inefficient sectors.
\begin{align*}
K_e &= \frac{1}{2} \bar{K}^i + \frac{\alpha - \alpha c}{4 \gamma} \\
K_i &= \frac{1}{2} \bar{K}^i - \frac{\alpha - \alpha c}{4 \gamma}
\end{align*}

(54) \quad (55)

Because of the equivalence of the tax rate, these are also the capital allocations found in the single sector asymmetric game with no taxes. Therefore the utility for each jurisdiction under a cooperative solution that finances the large public sector project is

\[ U_i = \ln(\gamma K_i^2 + \gamma K_e^2) + \eta \ln(p_h) \]

(56)

Of course, each jurisdiction has the opportunity to cheat on this arrangement. For tractability, suppose that

\[ p_i = t_u K_i \]

(57)

Thus if a jurisdiction defects from the cooperative regime, it may finance the smaller public good quantity while capturing a larger capital stock in the sector for which it is efficient. Also let

\[ \bar{K}^i = \bar{K} \quad \forall j \]

(58)

Therefore, each jurisdiction possesses a total capital stock of \( \bar{K} \) in the cooperative regime. Thus, the defecting jurisdiction’s capital stock, \( K^{\text{defect}} \), is determined by examining the capital market.

\[ \alpha - 2 \gamma K^{\text{defect}} = \alpha c - 2 \gamma K_i - \frac{p_h}{\bar{K}} \]

(59)

Solving equation (59) produces

\[ K^{\text{defect}} = \frac{1}{2} \bar{K} + \frac{\alpha - \alpha c}{4 \gamma} + \frac{p_h}{4 \bar{K} \gamma} \]

(60)

Using these solutions, the PD requirement for the jurisdictions is found

\[ \ln(\gamma K_{\alpha}^2 + \gamma K^{\text{defect}}_{\alpha}^2) + \eta \ln(p_i) \geq \ln(\gamma K_i^2 + \gamma K_e^2) + \eta \ln(p_h) \]

(61)
Examination of this condition reveals that capital markets with a smaller second derivative of the production function are more likely to face Prisoner’s Dilemmas. These markets tend to more closely resemble the constant returns to scale model. In other words, the smaller the effect of increased capital accumulation has on the marginal product of capital within that sector, the more competitive that capital market is. In turn, a more competitive capital market implies that the problem of tax competition and efficient public good provision is greater. The CRS model examined earlier represents an extreme variation of the DRS model because the second derivative of the production function is zero.

If either jurisdiction deviates from the cooperative solution, the punishment rounds consist of the asymmetric single sector capital allocations, or the capital quantities that result when both jurisdictions announce zero tax rates. As a consequence, no public good financing occurs in punishment rounds. Thus utility in a punishment round is

\[ U_i = \ln\left(\gamma K_e^2 + \gamma K_i^2\right) \]  

(62)

Due to symmetry, the discount factors for the two jurisdictions are equal. Using the same techniques as before, this discount factor is

\[
\delta_{\text{uniform}} = \frac{\ln\left(\gamma K_i^2 + \gamma K_{\text{defect}}^2\right) + \eta \ln(p_i) - \ln\left(\gamma K_i^2 + \gamma K_e^2\right) - \eta \ln(p_e)}{\ln\left(\gamma K_i^2 + \gamma K_{\text{defect}}^2\right) + \eta \ln(p_i) - \ln\left(\gamma K_i^2 + \gamma K_e^2\right)}
\]  

(63)

Clearly, this ratio is always less than one. This result indicates cooperation is feasible for some admissible values of the discount factor. Although not explicitly specified in the current analysis, it is assumed that the marginal products of capital are positive for all capital quantity assignments. If all the capital accumulates in one jurisdiction, the resulting marginal product represents a reserve rate of profit for the regional capital owners. Alternatively, if no jurisdiction possesses a non-negative marginal product, a portion of the regional capital supply is not employed.
The following figures are an example of the discount factor for the uniform tax case. For
the following computations, let $K=10$, $\alpha=20$, $\gamma=0.5$, $\rho_h=20$, $\eta=0.1$, and $\rho_l=20c-10$. The vertical
axis in Figure 11 measures the required social discount factor as a function of $c$. The concavity of
the relationship is due the tradeoff between the ability to attract a rival’s capital and its ability to
punish. The relationship over the entire unit interval range of $c$ is seen in Figure 12. The discount
factor becomes non-positive as $c$ decreases because of the decreasing productivity of utilizing
capital in that jurisdiction. The lowered productivity reduces the potential land rent for attracted
capital, and this reduces the incentive for cheating on the cooperative policy.

The sustainability of the cooperative outcome involving uniform taxation contrasts with
the existing literature on tax competition. Cooperative solutions are rarely discussed. Indeed, the
authors of these studies describe a bleak picture due to their use of single round games. The
resulting conclusions suggest that governments face a challenge in financing public services due
to the mobility of capital. However, examination of the repeated game suggests otherwise.

Furthermore, the existence of multiple production sectors may allow a more flexible set of
strategies. In this model, landowners benefit exponentially from the accumulation of one type of
capital. This effect produces an incentive to specialize in production activities, giving rise to
agglomeration in production. The capitalists, who face diminishing marginal returns, have no
corresponding incentive. However, the landowners, through the action of government, can create
such an incentive. By assessing differentiated tax rates on individual stocks of capital, the
jurisdictions create spheres of influence with respect to tax bases.

The formation of spheres may accomplish more than increasing private consumption.
Indeed, by defining areas that are to be encouraged in each jurisdiction, the governments may
reduce the potential for cheating. In other words, the discount factor requirement for sustained
cooperative behavior is smaller in the sphere of influence solution relative to uniform taxation for
some cases of the underlying parameters.

To demonstrate this, the sphere of influence solution is found. First, the jurisdictions
announce tax rates for each production sector. Because the landowners benefit exponentially in
distinct capital type accumulation, the jurisdictions demand complete capital segregation. Additionally, the tax rates must be sufficient to finance the large public sector project. The following tax rates satisfy these requirements.

\[ t_e = \frac{p_h}{K_e} \]  
(64)

\[ t_i = \alpha c - \alpha + \gamma K_i + \frac{p_h}{K_i} \]  
(65)

where \( t_e \) and \( t_i \) are the tax rates announced for a jurisdiction’s efficient and inefficient production sectors. The resulting utility for each jurisdiction is

\[ U_i = \ln\left(\gamma R^2_e\right) + \eta \ln(p_h) \]  
(66)

As noted before, each jurisdiction possesses an incentive to defect from the cooperative arrangement. In fact, the benefit for cheating increases in the sphere of influence model because each jurisdiction can continue to finance the large public sector good, from its preferred sector, while announcing a zero tax rate in its rival’s sphere. Indeed, this policy has the potential to attract a large amount of capital because the rival is assessing a high rate to finance its own public good provision. Solving finds

\[ K_i^{\text{defect}} = \frac{1}{2} K_i - \frac{\alpha - \alpha c}{4 \gamma} + \frac{p_h}{K_i} \]  
(67)

Thus, the utility earned through deviation is

\[ U_i = \ln\left(\gamma R^2_e + \gamma K_i^{\text{defect}}\right) + \eta \ln(p_h) \]  
(68)

Punishment is the same as the uniform tax case. The required discount factor for the sphere of influence arrangement is therefore

\[ \delta_{\text{stab}} \geq \frac{\ln\left(\gamma R^2_e + \gamma K_i^{\text{defect}}\right) - \ln\left(\gamma K^2_e\right)}{\ln\left(\gamma R^2_e + \gamma K_i^{\text{defect}}\right) + \eta \ln(p_h) - \ln\left(\gamma K^2_i + \gamma K^2_e\right)} \]  
(69)
This ratio is less than one, so cooperation is feasible. Figure 13 plots the required discount factor for this case, using the parameter values provided earlier. Solutions indicating negative social discount factors insure cooperative behavior. It becomes increasingly difficult to maintain cooperative behavior, as noted in Figure 13, as $c$ increases because cheating becomes more attractive due to the relative similarity of the economic sectors.

As stated earlier, the sphere of influence package of differentiated tax rates for capital types may offer the benefit of increased resistance to defection over the uniform tax rate regime. Analysis of the difference between the two required discount factors is complex. However, a graph of the relevant interval is illustrative. Figure 14 measures the difference between the discount factor requirements for the uniform tax case and the sphere of influence tax case. Positive values indicate that the requirement for the uniform case is larger. For values of $c$ lower than those contained in Figure 14, the uniform tax regime requires a lower discount factor. In these cases, there is no strategic benefit with respect to discounting because the low value of $c$ indicates that the jurisdictions are relatively different. However, local income is higher under the sphere of influence or differentiated tax rate case. Hence, if both jurisdictions are able to adhere to its required discount factor, this policy is preferred.

It is also illustrative to examine the relationship between the productivity difference parameter, $c$, and the capital market's competition intensity parameter, $\gamma$. First, examine the uniform tax case requirement for ranges of the parameters in which differentiated taxation requires less patience. Note the concave relationship between the discount factor requirement and $\gamma$ in Figure 15. For high values of the parameter, the market strongly divides the capital stock between the two jurisdictions. The incentive to cheat in either market is correspondingly diminished. For smaller values of the parameter, there is a slight decline in the discount factor requirement. In this range, the inefficiency parameter overwhelms the marginal product effects of the production functions.
The scale of $\gamma$ also impacts the discount factor requirement in the sphere of influence solution. As seen in Figure 16, the requirement increases monotonically in $c$. Similarly, as $\gamma$ increases, the required discount factor increases as well. The benefits from cooperating, namely increased land increase, as $\gamma$ rises. This causes defecting to increase in value. Notice the diminishing aspect of this effect. This is a result of the decreasing returns to scale in the production function. Also note, that for large values of $c$, the effect of $\gamma$ tends to be overwhelmed. In this range, the benefits from tax differentiation fall because the exogenous production characteristics diminish.

Figure 17 plots the difference between the uniform and sphere of influence discount factor requirements. For those values for which the sphere of influence policy is preferred, some tentative conclusions are evident. First, increasing $\gamma$ tends to decrease the difference between the two values. Second, $c$ has a concave effect on the difference. Small and large values provide smaller differences between the two requirements. For small values of $c$, the uniform case in fact approaches the sphere of influence result. If the market generates capital segregation without policy interference, the uniform tax policy will be equivalent to the sphere of influence tax policy. For large values of $c$, the value of cheating correspondingly increases in the sphere of influence case. As such, the uniform tax case grows in strategic importance.

3.5 Evidence of Cooperative Tax Strategies

Unlike previous models of tax competition, the theoretical conjectures in this chapter suggest that local jurisdictions avoid the strategic dilemma of tax competition by employing a set of differentiated tax rates on economic sectors in order to define spheres of influence with their neighbors. Hence, a diversity or variance of tax assignments with respect to neighboring jurisdictions enables tax authorities to achieve higher aggregate levels of taxation. Thus, what
may appear, when studied singly by economic sector, as costly tax competition is in fact a component of a larger, strategic attempt to maintain a cooperative outcome with respect to tax policy.

To test this proposition, I employ the BEA data identified earlier. The units of observation are the 48 contiguous states and the District of Columbia, which is treated as a state. The dependent variable is the aggregate consolidated tax rate (ACTR) for each state. This variable is constructed from 1999 data by determining the total amount of business taxation for each state, and then dividing this amount by gross state product (GSP). Because the focus here is on capability of or potential for tax financing of non-federal public institutions, and not the corresponding effectiveness of public spending, higher tax burdens are assumed to indicate policy success. Low aggregate consolidated tax rates are considered examples of policy failure, perhaps due to tax competition.32

The key control variables of interest are deviations from spatial mean behavior.33 As noted earlier, a spatial mean is the average behavior of a state’s contiguous neighbors. A deviation from the spatial mean notes the difference between a state’s actions and the average of its neighbors’ actions. The theoretical model suggests two impacts for the deviation from the spatial mean of any given industry. First, the sum of these deviations (SUMDEV) may be positively or negatively associated with the aggregate consolidated tax rate of a state. The potential for a positive impact reflects the direct, additive impact of tax rates to raise revenue. The potential for a negative impact indicates a conventional tax competition impact; namely, that a state suffers from having higher tax rates than its neighbors, thus reducing its tax base. Formally, SUMDEV is equal to the sum of industry spatial deviations, CTR minus W CTR, where CTR is a vector of tax rates and W is a row-normalized spatial weight matrix. I use the contiguity weight identified earlier. The second term of SUMDEV is the computation for spatial means.

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32 A low consolidated tax rate may mathematically also be due to a decreased level of GSP. However, as noted earlier in this paper, the evidence regarding the impact on output of relative tax policies, namely spatial mean deviation, is lacking.

33 This variable is a type of spatially lagged independent variable.
Second, the sum of the squared deviations (SUMSQDEV) provides a measure of consolidated tax rate spatial variation. Earlier models of tax competition implicitly suggest that such a measure should have a negative impact on the ability of state and local governments to maintain efficient tax policies. In contrast, the model in this chapter demonstrates that this variance is evidence of tacit, strategic cooperation among rival tax jurisdictions in the form of spheres of influence. Thus, this variable should have a positive impact on the ACTR. However, it likely that too much differentiation is detrimental to efforts to fight costly tax competition. The empirical model includes a squared term of SUMSQDEV (SQSUMSQDEV) to evaluate this possibility. SUMSQDEV is constructed by squaring each industry term in SUMDEV.

A number of other control variables are included. These 1999 data are from the Statistical Abstract of the United States. A constant measures common determinants on tax policies, including federal influences. Economic variables include per capita income (PCI) and the state homeownership rate (HRATE). Theory suggests that these variables should have positive influences due to increased demand for public good provision for higher income or less mobile households. Area in square miles (AREASQMI) accounts for geographic differences in public good financing requirements. Finally, social and political differences among the states are controlled for by the following variables: percentage of population that is white (WHITE%), the percent of votes allocated to George W. Bush in the 2000 presidential election (BUSH%), the percentage of the population with a bachelor’s degree (BA%), and the percentage of the population in poverty (POVERTY%).

Table 4 presents OLS estimates of this model. The econometric results are consistent with the theoretical model. SUMSQDEV is significant at a 5% level and possesses a positive sign. The results concerning SUMSQDEV provide initial verification of the role of differentiated taxation of economic sectors. These results indicate that increasing SUMSQDEV, that is employing differential tax rates and thereby delineating spheres of influence, increases the ability of local and state tax authorities to maintain overall higher levels of business taxation. It is important to
note what this result does not indicate. $SUMSQDEV$ is not a measure of an exponential impact of $SUMDEV$. It is calculated by examining the differences in state-level tax activity within each individual sector.

Thus, when viewed singly by economic sector, what appears to be evidence of tax competition, is in fact a component of a strategy of tax cooperation. Indeed, a one standard deviation increase in $SUMSQDEV$ for the average state generates an increase in the ACTR of 0.005, an increase of 7.47% with respect to the average ACTR. These results are presented in the maps contained in Figures 18 through 20. Figure 18 indicates those states with low ACTR and low $SUMSQDEV$. These states have limited sphere of influence behavior and this manifests itself and less effective taxation. Figure 19 presents state with the opposite experience. These states have high ACTR and high $SUMSQDEV$. These states have created spheres of influence with their neighbors and this enables overall higher levels of ACTR. Figure 20 shows states with high ACTR but without the use of spheres or differentiated taxation with respect to neighboring states. However, it is revealing that these states are mostly clustered together. These are states with similar tax behavior but high ACTR. As such, they are examples of states adopting the uniform cooperative tax strategy. Figure 21 indicates quintile rankings for spheres of influence as measured by $SUMSQDEV$.

$SQSUMSQDEV$, which measures the diminishing value to differentiated taxation, indeed possesses a negative impact and is significant at a 10% level. This result indicates that excessive differentiation is harmful, and as such should be considered a type of costly tax competition. Nonetheless, using the estimates in Table 4, the level of negative returns to sphere of influence behavior occurs at 0.03091. The average $SUMSQDEV$ is 0.0135, which is considerably far in policy space terms from this level of negative returns. This level is nearly two standard deviations from the average $SUMSQDEV$.

The remaining independent variables are mostly insignificant. Among the exceptions, the coefficient for $PCI$ is significant and positive as expected, which is consistent with the notion that local public goods are income-normal goods. The coefficient for $BUSH\%$ is significant and
positive, indicating a surprising result given the political preferences of conservative voters. \( \text{SUMDEV} \), which controls for direct spatial impacts due to tax policies, significant at the 1% level, and possess a positive sign. \( \text{SUMDEV} \) therefore controls for the additive effect of higher individual tax rates generating higher overall tax rates.

To insure the robustness of these empirical results, an additional spatial econometric model was estimated. The same data were employed, except for this test the spatial weight matrix was altered. To control for the economic size of the states, the elements of the new spatial weight matrix consisted of the state population of an element’s column multiplied by the state population of an element’s row for all contiguous states. Non-contiguous states continued to have a weight of zero. Table 5 reports the estimates of the OLS regression using this new weighting scheme. The results do not significantly differ from those already discussed.

In summary, the empirical results offer supportive evidence of the forms of cooperative tax policies explored theoretically in this model. Differentiated taxation of economic sectors is associated with higher levels of taxation, not lower levels as the conventional tax competition model suggests. Furthermore, states with high levels of taxation but low levels of differentiation of capital taxation are generally clustered together, consistent with a cooperative tax policy of generally uniform rates.

3.6 Conclusion

Tax competition is a problem commonly associated the U.S. system of decentralized public finance. In the typical model, local jurisdictions encounter a Prisoner’s Dilemma with respect to taxation of mobile capital. Each jurisdiction possesses an incentive to reduce its tax rate in order to attract capital and increase local income. In equilibrium, these jurisdictions therefore set inefficiently low tax rates on capital and thus inadequately fund local public goods.

In contrast, the theoretical models developed in this chapter demonstrate that local jurisdictions are capable of creating and sustaining cooperative tax policies in repeated games. In particular, these jurisdictions may create spheres of influence or sets of differentiated taxes on
independent economic sectors. Spheres of influence, as explored in chapter 1, are policy regimes for institutions in conflict. These policies increase the potential for cooperation by linking issues of conflict. These types of policies are shown to be essential for cooperative outcomes in economic sectors with increasing returns to scale. Differentiated taxation of capital is preferred in constant returns to scale sectors because the strategic liabilities associated with defection from the cooperative regime are equally shared. For decreasing returns to scale production, cooperative tax policies are shown to assume the form of differentiated or uniform taxation, although the sphere of influence result is preferred because it increases local income.

The most striking conclusion of this theoretical model of local government interaction is that differences in jurisdictional tax rates for specific economic sectors cannot be considered \textit{prima facie} evidence of tax competition. Indeed, the model in this chapter demonstrates that these policies indicate cooperative tax strategies. The empirical investigation of state and local tax behavior in this chapter is consistent with this theoretical conjecture. States with moderate differentiation in the taxation of economic sectors with respect to their neighbors possess overall higher levels of aggregate business taxation. Furthermore, states with high levels of taxation but little differentiation in respect to their neighbors are generally clustered together. This result is consistent with the cooperative tax policy of uniform taxation.

Clearly, more empirical testing is required of this hypothesis. Most importantly, the geographic scale and scope of the local jurisdictions needs to be expanded. This chapter examines the regional or national levels of tax policy interactions. However, many anecdotal accounts of tax competition concern intrametropolitan area competition. Indeed, the suburb, inner suburb, and central city conflict present obvious future case studies. In addition, tax abatement policies are often the identified manifestations of contemporary tax competition. The theory developed here predicts that political jurisdictions in the same metropolitan area avoid issuing tax abatements for common economic sectors or industries if they wish to avoid costly tax competition. Other issues of conflict among political jurisdictions within urban areas are also candidates for future study using the methodology developed in this chapter.
3.7 Works Cited


## Descriptive Statistics of Chapter 3 Data

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<th>Variable</th>
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Table 3.1 Descriptive Statistics
### Spatial Autoregressions of Tax Activity by Industry

Dependent Variable: INDUSTRY CONSOLIDATED TAX RATES

<table>
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- Note each industry is a separate regression.

Table 3.2: Spatial Autoregressions of Tax Activity by Industry
## OLS Regressions of Tax Policy Impacts on GSP

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<th>t-probability</th>
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- Note nine separate regressions.

Table 3.3: OLS Regressions of Tax Policy Impacts on GSP
### OLS Analysis of Aggregate Consolidated Tax Rates

**Dependent Variable:** STATE AGGREGATE CONSOLIDATED TAX RATE  
\( n = 49 \quad R^2 = 0.8318 \quad \overline{R}^2 = 0.7876 \)

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<tr>
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*** Significant at a 1% level  
** Significant at a 5% level  
* Significant at a 10% level

Table 3.4: OLS Analysis of Aggregate Consolidated Tax Rates
# OLS Analysis of Aggregate Consolidated Tax Rates

**Dependent Variable:** STATE AGGREGATE CONSOLIDATED TAX RATE  
\[ n = 49 \quad R^2 = 0.7861 \quad \bar{R}^2 = 0.7298 \]

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Population weighted spatial weight employed.

*** Significant at a 1% level  
** Significant at a 5% level  
* Significant at a 10% level

Table 3.5: OLS Analysis of Aggregate Consolidated Tax Rates with Population Weights
Figure 3.1: Aggregate Consolidated Tax Rates

Figure 3.2: Consolidated Tax Rates for Agriculture
Figure 3.3: Consolidated Tax Rates for Construction

Figure 3.4: Consolidated Tax Rates for Finance, Insurance, and Real Estate
Figure 3.5: Consolidated Tax Rates for Manufacturing

Figure 3.6: Consolidated Tax Rates for Mining
Figure 3.7: Consolidated Tax Rates for Retail

Figure 3.8: Consolidated Tax Rates for Services
Figure 3.9: Consolidated Tax Rates for Transportation and Utilities

Figure 3.10: Consolidated Tax Rates for Wholesale
Figure 3.11: Discount Factor Requirements for Uniform Tax Rates on Capital

Figure 3.12: Unit Interval Range for $c$
Figure 3.13: Discount Factor Requirements for Differentiated Tax Rates on Capital

Figure 3.14: Uniform minus Differentiated Tax Rate Discount Factor Requirements
Figure 3.15: Discount Factor Requirements for Uniform Tax Rates for Ranges of $c$ and Gamma

Figure 3.16: Discount Factor Requirements for Differentiated Tax Rates for Ranges of $c$ and Gamma
Figure 3.17: Uniform minus Differentiated Tax Rate Discount Factor Requirements

Figure 3.18: States with Limited Spheres of Influence
Figure 3.19: States with Extensive Spheres of Influence

Figure 3.20: States with High Taxes and Limited Spheres of Influence
Figure 3.21: Quintile Rankings of Spheres of Influence
CHAPTER 4

POWER PROJECTION: A SPATIAL STUDY OF MILITARY EXPENDITURE

4.1 Introduction

The first duty of the sovereign, that of protecting the society from the
violence and invasion of other independent societies, can be
performed only be means of a military force...which grows gradually
more and more expensive, as the society advances in civilization.

Adam Smith, The Wealth of Nations, Book V, Chapter 1

The role of space is a surprisingly neglected aspect in studies of military expenditure. This is a curious state of affairs given the undisputed recognition of the role that location and geography play in military affairs. Although existing studies of defense economics have occasionally included contiguous neighbor rivalries, a rigorous spatial methodology that examines national defense decisions globally is not present in the existing research catalogue. The importance of this approach is enhanced by the increasingly dominant, perhaps hegemonic, role of the United States in the global security structure.

The primary objective of this study is the completion of a theoretical analysis and a spatial econometric investigation of the determinants of military expenditure. Two theoretical models are developed in this paper: a two-period game illustrating the effect of proximity in a
dyadic defense rivalry and a model of alliance defense provision in a spatial context. The latter model is also a useful tool for analyzing hegemonic provision of defense goods. Together, these models generate distinct hypotheses concerning geopolitical defense expenditures. These hypotheses are tested and evaluated with spatial econometric models. The results indicate evidence for U.S. hegemonic behavior, but an underlying rivalry in defense expenditure and armed forces for all other nation-states. Additional hypotheses concerning the composition of military expenditure reveal income and governance impacts on the relative capital-intensity and labor-intensity of armed forces. Finally, evidence of free-riding allies of the U.S. is identified.

4.2 Studies of the Determinants and Effects of Military Expenditures

The literature on economics of defense is interdisciplinary due its academic location at the intersection of the economics fields of public finance, game theory and macroeconomic growth, while spilling over into the study of political science, history and geography. Most studies of defense economics focus on either determinants or effects. The research of the determinants of military expenditures, to which this study contributes, contains a well-developed theoretical foundation and an empirical catalogue that blossomed in the 1990’s. The existing theoretical analyses have either focused on two player conflict models or alliance provision models. Empirical analyses assume the form of case studies of single states, examinations of rival behavior and evaluation of alliance provision models. Existing studies of the effects of military spending have focused on the conjecture that increased military spending increases economic growth because it improves security and property rights, reduces uncertainty and generates imperialistic payoffs. Although spatial aspects are included in many of these studies, rare is the study that accounts for the simultaneous spatial interaction among rival powers.

4.2.1 Theoretical Research

Olson and Zeckhauser (1966) develop the earliest model of alliance behavior for military models. Drawing on existing studies of public economics, these authors model military alliance
partners as voluntary local public good providers. Consequently, the more a nation’s allies provide for military defense, the less that nation provides. Also consistent with voluntary public good provision, larger nations within alliances tend to provide more military services than smaller nations. A number of studies relaxed various assumption of the Olson and Zeckhauser model to account for impure public goods, joint military products and specific theoretical case studies. These studies include van Ypersele de Strihou (1967), Sandler and Cauley (1975), Sandler (1977), Hartley and Peacock (1978), Murdoch and Sandler (1982), Murdoch and Sandler (1984), McGuire (1990), Sandler and Murdoch (1990) and Melese and Smith (1991). Sandler (1993) provides an excellent review of this work. Although each of these studies examined variants of the Olson and Zeckhauser model, their basic theoretical conclusion stands.

However, a common element of existing studies is the inability to examine alliance membership issues. Indeed, in almost all these models there is no strategic conceptualization of endogenous alliance membership. For example, for the pure public good case, benefits do not diminish in new membership, but cost per ally decreases. Hence, it is in every nation’s interest to create the most inclusive military association possible. A set of articles attempts to address this issue of alliance membership with club theory. These articles, including Sandler (1977), Sandler and Forbes (1980) and Murdoch and Sandler (1982), note that membership is governed by the ability to cost share and improve the benefits of conventional military expenditures.

Unfortunately, club theory models ignore spatial considerations, which most observers agree are a critical aspect of alliance formation in a general equilibrium approach of military expenditures and alliance formation. Sandler (1999) constructs the most ambitious attempt to develop a theoretical model of alliance formation with spatial considerations. Unfortunately, his model employs a cooperative game. Cooperative games differ from the non-cooperative approach found in almost all models in that cooperation is assumed within the model. The purpose of a cooperative model is to find the theoretical conditions for which cooperation is
sustainable. Typically this assumes the form of various types of payoff distributions. These coalition payments are described *a priori*, and thus do not represent Folk Theorem style cooperative equilibria for repeated non-cooperative games.

Sandler models nation-states as geometric figures that incur costs in defending each link or side of their space. Common with most studies in this literature, the threat is amorphous or omnipresent and exogenous. This approach is adopted in the present study’s modeling of alliance behavior. Sandler examines a series of geometric arrangements for sets of nation-states. His results indicate that in the core of the game, or sets of coalitions that are non-degenerative to alliance defection, nation-states that share borders with other alliance members receive the highest payoffs in an alliance. The reasoning is simple. These states provide multiple sides to other potential alliance members that do not require protection. In this setting, centrality possesses a distinct advantage. However, this model does not allow neighbors to engage each other as rivals or enemies. Thus, it cannot be determined whether spatial centrality generates advantages or disadvantages in a general equilibrium model.

A separate literature has arisen that examines conflict in a more abstract context. The models consist of two periods. In the first, each nation chooses to invest in either a private consumption good or a military good. In the second period, the total amount of the private good is determined jointly and its distribution is determined by a military investment function, which is essentially a measure of return on military spending. Hirshleifer (1988, 1989, 1991) examines this type of model for a parameterized form of the game. His work notes three types of equilibrium. The first is a banditry equilibrium in which the total wealth or initial endowment is relatively large but unevenly distributed. In this case, the larger power is able to secure gains from its inferior rival with ease. The poorer power is thus compelled to invest all its endowment in arms. The second equilibrium is the Hobbesian equilibrium in which total wealth is relatively large but more evenly distributed. In this case, both players supply military goods. As such, these equilibria are inferior in social welfare terms because resources are wasted through military competition. The third equilibrium is the communal equilibria in which neither power invests in
arms. This occurs if the powers possess a relatively small wealth endowment that is relatively evenly distributed. In this case, there is no incentive to invest in the military because the technology does not enable a potential profit.

Skaperdas (1991, 1992) constructs a variant of the Hirshleifer model in which the endowments of the nation-states are equal but the technologies governing private consumption and the military interaction are asymmetric. In this setting, a fourth type of equilibrium is possible: the suzernainty equilibrium. In this case, both states invest in the private good, but only a single nation-state supplies the military good. This scenario resembles a vassal or satellite state relationship in which one state acts as the de facto imperialist power. Skaperdas does not examine the banditry case. Neary (1997a) examines a non-linear technology for investment that allows all four types of equilibrium to be present. In addition, Neary (1997b) compares a rent-seeking model with the conflict models. The two models are related because both types describe rivalry in good acquisition. However, unlike models of rent seeking, it is possible in economic models of conflict for each player to invest more in arms than the total value of the ultimate prize. Neary suggests that rent-seeking is more appropriate when the size of the overall economy is relatively large, and a conflict model is more appropriate when the rivals are relatively large or few in number. That is rent-seeking occurs against large, relatively passive institutions.

Panagariya and Shibata (2000) examine a conflict model of two nation-states with a constant probability of war. As in other conflict models, a defense good is produced with an opportunity cost measured in terms of a private consumption good. The authors find that the reaction curve of the defense good, which maps the relationship between the rivals’ defense expenditures, is backward bending. Thus, at relatively high levels of military expenditure by one state, its rival reduces its expenditure. This is an important result reproduced in the present study because it demonstrates hegemonic leadership in defense provision. Empirical evidence of this situation is present in the spatial econometric models in this paper.

Oren (1998) offers a different perspective. In the author’s model, policy markers’ expectations and assessments of power generate different outcomes than a model in which
policy makers only care about power. Thus, it may be consistent for high and low arms levels to exist for rival states because expectations may be flawed or asymmetric. Oren uses a Cold War case study to justify the model. Many issues complicate the use of this model, including the accurate measurement of intentions of the policy makers.

4.2.2 The Determinants of Military Expenditure

The primary focus of the study of the determinants of military spending is the impact of alliance membership. As noted earlier, the existing theoretical models develop this interaction as a voluntary public good problem. Thus, estimation of alliance supply resembles the estimates of the voluntary provision of public goods, as modeled by Bergstrom and Goodman (1973). Dudley and Montmarquette (1981) provide an early test of alliance effects. Murdoch and Sandler (1982, 1984) and Sandler and Murdoch (1990) test the Olson and Zeckhauser model with a particular focus on the ability of NATO allies to free ride. Murdoch and Sandler (1986) also estimate the effect of military spending on neutrals, such as Sweden. McGuire and Groth (1985) construct a more general model of public good provision within a group. In general, these studies indicate that defense goods of allies are substitute goods, thus suggesting defense is a public good.

Some studies find contesting evidence of military spending as a pure public good. Hansen et al. (1990) empirically examine the difference in behavior of nuclear enabled and non-nuclear states within NATO during the era of Flexible Response. The authors report free riding behavior for the strategic pure public good, the nuclear capability, but not for conventional weapons. The authors believe this is due to the fact that conventional armed forces are a form of an impure public good. To a limited extent, this result mirrors elements of the empirical tests described later in this paper. Military expenditure exhibits global strategic substitution, but armed forces personnel quantities exhibit strategic complementarity. In contrast, Hilton and Vu (1991) study NATO members for the period of 1960-1985 and do not find evidence that allied spending

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Flexible response was a Western strategy designed to absorb a first nuclear strike and return a crippling response strike. Clearly, the purpose was to deter a first-strike by the Soviet Union. From a military production perspective, Flexible Response required building mobile nuclear assets.
is a substitute and rival spending is a complement for military goods. Indeed, Hilton and Vu report that some allies’ military expenditures appear to be complements. Furthermore, there is some evidence for seemingly selfless behavior in military provision.

The relationship between GDP and military expenditure is also unclear. Certainly GDP acts as budget constraint on total resources available for military spending. However, it is not necessarily the case that a higher GDP implies a larger percentage of GDP spent on the military. Indeed, Oneal (1990) reports that nations with more GDP and in North Atlantic Treaty Organization (NATO) possessed a higher ratio of military spending relative to GDP. This is consistent with a voluntary public good model in which wealthier individuals provide more of the good. However, Oneal notes that the relationship between economic size and defense burden declined for NATO members after the early years of the Cold War. His primary explanations for this observation are the increases in consumption for Turkey, Portugal and Greece, all economically smaller states within the alliance, and growing cooperation among European states. Consistent with this, Porter (1989) presents evidence that military expenditures and military personnel rose in the 1970’s for less developed countries (LDC), many of whom experienced declines in real GDP. Although the relationship between defense burden and GDP may not exist, most studies indicate a positive relationship between GDP and total military spending. This result is confirmed in the spatial econometric tests found later in this paper.

In addition to alliance effects, bilateral military relationships also affect the budgeting decisions of states. For example, direct military aid to Israel from the US constitutes a primary determinant of the stock of Israeli military material (McGuire 1982, 1987; War and Mintz 1987). In contrast, bilateral rival relationships constitute a classic arms race. For example, Stoll (1992) examines British naval production in the context of its rivals from 1860 to 1913. He finds strong evidence of strategic interaction.

Okamura (1991) examines the interaction of the US and Japan in the provision of military services in their alliance. The author models the alliance provision as a pure public good. Unique in this research, demand is explicitly modeled because average prices for defense goods
are included. In addition, Soviet expenditures are included to capture the exogenous threat. Among Okamura’s results, Japan’s spending is more sensitive to the level of Soviet expenditures than the US. This result is primarily attributable to the small scale of Japan’s defense spending, thus it has a higher elasticity with respect to Soviet spending. Furthermore, the author shows that American and Japanese military spending are substitutes. However, no accounting for the spatial locations of the two states occurs. Okamura (2000) revisits this bilateral relationship in a study of military production and foreign aid. Consistent with earlier models, the defense good is treated as a public good. However, Okamura treats foreign aid as a public good as well. This seems a tenuous if not spurious assertion. The reported empirical results indicate that Japan possesses a comparative advantage in foreign aid, while the US possesses a comparative advantage in military production. An alternative, and more likely explanation, is that Japan free rides on US military spending and uses surplus funds to further its private, not public, foreign policy objectives. Indeed, the results in the empirical portion found later in this paper provide very strong evidence that Japan free rides on U.S. defense expenditure.

The notion of strategic rivalry does not imply that the opposing states are engaged in a war. Richardson (1960) develops an early methodology for examining military spending in periods without direct combat. His times-series approach specifies arms expenditures in terms of an interdependent arms race between military rivals. This approach enabled a number of further empirical studies. For example, McGuire (1977, 1981) examines the strategic interdependence between nuclear weapon stocks. Surprisingly, many of these studies lack explanatory power in identifying the determinants of defense budgets. For example, Ostrom and Marra (1986) find little evidence of feedback between US and Soviet military expenditure. These authors, among others, attribute this failure to data problems.

Some parts of the Cold War were “hot.” Kamlet and Mowery (1987) demonstrate that battle deaths are determinants of US military spending. However, because of extended periods of Cold War the authors also include a Soviet threat variable, which indicates non-combat conflict or potential for conflict. Wenger (1997) develops this point for the specific case of the “missile
gap,” as popularized in the 1960 Kennedy presidential campaign. Wenger argues that both Eisenhower and Kennedy pursued more military spending than either thought was militarily sound to appease bureaucratic challenges, play to popular psychological fears and reassure international allies in the face of nuclear parity with the Soviets in technology.

There are many case studies of individual states. Smith (1980) examines the determinants of UK defense spending. Using a neoclassical model of civilian and military production, the author shows that the most important causal factors in the UK’s choice of military goods is the corresponding level of US and USSR production. In fact, Smith demonstrates that the UK is a free rider by noting that the UK is very sensitive to the cost of defense spending. Hartley and Mclean (1981) revisit UK defense expenditures. The authors also find that UK expenditure is associated with US and USSR expenditures. However, both associations are positive. An alliance model suggests that the US effect should be negative. The authors speculate that the US military expenditure level is a proxy for world tension. Unfortunately, the authors do not test the US and the USSR effects simultaneously. Hartley and Mclean (1981) also examine the effect of various domestic social and economic factors on the UK military expenditure level.

Sun and Yu (1999) study the determinants of China’s military budget. The authors report that China’s growth in GNP, its rivals, not necessarily neighbors, military budgets, and lagged military spending are positively correlated with Chinese military spending. China’s effort to promote economic growth after 1979 led to less military spending, and its border wars with the Soviets and Vietnam had no effect. Interestingly, the authors also find that the results are consistent for U.S. government estimates and official Chinese data.

Fontanel and Smith (1990) use a dynamic model to examine the changes in French military expenditure during the Cold War. The authors find three important events in this analysis: the end of French colonialism and imperialism, the commitment to an independent nuclear arsenal, and de Gaulle’s boycott of the NATO military command committee. They also note that their results are sensitive to the data employed. Fontanel and Hebert (1997) revisit French
military expenditures. The authors trace the change of French military strategy from that of the “policy of grandeur,” in which France sought to acquire the trappings of a superpower, such as an independent nuclear arsenal, to a more modest military strategy by the mid-1990’s. The authors attribute this change in military purchases to an increased support for European integration. Furthermore, they argue that France’s arms industry faces even more drastic changes in the near future, such as its transformation to an all-volunteer, or professional, force.

Smith (1989) tests a number of time-series specifications for UK and French military data. Although Smith’s work is primarily an econometric exercise with no research focus, the author finds a number of curious results. For example, lagged Soviet military spending does not improve the explanatory power of either the UK or French model. In addition, he finds a smaller effect from US military spending. Smith speculates that lagged US military expenditure acts as a signal for the need for new military spending within NATO.

As with other forms of public spending, military spending is also a function of political economy factors. For example, Rattinger (1975) demonstrates that the same kind of “incrementalism” that results in increases in budgets for government programs is also responsible in part for increases in defense budgets. Another type of political economy influence is the form of government. However, Zuk and Thompson (1982) find that military governments do not, ceteris paribus, produce larger military budgets. Ostrom (1978) examines the effect of the interaction among the branches of the US government on military spending. Griffin and his colleagues (1982) examine political lobbying and other institutional influences on defense spending. Cusak and Ward (1981) note strategic factors among China, the US and the USSR, while simultaneously considering domestic determinants of military spending. Weede (1995) notes the importance of cultural influences on OECD military expenditures.

Chan et al. (1982) in a study of the developing world find that a nation’s investment at the macroeconomic level and its GNP are not significant determinants of military expenditures. They employ Granger causality to test this proposition. In addition, they fail to find evidence that military expenditures are significant determinants of GNP and macroeconomic investment. This
result is suspicious given the strong amount of evidence to the contrary, including the results found later in this paper. In a study of domestic determinants of military spending, Georgiou and Smith (1983) find no evidence of Granger causality between defense spending and economic growth, profits and unemployment in the UK and the US. However, the authors find that unemployment and profits are Granger causal for military expenditure in the US. This indicates that military spending may be used as a counter-cyclical macroeconomic policy.

Murdoch et al. (1991) conduct an intrastate analysis of the determinants of defense spending. Hence, their focus is not the strategic interdependency among states. Instead, they contrast two public choice models of defense budget determination: the median voter model and the oligarchy model. In the median voter model, defense expenditures for a nation are determined by the median voter’s preferences. In the oligarchy model, a social planner, perhaps representing the nation defense establishment, determines defense spending according to a desire to maximize social welfare. To determine which model is relevant for NATO members, the authors use an estimator that adopts several values including GDP and GDP per worker. If the median voter model is more applicable, then the authors expect GDP per worker to achieve the best fit. Their results indicate that the expenditures of Belgium, the United Kingdom and the Netherlands are consistent with the median voter model. In contrast, the United States, Italy, West Germany, and France are consistent with the oligarchy model. A cursory glance at these results suggests an alternative explanation. The states identified with the median voter model are also the furthest states from the Soviet Union, with the exception of the United States, which is the dominant agent in the NATO alliance. Perhaps the authors’ results reflect spatial effects and not an underlying decision making process.

Another determinant of military spending is the desire for international prestige or status. Political power absent military capital is often illusory. This concept is often noted in discussions of modern British political influence in the international context. Britain, which is a medium-sized military power, often “punches above its weight.” The sense of inferiority and its implication concerning the relationship between political influence and military capability is apparent. Indeed,
Hartley (1997) examines the transformation of the United Kingdom from Great Power to a medium-sized power. He argues that the most efficient policy is for the UK to pursue a defense budget appropriate to its economic size. The political capital Tony Blair has accumulated within Europe due to his participation in Operation Iraqi Freedom argues against Kammler's policy recommendation. Kammler (1997) also examines the relationship between international status and military spending. Kammler argues that the "exploitation of the strong by the weak," or the seemingly free rider problem of American military power within NATO is in fact a trade by the other Western Powers for protection in exchange for tacit approval of American hegemony. For this diplomatic regime to constitute an exchange, hegemony must confer some benefit on the U.S. or its allies must incur some cost. Neither case is clear. It is more reasonable to accept that these nations are simply free riding on U.S. military expenditure.

International treaties also play a role in the defense provision decisions of nations. For example, there are many examples of various kinds of arms control agreements that restrict the accumulation of stock of certain types of weapon systems. Craft (2000) studies the impact of such agreements. She identifies two hypotheses. First, arms control agreements may reduce military expenditures in a permanent manner. Second, arms control agreements divert military funding to more advanced and therefore more expensive systems. Craft tests these conjectures for the Washington Naval agreements in the 1920’s that bound the US, the UK and Japan to certain stocks of warships. Her study indicates the second hypothesis applies. The nation-states perceived short term reductions in military spending, but ultimately spent more as new naval platforms, like the aircraft carrier, that were not covered by the treaty became available.

Finally, Jones-Lee (1990a) and (1990b) in response to McClelland (1990) attempts to examine defense spending as a form of risk abatement or safety public spending. She finds the approximate reduction in the risk of nuclear attack that is required to justify the defense budget on comparable grounds to other types of safety spending, given value of life assumptions. Of course, this type of analysis ignores many other benefits of defense spending.
4.2.3 The Effects of Military Spending

A distinct literature has emerged that examines the effect of military spending. Although the empirical model in this paper does not evaluate the impacts of military expenditure, a review of military spending impacts in the academic literature is important in order to construct the theoretical models in this paper. The most common impact studied is the effect of military spending on economic growth. The reasons for increased economic growth from military spending are numerous. As a form of government spending, military expenditure may result in increased macroeconomic output. This is of course a common Keynesian tenant, however the notion that military spending can increase output is often found in the work of the Neoclassicals, such as Barro (1981). Furthermore, because of the size and scope of military production projects, the variations in spending across time can be used to manage aggregate expenditures in an economy (Baran and Sweezy 1966). These flexible expenditures are technically known as ‘unspent budget authority.’

Benoit (1973, 1978) provides a number of distinct conjectures concerning the effect of military expenditures on GDP growth. Military spending improves property rights and reduces uncertainty. Strong militaries may result in the transfer of wealth or improved terms of trade for superior powers. Military spending may also constitute a type of investment with technology spillovers. Benoit’s analysis indicates that defense spending increased output growth in less developed countries. However, this issue is contested because his analysis focused on the 1950’s and 1960’s. Deger and Smith (1983) present contrasting evidence that military expenditure reduces economic growth for developing countries. Grosbar and Porter (1989) also find no evidence of the Benoit effect in a study of 1970’s. The authors note that this period witnessed a larger capital expenditure as opposed to operating costs.

Smith (1980) notes an important cost of military spending; namely, the crowding out of non-military capital investment at the macroeconomic level. Indeed, in a series of econometric tests of 14 OECD states, the author finds that almost every dollar of military spending crowds out one dollar of non-military spending. Smith explains that this is a result of both short run and long
run effects in capital markets. In the short run, capital-intensive industries substitute to military production. Smith (1977) also shows that most military spending occurs in capital-intensive industries. In the long run, Smith argues that consumers expect to realize lower incomes due to higher public spending; hence, the economy invests less in non-military industries. However, Smith’s conjectures are unfounded. He offers no substantive evidence that military spending crowds out private investment any more than other forms of public spending.


Shin and Ward (1999) present the most spatially sophisticated analysis in their study of the effect of military spending on the GDP for states in the Middle East. They note that earlier regional studies are, at best, case studies because the spatial arrangement of the states is not included. The thrust of Shin and Ward’s study is spatial, so the authors first report a Moran’s I statistic for the entire system, noting a high degree of spatial clustering of military expenditures. The authors also report a series of $G_i$ tests that note clustering around individual locations or nation-states (Getis and Ord 1992 and Ord and Gettis 1995). Finally, employing a spatial autoregressive model that treats military expenditures as exogenous, the authors report that

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35 Smith also presents the Marxist theory of military expenditures; namely, that these activities are necessary to sustain the capitalist system. A Realpolitik response to this claim is that in a Hobbesian world, military expenditures are necessary to sustain any socioeconomic system. Dunne (1990) examines theories of the military-industrial complex.

36 There are several formulations for G-tests. Instead of examining the global nature of clustering, as many of the tests in this paper attempt, G-tests examine local clustering. They are computed in a similar manner to as a Moran’s I, except distance and location is defined relative to one observation.
economic growth is characterized by a spatial lag and that military expenditures possess a positive effect.

Although the use of spatial tools is to be lauded, this analysis is problematic because it seems that the relevant dependent variable is the military expenditure, not GDP. GDP impacts reflect resolutions of military interactions, and as such, are long-run phenomena. Instead, current or lagged period GDP is a relatively fixed budget constraint for the strategic policy variable, military expenditures. The spatial component lies in the interaction of this choice, not the spillover of economic activity. A proper specification of this model explicitly notes that the defense decision is endogenous and simultaneous. The econometric model in this project attempts to estimate this correctly.

4.2.4 Data Challenges in Defense Economics

Ball (1984) examines the challenges of data reliability for studies of military expenditure. Two primary sources of information regarding expenditure and military stocks are available: nationally released figures, perhaps in national income accounts, and data from Western sources. This later source includes the US Arms Control and Disarmament Agency\(^{37}\), the Stockholm International Peace Research Institute, the International Institute for Strategic Studies and the International Monetary Fund. Ball’s research note indicates possible sources of intentional error in the national releases in information. Indeed, she identifies five such sources. Nation-states may engage in double-bookkeeping, in which the set of true figures is not released. Highly aggregated budget categories may also be responsible for inaccurate data. For example, suppose civil and military aviation accounts are not separated. Third, many countries depend on foreign military assistance for a sizeable amount of their military expenditures. Such aid often manifests itself in national accounts as foreign aid or assistance. Finally, many states may use unrecorded export earnings to directly purchase arms. In this case, the expenditure is not

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\(^{37}\) This agency is now a bureau in the State Department. It is responsible for publishing the World Military Expenditure and Arms Trade data set (WMEAT).
included in the conventional military budget. Ball concludes that although the non-governmental and U.S. government sources are flawed, these data are more reliable than public data from other nation-states. Indeed, the data challenges associated with such sets as the World Military Expenditure and Arms Trade (WMEAT) are common to most public use data released by the U.S. government. In contrast to the commonly accepted unreliability of Soviet military figures, Crane (1988) demonstrates that Eastern Europe’s Visegard states\(^3\) possess fairly reliable military accounts. The author verifies these published numbers through the use of input-output analysis, national income accounts and trade data.

4.2.5 Spatial Aspects

Few of the review studies, theoretical and empirical, treat space in a sophisticated manner. The standard treatment of neighborhood effects with respect to military activity is to include rival neighbors’ military behavior as a control variable. Of course, as the first model in this paper indicates, such expenditures are endogenous. Some models simultaneously estimate expenditure levels, but typically in studies of the superpowers and not in a spatial context. Shin and Ward (1999) use a spatial model, but treat defense spending as exogenous. What is missing is a truly spatial and simultaneously estimated empirical analysis of the appropriate policy choice, military expenditures.

A data issue in such a study is the measurement of distances. This is critically important for a spatial econometric model because the weight matrix is \textit{a priori} specified (Anselin 1988). Indeed, it is assumed an exogenous factor in the analysis. O’Loughlin (1986) uses contiguity, or a shared national border, of conflict behavior. Gochman (1991) constructs proximity metrics for states included in the Correlates of War project. Gleditsch and Ward (2000) provide nearest neighbor distances for all independent polities between 1875 and 1996 that are less than 950 kilometers apart.

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\(^3\) The Visegard states – Czechoslovakia, Hungary and Poland – is an archaic reference because the term originated after the Cold War. However, it is a useful term for these three states, part of “New Europe.”
Social scientists, and economists in particular, have recently included space in studies of conventional economic activity. Examples of such studies in macroeconomics include Krugman (1991) and Frankel and Romer (1999). Political scientists have also noted spatial effects (Mansfield and Milner 1997). The notion that geography plays a role in the strategic issues surrounding military expenditures has long been noted. Examples of this recognition include Mackinder (1904), Russett (1967), Spykman (1994) and Vasquez (1995). One popular theory in the diffusion of war literature posits that the probability of armed conflict increases with the number of contiguous neighbors a nation possesses (Siverson and Starr 1991). However, this type of analysis appears to be more of a tautology than a behavioral conjecture.

In an investigation of the shape of modern France, the so-called geographic hexagon, Blum and Dudley (1989) conduct a study of space as an outcome. Motivated by Losch’s (1940) work on the relationship between transport costs and the location of economic activity, the authors note the effect of the introduction of iron artillery on the ability of the feudal France to establish a modern state. The authors conclude that an increase in military technology enables a larger state characterized by a single tax authority at the summit of its political hierarchy. This analysis is flawed because it ignores the external pressures that result in the delineation of national borders. In fact, the authors fail to mention competing rivals outside of modern France. Furthermore, the authors do not explain the variation in comparable European nation-state boundaries. In effect, the study has a sample size of one.

4.2.6 Summary

The literature examining defense economics is growing because of the relevance of its topic and the existence of disputed results. For example, there is a general theoretical consensus of the alliance model of Olson and Zeckhauser (1966). Although there are many studies indicating that allied defense provision acts as a substitute good, there are studies that
find strategic rivalry among allies in military expenditure (Hilton and Vu 1991). Another result of the alliance model is that larger states possess a larger defense burden. However, the existing evidence is mixed (Oneal 1990).

Bilateral or dyadic models indicate some interaction among states, but these studies lack of spatial influences and treatment of other states as exogenous limits their use. This is especially true of case study models that only consider the spending decisions of a single state. Such studies are useful if they examine domestic political economy factors, such as bureaucratic capture or the institutional effects that determine military expenditure. International influences, such as arms control treaties have been shown to generate unintended consequences including increasing arms expenditures (Craft 2000). A desire for international status may also influence defense expenditure decisions.

Finally, there are many empirical studies of the Benoit conjecture that increased military spending increases growth. On the whole, the evidence is contradictory on whether this is true. It appears it is the case for LDC’s, but perhaps not for industrialized states. This may be a result of regional stability. In a recent study, Shin and Ward (1999) study the Middle East and find evidence of the Benoit effect.

4.3 Theoretical Models of Defense Expenditure

The availability of hypotheses concerning spatial effects and military expenditure is limited because of the dearth of spatial theoretical models. The most notable exceptions are Sandler (1999) and Shin and Ward (1999). Sandler examines viable payoffs for alliance members in a cooperative game. Shin and Ward address the guns and growth relationship for states in the Middle East. To generate a series of hypotheses for empirical examination, consider the following theoretical models. The first model analyzes the intertemporal decision faced by nation-states in a military expenditure game. The second model examines the benefits or costs of spatial proximity in a game of defense provision within an alliance or with respect to hegemonic provision of defense goods.
4.3.1 A Dyadic Rivalry Model of Conflict

The following dyadic model illustrates the purposes and determinants of arms expenditure. Although different in certain respects, this model resembles the economic conflict models produced by Hirshleifer (1988, 1989), Skaperdas (1991, 1992) and Neary (1997a, 1997b). The primary distinction of the following model with respect to existing theoretical research lies in the inclusions of spatial effects. Suppose the existence of two nation-states. The nation-states are unitary or representative agents. Assume that they are rivals; that is, that they do not have friendly diplomatic relations. Each state has the ability to transform an endowed resource into either a numeraire consumption good or a unit of arms. In this respect, the model resembles existing guns vs. butter macroeconomic models. The production of arms does not *per se* increase the welfare of the nation-state. Instead, arms production is a policy tool that requires an opportunity cost of desired private consumption in order to preserve or possibly increase future resources for the nation-state. To capture this intertemporal nature, the model consists of two periods. Each state has the following utility function.

\[ u_i = \ln(c_1) + \delta \ln(c_2) \]  

(1)

The variables \( c_1 \) and \( c_2 \) are numeraire consumption of the private good for the first and second period of the game. The parameter \( \delta \) is the social intertemporal discount factor, which is defined along the unit interval. Each state also faces the following intertemporal budget constraints

\[ \omega_1 = c_1 + a \]  

(2)

\[ t + \omega_2 = c_2 \]  

(3)
where $\omega_1$ and $\omega_2$ are the resource endowments for period one and two respectively. The variable $a$ is the amount of arms expenditures for the first period. The variable $t$ is the interstate transfer of resource endowment that occurs in the second period due to arms supply and conflict in the first period. This transfer is governed by the following condition

$$t = \rho (a - z)$$

(4)

where $\rho$ is a scaling parameter that indicates the spatial effect on conflict resolution. This parameter consists of both geographic proximity and technological capacity to transfer wealth. Consequently, $\rho$ measures the nation-states’ ability to project power and is of central interest for this study. The scaling parameter is by definition greater than zero. Cases can be established for values of $\rho$. If $\rho$ is less than one, the transfer function exhibits decreasing returns to scale. Accordingly, if $\rho$ is equal to or greater than one, then it exhibits constant or increasing returns to scale. The variable $z$ is the arms expenditure of the rival nation-state. The function defined by (4) captures the benefits or costs that result to a state depending on its supply of arms and its rival’s supply of arms. Clearly, the state gains some of its rival’s second period endowment as booty or spoils of war if and only if it possesses military dominance.

The first order condition of the utility maximization problem in (1) yields the following result.

$$a = \frac{\delta \rho \omega_1 + \rho z - \omega_2}{\delta \rho + \rho}$$

(5)

Although this is not a closed form solution because $z$ is endogenous, equation (5) is the best response function of this nation-state in this strategic setting. The partial derivative of this
equation with respect to $z$ indicates whether the strategic interaction is a game of strategic substitutes of complements. In other words, the partial derivative indicates the slope of the best response function in strategy space. This partial derivative is provided in equation (6).

$$\frac{\partial a}{\partial z} = \frac{1}{\delta + 1}$$ (6)

Because $\delta$ is bounded by zero and one, the sign of this partial derivative is positive. Hence, the interaction is a game of strategic complements or a Bertrand game. Substituting structural parameters from the rival for $z$ and simplifying yields the closed form solution for arms expenditure.

$$a = \frac{\delta \sigma_1 + \rho^2 \delta \sigma_1^{rival} - \rho \sigma_2^{rival} - \sigma_2}{\frac{\delta + 1}{(\delta \rho + \rho)^2} - \frac{\sigma_2}{(\delta \rho + \rho)^2} - \frac{\rho^2}{(\delta \rho + \rho)^2}}$$ (7)

It is important to note that the solution found in (7) does not guarantee a non-negative quantity of arms. Certain values for $\delta$ and $\rho$ discourage arms expenditure by reducing the benefit to any hopeful piratical nation-state. Low values of the discount factor increase the incentive of the nation-state to reduce costly arms expenditures in the current period because private consumption is more preferred. Indeed, a negative value of arms in such a setting reflects a desire of the nation-state to transfer resources from the discounted future to the valued present. Likewise, a low value of $\rho$ punishes investment in arms by reducing the potential benefit of military dominance, as well as lowering the potential threat from other nation-states. Given that nation-states indeed supply positive quantities of arms, identifying ranges of $\delta$ and $\rho$ that
generate non-negative values of arms is therefore required to insure a sensible Nash equilibrium for the arms expenditure game.\textsuperscript{39}

The construction of several cases is useful for identification of theoretically sensible ranges of $\delta$ and $\rho$. First, examine the simplest case. Suppose there is no change in resource endowments from period one to period two for both nation-states. Furthermore, suppose that each nation-state possesses identical resource endowments. In this setting, the following inequality insures non-negative arms expenditure.

$$\delta \geq \frac{1}{\rho} \tag{8}$$

Suppose now that the nation-states do not possess symmetric resource endowments. Let $\omega = \theta \omega^{\text{final}}$, where $\theta$ is greater than zero. Again, suppose there is no intertemporal change in resource endowments for both nation-states. Perhaps not surprisingly given the Bertrand nature of the game, there is no binding change in the requirements on $\delta$ and $\rho$. The constraints are inequality (8) or the following inequality, which is not fulfilled by definition.

$$\delta \leq -1 - \theta \tag{9}$$

The introduction of economic growth, as modeled by an intertemporal resource endowment change, changes these conditions slightly. Suppose now that $\omega_2 = \gamma \omega_1$ for both nation-states. The parameter $\gamma$ is greater than zero and measures macroeconomic growth or decline. The condition for non-negative arms expenditure is now

\textsuperscript{39} Iceland, which does not have a military, is an exception that proves the rule. The United States is responsible for its international security in exchange for bases. This type of hegemonic behavior is explored throughout this study.
As growth increases for both nation-states, the condition for non-negative arms expenditures becomes more stringent. The requirements on $\delta$ and $\rho$ become considerably more complex for asymmetric growth cases. However, general conclusions can be stated. Relatively low values for $\rho$ may generate non-negative values in the model due to the lack of military power projection. Relatively low levels of $\delta$ may also generate negative values for arms because of an increased emphasis on the present and a reduced concern for the consequences in the future. High growth rates for rivals also increase the likelihood of negative arms in the theoretical model due to a consumption-smoothing motive. These scenarios can be ruled out theoretically.

Having established feasibility conditions on the Nash Equilibrium of the arms expenditure game, details of the strategic nature of the game can be examined. Although the game is characterized by strategic complements, the solution of this dyadic model is not necessarily symmetric. Indeed, except for cases in which the rival states possess identical resource endowments, the arms expenditure quantities are not symmetric among rival nation-states. Examining the asymmetric manner in which the resource endowments appear in equation (7) reveals this assertion. A numerical example is also illustrative. Suppose a nation-state possesses a first period resource endowment of 100 and a second period resource endowment of 110. Suppose its rival possesses corresponding resource endowments of 75 and 85. Further suppose $\delta$ is equal to 0.9 and $\rho$ is equal to 2. Solving the model finds that the wealthier nation-state provides an arms quantity of approximately 35.06 and its rival generates a quantity of approximately 31.61. The wealthier and militarily dominant nation-state obtains from its rival a second period resource capture total of approximately 6.90. Hence, unlike other conflict models, power differentials exist and military conflict is not always offsetting in this model.
Comparative statics of the solution found in (7) can be found. First, it is clear that spatial effects influence the outcome of the strategic interaction. Differentiating $a$ with respect to $\rho$ and simplifying yields,

$$\frac{\partial a}{\partial \rho} = \omega_2^{\text{rival}} + \omega_2 (1 + \delta) \quad (11)$$

Not surprisingly, equation (11) indicates that as the transfer parameter increases, arms expenditure increase. Given the definition of this parameter, two conjectures can be characterized from this result. First, reductions in spatial proximity between rival nation-states increase arms expenditure. Although this result is intuitive, it is important to explicitly define it as it is of central importance for the empirical tests of this study. Second, increases in military technology result in increased arms expenditure levels. This theoretical result is consistent with what Adam Smith calls “the advancement of civilization” and its corresponding impact on the growing expense of the military.

The level of future discounting also has an impact on arms expenditure. Differentiating $a$ with respect to $\delta$ and simplifying yields

$$\frac{\partial a}{\partial \delta} = \frac{(\omega_1 - 1) \rho \delta^2 + 2(\delta + 1) \omega_2^{\text{rival}} + (2(\delta + 1) + \delta^2) \omega_2}{\rho \delta^2 (\delta + 2)^2} \quad (12)$$

There are two reasons why increased valuation of the future increases arms expenditure, as noted in (12). First, the fear of consumption loss due to possible military weaknesses is valued more highly. Similarly, the gain in consumption terms due to potential military dominance is also valued more highly. Although clearly the ratio defined in equation (12) is positive, the relatively small negative term is due to an accounting for the expected increase in arms expenditure of the
nation-state’s rival. This increase must be matched in turn by increased expenditure, which results in reduced present consumption.

The impacts of a nation-state’s first and second period resource endowment on arms expenditure are indicated by the following partial derivatives, which reduce to surprisingly simple forms. Equation (13) defines the impact on arms expenditure from an increase in the first period resource endowment.

\[
\frac{\partial a}{\partial \omega_1} = \frac{\delta + 1}{\delta + 2}
\] (13)

Clearly, this ratio is less than one. However, interestingly this comparative static indicates that the marginal increase of the first period resource endowments results in large amounts of increased military spending with the new resources. This impact is due to the fact that it is the first period desire to consumption smooth, which is bound to the resource constraint of the first period, that is responsible for restraining military expenditure. Increases in these resources reduce the need to consumption smooth and hence free available resources for arms.

The following equation indicates the impact of increased resources in the future on contemporary arms expenditure.

\[
\frac{\partial a}{\partial \omega_2} = -\frac{1}{\delta + 2}
\] (14)

Equation (14) indicates a negative value with absolute value less than one. Clearly, expected future wealth reduces current arms expenditures. This result is due to the desire to consumption smooth over a period with increasing income. Note that as the discount factor increases, the reduction in arms expenditure decreases. This is due to the increase in value on future gains or losses from military activity.
The impacts of changes in the resource endowments of a nation-state’s rival are the following partial derivatives. Equation (15) indicates the change due to an increase the rival’s first period resource endowment.

\[
\frac{\partial a}{\partial \omega_1^{\text{rival}}} = \frac{\delta + 1}{\rho (\delta + 2) \delta}
\] (15)

It is important first to note that, given the non-negativity constraints identified earlier, in particular inequality (8), the denominator of equation (15) is greater than one. Therefore, the value defined in equation (15) is positive but less than one. The intuition for this impact is the same as that of the comparative static involving a nation-state’s own first period resource endowment. Increased wealth for the rival increases its arms expenditure. Consequently, the other nation-state must defend itself from its rival. However, this value is less than the ratio defined in equation (13) because of the defense motive. In other words, resources lost in the future are less valuable in time-discounted terms than current resources spent on arms. Furthermore, note that as \( \rho \) increases, the size of the ratio defined in (15) decreases. The greater the capacity or technology for resource transfer due to military activity, the smaller the influence of the budget constraint on the size of the military. This is due to the interaction of the consumption-smoothing motive and the military transfer impact. If the ability to transfer wealth is very large, then only a small amount of first period resources needs to be sacrificed for arms.

Finally, equation (16) notes the impact of future resources for a nation-state’s rival on current arms expenditure.

\[
\frac{\partial a}{\partial \omega_2^{\text{rival}}} = -\frac{1}{\rho (\delta + 2) \delta}
\] (16)
For the reasons noted above, this ratio is negative and has absolute value of less than one. Moreover, the absolute value of this ratio is less than the comparative static defined in equation (14), which indicates the change in own second period resources. The defense motive identified as a component of (15) is responsible for this relationship between growth in a nation-state’s resource endowment and its rival’s resource endowment. As in (15), note the dampening effect $\rho$ has on the value in this comparative static.

Of course, the preceding comparative statics indicate the changes in arms expenditure due to changes in essentially isolated or unrelated structural parameters. They are illustrative of the Nash equilibrium of the game, but not of the interplay between the rival states. The following comparative statics indicate changes in arms expenditure due to changes in the structural parameters defined explicitly as relative indicators among the nation-states. This testing of the theoretical model is consistent with the conceptualization of power as a game of differentials among the players. However, unlike many of these models, note that the game in this study is not zero-sum; rather, it is a Prisoner’s Dilemma.

To accomplish this type of evaluation, the parameters of the model must be redefined in relative terms. Thus, the resource endowments are defined in terms of $\omega_i$. Let $\gamma \omega_i$, equal $\omega_2$, where $\gamma - 1$ is equal to the growth rate. Let $\theta \omega_i$, equal $\omega_i^{rival}$, where $\theta$ is equal to the magnitude of difference for the first period resource endowment among the nation-states. Finally, let $\tau \theta \omega_i$, equal $\omega_2^{rival}$, where $\tau - 1$ is equal to the growth rate of the rival nation-state.

The first of this set of comparative statics indicates the impact of the relative size differential between the initial resources of the rival nation-states.

$$\frac{\partial a}{\partial \theta} = \frac{(\delta \rho - \tau \gamma)\omega_i}{\rho(\delta + 2)\delta}$$

(17)
Interestingly, the sign of this partial derivative is dependent on the first term in the numerator. The tradeoff is between the time discounted conflict transfer parameter and the rival nation-state’s resource growth rate. If the first of these terms dominates, the possibility of military loss is of great concern. This results in a conflict setting in which increasing the relative size of the rival nation-state’s economy causes an increase in arms expenditure. Alternatively, if the second term dominates, the rival nation-state’s growth is sufficient to deter its military ambition. Thus, increasing the relative size of the rival nation-state’s economy counter-intuitively reduces arms expenditures. Clearly, if the growth rate of the rival nation-state is negative or zero, then an increase in the relative size of its economy unambiguously increases arms expenditure. A specific example involving the subtle nature of growth and relative size differentials is explored below.

Consistent with the notion that growth deters military spending are the following partial derivatives. The following equations note the impact of a nation-state’s growth in resources and its rival’s growth in resources respectively.

\[
\frac{\partial a}{\partial \gamma} = -\frac{(\tau \theta + \delta + \gamma) \omega_1}{\rho (\delta + 1) \delta}
\]  \hspace{1cm} (18)

\[
\frac{\partial a}{\partial \tau} = -\frac{\theta \gamma \omega_1}{\rho (\delta + 1) \delta}
\]  \hspace{1cm} (19)

Each of these comparative statics indicate that increased growth, whether a nation-state’s own or its rival’s, decreases military expenditures. In each case, the motive to consumption smooth encourages a decision to sacrifice scarce resources in the current period to obtain resources for a relatively wealthier future. This does not suggest however that arms expenditure cease. As demonstrated earlier, the motive to deter a rival’s military dominance remains. However, growth reduces this motive for all players in the game.
The preceding comparative statics thus provide guidance regarding the impact of growth on arms expenditure. Increased economic growth of a nation-state reduces arms expenditures. Expected increases in growth of a rival nation-state reduce arms expenditures. However, equation (17) indicates that in some cases high levels of growth of a rival may be indirectly responsible for increased arms expenditure. As an experiment, suppose the nation-states are asymmetric with respect to the initial size of their economies. As the relative initial size of the rival increases, if the rival’s growth multiplier is less than $\delta \rho$, then arms expenditures increase. In such a situation, the nation-state must increase its defenses to deal with a rival with a relatively low growth rate. The rival desires to offset this relatively low growth with military dominance. Alternatively, if the rival’s growth rate is greater than $\delta \rho$, then as the relative initial size of the rival increases, arms expenditure decreases. In this setting, the nation-state indirectly benefits from the robust growth of its rival through a reduced provision of rival arms.

The situation is reversed as relative initial size of the rival decreases. If the rival’s growth multiplier is less than $\delta \rho$, then arms expenditure decreases. However, if the rival’s growth rate is greater than $\delta \rho$, then the increasing disparity in initial economic size results in increased arms expenditure for the nation-state. In this setting, the rival expects a larger resource endowment in the second period. Consequently, the opportunity cost of employing a defense in the first period is larger. Hence, it becomes easier for the other nation-state to achieve military dominance. It is an offensive motive, and its subsequent benefits, that results in the increased arms expenditure in this setting. Growth only indirectly results in increased arms because the opportunity costs change. Equation (19) notes the direct impact of increased growth, which is an unambiguous decrease in arms expenditure.

This possible indirect consequence of growth that may result in increased arms expenditures is subtle enough that a numerical example is illustrative. Suppose that a nation-state’s first period resource endowment is 100. Let $\delta$ equal 0.9 and $\rho$ equal 2. Suppose that this nation-state has no resource endowment growth. As the established comparative statics
indicate, none of the preceding assumptions are critical for demonstrating the impact noted in equation (17). Using these assumptions, it is possible to plot \( a \) in terms of \( \theta \) and \( \tau \). Figures 1 and 2 plot quantities of \( a \), which illustrate the direct and indirect impacts of a rival nation-state’s growth, as graphed by various values of \( \tau \).

The direct impact due to an increase in a rival nation-state’s growth rate is to reduce arms expenditure, as indicated by equation (19). This is seen graphically in Figure 2, in which \( a \) continuously decreases as a function of \( \tau \). For example, if \( \tau \) and \( \theta \) are equal to 1, then \( a \) is equal to approximately 44.44. If \( \tau \) increases to 1.9, then \( a \) decreases to approximately 27.20. However, its rival supplies an arms quantity of approximately 11.69; hence, military dominance is still established and a transfer of 31.03 from the rival of second period resource endowment points results.

The indirect impact is illustrated in Figure 1. As noted in equation (17), if \( \delta \rho \) is less than \( \gamma \tau \), then a decrease in the relative size of the first period resource endowment of the rival nation-state reduces arms expenditure. Given the values identified above, this counter-intuitive result occurs if \( \tau \) is greater than 1.8, which can be seen by the inflection line in Figure 2 at 1.8.

Continuing the previous numerical example, suppose \( \tau \) remains equal to 1.9 but \( \theta \) falls to 0.5. In this case, arms expenditure increases to 28.16. In this example, the growth rate for the rival nation-state is large enough, that the opportunity cost of supplying arms in the relatively resource scarce first period is large. Hence, the nation-state in question increases its military expenditure to establish military dominance over its rival. Indeed, the rival nation-state supplies an arms quantity of 13.51, which establishes it as the militarily inferior nation-state. Consequently, a second period resource transfer of 29.31 occurs.

4.3.2 Allied and Hegemonic Defense Model

The preceding model notes the interaction of two rivals. However, a focus of the existing research concerning the determinants of military expenditure is the interaction of allies. All
existing studies employ what I term a partial equilibrium model; that is, these models treat alliance formation as predetermined. With the exception of Sandler (1999), no studies have examined spatial considerations of the military provision of the alliance. Although illustrative, Sandler’s model is a cooperative game. In contrast, a non-cooperative spatial model of defense provision for an alliance is presented below. This model is characterized as a game of strategic substitutes because nation-states have an incentive to free ride on the costly efforts of their more powerful allies.

Another defense context that involves strategic substitution, or Cournot strategic behavior, is the provision of international security by a hegemon. A hegemon is a nation-state in the international system that exhibits leadership with respect to global public goods. The analysis of Kindleberger (1970) is an early example of this conceptualization. International public goods constitute the global infrastructure, which enables international enmeshment or globalization. Examples include an international communication system, an international finance system and global stability. Global stability, achieved by reducing economic risk associated with war and other forms of political violence, is the manifestation of defense expenditure as a public good. And like other public goods, the incentive to free ride exists because of the non-rival and non-excludable nature of the hegemonic service. This is not to suggest that hegemonic provision is universally appreciated or that it occurs without cost to the other nation-states. Indeed, a system of voluntary public good provision exhibits many of the characteristics of an aristocratic patronage system. Individuals may without contradiction consume the public service and resent the socioeconomic system that is responsible for the established inequity of economic power.

Because hegemonic activities involve the potential for Leviathan style corruption, distinguishing types of Great Power behavior is critical. A powerful nation-state that engages in international looting, as modeled in the dyadic defense model above, is known as a malevolent hegemon or, in common language, an empire. In contrast, a hegemon that undertakes costly provision of defense for international public good purposes is referred to as a benign hegemon. For example, many of the actions of the British Royal Navy of the 19th century may be classified

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under the category of benign hegemony. The British Navy ended the transatlantic slave trade, enforced the Monroe Doctrine, fought piracy, and performed other maritime operations that reduced the risk associated with international trade. A naval officer of the time commented, “We looked upon the navy more as a world police force than as a warlike institution. Our job was to safeguard law and order, put out fires on shores and act as guide, philosopher and friend to merchant ships of all nations.” (Spector 2001) The ultimate foreign policy question of the post-9/11 era is whether the United States military should engage in similar activities.

The theoretical strategies of nation-states in hegemonic systems and alliances may be analyzed using the same type of model. In each case, the costly provision by one or more nation-states generates positive externalities for its neighbors. Indeed, the hegemonic model is a special case of the alliance defense provision. This is described in more detail below. Unlike the dyadic model, let the utility of the states be

\[ u_i = \ln(c_i) + \ln(A_i) \]  

(20)

where \( c_i \) is private consumption of nation-state \( i \), and \( A_i \) is the effective military protection offered by the military alliance in which nation-state \( i \) is member. Although consistent with existing research, this model is a reduced form of the earlier model in that the threat is passive; hence military provision is included directly in the social welfare function. This reduces the immediate use of the model but allows an examination of the alliance provision of arms. \( A_i \) may also be thought of as the international public good or service generated by defense expenditure, as in a hegemon model. Thus, the primary difference between the hegemon and alliance formulations of this strategic substitution model of defense expenditure is partly a matter of excludability. Alliances are more easily able to exclude the benefits from their existence than those provided by a hegemon. However, even alliances are capable of producing positive externalities for non-members. An excellent example is the security benefit generated by NATO on neighboring but neutral nation-states like Switzerland.
As in the dyadic rivalry model, each nation-state faces a tradeoff between arms and private consumption. Let nation-state $i$’s budget constraint be

$$\omega_i = c_i + a_i \quad (21)$$

where $m_i$ is the resource endowment of the nation-state that can be transformed into the private consumption good, $c_i$, or military goods, $a_i$. The spatial impact of the model is captured in the definition of $A_i$. Suppose that the coalition of nation-states consists of three states located along a line with nation-state 2 located centrally. Distance acts to decay the ability to project power. So let

$$A_i = a_i + \sum_{j \neq i}^{2} d_{ij}^{-1} a_j \quad (22)$$

where $d_{ij}$ is the distance between state $i$ and $j$. The distance parameter is a measure of spatial decay or increasing ineffectiveness of assisting allies across geographic space. Obviously, given this definition of distance decay, all distance measures must be less than one; otherwise, alliance provision effectiveness would experience a multiplier across space. Defense spending in an alliance according to this definition of the model is thus an impure public good.

With this model, it is possible to examine strategic nature and the benefits or costs of spatial centrality. First, given the arrangement defined above, the first order conditions of the alliance game are found for the three nation-states.

$$a_1 = \frac{\omega_1}{2} - \frac{a_2}{2d_{12}} - \frac{a_3}{2(d_{12} + d_{23})} \quad (23)$$
\[ a_2 = \frac{\omega_2}{2} - \frac{a_4}{2d_{12}} - \frac{a_3}{2d_{23}} \]  

(24)

\[ a_3 = \frac{\omega_3}{2} - \frac{a_2}{2d_{12}} - \frac{a_1}{2(d_{12} + d_{23})} \]  

(25)

Unlike the provision of military goods among rival nation-states, the strategic interaction among allies is a game of strategic substitutes. This is verified by examining the partial derivatives with respect to allied expenditure of the non-closed form solutions in equations (23) through (25). For example, consider the partial derivative of \( a_1 \) with respect to \( a_3 \).

\[ \frac{\partial a_1}{\partial a_3} = -\frac{1}{2(d_{12} + d_{23})} \]  

(26)

Clearly, the sign of this derivative is less than zero, which is consistent with a game of strategic substitutes. An exogenous increase in defense provision by an ally causes that nation-state’s allies to reduce their defense provision. In other words, this strategic environment is consistent with free riding because of the spillover benefits allied defense expenditure generate.

The impact of own income on defense spending in an alliance model helps define the difference between the alliance model and hegemon model. Clearly, an increase in a nation-state’s income results in an unambiguous increase in the provision of defense goods. Thus, as the size differential with respect to income or resources among allies increases, the amount of free-riding or unilateral provision of defense goods increases. A hegemon emerges if nation-state is of sufficient size to effectively provide a security umbrella under which its neighbors significantly reduce or eliminate their defense expenditures.

In addition to differences in economic potential, the spatial arrangement of the allies may also generate impacts on the provision of allied defenses. A few simplifying assumptions allow a useful examination of this strategic element. For the three nation-state model identified earlier,
suppose the distances between the peripheral nation-states and the central nation-state are equal to $d$. To focus the examination on spatial effects, also suppose the resource endowment of each state is $\omega$. Employing these assumptions and the first order conditions defined in (23) through (25), the Nash Equilibrium quantities of the defense good are

\[ a_{\text{peripheral}} = \frac{(2d - 1)\omega d}{4d^2 + d - 2} \]  \hspace{1cm} (27)

\[ a_{\text{central}} = \frac{(2d - 1.5)\omega d}{4d^2 + d - 2} \]  \hspace{1cm} (28)

It is clear the central nation-state, possessing the advantage of centrality, provides less of the impure public good in equilibrium. Moreover, the central nation-state gains more security from the alliance than the peripheral nation-states. Equations (29) and (30) indicate the effective alliance benefit provided to the central nation-state and a peripheral nation-state.

\[ A_{\text{central}} = \frac{\omega(2d^2 + 2.5d - 2)}{4d^2 + d - 2} \]  \hspace{1cm} (29)

\[ A_{\text{peripheral}} = \frac{\omega(2d^2 + 2d - 2)}{4d^2 + d - 2} \]  \hspace{1cm} (30)

Given that $d$ is greater than one, it is clear that the central state enjoys a privileged position within an alliance of economically symmetric nation-states. A central nation-state provides less of the spatial public good. It captures more of the effective benefits. And consequently, this nation-state possesses higher utility than its less geographically favored neighbors.
4.3.3 A Note on a Spatial General Equilibrium Model of Defense Provision

The preceding models of defense expenditure assume that diplomatic relations among nation-states are predetermined. Hence, these models are best characterized as partial equilibrium models. For a general equilibrium version of the conflict game, alliance membership is treated as endogenous. In the first stage of such a game, alliances are announced. In the second stage, the partial equilibrium of arms expenditure is determined. The solution concept is subgame perfect Nash Equilibrium and is identified using backwards induction. Each possible subgame is solved and then the first stage Nash Equilibrium alliances are determined according to the standard utility maximization criterion relative to each nation-state.

The literature on this type of balance of power model is large within political science; hence, it is not the goal of this study to reproduce this work. For example, it is known that in some models there is no guarantee of a non-empty core for the game. Thus, some powers may act as balancing powers, which alternate alliance memberships in an iterative attempt to maintain a balance of power. Other models describe fixed coalitions of nation-states in static opposition due to geographic and economic structural factors. Finally, other models suggest that culture, trade, or institutional similarities determine alliances. Morgenthau (1950), Kennan (1984), Kennedy (1987) and Kissinger (1994) are excellent examples of analyses of international relations and alliance formation.

General equilibrium solutions of alliance formation and defense good supply for the models in this study are inherently idiosyncratic. With a given set of economic parameters and a spatial arrangement of the nation-states, alliance formation may be solved in the manner described above. There is no guarantee that a Nash equilibrium exists. Moreover, this method offers little in terms of testable hypotheses, the subject of the next section of this study.

4.3.4 Theoretical Conjectures

The theoretical models of nation-state military expenditure developed in this study offer the following conjectures. Fundamentally, military spending is a strategic action among nation-
Military spending *per se* does not increase the welfare of a nation-state. Instead, military expenditure offers protection against risk and possible benefits through military dominance. This study has identified three categories of military expenditure as a strategic interaction: non-hegemonic nation-state rivalry, non-hegemonic nation-state alliance and hegemonic leadership.

The dyadic model of defense rivalry indicates that the supply of defense goods is a game of strategic complements. An increase in a nation-state’s income increases military expenditure. However, increases in the income growth rate of nation-state reduce military expenditure because the opportunity cost of military expenditure increases. Increases in a rival’s income and growth also reduce military expenditure because of strategic complementarity. From a relative power perspective, increasing the relative size of a nation-state’s rival generates an ambiguous result on own arms expenditures. If the rival is growing fast, as defined in (17), then an increase in the relative size of the rival reduces own arms expenditures. However, if the rival is not growing fast relative to the potential benefit for future military dominance, then an increase in the relative size of a rival increases own arms expenditure.

Allied nation-states are present in a distinctly different process involving arms expenditure, albeit a strategic process. In this case, provision of defense is a game of strategic substitutes. Military provision within an alliance of nation-states resembles the provision of an impure public good. The arms are pooled and thus useful to all the members of the alliance. However, geographic space diminishes this pooled benefit among the allied nation-states. Similar to models of voluntary public good provision, an increase in the income of nation-state causes it to increase its supply of military goods. Increases in the income of allies generate reductions in a nation-state’s provision of military goods. Smaller nation-states free ride on the defense expenditure of other nation-states. Central nation-states, possessing the benefit of relatively weaker distance decay, also free ride in this model.

The hegemonic model shares many characteristics of the alliance model. The key difference between the two models is that leadership, in the form of defense expenditure, is undertaken by the existence of a disproportionately powerful nation-state in a hegemonic model.
Moreover, free riding occurs among a larger set of nation-states and to a larger degree in a hegemonic international system. Hence, the degree of strategic substitution is higher in a hegemonic model. The manifestation of this system is a larger share of total military expenditure for the hegemon and a reduced share among the other nation-states.

Finally, in addition to the straightforward impact of distance as modeled by $\rho$ on arms expenditure, the location of a nation-state relative to its neighbors impacts defense expenditures. A central nation-state in an alliance model is able to maintain a smaller level of defense expenditure due to its increased potential to free ride on alliance defense supply. Although not explicitly formulated in the dyadic rival model, a central nation-state among rivals faces a greater security dilemma due to larger number of possible threats. Thus, an increase in relative geographic centrality cannot be associated with an unambiguous increase or decrease in defense expenditure. However, it is clear that centrality can be associated with positive or negative outliers in a defense game. An example of central nation-state with a heightened security dilemma is Israel. An example of central nation-state within an alliance is Canada. In each case, conventional wisdom holds that each of these nation-states possesses significantly different defense expenditure than its economic and political characteristics suggest.

4.4 An Empirical Study of Post-Cold War Global Defense Expenditures

The preceding theoretical conjectures offer a variety of testable hypotheses regarding the defense spending decisions of nation-states. These behavioral conjectures are evaluated in this study by a spatial econometric analysis of defense expenditures. The time period of investigation is the post-Cold War era. With the dissolution of the Soviet Union and its network of satellite nation-states, the world anticipated a period of decreasing defense expenditures. This “peace dividend” was eagerly anticipated to supplement private and public spending.

However, the end of the bipolar system of the Cold War did not eliminate the underlying security concerns of the world. The peace dividend, such that it was, is illustrated in Figure 3, which indicates world spending on defense. It is clear from these data that the developed world,
including the United States, experienced a period of real decreases in defense expenditures. By 1994, a rough equilibrium appears to have been achieved. The United States remained the dominant player in global defense spending, although its defense burden fell from 5.5% of GNP in 1989 to 3% in 1999, as seen in Figure 4. Also during this period, the developing world experienced an increase in real defense spending, while realizing a decrease in armed forces personnel, as illustrated in Figure 5. Together, these facts suggest that increases in national income played a central role in the defense spending decisions of developing nation-states.

Figures 3 through 5 indicate that a relative stability in defense affairs was achieved in the late 1990's. This period therefore offers an excellent opportunity to investigate the determinants of defense expenditure in an era free of the polarizing ideological conflicts that may drive defense policy. Clearly, September 11th and its subsequent impacts destroyed this paradigm in world affairs. Unfortunately, the data do not yet exist to examine these events from a global military perspective. Regardless, it is clear that the United States will experience a large increase in military spending. From $281 billion in 1999, the defense budget of the United States may exceed $350 billion by 2004, a projected increase of approximately 25%. Moreover, there is little evidence that the other nation-states of the world have altered their own behavior. As will be seen in this study, these events suggest that the hegemonic leadership of the United States will characterize the first decade of the 21st century. Indeed, the evidence for this behavior is clearly visible in 1998 and 1999. The geopolitical changes generated by September 11th will only increase these observed system characteristics. However, there are rivals to U.S. military dominance. Figure 6 indicates those nation-states with military expenditure of $10 billion or more. Figures 7 through 13 map military expenditures for all nation-states examined in this research.

A series of econometric tests are performed in this study. These tests are designed to evaluate the theoretical model developed earlier, as well as to evaluate several ancillary hypotheses concerning defense spending and geopolitics. First, ordinary least squares (OLS) estimates of defense spending are reported to provide a non-spatial benchmark. Then these
estimates are contrasted with estimates from spatial autoregressions (SAR). Several spatial weight matrices, indicating the geographic nature of nation-state interaction, are employed to test robustness of the spatial analysis. Next, a similar set of estimations is computed for changes in defense spending. For all of the preceding tests, a second set of estimates is found for the world excluding the United States. Next, a series of tests indicates the determinants of defense spending relative to GNP and the total personnel strength of nation-states’ armed forces. Finally, an attempt is made to study a composite measure, consisting of spending and personnel, for defense activity and the strategic process involved in its selection by each nation-state. The objective of this entire set of tests is to evaluate the strategic impact of U.S. defense spending, as well as the nature of the underlying strategic interaction of all other nation-states.

4.4.1 Data Description

Data for this econometric investigation are from the U.S. State Department’s World Military Expenditures and Arms Trade (WMEAT) 2000 dataset, the latest release as of 2003. This source of military data is by far the most comprehensive and reliable in the public domain. This assertion is justified by the fact that most public sources, such as the World Bank or the U.S. government, use the information reported in this dataset. The WMEAT dataset contains data for total military expenditures, total armed forces population, gross national product, central government expenditure, and population for all nation-states, including Taiwan, which is often not present in global datasets for political reasons. A number of nation-states present in the data are not included because of lack of size, geographic remoteness, or incomplete data. None of these nation-states is a serious player in global or regional military affairs. A total of 148 nation-states are used in this study. For some statistical tests, the United States is excluded for reasons noted later.

40 The nation-states in the WMEAT excluded for lack of size are Barbados, Cape Verde, Dominican Republic, Fiji, Gambia, Guinea-Bissau, Jamaica, Lesotho, Liberia, Malta, and Sao Tome Principe. Iceland, which is the only nation-state in the world without military expenditure (it is under the military aegis of the U.S.) was eliminated from the study because it is geographical remote. Finally, Afghanistan, Bhutan, the Republic of the Congo, Equatorial Guinea, Haiti, Liberia and Somalia are not included due to lack of military data.
The data in the 2000 release of WMEAT cover the period 1989 to 1999, although they are incomplete for some nation-states. This study uses data from 1998 and 1999, and thus represents an effort to study the pre-9/11 stability that perhaps represented a post-Cold War global equilibrium in military affairs. This period is critical to an understanding of the current international security system because the seeds of a possible Pax Americana or U.S. hegemony were planted after the conclusion of the Cold War.

Additional data from the Central Intelligence Agency’s 2000 World Factbook were used to supplement the WMEAT data. In particular, information regarding geographic, political, social and additional economic characteristics is constructed for each nation-state. Maps from the Factbook also served as the primary source of information regarding neighborhood definitions for the nation-states. This geographic information was also supplemented by Huntington’s (1996) map of civilizations. Table 1 records descriptive statistics concerning the variables in this chapter.

A fixed set of independent variables is employed in all of the econometric tests in this paper. The first three of these variables are geographic controls. AREA is a measure of a nation-state’s size in square kilometers. It includes land and non-oceanic water territory. Throughout the empirical study, AREA is hypothesized to increase military expenditures by increasing transport costs and deployment requirements. LBORDER is a measure in kilometers of a nation-state’s contiguous land borders with other nation-states. It is also believed to increase military expenditures by increasing the defensive requirements of the military. AREA and LBORDER are both available in the CIA data. The final geographic variable, HISLAM, is a dummy control that indicates the impact due to a nation-state’s position along the borders of what Huntington defines as Islamic civilization. Huntington (1996) develops the hypothesis that Islamic civilization has “bloody borders” by noting that most of the high profile military conflicts in the post-Cold War era have occurred where Islamic societies contact non-Islamic societies. Examples include the Sudanese civil war, the Yugoslav wars of Bosnia and Kosovo, Chechnya, and of course the Israel-Palestinian conflict. Figure 14 indicates the nation-states that qualify.
A salient criticism of Huntington’s conceptualization is that civilizations are not easily recognizable entities in the modern nation-state dominated international system. Hence, the dummy employed in this study is not a test of the Huntington hypothesis *per se*; but rather, it is a test of whether a nation-state’s position along these international fault lines generates an observable impact in nation-state military expenditures. The impact of the sign of this coefficient should be positive if this manifestation is indeed present.

The next three variables are political indicators of the nation-states. The first two are dummy variables representing types of political systems for governance of the nation-states in 1999. They are constructed from CIA data. *DEMOCRACY* is a dummy variable indicating whether the nation-state possesses a modern representative democracy. This category includes republics and constitutional monarchies with established democratic traditions. It does not include transitional governing systems, especially with respect to post-Soviet republics. Because democracies are more uncomfortable with war as means of accomplishing limited political objectives, the estimated coefficient should possess a negative sign. *TYRANNY* is a dummy variable for governing systems that are characterized by dictatorship. It includes rule by the few remaining communist dictatorships, such as Cuba and Laos, Stalinist rule in North Korea, and traditional monarchical rule in nation-states such as Saudi Arabia. This variable is hypothesized to have positive sign due to the historical willingness of such states to use military force as policy tool. The final variable in this category is constructed from data in the WMEAT. *NMCGE* is a measure of non-military central government expenditure. It is constructed by subtracting military expenditure as a percentage of GNP from central government expenditure as a percentage of GNP. The expected sign of this coefficient is positive because it indicates available resources under existing tax finance policies for government expenditure, including military expenditure.

The final category of variables contains economic characteristics. *POP* is the 1999 population of the nation-state in millions of people. Larger populations should be positively increased

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41 The default status, given that democratic and tyrannical governments are indicated, is transitional. As this is the political status of most of the nation-states in the study, it is the appropriate non-dummied condition.
42 Iran is not included in this set due to its regular use of elections in the 1990’s. It is, however, not included as a democracy due to the lack of authority exercised by the elected elements of government.
associated with military expenditure because a larger labor force is a component of national resources, as modeled in the dyadic rivalry model. These data are from the WMEAT. POPG is the 1999 population growth rate, as reported by the CIA. There are two contradictory expectations for the sign of this coefficient. The sign may be negative because it represents growth in the next period’s resource endowment for the nation-state. On the other hand, the sign may be positive because a growing population with little or no economic growth can reduce per capita income and thus increase the incentive of the nation-state to use military tools as a means of enrichment. This ambiguous theoretical expectation is illustrated in (17). Because population growth tends to be higher in the developing world, the expected value for this sign is positive.

The next three economic variables are constructed using CIA data. The first is GNPAG, which indicates the percentage of GNP dedicated to agriculture in 1999. This variable is intended as an indicator of the nation-state’s level of economic development or modernity. The expected sign is negative because modern nation-states purchase more expensive military equipment. Likewise, TVPC is televisions per capita for 1999. It is intended as a micro-level complement with the macro-level GNPAG as an indicator of nation-state modernity. OPEN is a unitless measure of the nation-state’s enmeshment in international trade. It is constructed from CIA data from 1999 for imports and exports. The sum of imports and exports is divided by two and then divided by 1999 GNP. The expected sign of this variable is positive because increased global enmeshment suggests a greater stake in international affairs and a greater desire to reduce international security risk.

Finally, the WMEAT provides 1998 and 1999 gross national product data, defined as GNP98 and GNP99 respectively. Both variables are measured in terms of millions of constant 1999 dollars. The WMEAT provides, and this study employs, gross national product, not gross domestic product. Gross national product is a more appropriate measure because it indicates national income, which ultimately the budget constraint for the nation-state. Gross domestic product is more appropriate for macroeconomic studies attempting to study the economy of a particular nation-state. Using these data, two independent variables are included in the study.
First, $GNP99$ is employed. No stronger hypothesis exists than the expectation that the sign of the estimated coefficient of current income is positive. Second, $GNPG$ measures gross national product growth from 1998 to 1999 and is constructed using $GNP98$ and $GNP99$. As the theoretical models indicate, the expected sign of the coefficient for this variable is negative due to the increase in the opportunity cost associated with arms expenditure in a growing economy.

Several variables were created that were not used in the formal econometric tests in this study. They are noted here because from a conceptual perspective it is sensible to expect each to explain some aspect of military expenditures. Water border measured the length of nation-state’s international border along coastlines, as reported by the CIA. Unfortunately, this variable was badly skewed in favor of nation-states with irregular coastlines, thus reducing it potential utility. For example, Canada has an immense coastline; however, most of this border lies along the Arctic Ocean. A related geographic variable was discarded for similar reasons. A score was created for each nation-state to measure its deviation from a perfect circle. A circle is more easily defended than other two-dimensional geometric objects because it possesses, in military jargon, the strongest interior lines. The reasoning is the same as the spatial arrangement of the monocentric urban model. The score was a ratio of the squared length of the border, land and water, divided by the area. A circle possesses the minimum score of $\frac{4\pi}{4}$, with larger scores for increasingly non-circular borders. The variable was discarded because the water border measured was not practical. Two other geographic variables were abandoned because they proved less useful than other elements in the econometric test. One was a dummy variable indicating nation-states that lay along a civilization border, not just Islamic civilization, as defined by Huntington (1996). The second of these two variables measured the number of contiguous neighbors for each nation-state. This proved less valuable than the lag parameter in spatial autoregressions described later. Population density was eliminated as an independent variable because of multicollinearity problems with $AREA$. Finally, a dummy variable indicating a chaotic government, or the lack of any organized government, was eliminated because too few nation-states qualified.
4.4.2 Econometric Tests

The first objective is to obtain benchmark non-spatial estimates of the determinants of military expenditure. OLS estimation is used. The dependent variable is military expenditure for 1999 in millions of dollars, as reported by the WMEAT. The set of independent variables includes all variables discussed above. The results contained in Table 2 indicate that only three of the independent variables possess statistically significant impacts. The most important verified impact is with respect to current income, \( GNP_{99} \), which is strongly positive. The coefficient indicates that for every $1,000,000 added to GNP, nation-states on average increase military expenditure by approximately $26,000. \( AREA \) has a positive impact on military expenditure as expected. The results suggest that for an increase of 1000 square miles, nation-state increase military expenditure by $1,000,000. This finding suggests a small but significant impact for geographic size. Finally, \( POP \) has statistically significant but unexpectedly negative impact on military expenditure. The coefficient indicates that an exogenous increase in population of one million, military expenditure falls by approximately $15,300,000, which is relatively small. The reason for this negative sign is possibly due to the fact that population acts as a budget constraint for another, albeit strongly related, form of military allocation: manpower. Thus, a negative sign in this estimation for \( POP \) appears to indicate that manpower and money are military input substitutes, and by increasing the population, the relative cost of fielding an army that is manpower intensive falls. This is explored in more detail below. Of the variables not found to have a statistically significant impact, the most surprising is GNP growth, \( GGNP \). A possible explanation for this impact is that it reflects a nation-state’s evolution from the developing to the developed world. Among the impacts of such an evolution is military transformation, or changing from a manpower-intensive to a capital-intensive military. Prominent examples include Eastern European nation-state that recently joined the North Atlantic Treaty Organization (NATO). Further confirmatory evidence of the existence of this type of income expansion path is found in later tests dealing with armed forces manpower quantities and the composition of militaries.
Table 3 reports OLS estimates from the same econometric test, except without the presence of the United States. The technique of excluding the U.S. is repeated for a number of the tests in this study because of its extreme size. The results hint at the hegemonic role of the U.S. The same variables are statistically significant, although the size of the coefficient for GNP99 decreases by almost 50%. Clearly, the U.S. is responsible for a significant portion of the variation in military expenditure that is explained by covariation in national income. Indeed, such a large proportion of this impact associated with the U.S. suggests hegemonic provision of military services. Moreover, it indicates that the spatial lag parameter in the spatial econometric estimations should reveal this leading defense role. Additionally, with the U.S. removed from the estimation, POP remains significant but switches signs. It now has a positive impact on military expenditure. Removing the U.S. has apparently eliminated the income expansion path effect noted above, and revealed a more conventional explanation for the relationship between population size and military expenditure.

With these benchmark results, estimates regarding the strategic interaction among nation-states can be found. Spatial econometric methods are the tool for this task. Using the same set of independent variables, a mixed regressive, spatial autoregressive model (SAR) is estimated. The specification of this model is defined in (31).

\[ y = \rho W y + X \beta + \varepsilon \]  

(31)

The vector \( y \) is the dependent variable. The variable \( \rho \) is the spatial lag parameter, which is estimated and bounded by [-1,1]. The matrix \( W \) is the a priori defined spatial weight matrix. It governs the spatial relationship between the nation-states by defining neighbors. As in a non-spatial regression, \( X \) is a matrix of independent variables and \( \beta \) is vector of regression coefficients. Finally, \( \varepsilon \) is a classical error term. Anselin (1988) provides the details regarding estimation and limitations.
The benefit of the SAR model is two-fold. First, the model incorporates endogenous geographic impacts, or what might be referred to as neighborhood effects, by including neighboring nation-state actions. Moreover, it estimates these impacts simultaneously, thus eliminating endogeneity problems associated with some studies of defense activity. In these flawed studies, hostile nation-state activity is included but only as an exogenous independent variable. Second, the estimated value of the spatial lag parameter indicates the nature of the strategic process. A negative value indicates a Cournot game of strategic substitutes. A positive value indicates a Bertrand game of strategic complements. However, it is important to note that one advantage of this study, which is explicitly global, is that the lag parameter cannot estimate regional differences in behavior. As estimated, the spatial lag parameter measures strategic interaction for the entire system.

The spatial weight parameter must be defined a priori. Thus, to insure robustness, I use several spatial weight matrices in this study. The first one is simple contiguity matrix. A spatial weight matrix is $n \times n$, where $n$ is the number of nation-states in the estimation. Each element in the matrix, $w_{ij}$, indicates a measure of spatial interaction between nation-state $i$ and $j$. For the contiguity matrix, $w_{ij}$ is defined as one if the nation-states are contiguous neighbors and zero otherwise. This framework may be problematic for some types of economic studies, but for a military model is it ideal. Except for the U.S. and perhaps the United Kingdom, no nation-states have the military potential to project power except along their border. It is inconceivable, for example, that Brazil would go to war against Saudi Arabia, not due to politics, but because it is technically infeasible. In fact, many analysts believe the U.K.’s war against Argentina in the Falklands was its last hurrah for what is termed “expeditionary war.” For example, the United Kingdom in Operation Iraqi Freedom was entirely dependent on the U.S. for air support and partially dependent on the U.S. for logistics and strategic transport because it does not have the aircraft carriers and C-17 or C-5 transport aircraft necessary to project military power. Thus, a contiguity matrix is acceptable for this type of analysis conducted in this study. This does not however preclude that actions or structural characteristics in nation-states that are not contiguous
to a nation-state have no impact. Because the estimation is simultaneous, arms expenditure in one state can influence its immediate neighbors, and they in turn influence their immediate neighbors. This suggests an indirect chain of spatial spillovers that decay, because the spatial lag parameter is less than one, but exist nonetheless.

Assigning values for the matrix is straightforward for nation-states with contiguous land borders. For nation states with no contiguous land neighbors, some intuition is required to assign neighbors and prevent strategic isolation as a consequence of geographic characteristics. Thus, Japan is defined as a neighbor with North and South Korea, as well as China and Russia. China and Taiwan are also assigned as neighbors. The United Kingdom borders Ireland and France. Sri Lanka is assigned as a neighbor to India. Australia borders Indonesia and Indonesia borders Singapore and Thailand. Madagascar is a neighbor with Mozambique. Russia and the United States are also defined as neighbors due to the proximity of Siberia and Alaska.

The spatial model was estimated using Matlab code. The contiguity matrix significantly eases estimation by exploiting Matlab’s ability to reduce computational complexity through sparse matrices, or matrices with larger regions of zeros. Figure 15 indicates a map of the weight matrix used in this study. The axes refer to the identification numbers assigned to each nation-state. The identification system is alphabetical except for the United States, which is number 148. The points in the figure indicate ones within the 148x148 matrix. There are 562 points in the matrix map, indicating 281 distinct dyadic interactions within system. Furthermore, there are no isolated regions in the system. It is possible for each nation-state to influence everyone other nation through a chain of indirect impacts. Clearly, this impact can be negligible, but it remains possible.

Without the sparse matrix algorithm, estimation of spatial models is computationally intensive. Because the technique estimates each spatial interaction a simultaneously, that is endogenously, estimation requires inverting a 148x148 matrix multiplied by the matrix of independent variables. Such a task strains all but mainframe computers. The code used to

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43 James LeSage of the University of Toledo generously provides these codes without cost. The estimation techniques are consistent with Anselin’s (1988) statistical theory of spatial econometrics.
estimate the spatial model also row normalizes the weight matrix to ease computation. For each row in \( W \), each element is divided by the row sum. Thus, the SAR model is best conceptualized as estimation on an endogenous spatial mean. The cost of this approach is that every nation-state is treated symmetrically in terms of importance. As the theoretical model indicates, this is clearly not the case. The size of a nation-state’s income increases its security risk. The method for addressing this concern is discussed below.

Table 4 contains the estimates for the SAR with the contiguity matrix. The dependent variable remains \( GNP99 \). There are some key differences, corrections in the sense that the non-spatial estimates employ incomplete information, between these results and the OLS estimates. First and most importantly, \( \rho \) is significant and negative. This result indicates that strategic interaction among the nation-states exists in the selection of total military expenditures. Moreover, the interaction is Cournot or a game of strategic substitutes. Military spending globally is thus characterized more by concentration rather than diffusion. Recalling the theoretical model, this estimate indicates that the global system of military expenditures is consistent with the alliance or hegemonic model. Because a global alliance does not exist, this result is consistent with the hegemonic interpretation; that is, U.S. military spending deters hostile nation-state military spending and provides a security umbrella that allies may free ride under. Surprisingly, the size of the coefficient of \( \rho \) is small, only 0.04 in absolute value terms. Computationally, this may be due to the fact that \( GNP99 \) is such a strong determinant of military spending that there is little remaining variation in the dependent variables to be attributable to the neighborhood effect or strategic interaction. The fact that the constant is not a significant variable is consistent with this assertion. Among other changes from adopting the SAR model, non-military central government expenditures, \( NMCGE \), is significant with a positive sign in the SAR estimation. Nation-states with a larger non-military public sector are also likely to have larger defense budgets. Finally, \( AREA \)’s estimated coefficient increases by almost 50%. This type of change is likely due to the indirect accounting possible in a spatial econometric estimation. Large nation-
states likely have more neighbors, which in turns suggests that their characteristics, including \(\text{AREA}\) itself, may produce larger impacts in the dependent variable.

The next estimation, reported in Table 5, is an SAR estimation without the presence of the United States. This type of estimation may be thought of a form of spatial counterfactual, similar to a time series study in which the events of some pivotal year are removed. The cost of this technique is the observations that are contiguous neighbors of the U.S. are likely missing crucial information. Nevertheless, this method provides a method of examining the strategic environment of defense spending, absent the U.S. Similar to the OLS estimation without the U.S., one difference is a reduction in the size of the \(\text{GNP99}\) coefficient. The spatial lag parameter switches signs and loses its statistical significance. This is an important finding because it records the impact removing U.S. actions from the system has on the other nation-states. Performing a \(t\)-statistic on whether the lag parameter estimated in Table 4 is greater than the value of the point estimate in Table 5 generates a \(t\)-statistic greater than 2. Thus with reasonable certainty, removing the United States from the system produces an increase in the spatial lag parameter. The conclusion, that the U.S. is responsible for downward pressure on the spatial lag, is consistent with the U.S. as hegemon hypothesis. As the U.S. defense budget grows, this impact will become even clearer in coming years.

As noted earlier, a problem with the contiguity spatial weight matrix is that it treats nation-states symmetrically with respect to their potential for impact on the defense policies of their neighbors. To check the robustness of the SAR results already presented, two other weight matrices are employed. For the first, GNP weights are added to the contiguity matrix. Thus, for each element in \(W\), if nation-state \(i\) and \(j\) are contiguous then

\[
w_{ij} = (\text{GNP99}_i) (\text{GNP99}_j)
\]

Otherwise, \(w_{ij}\) is equal to zero. With row normalization of the weight matrix, each spatial interaction is thus weighted by economic size. This is entirely consistent with the theoretical
model developed in this study. Table 6 reports the estimates from an SAR estimation using this GNP-weighted $W$. Perhaps unsurprisingly, the results indicate no major changes due to the use of a new spatial weight matrix. Table 7 notes estimates from a GNP-weighted estimation without the U.S. The results are similar to those in Table 5.

The second alternative spatial weight matrix attempts to explicitly model the U.S. as a hegemon. For this estimation, the GNP-weighted $W$ was used, except the row and column defining U.S. interactions were altered so that the U.S. is defined as a contiguous neighbor for every nation-state in world. Given the ability of the U.S. to position aircraft carriers off the coast and marine task forces on the beaches, this geographic alignment reflects military capabilities. Table 8 reports the findings of this SAR. The results differ negligibly with those in Table 5. This suggests that the existing spatial models indeed incorporate the U.S. impact, which is clearly present given the estimates of the models that exclude the U.S.

In summary, the tests of the determinants of military expenditure reveal the following conclusions. National income is the primary determinant of defense expenditure. Increased geographic size of a nation-state increases defense spending. Increased population decreases total defense spending for the U.S., but increases it all other nation-states. The presence of a totalitarian government likely increases military expenditure. The global system appears to be characterized by Cournot strategic interaction, which is consistent with the U.S. as a hegemonic power. This assertion is further justified by the fact that the estimated coefficient for $\text{GNP}99$ falls by nearly 50% in tests without the U.S. The results are robust to various definitions of the spatial interaction.

The second set of econometric tests examines the determinants and possible strategic impacts of annual changes in levels of defense expenditure. The dependent variable for these tests is $\text{MEC}$, which is constructed by subtracting $\text{ME}98$ from $\text{ME}99$. Examining the adjusted $R$-squared for these tests immediately reveals that they are less successful than the first set of tests in explaining the variation in the dependent variable. Table 9 reports OLS estimates for these determinants. The same set of independent variables is used. The results are surprisingly
similar to the first OLS estimation of the level of military expenditure in 1999 in terms sign and significance. The important factors are once again AREA and GNP99. Again, surprisingly the economic growth rate is not an important independent variables according to the estimates. Table 10 reports the OLS estimates excluding the U.S. AREA remains the only significant independent variable in this weak estimation. According to these results, a larger nation-state in terms of area is associated with a larger change in military expenditures from 1998 to 1999.

Tables 11 through 15 report the SAR estimates for the dependent variable MEC. For a spatial estimation, the expectation is that the change in defense expenditure should be associated with a larger, in absolute value terms, spatial lag parameter than the estimates associated with the level of military expenditure. The results fail to justify this expectation. Indeed, the results indicate no statistically identifiable strategic interaction with respect to changes in military expenditure. This conclusion holds regardless of whether the U.S. is included or excluded and for a series of spatial weight matrices. In fact, the only firm conclusion that may be drawn regarding the determinants of changes in military expenditure is that the area of a nation-state is positively correlated with increases in military expenditure. The reasons for this randomness in this ostensibly strategic variable are unclear, although perhaps it is the case that military expenditures are slow to change, that is they are “sticky”, and therefore only long run changes in actions are suitable for analysis.

The next category of evaluation examines the military expenditure to GNP ratio. Although strategically meaningless, this ratio receives a lot of attention because it is a decent intensity or dedication measure. In other words, it indicates what amount of national treasure a nation-state is willing to commit to national defense. North Korea possesses the world’s highest ratio at 18%\textsuperscript{44}. The Soviet Union in its heyday in the 1970’s possessed a ratio of 20%. Of course, it is the absolute level of military spending that generates security, not the percentage of national income. But an analysis of this measure is revealing of the nation-state itself. Table 16 reports OLS analysis of MEGNP, this ratio. TYRRANY is significant and positive and for quite

\textsuperscript{44} In recent years, it has been has high as 30%.
intuitive reasons. Only a government not subject to the immediate demands of its population could sustain such high levels of military spending. Indeed, it is reasonable to believe that this was the marginal reason for the demise of the Soviet Union. Population growth is significant and possesses a positive sign. The reason for this association is unclear, although given the identified impact of TYRRANY, this determinant reveals the domestic security role a nation-state’s military, especially vis-à-vis growing and potentially unhappy population.

The next dependent variable of interest is AF99, or the manpower quantity of a nation-state’s armed forces. As noted earlier, the total armed forces and total military expenditures are related but reflect differences in national resources. Clearly, increasing the size of a nation-state’s armed forces increases its total expenditure. However, a nation-state may also reduce its armed forces size while increasing its expenditures, thus becoming a more capital-intensive military. The determinants of this are investigated below. The first task is to examine the determinants of the size of the armed forces in manpower terms. Table 17 records OLS estimates for the dependent variables AF99. Similar to the examination of ME99, AREA is a significantly positive determinant of manpower. GNP99 retains its role as the budget constraint, although the coefficient diminishes in size. In contrast, several variables reveal differences between this test and that for military expenditure. First, POP is positive and significant. For an increase in one million people, the armed forces of a nation-state increase by one and a third thousand, according to the estimates. Second, TYRANNY is positive and significant, unlike the military expenditure test. This result possibly reveals the desire to keep a population in check under a totalitarian regime. Finally, NMCGE is positive and significant. This result clearly reflects a crowding out motive, that is, selecting quantity over quality, in the provision of military services.

Tables 18 and 19 note the SAR estimates for AF99 employing the contiguity spatial weight and the GNP-weighted spatial weight respectively. The results differ only marginally with respect to the choice of spatial weight. However, there are significant changes with respect to the adoption of a spatial model. First, the spatial lag parameter is significant and positive. This suggests that global military rivalry, that is strategic complementarity, exists, even with the U.S.
present in the test. Apparently, U.S. hegemony deters nation-states from engaging in capital-intensive military competition, but does not reduce competition in individual soldiers. A second change in the spatial model is the elevated significance of GNPG, GNP growth. The estimated coefficient possesses a negative sign, which is consistent with the conjectured income expansion path with respect to labor- and capital-intensity in military provision. This result indicates that as national income grows, the quantity of personnel in the armed forces decreases.

The preceding tests indicate that a predictable choice exists between a labor-intensive and capital-intensive military, and that this choice is linked to structural characteristics of a nation-state. The final set of tests investigates this point further. Tables 20 through 24 record estimates for a composite measure military output. This score is a production function in which labor and capital are inputs, each exhibiting diminishing marginal returns. Because the data do not exist to estimate properly the form of this production function, several versions are evaluated. The three versions are each assigned a different parameter indicating a mix of labor and capital. \textit{LME25LAF}, \textit{LME10LAF}, and \textit{LME60LAF} are thus constructed dependent variables in which the natural log of military expenditures is added to a parameter (10, 25, or 60) multiplied by the natural log of the armed forces size. Although this formulation appears to be \textit{ad hoc} in nature, it is well-motivated by microeconomic theory. As noted above, it is a production function. More importantly, the inputs, money and labor, are complements. Given a budget constraint for these inputs, a nation-state may select the optimal mix to achieve a desired level or production quantity of military services. A labor rich nation-state may use more labor, and a wealthy nation-state may use more money or capital. The proportions of the parameters originate from the differences in spending per soldier in the developed, developing, and world average, and thus are an attempt to include the elasticity of substitution of the inputs from the observed behavior. The employed formulation of a composite score clearly favors labor over capital. However, only in \textit{LME60LAF} is U.S. military dominance surpassed, and only by China.

Table 20 reports OLS estimates using the dependent variable \textit{LME25LAF}. The results are more, but not entirely, consistent with the theoretical conjectures established in this study.
than the determinants of military expenditure or armed forces size. *TYRANNY* and
*DEMOCRACY* are both positive and significant determinants of the composite measure. As
noted earlier, the manner in which each of these governance types increases the composite
score is different. Totalitarian regimes prefer labor, while democracies prefer capital, this last
point justified in more detail below. Huntington’s Islamic civilization frontier variable is positive
and significant, which indicates that nation-states in these locations are arming using a mix of
capital and labor. The remaining significant variables are consistent with the theoretical
predictions. Current levels of resources or inputs, whether population or national income, are
positively correlated with *LME25LAF*. Furthermore, positive growth rates of these resources
reduce military provision. Lastly, relatively larger agriculture sectors reduce military provision,
perhaps reflecting the modernity impact described in the data section. Tables 21 and 22 repeat
this analysis for *LME10LAF* and *LME60LAF*. The results are nearly identical.

Given the success the independent variables have in explaining this composite
dependent variable, a spatial examination is the next step. Tables 23 and 24 record the result
from SAR analysis of *LME25LAF* using the contiguity and GNP-weighted matrices. The results
are the strongest evidence in the study of rivalry or strategic complementarity among nation-
states. In each spatial test, the spatial lag parameter is positive and significant. Moreover, the
lag parameters are the largest in this study. It seems clear that these spatial tests confirm that
nation-state rivalry in defense exists, but not within a purely expenditure based contest. Defense
competition in armed forces size or a mix of personnel and spending appears to be present, even
in a system that displays hegemonic tendencies.

The last two empirical tests examine the determinants of military spending per armed
forces personnel (*MEAF*). Several hypotheses exist in for this topic. Hanson (2001) indicates
that Western-style democracies have a long history of heavy infantry. Well-defended soldiers
who fight en masse and use shock tactics characterize heavy infantry. In contrast, dictatorial
regimes prefer light infantry, whose soldiers fight with little discipline and little protection.
Economics defines these divisions of military labor. Democracies, with broad property ownership
and a stakeholder political system, equip their soldiers to win with little cost in terms of own casualties. Dictatorial regimes are more concerned with maximizing return on conquest by minimizing military expenditure. Hanson’s examples for these typologies are Greek hoplites and Persian infantry. Thus, **DEMOCRACY** should produce a distinct positive impact on **MEAF**, which is separate from the positive impact of national income. Increased **POP** should reduce **MEAF** by reducing the opportunity cost of labor.

Table 25 contains the OLS estimates for the analysis of **MEAF**. Democracy indeed is positively associated with higher spending per soldier, and thus greater capital intensity, presumably due to a casualty minimization motive. National income increases **MEAF**, while **POP** reduces it as expected. Interestingly, the size of a nation-state’s land border increases **MEAF**, perhaps reflecting a technical requirement in defense. Population growth increases **MEAF**, which perhaps indicates a willingness to finance defense spending with borrowing from future generations. Table 26 reports the SAR analysis. The spatial lag parameter is positive and significant indicating that nation-state rivalry in spending per soldier exists. This result confirms that military spending is rival in terms of quality.

The preceding econometric tests evaluated the nature of global strategic interaction for a series of military behaviors. However, a remaining conjecture from the theoretical models remains unevaluated. Does centrality generate extreme values with respect to military behavior and in which direction, underprovision or overprovision? To consider this question, the residuals from one of the previous econometric tests were mapped and evaluated for statistical importance. Residuals from the OLS regression reported in Table 2 were examined. Constructed $t$-statistics for each residual were computed using the variance reported in model estimation. Significance was evaluated according to a $t$-statistic greater than 1.96.

The United States possessed significantly more spending ($36 billion) than its own characteristics predict. This is the final and most convincing element of evidence indicating a hegemonic role for the U.S. The following nation-states nominally aligned with the U.S. possessed significantly less military spending than the predicted by their own characteristics:
Germany, Poland, Hungary, Austria, Italy, Canada, Mexico, Japan and Australia. A map of these states is found in Figure 16. The allied defense model in this paper noted that nation-states with relatively more centrality should benefit from their location by being able to free ride on the military efforts of their allies. Statistically significant negative residuals for Germany, Poland, Hungary, Austria and Italy are consistent with this hypothesis. These nation-states are clustered in the center of Europe, thus receiving some protection from peripheral allies, such as Greece, Turkey, Spain the United Kingdom, and of course the United States. Canada and Mexico are more obvious free riders from U.S. military hegemony. Japan's and Australia's lack of land borders are included in the OLS regression; hence, their statistically significant negative residuals may also reflect a dependence on the U.S. This is must certainly true of Japan which possessed a t-statistic of negative 6.3, indicating significant underprovision of military goods. On the other extreme, Saudi Arabia and Taiwan possessed significantly more military spending than their own characteristics predict. For each, a hostile neighbor, Iraq and China respectively, may be responsible for this positive residual.

4.5 Conclusion

The results in this paper demonstrate several structural characteristics of the Post-Cold War global security regime. First, the U.S., even before September 11th, demonstrates hegemonic properties. Most observers simply indicate the massive difference between U.S. military spending and the rest of the world to prove U.S. hegemony. This paper adds an empirically verified strategic property, that U.S. military activity transforms an expected game of strategic complements into a game of strategic substitutes. This suggests that allies are free riding under the security aegis of the U.S., while hostile states are deterred in expenditure competition.

However, strategic complementarity in military behavior is still observed in the selection of armed forces size and a composite variable indicating the mix of personnel and expenditure. Finally, evidence is found of an income expansion path with respect to military expenditure. Poor
nation-states, especially those with tyrannical governments, are likely to employ large, poorly equipped militaries. As nation-states increase in income, and democracy, these governments substitute labor-intensive armed services for capital-intensive armed services. However, an alternative explanation may also be present. Nation-states have chosen not to compete with the U.S. in terms of capital-intensive military provision; thus ceding a sphere of influence to the United States and reducing costly competition. After all, it was this competition that weakened the Soviet Union and caused it to fall from within. The nation-states of the world have not ceded dominance to the United States by reducing competition for armed forces size. Thus, some form of competition with the hegemon, and of course with their neighbors, remains.

Whether these results are robust to the dramatic change in global affairs from September 11th and the War on Terror remains to be seen. My expectation is that, if anything, the change in world affairs has only reinforced this set of structural characteristics by increasing the hegemonic role of the United States.
4.6 Works Cited


Losch, August. 1940. Theory of Location. English translation: New Haven, CT.


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Table 4.1 Descriptive Statistics
### OLS Analysis of 1999 Military Expenditures

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<tbody>
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Table 4.2: OLS Analysis of 1999 Military Expenditures

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Table 4.3: OLS Analysis of Non-US 1999 Military Expenditure
### SAR Analysis of 1999 Military Expenditures

**Dependent Variable:** ME99  
\( n = 148 \quad R^2 = 0.9227 \quad \bar{R}^2 = 0.9152 \)  
Spatial Weight: Contiguity

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*Table 4.4 SAR Analysis of 1999 Military Expenditures*

### SAR Analysis of Non-US 1999 Military Expenditures

**Dependent Variable:** ME99  
\( n = 147 \quad R^2 = 0.8635 \quad \bar{R}^2 = 0.8501 \)  
Spatial Weight: Contiguity

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*Table 4.5: SAR Analysis of 1999 Military Expenditures*
### SAR Analysis of 1999 Military Expenditures

**Dependent Variable:** ME99  

\[ n = 148 \quad R^2 = 0.9223 \quad \overline{R}^2 = 0.9147 \quad \text{Spatial Weight: GNP Weighted} \]

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Table 4.6: SAR Analysis of 1999 Military Expenditures

### SAR Analysis of Non-US 1999 Military Expenditures

**Dependent Variable:** ME99  

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Table 4.7: SAR Analysis of Non-US 1999 Military Expenditures

190
### SAR Analysis of 1999 Military Expenditures

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Spatial Weight: Hegemon GNP Weighted

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Table 4.8: SAR Analysis of 1999 Military Expenditures

### OLS Analysis of Change in Military Expenditures

**Dependent Variable:** MEC  
\( n = 148 \quad R^2 = 0.4583 \quad \overline{R^2} = 0.4057 \)

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Table 4.9 OLS Analysis of Change in Military Expenditures
## OLS Analysis of Non-US Change in Military Expenditures

Dependent Variable: MEC

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Table 4.10: OLS Analysis of Non-US Change in Military Expenditures

## SAR Analysis of Change in Military Expenditures

Dependent Variable: MEC

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Table 4.11: SAR Analysis of Change in Military Expenditures
### SAR Analysis of Non-US Change in Military Expenditures

**Dependent Variable:** MEC  
\( n = 147 \)  \( R^2 = 0.3823 \)  \( R^2 = 0.3219 \)  Spatial Weight: Contiguity

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<td>DEMOCRACY</td>
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Table 4.12: SAR Analysis of Non-US Change in Military Expenditures

### SAR Analysis of Change in Military Expenditures

**Dependent Variable:** MEC  
\( n = 148 \)  \( R^2 = 0.4614 \)  \( R^2 = 0.4091 \)  Spatial Weight: GNP Weighted

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Table 4.13: SAR Analysis of Change in Military Expenditures
### SAR Analysis of Non-US Change in Military Expenditures

**Dependent Variable:** MEC  
\( n = 147 \)  \( R^2 = 0.3812 \)  \( R^2 = 0.3207 \)  Spatial Weight: GNP Weighted

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Table 4.14: SAR Analysis of Non-US Change in Military Expenditures

### SAR Analysis of Change in Military Expenditures

**Dependent Variable:** MEC  
\( n = 148 \)  \( R^2 = 0.4617 \)  \( R^2 = 0.4094 \)  Spatial Weight: Hegemon GNP Weighted

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Table 4.15: SAR Analysis of Change in Military Expenditures
### OLS Analysis of Military Expenditures to GNP Ratio

**Dependent Variable:** MEGNP  
\( n = 148 \quad R^2 = 0.1829 \quad \hat{R}^2 = 0.1036 \)

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Table 4.16: OLS Analysis of Military Expenditures to GNP Ratio

### OLS Analysis of 1999 Armed Forces Personnel

**Dependent Variable:** AF99  
\( n = 148 \quad R^2 = 0.7887 \quad \hat{R}^2 = 0.7682 \)

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Table 4.17: OLS Analysis of 1999 Armed Forces Personnel
### Table 17: SAR Analysis of 1999 Armed Forces Personnel

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Spatial Weight: Contiguity

### Table 4.18: SAR Analysis of 1999 Armed Forces Personnel

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<td>DEMOCRACY</td>
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<td>TYRANNY***</td>
<td>95.262549</td>
<td>3.040388</td>
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<td>NMCGE**</td>
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<td>2.443758</td>
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<td>POP***</td>
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<tr>
<td>RHO*</td>
<td>0.034683</td>
<td>1.811762</td>
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Spatial Weight: GNP Weighted

### Table 4.19: SAR Analysis of 1999 Armed Forces Personnel

With the conclusion of the SAR analysis, it is evident that the dependent variable, AF99, is significantly influenced by various independent variables. The model demonstrates a strong explanatory power, with an R² of 0.7957 for the first model and 0.7938 for the second model, indicating a high degree of fit. The spatial weights, whether contiguity or GNP weighted, further enhance the model's predictive capability, capturing the geographical patterns and spatial dependencies in the data.
## OLS Analysis of 1999 Composite Military Score

### Dependent Variable: LME25LAF

\[ n = 148 \quad R^2 = 0.3604 \quad \overline{R^2} = 0.2984 \]

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<td>HISLAM**</td>
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<tr>
<td>DEMOCRACY**</td>
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<td>TYRANNY***</td>
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<td>NMCGE</td>
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<td>POP*</td>
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<td>1.773255</td>
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<td>POPG*</td>
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<td>-1.709313</td>
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<td>GNPAG*</td>
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<td>TVPC</td>
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<td>OPEN</td>
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<td>-0.064107</td>
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<td>GNPG</td>
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Table 4.20: OLS Analysis of 1999 Composite Military Score

## OLS Analysis of 1999 Composite Military Score

### Dependent Variable: LME10LAF

\[ n = 148 \quad R^2 = 0.3724 \quad \overline{R^2} = 0.3115 \]

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<td>HISLAM**</td>
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<td>DEMOCRACY**</td>
<td>7.337326</td>
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<td>TYRANNY***</td>
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<td>NMCGE</td>
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<td>POPG*</td>
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<td>-1.726870</td>
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Table 4.21: OLS Analysis of 1999 Composite Military Score
### OLS Analysis of 1999 Composite Military Score

**Dependent Variable:** LME60LAF  
\[ n = 148 \quad R^2 = 0.3556 \quad R^2 = 0.2931 \]

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<td>DEMOCRACY**</td>
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<td>TYRANNY***</td>
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<td>POPG*</td>
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Table 4.22: OLS Analysis of 1999 Composite Military Score

### SAR Analysis of 1999 Composite Military Score

**Dependent Variable:** LME25LAF  
\[ n = 148 \quad R^2 = 0.4163 \quad R^2 = 0.3597 \quad \text{Spatial Weight: Contiguity} \]

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<td>DEMOCRACY**</td>
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Table 4.23: SAR Analysis of 1999 Composite Military Score
### SAR Analysis of 1999 Composite Military Score

**Dependent Variable:** LME25LAF

\[ n = 148 \quad R^2 = 0.3964 \quad \bar{R}^2 = 0.3378 \]  
Spatial Weight: GNP Weighted

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Table 4.24: SAR Analysis of 1999 Composite Military Score

### OLS Analysis of Spending per Armed Forces Personnel

**Dependent Variable:** MEAF

\[ n = 148 \quad R^2 = 0.7241 \quad \bar{R}^2 = 0.6974 \]

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</tr>
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<td>NMCGE</td>
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Table 4.25: OLS Analysis of Spending per Armed Forces Personnel
**SAR Analysis of Spending per Armed Forces Personnel**

**Dependent Variable:** MEAF

\[ n = 148 \quad R^2 = 0.7312 \quad \bar{R}^2 = 0.7052 \quad \text{Spatial Weight: Contiguity} \]

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<td>DEMOCRACY***</td>
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<tr>
<td>RHO*</td>
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<td>1.841645</td>
</tr>
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</table>

Table 4.26: SAR Analysis of Spending per Armed Forces Personnel

Throughout this section, the following symbols are employed.

*** Significant at a 1% level
** Significant at a 5% level
* Significant at a 10% level
Figure 4.1: Impact of Rival Nation-State Growth on Arms Expenditure

Figure 4.2: Impact of Rival Nation-State Growth on Arms Expenditure
Figure 4.3: World Arms Expenditures in the Post-Cold War Era

Figure 4.4: World Arms Expenditures in the Post-Cold War Era
Figure 4.5: Armed Forces Size in the Post-Cold War Era

Figure 4.6: Nation-States with at Least $10 Billion in Military Expenditure in 1999
Figure 4.7: 1999 North American Military Expenditures
Figure 4.8: 1999 Central American Military Expenditures
Figure 4.9: 1999 South American Military Expenditures
Figure 4.10: 1999 European Military Expenditures
Figure 4.11: 1999 Southwest and Central Asian Military Expenditures
Figure 4.12: 1999 Asian Military Expenditures
Figure 4.13: 1999 African Military Expenditures
Figure 4.14: Nation-States Located along Huntington's Islamic Civilization Border
Figure 4.15: Map of the Contiguity Spatial Weight Matrix

Figure 4.16: Free Riding U.S. Allies
CHAPTER 5

SPHERES WITHIN THE DOME: CONGRESS AND SWEETHEART GERRYMANDERING

5.1 Introduction

Gerrymandering is an often-noted element of strategic competition among political parties. In the typical narrative of gerrymandering, a dominant political party determines new jurisdictional boundaries for state and federal elections. The objective of the party is to maximize the number of offices its members win in popular elections. A cottage industry of research within political science and economics has examined optimal gerrymandering schemes and their various impacts. In general, this research has found evidence of partisan bias due to the manipulative impact of gerrymandering.

In contrast, sweetheart gerrymandering denotes a more subtle strategic process. Sweetheart gerrymandering describes a bipartisan or cooperative effort by political parties to draw election districts in their mutual favor. This strategy is usually attributed to a desire for incumbent protection. Consequently, the relatively insignificant history of electoral defeat of congressional incumbents is attributed to the lack of competitive districts. A November 11, 2002 Washington Post editorial declared,

“A major, though certainly not only, reason for this acclamation of incumbents is the corruption of the redistricting process eagerly entered into by both parties. Redistricting, which redraws congressional districts following the census every decade, ought to be designed to make districts more competitive and to make
incumbents more accountable. Yet in practice, state legislatures proceed with two aims in mind – protecting incumbents from challenge and maximizing partisan advantage.”

Putting aside the ridiculousness of a Washington newspaper displaying incredulity that politics intercedes in a political affair, this editorial expresses the conventional wisdom regarding redistricting; that it protects incumbents from a strong electoral challenger from the rival party due to lack of local ideological support.

No study in economics or political science has adequately explained the motives behind this cooperative behavior. In fact, the only motivation identified among the studies of gerrymandering is an assertion that gerrymandering protects incumbents. This is true up to a point; however, the political parties are also rival institutions that are locked in zero-sum contests within election districts. This paper seeks to develop a model of political party objectives that explains this local cooperation among national conflict.

The theoretical model developed in this study indicates that if the political parties possess objective or utility functions defined according to the passage of desired legislation, then a form of cooperative behavior consistent with sweetheart gerrymandering is rational. Cooperation in this strategic setting takes the form of spheres of influence or well-recognized political bases that are determined by district apportionment or the allocation of campaign effort. The net effect of this cooperative strategy is to increase incumbent governing flexibility, and thus the ability to support a member’s party in the face of potential district opposition. This impact has also been noted as a by-product of the existence of safe congressional districts. Former Congressman Dan Rostenkowski is quoted in the November 10, 2002 Chicago Sun-Times as saying,

“Reformers have argued that elections have often been hijacked by political fundraisers who have no familiarity with or sensitivity to local problems. But there’s another elite, more powerful and less public, who have played a much
larger negative role. These are the redistricting pros, who use computers to artfully draw maps carefully calibrated to solidify the power of the party they are working for. That protects incumbents. Trust me. I know. It is a technique I used. But is also creates a take-no-prisoners legislative style that makes compromise very difficult and progress nearly impossible.”

The model in this paper supports several elements of this statement from the felonious Chicago Congressman, who nevertheless is an astute observer of the power game in the House of Representatives. In the sphere of influence solution, bipartisan compromise is made more difficult because the incumbent politicians are party loyalists that are less likely to cross to the aisle with their votes. The risk associated with the passage of party legislation, whether majority or minority party, increases consistent with the takes-no-prisoners element of conflict described above. However, this model indicates that sweetheart gerrymandering as a cooperative strategy has no impact on the expected probability of passage for individual legislative items.

The model developed in this study is based in the sphere of influence model analyzed in chapter two and used to study cooperative tax strategies in chapter three of this dissertation. There is a notable strategic difference with respect to the present study. Unlike the previous models, there is no uniform or non-sphere of influence cooperative strategy for the political parties. The previous studies focused on demonstrating the strategic superiority of the sphere of influence policy regime. In this study, establishing spheres of influence is the only way to sustain a cooperative arrangement among the political parties. This is due to the fact that in electoral competition, unlike the Great Power conflict in chapter two and capital market competition in chapter three, there is no method in which both political parties may engage in an election and both emerge with positive payoffs. However, both parties may emerge from the legislative process with political victories. This dichotomy is primarily responsible for determining the cooperative strategy.
This chapter is organized as follows. The next section reviews the research literature and legal foundation concerning gerrymandering. A brief review of the strategic aspects of sphere of influence cooperation is also noted. The third section defines and develops the theoretical model. The focus of this section is an evaluation of the prospects of cooperation among rival political parties. This section also details the linkage to sweetheart gerrymandering, which proves to be a special case of cooperative party behavior. The paper concludes with thoughts concerning the positive or negative impacts of this evolution of party strategies. An appendix of figures is also included.

5.2 Sweetheart Gerrymandering as Sphere of Influence Formation

Gerrymandering is a political technique with a long history in the United States. The term refers efforts to design boundaries of legislative districts to benefit one group or political party for the detriment of another group or political party. The term is derived from the name of Elbridge Gerry, who was a signer of the Declaration of Independence, a non-signing member of the 1787 Constitutional Convention, and a prominent member of the Democratic-Republican Party of Thomas Jefferson. In 1812, while Gerry was the governor of Massachusetts, members of his own party in the state legislature drew district lines to favor themselves relative to the Federalist Party. The Federalists naturally blamed Gerry, although he had nothing to do with the plan. A newspaper with Federalist leanings published a political cartoon of one of the oddly shaped districts within Essex County. The district resembled a salamander, and the artist defined it as a “Gerry-mander.”

In the academic literature, the study of the determinants and impacts of gerrymandering is a rich area of research. Butler and Cain (1992) and Gelman and King (1994) provide excellent reviews of congressional redistricting and its impacts. Cain (1984) usefully identifies three types of gerrymandering: partisan, bipartisan and affirmative action. Partisan gerrymandering has received the most attention, and it is conceptually what most think of as gerrymandering, a

45 Source material for this paragraph was found in The Reader’s Companion to American History.
process that seeks to maximize the number of officeholders. Bipartisan gerrymandering, also known as sweetheart gerrymandering, refers to cooperation among the political parties. Unlike partisan gerrymandering, the political parties cooperate to cluster their supporters, thereby reducing the number of competitive districts. The reason for this desired reduction in electoral competition is the focus of the present study. Affirmative action gerrymandering refers to the creation of majority-minority districts with the objective of increasing the number of minority legislature members.

From colonial times, views of partisan gerrymandering were a matter of perspective. Parties in the majority viewed it as the spoils of electoral competition. Parties in the minority viewed gerrymandering as exploitation. Not surprisingly, gerrymandering was an issue often taken to the courts by minority parties unhappy with newly designed district boundaries. The Supreme Court was at first reluctant to interfere with the affairs of the legislative branch. In *Colegrove v. Green* (1946), the Supreme Court ruled, “Courts ought not to enter this political thicket.” With the rise of an activist judiciary under Chief Justice Brennan, the Supreme Court reversed its position in *Baker v. Carr* (1962). In this ruling, the Court decided that courts might demand that legislatures redraw their boundaries to ensure the political rights of all citizens, but that the defining of the jurisdictions remained a prerogative of the legislative branch. In the following years, the court provided additional details regarding fair district design. In *Wesberg v. Sanders* (1964), the Court required population equity in district definitions. The decision of *Reynolds v. Sims* (1964) mandated that legislative apportionment should be based substantially on population. In *Kirkpatrick v. Preisler* (1969), the Court decided that legislators must make a good faith effort to achieve mathematical equality in district creation. More recently, the Supreme Court ruled in *Davis v. Bandemer* (1986) that political gerrymandering is illegal. Together with *Thornburg v. Gingles* (1986), the Court defined what constitutes illegal gerrymandering. For gerrymandering to be unlawful, the legislative action must be intentional, severe, and predictably non-transient in its effects.

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46 Cohen (1993) provides a review of Supreme Court decisions with respect to gerrymandering.
Although the Court has established a precedent that the judicial branch may mandate new district boundaries, the legislative branch retains considerable flexibility in defining jurisdictions. For example, in 1982 the Congress adopted an amendment to the 1965 Voting Rights Act that called for the creation of majority-minority districts, a form of affirmative action gerrymandering, in order to increase the number of minority members of Congress. Terrie (1996) reviews recent Supreme Court decisions that alter the context and application of the Voting Rights Act. Affirmative action gerrymandering and the continued existence of political party involvement in defining districts suggest that gerrymandering remains an active pursuit. For example, Foerstel (2001) reports the strong and at times admonishing role that the national parties play in the state-level redistricting process. She notes the Democratic party encouraged members to think of party unity before engaging in local agenda items in the redistricting that occurred after the 2000 census. Thus, gerrymandering, provided it is not egregious, as defined by the courts, exists as a tool of electoral competition among the political parties.

The set of articles analyzing the impacts of gerrymandering is large. This set includes studies from political science and economics. Some early studies found little impact of redistricting on election outcomes. Examples include Ferejohn (1977), Squire (1985), Campagna (1991), Niemi and Jackman (1991) and Niemi and Abramowitz (1994). Recent research has criticized these results for reasons of data and empirical methodology.

In contrast, other studies find evidence of gerrymandering impacts. Abramowitz (1983) shows a significant impact of gerrymandering on election outcomes. Wyrick (1991) does the same for 1980’s elections. Gopian and West (1984) and Cain (1985) note redistricting has tended to protect incumbents. Cranor et al. (1989) provide a case study of gerrymandering in Indiana. Gelman and King (1990) report statistical evidence that redistricting has measurable short-term benefits for the party that controls the redistricting process. Banaian and Luksetich (1991) report several useful findings regarding congressional election outcomes. Noting that previous research has found that incumbent spending is associated with lower tallies of votes, the authors employ two-stage least squares to account for incumbent value to voters. Their results
indicate that campaign spending increases votes, that campaign spending and office tenure exhibit diminishing marginal returns, and voters punish politicians who vote against their wishes. These empirical findings support many of the theoretical assumptions employed in the present study.

Gelman and King (1994) examine the effects of legislative redistricting on state legislature outcomes. The authors find strong evidence of gerrymandering during the 1968 to 1988 period. Squire (1995) examines elections outcomes for seven states in the 1980’s and also finds significant evidence of gerrymander related partisan bias. Mixon and Upadhyaya (1997) examine the 1982 Amendment to the 1965 Voting Rights Act. They report that the newly drawn districts possessed a turnover rate 8.9 to 10.3 percent lower than previous jurisdictions. In a 1998 study, the authors further note that the retirement rate was lower by 10.5 to 15 percent. Both studies suggest that gerrymandering designed to benefit minorities in fact protected incumbents. The 1997 study also reported decreased competition for primary elections. Swain et al. (1998) find some evidence of partisan bias due to gerrymandering. Controlling for incumbency and idiosyncratic factors, the authors report that Republicans likely gained more than Democrats in the 1992 redistricting of Congressional districts. Cox and Katz (1999) empirically verify for the time period 1946-1970 that state legislature control impacted redistricting and subsequent election outcomes. For example, they demonstrate that an existing Republican bias in northern congressional districts was eliminated circa 1966 through redistricting. Marshall et al. (2002) investigate the impact of district apportionment on legislature representation in political systems with proportional representation.

Other studies have noted elements other than election outcomes that are associated with gerrymandering. Ansolabehere et al. (2002) study the impact of court-ordered redistricting on federal spending within U.S. states. Depkin (1998) in a study of 1996 congressional races finds that political action committee (PAC) campaign contributions had more impact than individual or party contributions as measured by percentage of voters received. This finding suggests that appealing to client groups, or groups with narrowly defined interests and mobilized voters, is an
important element of congressional campaigning. Gilligan and Matsusaka (1999) demonstrate that the ability to gerrymander depends on the size of the voting population and the number of single member districts within a jurisdiction. Macmillian (2001) is a technical report on district creation techniques using GIS software, ostensibly to obtain gerrymander-free district definitions.

The theoretical modeling of gerrymandering appears to be connected relatively less to its empirical counterpart than other topics in social science. Some topics benefit from an interdisciplinary perspective. Unfortunately, the study of gerrymandering appears to be an example of a topic that suffers from the disciplinary divide. The empirical studies surveyed above primarily originate in political science journals. The theoretical models primarily reside in the field of public choice. The level of interaction between these fields is small. And importantly with respect to the present study, there are no theoretical models of bipartisan or sweetheart gerrymandering.

Sherstyk (1998) analyzes the theoretical models of gerrymandering for various distributions of voters and party supporters. She finds that well-defined equality conditions on district definitions may help to combat bias producing gerrymandering. Milyo (2001) offers a theoretical framework and empirical observations that are most valuable for the present study. Milyo notes that the effort level of incumbent legislators varies across elections. Incumbents may “slack off” if there is no significant challenge at election time. He notes that this behavior is inconsistent with traditional public choice assumptions regarding politician behavior; namely, that politicians seek maximize votes in all circumstances. Similarly, he finds that politicians can “crank up” their campaign efforts if a significant challenge presents itself. Milyo’s conclusion, that political effort is the strategic variable of interest, is employed in the model developed below.

Fleck and Kilby (2002) highlight the importance of constituent political preferences on legislator behavior in a theoretical model of congressional voting. Dharmapala (2002) demonstrates theoretically that incumbents may accumulate “war chests,” or large amounts of campaign finance, to discourage challengers. Epstein and Zemsky (1995) provide empirical support for this theoretical result.
Shotts (2002a) develops a theoretical model to investigate whether racial gerrymandering influences policy outcomes in the House of Representatives. Shotts notes that many social scientists believe that racial gerrymandering has had the unintended consequence of moving policy to the political right by concentrating ideological left voters in districts. Shotts demonstrates the left policy makers can draw districts to concentrate minorities, but without wasting liberal white voters. The result is that the strategically preferred gerrymander generates a left bias in the legislative game. In later work, Shotts (2002b) analyzes the optimal gerrymander for Republicans and Democrats for House districts. He proves that if the federal government mandates redistricting to favor minority politicians, then a Republican controlled state experiences a small decrease in Republican seats. For a Democratic state, the Democratic party may experience no loss of House members if the geographic distribution of white, liberal voters is amenable. Otherwise, the Democrats too may face a small decrease in the number of House members due to a deviation from the optimal gerrymander due to a need to create majority-minority districts.

To contribute the theoretical literature of gerrymandering, this chapter draws upon strategic issues developed in much greater detail in chapter two. A brief review of issues relevant to sphere of influence formation is sufficient here. Elections, as will be shown below, are games of strategic complements. Examples of this type of game include Powell (1996) and Fearon (1998). The methodology of this paper employs previous analyses of linked or interdependent games through a simultaneous set of jurisdictional elections. McGinnis (1986) examines the effect of issue linkage on the prospects for cooperation in international relations. Bernheim and Whinston (1990) examine the topic of issue linkage with respect to markets and firms’ ability to collude in price formation. The game developed in the present paper borrows from their framework. Bernheim and Whinston formally establish the conditions under which collusion is possible in an iterated price game of multimarket contact. Among their findings, they conclude that multimarket contact only increases the ability to collude when strategic differences are present in the linked markets. They also examine the conditions under which the firms will
establish spheres of influence, that is markets where other firms respect the primacy of some firm’s interests. Spagnolo (1999) proves that multimarket or multicontext interaction always eases cooperation between agents in games with strictly concave objective functions. For more detail concerning spheres of influence, consult the second chapter of this dissertation. With these strategic concepts in mind, a model of electoral competition is now defined.

5.3 A Model of Political Party Cooperation

Political parties engage in cooperative behavior in order to produce victorious congressional candidates with greater degrees of governing flexibility. There are two ways the parties may cooperate. First, they may reduce their campaign efforts in the political bases of their rival, in exchange for concomitant behavior. Second, the parties may apportion voters into congressional districts as to render elections uncontestable. The first cooperative strategy is applicable for House of Representatives and Senate elections. The second cooperative strategy may only be used for House elections. House districts are defined within states by state legislatures. Each of these two strategies constitutes a sphere of influence policy regime.

The first task in constructing a model of party cooperation is to define the structural rules of congressional elections. There are two national political parties: left ($l$) and right ($r$). These political parties sponsor candidates for congress in $J$ congressional districts. Let each congressional district $j$ possess a measure of jurisdictional ideology, denoted by $\theta_j$. This preference parameter has a lower bound of zero and an upper bound of one. The parameter denotes the latent support for the left party among voters in the congressional district. Similarly, $1 - \theta_l$ denotes the latent support for the right party.

The political parties, through the actions of local candidates, conduct political campaigns to alter the proportions of voter support. Each candidate selects an effort level, $e_l$ or $e_r$, which define the intensity of the left and right candidates’ election campaign respectively.\footnote{Milyo (2001) demonstrates the utility of defining political campaigns in this manner.} Together,
the underlying political preferences of the jurisdiction and the effort of the candidate determine the winner of the congressional election. For the left candidate, election victory occurs if the following inequality is true.

\[(2 \theta_j - 1) + e_l - e_r > 0 \quad (1)\]

According to this definition, party candidates in jurisdictions with similar ideological beliefs require less campaigning effort to achieve electoral victory. This specification of election competition defines the strategic interaction among parties as a game of strategic complements. In the event that the condition defined in (1) holds with equality, then the election is “tied.” In this situation, with a probability of ½, either the left or right party candidate wins the election.

Campaigning is a costly activity. In this model, candidates obtain resources from client groups.\(^{48}\) In exchange, the candidate pledges commitments to pursue policies consistent with the political objectives of the client group. These campaign promises reduce the governing flexibility that the candidate possesses in the event of electoral victory.\(^{49}\) Instead of pursuing policies that are consistent with party objectives, commitments to local client groups cause the incumbent to perhaps vote against his party. Reduced governing flexibility is thus the opportunity cost of campaigning. Moreover, these costs are increasing or convex because as a candidate commits to an increasing number of policies, the political maneuvering ability of the candidate decreases exponentially. That is, as a candidate commits to interest groups, the probability of a situation in which the candidate must commit to contradictory policies grows non-linearly. However, campaigning also produces a benefit for the candidate in addition to its role in the determination of election victory. Campaign effort has the potential to influence public opinion in favor of the candidate. Reflecting these costs and benefits of campaigning, let the net benefit of campaigning for a victorious candidate of party \(p\) equal

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\(^{48}\) Depkin (1998) notes the importance of this activity to campaign success.

\(^{49}\) This assertion requires the assumption that incumbent politicians pay a price for breaking campaign commitments. Banaian and Luksetich (1991) provide empirical support for this assertion.
This net benefit is concave in effort, indicating that an optimal level of campaign effort exists. The candidate may not select a campaign effort that yields a negative value for (2). Such a scenario is inconsistent with a balanced budget constraint for the campaign. Recalling that election competition is a game of strategic complements, the function defined in (2) suggests that election contests cause the rival candidates to engage in costly if not exhaustive competition.

The net benefit function defines the welfare of the victorious candidate. As suggested above, the utility of political candidates is defined by governing flexibility or campaign mandates. This flexibility is a function of the net benefit of the most recent campaign, and the latent support of the congressional jurisdiction. Let equation (3) and (4) define the political mandate for a representative in jurisdiction $j$ who is a member of party $l$ or party $r$ respectively. A losing candidate achieves a utility of zero by definition because the candidate offers no benefit for the political party in the Congress.

$$u_j^l = (e_p - e_p^2) + \theta_j$$  \hspace{1cm} (3)$$

$$u_j^r = (e_p - e_p^2) + 1 - \theta_j$$  \hspace{1cm} (4)$$

It is clear that a larger mandate is associated with a stronger political base, as defined by the political preferences of the jurisdiction. An incumbent with a larger mandate is more likely to pursue partisan or ideological objectives over the possible objections of constituents. Such incumbents are more likely to be party loyalists, in contrast to incumbent representatives with small mandates, who must be concerned with jurisdictional political concerns. Edmund Burke, an Irish Member of the British Parliament during the American Revolution and a political
philosopher, famously suggested that legislators, when faced with the competing interests of their
district and their own political calculus, should lean toward their own conclusions. This option is
only available to those legislators who possess some safety with respect to their electoral victory
margin.

An unopposed candidate’s electoral strategy is found by maximizing (2) with respect to
effort. The candidate’s optimal effort is equal to $\frac{1}{2}$, which is interpreted as a 50% effort. The
victorious candidate gains a campaign mandate equal to $\frac{1}{4}$ plus the candidate’s jurisdictional
latent support. Given that $\frac{1}{2}$ is the optimal effort, it is clear that for some ranges of $\theta_j$ one party’s
candidate is unable to deviate his opponent from this optimal strategy. For example, if $\theta_j$ is less
than $\frac{1}{4}$, then the district strongly supports the right candidate. The left candidate plays one
indicating a full campaign effort. Using equation (1), the right candidate selects a strategy that
satisfies inequality (5).

$$e_r > (2\theta_j - 1) + e_i$$

If $\theta_j$ is less than $\frac{1}{4}$, the winning effort level for the right candidate is less than $\frac{1}{2}$. Thus, for this
range of $\theta_j$ the district is uncontestable for the left party; that is, the weaker party is unable to
generate inefficient electoral competition levels for its rival party. Likewise, if $\theta_j$ is greater than
$\frac{3}{4}$, the district is uncontestable for the right party. The range $\frac{1}{4} < \theta_j < \frac{3}{4}$ therefore forms the
range of interest for the strategic analysis in this study. Districts outside this range are not part of
the sphere of influence game because they are not strategic viable.

For contestable ranges of $\theta_j$, equilibria of the campaign game are straightforward. If the
district is contestable and left leaning, then the right candidate plays one and the left candidate
plays $2\theta_j + \epsilon$, where $\epsilon$ is an infinitesimally small positive number. The left candidate wins the
election and possesses a mandate or payoff of $3\theta_j - 4\theta_j^2$. Similarly, if the district is contestable
and right leaning, then the left candidate plays one and the right candidate plays $2\theta_j + \varepsilon$. The right candidate wins the election and possesses a campaign mandate of $\theta_j - 4\theta_j^2 + 1$. Figure 1 notes the payoff of the right candidate for meaningful ranges of $\theta_j$.

The victorious candidates are allocated into party caucuses within the U.S. Congress. Each political party has policy objectives that they wish to pass through the legislature. Unlike the campaign game, the strategic interaction within the Congress is not a zero-sum competition. The legislative game for the parties is modeled to reflect the disparate interests of the political parties in the Congress. Let the utility function of each political party $p$ be

$$U_p = \sum_{k=1}^{K} \left( \frac{\sum_{j\in p} v^k_j}{\sum_{j=1}^P v^k_j} \right) M^k$$

(6)

The parameter $V^k$ is the value of legislative agenda item $k$ to political party $p$. These values are idiosyncratic to the political party’s ideological objectives. Variable $v^k_j$ is an indicator of house member $j$’s vote on legislative item $k$. The variable is equal to one for a yes vote and equal to zero for a no vote. The second term of the right-hand side of equation (6) indicates a weight for each legislative item approved by the house. The numerator is a count of the number of yes votes from political party $p$. The denominator indicates the total number of yes votes from both political parties. This weight indicates a measure of political credit or prestige given to a single political party for the adoption of legislation. According to (6), the more bipartisan the support, the less credit the political party receives for its role. Note then that the utility function defined in (6) is not the same as welfare achieved through ideological objectives, as might be associated

$^{50}$ For this study, the party interests are assumed distinct, such that there are no positive or negative utility consequences for the rival party if legislation of its rival is adopted. Given the lack of direct strategic control the political parties have on house members, this assumption has no strategic impact on potential cooperation.
with an interest group. Instead, this utility function measures the effectiveness of political parties in achieving political goals.

Variable $M^k$ indicates the action of the legislature of a particular legislative item. Similar to the votes of individual members, it assumes a value of one for legislation approved and a value of zero for items not approved. Assume that majority rule is used to determine legislative action. Thus, define $M^k$ as

$$M^k = \left[ \frac{\sum_{j=1}^{J} v_j^k}{J} + \frac{1}{2} - \varepsilon \right]$$  \hspace{1cm} (7)$$

The right-hand side of equation (7) is an evaluation of a greatest integer function. For legislation to be accepted in the legislature, a majority plus one must approve it. Equation (7) assumes a value of one if it satisfies this condition for a legislative chamber with $J$ members.

The political parties do not exercise direct control over the votes of individual members, despite the efforts of party leaders and whips. Individual members’ decisions are a complex mix of representative and constituent interests. To reflect this, probabilistic voting for individual House or Senate members is employed in this study. Clearly, members of a party are more likely to vote for their own party’s legislation. And as defined above, incumbents with large campaign mandates are freer to pursue party legislation that may not coincide with their own district’s interests. This interaction between election constraints and party loyalty is the crux of this study. Thus, let the campaign mandate equal the House member’s probability of voting for any of his own party’s legislation. The mandate score is well defined for this task because it bounded by zero and one. Similarly, let one minus the campaign mandate equal the probability a legislator supports legislation from the rival party. Using these probabilities, the expected utility for political party $p$ is provided in equation (8).
5.3.1 Spheres of Influence in Political Party Competition

With the model constructed, the ability of the political parties to engage in localized cooperation while remaining engaged in global competition can be examined. Cooperation among the political parties assumes the form of spheres of influence. Because the parties are engaged in costly or exhaustive competition within individual congressional jurisdictions, their ability to produce politicians with greater electoral security, and hence greater governing flexibility, is reduced. By developing spheres of influence, the parties reduce this localized competition. This study examines two pathways for this strategic outcome: reduced electoral competition and sweetheart gerrymandering. The later is actually a special case of the former, so the following analysis focuses on reduced electoral competition.

The first task is to determine whether the political parties gain utility from forming spheres of influence. As is demonstrated below, a sphere of influence strategy results in an increased number of party loyalists in Congress. With respect to equation (8), this impact is realized by a political party as an increase in some $p_j$, which are members of the party, and reduced $p_j$ for some members of the opposition party. Suppose the impacts are symmetric. Thus, for every increase in an individual member’s probability of voting for the party’s legislation, there is an equal decrease in an opposition member’s probability of supporting that party’s bill. Examining equation (8) reveals that the probability of the legislation being approved is unaffected by such a change.\footnote{The expected probability is unchanged; however, the risk associated with passing the legislation increases because the expected legislative burden now rests with a set of party loyalists. The ability to pass the legislation with random support from opposition members is reduced. This is explored in more detail below.} This impact is seen in both the greatest integer term and the denominator of the party weight. However, introducing spheres of influence in the election game increases the numerator of the party weight, thereby increasing the expected utility of the party. In the sphere of influence

$$
E(U_p) = \sum_{k=1}^{J} V^k \left( \frac{\sum_{j \in P} p_j}{\sum_{j \in P} + \sum_{j \in P} 1-p_j} \right) \left[ \frac{\sum_{j \in P} + \sum_{j \in P} 1-p_j}{J} + \frac{1}{2} - \varepsilon \right]
$$

(8)
regime, the political parties gain more by having loyalists who support party policy and in larger numbers. Therefore, there is an incentive to create spheres of influence among rival political parties.

However, the issue of sustainability exists with respect to this inter-party cooperation. For electoral cooperation, the parties may implicitly undertake strategies that involve reduced challenges in certain jurisdictions. But sustainability requires an evaluation of the potential for defection from this cooperative regime. For example, a party may challenge an incumbent who has supported policies that are popular with the party but unpopular with his district. This incentive exists because a sphere of influence regime necessarily offers districts that are vulnerable to renewed competition.

To evaluate this strategic problem, suppose a simple three-jurisdiction legislature.\textsuperscript{52} Suppose one of these jurisdictions possesses a $\theta_j$ equal to $\frac{1}{2}$. This congressional district is the middle district in terms of ideological distribution. Let the other two jurisdictions be contestable, but each district ideologically leans toward one of the two political parties. Assume symmetry so that for each party the ideological preferences of these two congressional districts are $\theta_j$ and $1 - \theta_j$ respectively, where all $\theta_j$ are equal to $\theta$. The district favoring the left party is the left jurisdiction and the district favoring the right party is the right jurisdiction. Without loss of generality, suppose the competitive election in the middle jurisdiction results in the victory of the right candidate. Thus, the right party is the dominant or majority party. The left party in the competitive solution is only victorious in the left jurisdiction.

In the solution to the competitive election model, the following probabilities are associated with the elected members of the legislature. These probabilities are reported as the likelihood of voting for the right party's legislation.

\textsuperscript{52} The evaluation holds for political systems with many more jurisdictions. Unfortunately, the solutions even in the three-jurisdiction problem are complex, so increasing the number of election districts results in a significant loss of transparency with respect to the problem at hand. Similar to strategic investigations in the field of industrial organization, a model of a few agents is sufficient for analyzing strategic incentives and behavior.
\[ p_{\text{right}} = \theta - 4 \theta^2 + 1 \quad (9) \]

\[ p_{\text{middle}} = \frac{1}{2} \quad (10) \]

\[ p_{\text{left}} = - \theta + 4 \theta^2 \quad (11) \]

The probability of adopting legislation proposed by the right is easily found. This probability is the sum of the probability of all events in which at least two representatives vote yes. The following probabilities constitute this set.

\[ \Pr(\forall v_j = 1) = (\gamma_2) \left( \theta - 4 \theta^2 + 1 \right) \left( - \theta + 4 \theta^2 \right) \quad (12) \]

\[ \Pr(v_{\text{right}}, v_{\text{left}} = 1 \land v_{\text{middle}} = 0) = (\gamma_2) \left( \theta - 4 \theta^2 + 1 \right) \left( - \theta + 4 \theta^2 \right) \quad (13) \]

\[ \Pr(v_{\text{right}}, v_{\text{middle}} = 1 \land v_{\text{left}} = 0) = (\gamma_2) \left( \theta - 4 \theta^2 + 1 \right)^2 \quad (14) \]

\[ \Pr(v_{\text{middle}}, v_{\text{left}} = 1 \land v_{\text{right}} = 0) = (\gamma_2) \left( - \theta + 4 \theta^2 \right)^2 \quad (15) \]

The sum of these terms is unsurprisingly, given the symmetric definition of the political system, equal to \( \frac{1}{2} \).

The expected utility for the right party is the interaction of these probabilities and the political prestige weights associated with the final voting tallies. The weight for the event in (12) is \( \frac{3}{2} \) because two of the three yes votes are due to right party members. The weight for the outcome in (13) is \( \frac{1}{2} \) because only one of the voters is from the right party. Likewise, the weights for (14) and (15) are one and \( \frac{1}{2} \) respectively. Weighting the probabilities in (12 through (15) and
summing yields the expected utility for the right party. Normalizing all $V^k$ as equal to one and simplifying generates

$$E(U_{\text{right}}) = -\frac{4}{3} \theta^3 + \frac{8}{3} \theta^4 - \frac{3}{2} \theta^2 + \frac{5}{12} \theta + \frac{1}{2}$$ (16)

Figure 2 graphs this function over the range $\frac{1}{4}$ to $\frac{1}{2}$ for $\theta$. Values less than $\frac{1}{4}$ yield non-strategic outcomes. Not surprisingly, this value is decreasing in $\theta$. Recall that given the symmetric definition of the jurisdictions, small values of $\theta$ are consistent with relatively ideological dissimilar congressional districts. As $\theta$ approaches $\frac{1}{2}$, the districts approach similarity.

Thus, a result of this study is foreshadowed here. The parties benefit from possessing dissimilar congressional districts because they produce politicians with more secure political bases, and hence more flexibility in legislative affairs.

With the competitive electoral model characterized, the sphere of influence solution is evaluated. In the cooperative regime, the political parties reduce their efforts in their rival’s strategically advantaged district. In exchange, their rival reduces its efforts in their political base. The impact of this strategy is to reduce costly competition through excessive political commitment. Each political party pursues the optimal election effort, $\frac{1}{2}$, in its sphere of influence. The middle jurisdiction remains in electoral competition. The resulting campaign mandates are

$$p_{\text{right}} = -\theta + \frac{5}{4}$$ (17)

$$p_{\text{middle}} = \frac{1}{2}$$ (18)

$$p_{\text{left}} = -\frac{1}{4} + \theta$$ (19)
With respect to the right party, the sphere of influence regime increases the probability of the right jurisdiction and reduces the probability of the left jurisdiction supporting right party legislation. The expected probability of passing legislation from the right remains ½ under the sphere of influence regime. However, because the burden of approving the legislation is now increased for the party loyalist from the right jurisdiction, the risk associated with passing the legislation increases. The legislative variance associated with competitive Congressional elections equals

\[
\sigma_{\text{competitive}}^2 = \frac{1}{6} + \frac{2}{3} \theta - 2\theta^2 - \frac{16}{3} \theta^3 + \frac{32}{3} \theta^4
\]  

(20)

The legislative variance associated with the sphere of influence set of legislators equals

\[
\sigma_{\text{soi}}^2 = \frac{3}{8} - \theta + \frac{2}{3} \theta^2
\]  

(21)

The variance or risk associated with the sphere of influence regime, \( \sigma_{\text{soi}}^2 \), is larger than the risk associated with the competitive system, \( \sigma_{\text{competitive}}^2 \). Figure 3 demonstrates this unambiguous difference.

This computation reflects an observation that is typically coupled with the observed reduction in competitive elections for the House of Representatives. Analysts have noted that with the decrease in competitive elections, the House has become more conflict oriented and less bipartisan. The tone of the debate is more strident and the prospects for achieving legislative compromise are reduced. These legislative impacts are reflected in this model. Under the sphere of influence regime, the probability of bipartisan legislative outcomes is reduced. The increase in risk is noted and may be responsible for the decrease in legislative civility if individual members possess risk aversion with respect to the legislative process. However, the model
constructed in this study does not support the observation that reduced competition in elections reduces the probability of adopting individual legislative objectives. This probability remains unchanged.

For the incentive to pursue a cooperative strategy to exist, it must be the case that the expected utility for the political parties is larger in the sphere of influence regime than the competitive system. The expected utility in the cooperative system is

$$E(U_{\text{right}}) = \frac{1}{6} \theta^2 + \frac{1}{2} \theta + \frac{59}{96}$$

(22)

Figure 4 graphs this value. Subtracting (16) from (22) provides the difference between the cooperative and competitive outcomes for the right political party.

$$-\frac{11}{12} \theta + \frac{5}{3} \theta^2 + \frac{11}{96} + \frac{4}{3} \theta^3 - \frac{8}{3} \theta^4$$

(23)

Figure 5 plots this value. This figure demonstrates that expected utility is higher under the sphere of influence regime. Interestingly, the adoption of a cooperative election policy generates the largest benefits when the congressional districts are relatively ideologically similar. In these cases, the parties are more capable of engaging in costly competition, and thus the benefit to cooperation is higher. This analysis confirms that an incentive indeed exists for the political parties to engage in cooperative policies.

Of course, the opportunity for cooperation in a competitive process creates an opportunity for cheating or defecting from the cooperative regime. By adopting spheres, the political parties effectively create an expectation of safe jurisdictions or political bases. Cheating therefore represents an unexpected political effort in a rival’s base. Of course, given this action, the expectation is that the incumbent in that district would increase his effort as much as possible. Suppose instead that the political process is sticky or relies on long-term endeavors, thus
allowing a rival political party to conduct a surprise campaign effort. This assumption is the most restrictive on the prospects for cooperation and therefore useful as an analytical benchmark.

Presumably, the dominant party may match accelerated rival efforts with increased efforts of its own. If a competitive campaign can be assembled in time for the election, cheating is equivalent to returning to the competitive equilibrium. Moreover, it is assumed that cooperation relies on varying effort levels among congressional district elections. In contrast, the ability to cooperate through redistricting or sweetheart gerrymandering is discussed later.

Suppose the right party opts to cheat against its rival. In the right congressional district, the party selects a 50% effort, which is the optimal level if unopposed. The middle jurisdiction is contested, and thus offers no cheating opportunities. In the left congressional district, the left party has planned a 50% effort. The right party’s level of ideological support in this district is $1 - \theta$. Define this level as $\theta'$, which is bounded by $\frac{1}{2}$ and $\frac{3}{4}$. To win the election, the right candidate must exceed the left party’s 50% effort plus its ideological advantage. Thus, the right candidate pursues a campaign effort level of

$$\frac{1}{2} + 2\theta' - 1 + \varepsilon \quad (24)$$

The payoff or campaign mandate for this strategic scenario is

$$\frac{1}{4} + 3\theta' - 4\theta'^2 \quad (25)$$

Figure 6 graphs this value over the competitive range of $\theta'$. Just as the benefit to cooperation is highest for relatively similar congressional districts, the benefit to cheating is the largest in these districts. This is reflected in the downward slope of the campaign mandate function in Figure 6.
Also note that Figure 6 indicates that it is possible to have representatives who are more likely to vote against their party than support it, as demonstrated by campaign mandates less than $\frac{1}{2}$.

The right party in the defection scenario possesses all the members of the legislature. Substituting for $\theta'$ yields the following voting probabilities for right party legislation.

$$p_{\text{right}} = -\theta + \frac{5}{4}$$  \hspace{1cm} (26)

$$p_{\text{middle}} = \frac{1}{2}$$  \hspace{1cm} (27)

$$p_{\text{left}} = \frac{13}{4} - 3\theta - 4(1-\theta)^2$$  \hspace{1cm} (28)

Using these probabilities, the probability of passing legislation of the right party is

$$2\theta - 2\theta^2 + \frac{1}{4}$$  \hspace{1cm} (29)

Figure 7 graphs the function in (29). As $\theta$ approaches $\frac{1}{2}$, that is, as the congressional districts become more ideologically similar, the probability of passing legislation increases. This observation is consistent with the large benefits to cheating that are possible in relatively similar jurisdictions. Because all the incumbents belong to the right party, all the weights in the expected utility equation, equation (8), are equal to one. Thus, the value in equation (29) is also the expected utility of the right party under defection.

For cheating to be strategically preferred over cooperation, the payoff cheating must exceed the payoff for cooperation. The difference between cheating, the value in (29), and
cooperation, the right hand side of equation (22), is equal to

\[
\frac{5}{2} \theta - \frac{13}{6} \theta^2 - \frac{35}{96}
\]  

(30)

Figure 9 graphs this value. Clearly, cheating generates higher payoffs than cooperation. Hence, cheating is a strategic concern for the political parties.

To evaluate whether cooperation is pursued, a Folk Theorem requirement on the intertemporal temptation to cheat is constructed. For cooperation to be considered feasible, the incentive compatibility constraint must require a discount factor no larger than one. Smaller values of the discount factor are consistent with relatively easier to implement cooperative strategies. For cooperation to be sustainable, the Folk Theorem indicates the following inequality must be satisfied.

\[
\Pi_{\text{deviation}} + \sum_{t=0}^{\infty} \delta^{t+1} \Pi_{\text{punishment}} \leq \sum_{t=0}^{\infty} \delta^t \Pi_{\text{cooperative}}
\]  

(31)

where \( \delta \) is the discount factor and \( t \) refers to time periods. Note the game is infinitely repeated. The first term of the left-hand side, the payoff to deviation or cheating, is equal to the value in (30). The payoff to cooperation is equal to the right-hand side of equation (22). To sustain intertemporal cooperation, a punishment strategy must be announced. The punishment is implemented if a single round of cheating occurs. The punishment in this game is a grim trigger strategy, for which the cheated political party pursues only competitive strategies after a round of cheating. The payoff to punishment is therefore equal to the competitive payoff defined in (16). Inequality (31) simplifies to the following inequality.

\[
\Pi_{\text{deviation}} + \frac{\delta}{1-\delta} \Pi_{\text{punishment}} \leq \frac{1}{1-\delta} \Pi_{\text{cooperative}}
\]  

(32)
Substituting for the payoff solutions and solving for the discount factor yields the intertemporal requirement for cooperation.

\[ \delta \geq \frac{-240 \theta + 208 \theta^2 + 35}{-128 \theta^3 + 256 \theta^4 + 48 \theta^2 - 152 \theta + 24} \]  

(33)

Figure 9 graphs (33) at equality and indicates that cooperation is indeed feasible. Moreover, the requirement on cooperation is eased as the districts become more similar. This may seem a surprising theoretical result given the benefit to cheating increases with relatively more similar districts. Clearly, the ability to punish, by adopting competitive strategies, is responsible for the downward slope of Figure (9). Competition is fierce in relatively similar districts, so the incentive to defect from the cooperative regime is reduced. This is similar to a sort of mutual assured destruction with respect to inter-party activity. The impacts of this result on congressional district apportionment are discussed below.

The preceding analysis examined the cooperation prospects of the right party, which was defined as the majority party due to the resolution of the middle jurisdiction election. It is reasonable to expect that cooperation is harder to sustain for the minority party. The benefits to cheating are relatively higher for the minority, or the left party here, because of this party’s dependence on rival party votes to pass legislation. This occurs, but the minority party realizes less prestige because of this dependence on bipartisan legislative activity. The process of determination is the same, so the theoretical results for the left party are reported here in a condensed manner.

First, the expected utility for the left party in the competitive election model is the same calculation as (16), except the weights are smaller to reflect the fact that the middle jurisdiction incumbent belongs to the right party. Again, normalize all \( V^k \) as equal to one.
Equation (34) simplifies to

\[ E(U_{\text{left}}) = -\frac{1}{2} \theta^2 + \frac{4}{3} \theta^3 - \frac{8}{3} \theta^4 + \frac{1}{12} \theta + \frac{1}{4} \]  

(35)

Figure 10 graphs this solution over the sensible ranges of \( \theta \). Likewise, the cooperative expected utility for the left party is the same calculation as found in (22), except again the party weights are lower to reflect minority party status.

Equation (36) simplifies to

\[ E(U_{\text{left}}) = -\frac{1}{6} \theta^2 + \frac{25}{96} \]  

(37)

The difference between the cooperative expected utility and the competitive expected utility for the minority party is

\[ \frac{1}{3} \theta^2 - \frac{4}{3} \theta^3 + \frac{8}{3} \theta^4 - \frac{1}{12} \theta + \frac{1}{96} \]  

(38)

Figure 12 indicates that the cooperative payoff is always larger; thus, the minority party possesses an incentive to engage in sphere of influence behavior with its political rival.
The solutions for cheating strategies for the left party are somewhat different because the middle jurisdiction incumbent belongs to the right party. When cheating, the left party has incumbents in the left jurisdiction, which is its sphere of influence, and the right jurisdiction, the jurisdiction in which the left party surprises its rival. Hence, unlike the right party in a cheating round, the left party does not possess every seat in the legislature. The expected utility of the left party for the events in which all the legislators and the left and right incumbents vote for left party legislation is as follows.

\[
\left( \frac{2}{3} + \frac{2}{2} \right) \left( - \theta + \frac{5}{4} \right) \left( - \theta + \frac{1}{2} \right) \left( \frac{13}{4} - 3\theta - 4(1-\theta)^2 \right) \tag{39}
\]

The expected utility of the left party from the event in which the left and middle jurisdiction members vote yes is

\[
\left( \frac{1}{2} \right) \left( - \theta + \frac{5}{4} \right) \left( - \frac{9}{4} + 3\theta + 4(1-\theta)^2 \right) \left( \frac{1}{2} \right) \tag{40}
\]

And finally, the expected utility from the event in which the right and middle jurisdiction members vote yes is

\[
\left( \frac{1}{2} \right) \left( \theta - \frac{1}{4} \right) \left( \frac{13}{4} - 3\theta - 4(1-\theta)^2 \right) \tag{41}
\]

Summing (39) through (41) provides the expected utility of the left party in a cheating round.

\[
E(U_{\text{left}}) = \frac{10}{3} \theta - \frac{13}{3} \theta^2 + \frac{4}{3} \theta^3 - \frac{3}{16} \tag{42}
\]
Figure 13 graphs equation (42). Note that this value increases in $\theta$ because the benefits to cheating increase as the districts become more similar in ideological terms. In addition, the payoff is smaller for the minority party than the majority party for all $\theta$.

The feasibility of cooperation for the minority party may now be evaluated. Using equation (32) and substituting the value for punishment or electoral competition, equation (35), cooperation, equation (37), and defection, equation (42), and solving for the discount factor requirement to sustain cooperation yields

$$\delta \geq \frac{320\theta - 400\theta^2 - 43 + 128\theta^3}{-368\theta^2 + 256\theta^4 + 312\theta - 42}$$  \hspace{1cm} (43)$$

Figure 14 demonstrates that this requirement possesses a similar form for the left party as it did for the right party. The expectation is that the requirement is more difficult, which implies the discount factor must be larger, with respect to the minority party because the opportunity cost of cooperation is higher. Subtracting the requirement for the majority party, inequality (33), from inequality (43) yields the following solution.

$$\frac{-11520\theta^4 + 100352\theta^5 - 34240\theta^3 + 18096\theta^2 - 3392\theta - 86016\theta^6 + 219 + 16384\theta^7}{8[-184\theta^2 + 128\theta^4 + 156\theta - 21][-16\theta^3 + 32\theta^4 + 6\theta^2 - 19\theta + 3]} \hspace{1cm} (44)$$

Figure 15 demonstrates that this value is larger than zero for admissible values of $\theta$, confirming that the requirement on cooperation is more difficult for the minority party. However, the requirement is less than one, indicating that cooperation is feasible for the minority party. If both parties are able to fulfill these requirements on intertemporal discounting, cooperation is realized.
5.3.2 Sweetheart Gerrymandering

The political parties have a policy tool that insures sphere of influence behavior for House of Representative elections. By engaging in sweetheart gerrymandering, the political parties create congressional districts that segregate voters by political preference. The model in this study indicates that the parties can effectively define spheres of influence by insuring that congressional districts contain 75% or more voters of a single political persuasion. Thus, the parties treat $\theta_j$ as an endogenous variable for all congressional districts.

This type of action creates an odd discontinuity in terms of the discount factor requirement on cooperation. As noted in Figures 9 and 14, as the districts become more dissimilar, the condition on cooperation becomes more stringent. However, once the districts reach the 75% level for a single party, they become uncontestable. Cooperation or sphere of influence behavior is assured. Thus, sweetheart gerrymandering is clearly the preferred strategic method for obtaining cooperative electoral behavior for the political parties for the House of Representatives. Although not addressed in this study, it may be the case that the voters prefer to be clustered by political preference as well. For example, Garasky and Haurin (1997) examine jurisdiction realignment for the purposes of Tiebout sorting. A similar argument can be made for voters. No survey of individual voters exists to address this question, but it seems reasonable to expect that citizens are happier when their representatives reflect their political preferences. If this is the case, then voters may approve of sweetheart gerrymandering. This in turn may act as a demand on the actions of state legislators when designing jurisdictions.

There are a number of obstacles that might prevent the political parties from using sweetheart gerrymandering. First, it may never be used for Senate elections. Senate jurisdictions are state boundaries and thus not subject to change. The political parties may only engage in local cooperative behavior be selectively engaging in fierce electoral competition among states. Second, there are limits to which state legislatures may design congressional districts. The focus of congressional jurisdictional design has been race. However, given the overwhelming support African-American voters supply to the Democratic Party, a side effect of
race-based gerrymandering has been a limited form of sphere of influence behavior. These congressional district definitions have been subject to legal challenges because many of these districts were geographically contorted. This limit to jurisdiction definition applies to segregating voters by political preference. Finally, political parties at best imperfectly know voters' preferences. The parties can use demographic studies and polling to estimate these beliefs, but the limits of information and geographic distribution may limit the effectiveness of these cooperative policies.

5.4 Conclusion

The term gerrymandering typically suggests congressional district apportionment in which one political party seeks a competitive advantage over its rival through the allocation of voters. A variant of this behavior is sweetheart gerrymandering. Sometimes seen as an incumbent protection policy, this study has demonstrated the motives of rival political parties to engage in this behavior. In particular, sweetheart gerrymandering is a method of delineating spheres of influence in electoral competition. Alternatively, the political parties may strategically reduce their competitive efforts in the political bases of their rivals.

The benefit of this behavior is that the victorious candidates emerge with greater campaign mandates, and thus a greater degree of governing flexibility in the legislative process. The political parties benefit because their Senate and House caucuses contain a larger number of party loyalists, who are reliable assets in achieving the parties' legislative objectives. This impact forms the core of a set of testable hypotheses that follow from this theoretical study. This chapter indicates that sphere of influence behavior, or sweetheart gerrymandering, is rational for political parties. If practiced, then elections such become less close in terms of victory margins, and consequently, the amount of bipartisan legislation should decrease. A more difficult research topic is determining the conditions in which this type of cooperation is practiced. The model
developed in this chapter suggests that it is more likely as the propensity of the population to sort according to political preference increases. Thus, Tiebout sorting and sweetheart gerrymandering should be correlated.

Although clearly in the interests of the political parties, this study has not addressed whether this policy is in the interest of a democratic society. Sphere of influence formation increases the risk associated with passing individual legislative items, although it does not affect the expected probability associated with legislative approval of items. More importantly, reduction of competition within congressional districts seemingly reduces the most important element of democratic governance, namely choice at the ballot box. If voters possess effectively only one candidate, then democratic accountability is reduced. However, it is possible this assertion misses an important element of cooperative party behavior.

The competitive system ideally produces fierce competition within congressional districts, producing legislators who are bound by local concerns. These lawmakers are relatively timid due to their lack of governing flexibility, as manifested by their concern with the next election. In contrast, the sphere of influence system generates legislators who reflect their districts, but who are ultimately offered as a fait accompli to minority preference voters in the district. The ideological distance between members of the legislature increases in this system. These legislators are less likely to support the opposition party. Thus, competition is not eliminated in this system, but rather moved from the election game to the legislative game. The issue concerning the social welfare impacts of this system is therefore a debate concerning the appropriate forum for political conflict. This study is unable to address sufficiently this question.

History may provide clues. When Cleisthenes instituted Athenian democracy in 508 B.C., a representative system of magistrates, jurors and other civil officials was created. This system was in fact more complex than the conventionally accepted system of so-called direct democracy usually attributed to Athens. Among his reforms, Cleisthenes divided the population of Attica into ten new tribes that reflected disparate socioeconomic interests. He also created 139

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53 *The Oxford Companion to Classical Civilization* is an excellent reference source used for this discussion.
municipalities or demes (Δῆμοι), which he distributed among the tribes. Magistrates elected from these districts were routinely organized into boards of ten members, one for each tribe. Although the decisions of these boards were subject to approval by the popular assembly, the ekklēsia, it was in these councils that political conflict resided as a professional pursuit.

To a certain extent, this distribution of competition, conflict and cooperation among the levels of Athenian society mirrors the sphere of influence formation attributed to sweetheart gerrymandering as described in this study. Within each deme, a single tribe dominated, in the same way that a single political party dominates many congressional districts in the United States. This analogy is not perfect given the important role of the popular assembly, but the this system of politics possessed the same objective as that described in this study: to reduce costly conflict among competing political organizations. The balancing role of the popular assembly may be found in primary elections of U.S. representatives. If the political parties are able to protect corrupt or incompetent incumbent representatives, then the sphere of influence pattern of behavior is surely harmful to democracy and social welfare. On the other hand, if the primary process serves as a useful check on incumbent behavior, without diluting district ideological representation and Burkean representative discretion, then the sphere of influence system may produce strong representatives capable of vigorous legislative debate and resolution.
5.5 Works Cited


5.6 Figures

Figure 5.1: Campaign Mandate for Right Candidate in Competitive Elections

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Figure 5.10: Expected Utility for the Left Party with Competitive Elections
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Figure 5.12: Differences in Payoffs between Cheating and Cooperation for the Left Party
Figure 5.13: Expected Utility for the Left Party in Defection Scenario

Figure 5.14: Discount Factor Requirement on Cooperation for the Left Party
Figure 5.15: Difference in Discount Factor Requirements for the Left and Right Parties


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