The Endless Space Race

The Influence of International Military and Economic Threats on NASA Competitive and Cooperative Spending

By

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1.0 Introduction

The national space program of the United States is not only a scientific institution, furthering knowledge for the common benefit, but also an important asset in international relations that reflects changing tendencies towards interstate competition and cooperation. Contemporary political scientists see space in particular as an expression of terrestrial nationalism (Marshall 1995, Dolman 2002, Spiller 2016). Upon historical reflection, some also note that the United States readily engaged in cooperative joint-endeavors with foreign powers when such activities could be justified within the national interest (Launius 2009). The National Aeronautics and Space Administration furthers economic, military, political, and scientific goals capable of providing important strategic resources and capabilities, as well as diplomatic goals through joint collaboration with foreign space programs. The focus on these various priorities has evolved periodically, waxing and waning as priorities change. The application of international relations theory plays an important role in explaining these shifts, suggesting a systematic policy-driven approach to the ordering of priorities for the space program.

Power transition theory provides a viable explanatory model, presenting national strategy as that of the foremost state attempting to preserve its favorable position in the global power distribution against the encroachment of rivals (Organski 1968 pg. 338-344, Organski and Kugler 2015). Likewise, certain theorists claim that the basis for interstate space policy considerations lies in the understanding of state actors of a shifting relational structure in a climate of imperfect information (Wang et al. 2013). These works suggest interstate cooperation is guided by instrumental rationality, with the United States and each prospective partner making

a cost-benefit assessment at each opportunity for cooperation, considering respective gains relative to the status quo as well as each other's status as a simultaneous competitor (Wang et al. 2013). Spacefaring states therefore balance simultaneous opportunities for cooperation and competition as the relative position of rivals and prospective partners allows.

This thesis explores how the programmatic contents of the American space program are shaped by governing policymakers' perceptions of the distribution of power on the international level. The United States seeks to maintain its position by carefully controlling its investment into programs serving competitive and/or cooperative functions. Competitive programs provide exclusive benefits to NASA and the United States, but incur the maximum costs for the sole investor, while cooperation can efficiently divide investment at the additional cost of sharing benefits with foreign competitors. Factors present along the entire lifespan of the space program, specifically military challenges to American interests and the strength of the American economy measured through indicators of its trade competitiveness, serve as the examined signals of international power distribution. Greater conflicts and a faltering economy should demonstrate a weakening relative position that may necessitate investment into competitive-oriented programs while fewer conflicts and a strong financial position can signal sufficient security to allow international cooperation.

To test this theorized relationship, this study collected a dataset of NASA's programmatic distribution of investments. This data was qualitatively subdivided into competitive and cooperative programs to allow assessment of each's trend, as well as the ratio of their historical relative share. The output of this categorization was analyzed through a time-series regression in

STATA to isolate proposed signals of international competition as significant, and qualitatively through case studies comparing the historical trends to contemporaneous political developments. Interviews were conducted with a topical authority to contextualize the proposed dynamic and help explain observed results.

Qualitative interviews support the top-down Rational Decisionmaker model for space policy, with programs selected for their capacity to support the specific objectives of concurrent national government leaders. Summary statistics demonstrate that the vast majority of annual spending is directed towards programs supporting international competitiveness, although there exists a cyclical pattern of rising and falling spending while cooperation has seen a much slower but steadier rise. Historical assessment likewise reveals distinct eras of differing investment strategies. The 1960s and 1980s match heightened tensions and conflicts to greater competitive investment while the diplomatic realignments of 1970s Detente and Post-Soviet relations in the 1990s demonstrate clear growth of internationally cooperative programs. In parallel, regression analysis suggests that annual conflicts play a significant role in heightening investments into competitive programs, while economic factors register as significant for determining spending on cooperation. Further statistical analysis is necessary to confirm the proposed relationship due to limitations of current data. This study demonstrates a viable foundation for continued research and the importance of analyzing space policy as a close companion to foreign policy considerations.

2.0 Background

The early American space program fundamentally emerged in the wake of the Second World War. Vannevar Bush's pivotal 1945 report *Science, The Endless Frontier* lauded the path of state-directed science for the common benefit, prompting the initiation of the National Science Foundation as a means of directing national sponsorship. In parallel, the United States' deployment of the nuclear weapons demonstrated the destructive capacity of nationally-applied science, while the German V-2 rocket program drew broad interest as a long-range delivery system. Subsequent centralization of domestic science alongside co-option of formerly-adversarial German rocketry experts reflected a growing respect for the competitive applications of emerging sciences. Of particular focus were those with military applications, most notably the Intermediate-Range and Inter-Continental Ballistic Missile programs (IRBM/ICBM), due to their critical role in the emerging doctrine of martial deterrence (McDougall 1997). Still, offensive and non-weaponized applications alike followed a common path during this period. Their initial outpour of postwar support was blunted by budgetary limitations until a resurgence in response to advances by the geopolitical rival of the era: the Union of Soviet Socialist Republics (McDougall 1997).

The application of early American space policy relative to its Soviet counterpart characterized the foundational structure of decision-making within the field as a whole. The 1957 Soviet launch of Sputnik, the first artificial satellite in space, saw the creation of the American National Aeronautics and Space Administration (NASA) within a year, exemplifying the inherent reactivity of the space program. The power of state-run development of the space-based

capabilities Sputnik implied, long-range weapon deployment and orbital surveillance, necessitated a formalized management of American advances that could mobilize assets behind concrete policy objectives. Opponents of a centralized, state-run endeavor found their outcries obsolete as rising competition from a command economy prompted an equivalently top-down response (McDougall 1997). Interviews suggest this dynamic persists to the present as policymakers determine the current policy and subsequently support space projects that meet this priority (Breaux 2020).

The creation of NASA was a complex process, with Congress considering how to delineate jurisdiction over types of space activities. Planners sought some division between the civil and military projects, despite the issue of inherent capacity for militarization of most space technology (McDougall 1997, 174). The resultant agency was a quasi-military civil space program in which projects with militarized and civil uses coexisted and even merged. For example, the XB-70 Valkyrie could be tested as a supersonic transport *and* a strategic bomber (Gibbs 2017). Early programs followed an approach of politicized advertisement, where scientific and technical successes were oriented to inherently communicate a superior relative international position. A successful launch didn't just put a payload into orbit, it broadcasted the value of American technology, culture, and government (Von Bencke 1997, pg. 39).

There was a concurrent exploration of peaceful uses for outer space and opportunities for the foremost nonmilitary expression: international cooperation. Officially, peaceful coexistence and mutual efforts were policy and priority. However, the United States feared revealing critical technologies, and amongst Soviet counterparts concerns over revealing their comparative

disadvantages prevented meaningful overtures for years (McDougall 1997, 184). Even with third parties, the United States opted to demand that partners provide some significant contribution, precluding most cooperation until their technological bases caught up (McDougall 1997, 207) As such, periods of cooperation such as the International Geophysical Year of 1957-1958 were the exception, not the norm, for civil space authorities.

2.1 The Space Race

The first decade of NASA's operation was characterized by the abandonment of the Eisenhower administration's cautious restriction of competition in favor of a true space race. The president had opposed what he deemed opportunities for expensive escalation, supporting surveillance satellites and defense research but few aggressive projects until Soviet technological advances forced his hand. However, his successors in the Kennedy, Johnson, and Nixon administrations simultaneously recognized and rapidly applied the rhetoric of a space race in the 1960 election (McDougall 1997, 223-225). The fictitious threat of a "missile gap" had emboldened the space race advocates relative to the scientific arm of NASA and the ascension of the Kennedy administration formalized the commitment to a contest of prestige through manned exploration of the moon and the concurrent development of dual-use rocket capabilities. The new president sought to counter perceived Soviet strategic advances in Laos, diplomatic successes during the Congo crisis, and the persistence of the Cuban revolutionary government against failed American-backed attempts to dislodge them (McDougall 1997, 318). Competitive projects flourished due to their utility in providing strategic military advantages, political prestige, and scientific advancements capable of supporting either. Rocketry produced the Inter-Continental

Ballistic Missile (ICBM), aeronautics led to the development of the X-20 "Dyna-Soar" spaceplane/bomber proof-of-concept, and of course manned spaceflight carried astronauts progressively further until the moon itself was in reach. What few internationally cooperative ventures appear in this era primarily take the form of escalation-denial through space policies banning specific competitive activities, primarily orbital weapons of mass destruction. However, these policies reflect more of a general recognition of the utility of mutual limitations, in which neither party enjoyed any dramatic practical advantage. These cases may be viewed simply as managed rates of competition rather than cases of genuinely-intended cooperation (Dolman 2002). And yet, these conscious attempts to manage the rate of competition set the stage for an era of true collaborative endeavors.

2.2 Detente

Space historians recognize that international concordance precedes genuine cooperation, not the other way around, and therefore that the state of Detente was necessary for a true break in the pattern (McDougall 1997, 350, Sheehan 2007, 63). With the achievement of the moon landing, funding fell dramatically and concurrently with the arrival of Detente proper between the superpowers. NASA was obligated to rationalize each budget request and while it sought a valid successor to Apollo allies and rivals alike had advanced to the point where they were capable of contributing to a mutual project. European programs consolidated within the European Space Agency (ESA) and developed an independent launch capability (Ariane) which placed them within the ranks of potential partners. Factions within the USSR observed the economic sensibility of Detente and the rare opportunity for access to American technology

(McDougall 1997, 433), prompting a period of unprecedented cooperation most visible in the 1972 Soviet-American Agreement Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes and the Apollo Soyuz Test Project (ASTP) of 1975 (Bencke 1997). However, European advances also heralded their impending economic competitiveness, to be followed by Japan in the incoming decade, while Soviet human rights abuses and militarization, including in space, prompted renewed concern within the newly-elected Carter Administration by 1977 (Bencke 1997).

2.3 The Second Cold War

The 1980s saw the scale of projects increase once more, beginning with the Space Shuttle's first launches at the beginning of the decade and culminating in the first steps toward the modern International Space Station (ISS). Throughout, the U.S. explored renewed competitive opportunities, famously during the Reagan administration's missile defense project, the Strategic Defense Initiative (known colloquially as "Star Wars"). The project signalled an end to Detente cooperation and a new willingness to invest in advanced technologies in space, directly seeking open advantage against the USSR, and accompanied the termination of ongoing cooperative treaties (Sheehan 2007, 66-67). In parallel, both weaponization and commercialization came into focus in this period. The Reagan administration ordered development of anti-satellite missiles (ASAT) in 1982 in a clear break of the Carter administration's policy of mutual capability denial (Sheehan 2007, 97). Commercialization took the form of exploratory organizations and consortia developed to determine opportunities for

privatization, as applied to both existing programs like LANDSAT and the invitation of new private service providers (primarily for launches) (Kay 1998).

2.4 Post-Cold War

A break to this new age of competition came only with the ascension of Mikhail Gorbachev to the Soviet First Secretariat in the mid-1980s, resulting in a new bilateral agreement in the vein of the 1977 accord (Bencke 1997). Informational exchanges resumed and advanced to joint projects by 1987, intensifying in the twilight years of the Soviet Union and setting the foundation for the unprecedented scope of post-Soviet cooperation. Soviet dissolution saw a third cooperative agreement signed in 1992, the first direct funding from the United States to Russian space corporations, and finally, the 1994 Memorandum of Understanding approving Russian participation in the International Space Station (Bencke 1997). These accomplishments unified global manned space efforts for almost a decade, but technological proliferation concerns continued to hold back many private and governmental opportunities for cooperation. Ultimately, economic factors blunted Russian space capabilities (Bencke 1997) and the War on Terror drew American focus elsewhere. The space program has continued to evolve in the decades since, but due to data limitations, these initial forty years constitute the period of focus in the current work.

3.0 Literature Review

Previous literature provides the basis for the model of space policy formation used in the current study. Power Transition theory provides an explanation for the environment in which space policy formation occurs, specifically how budgetary formation fits into an international

relations strategy. Past explorations of space policy demonstrate that efforts are fundamentally reactive, selected to meet salient national priorities at the time of program formation. Consideration of domestic and technological explanations is necessary to contextualize a deeper analysis, provide useful components for data analysis, and highlight the value of considering space policy formation through the lens of foreign policy. Previous approaches to connecting foreign and space policy are considered as well, providing a foundation for the current format of quantitative and qualitative analysis.

3.1 Power Transition Theory

The international aspect of the evolution in the space program's budgetary distribution is best contextualized through Power Transition theory. The model was first posited by A.F.K. Organski in 1958 and has since been reinforced by both empirical observations and evidence from the contemporarily shifting state of international influence. Distinguishing from realist schools and "balance-of-power" political theory, Organski posited that the most stable international environment involves not a group of settled equals but instead depends on a clear gap between a foremost power and its competitors (Organski 1958, Tammen 2008). Competitors are always in pursuit of greater power, seeking a stronger position from which to bargain or resist pressure from the primary power, but in doing so increase the risk of direct conflict. Either the existing hegemon will act to prevent its eventual replacement, or else the upstart power moves to secure first place by preempting such attempts at suppression, requiring powers interested in stability to continuously maintain their dominance. This dynamic does not necessarily take the form of preemptive war, as costs of modern conflict can accrue rapidly and

even in the event of a victorious suppression, a modernized and industrialized rival may recover from even widespread devastation within a single generation (Kugler et al. 2013). Instead, it is ideal for the leading state if the prospective challenger comes to accept a nondominant role in the existing order, becoming integrated into a system of favorable association and satisfied with cooperation instead of disruptive conflict (Organski and Tammen 1996, Kugler et al. 2015). My work will extend this dynamic to the dimension of space policy, noting the structural similarities of historical boom/bust periods of investment into competitive and cooperative policies to the archetype of a leading state working to maintain its position.

3.2 The Reactivity of Space Policy

There exists a growing literature surrounding the nature of interstate cooperation and competition in space. Legal scholarship has demonstrated that space law is fundamentally reactive, emerging in response to evolving capabilities, changing priorities, and shifting geopolitics that are difficult to predict (McDougall 1997 p. 188, McDougal 1958, 1963). This dynamic may perhaps be extended to applied policy, which follows as a corollary of the nationally-accepted legal regime. There are less formal schools of thought surrounding the determining factors behind space diplomacy; instead consisting of varying assignments of influence to different sectors. These include theorists who consider domestic factors within the United States, the changing capability of prospective partners for competition or cooperation in space, and individualized shocks from major international crises as motivation for directional revision of specific programs as the foremost drivers of space policy design. These factors all play important roles in influencing national capabilities and priorities and are therefore

considered within the current research. Additional theorists have explored the role of foreign policy, either through historical surveys or proposals of driving forces.

Cumulatively, these works point to a close relationship between the geopolitical environment and formation of space policy but can benefit from both a testable application of their mechanisms and a consideration of their generalizability. This research explores an addition to these influencing factors, which is considered to be useful in quantifying and explaining the overall course of the space program. The current thesis also contributes a concrete quantitative model that examines the space program as a whole, through several measures, to offer a more systematic analysis of the role of the major international factors that might influence its design.

3.3 Domestic Factors

Previous studies have considered that, as a public policy dimension, space policy models itself to some degree on domestic factors. Political economist Mary A. Holman brings attention to space policy's role in fulfilling the four traditional public policy objectives: social, economic, defense, and foreign policies (1974). Space policy provides useful scientific discoveries, commercializable products, and services critical to national goals. She points to multiple factors therefore influencing the deployment of space investments in pursuit of these goals.

Importantly recognized is the role of public opinion in shaping preference. Noted amongst interest groups and policymakers are contrasting views of both politicians and private actors on the space program as a worthy investment versus opposition to concerns that it would incur an unacceptable opportunity cost and/or distort the interests of private enterprise. These arguments reached the highest levels of government, notably shaping post-Apollo goals as senior

officials decried perceived luxury spending as superfluous and deleterious to underfunded social needs (Byerly 1989, pg. 39). Of particular note is the examination of mass media and opinion polls as representations of the opportunity for popular demand to shape developments. Here, Holman acknowledges a fickle public with wavering opinions sensitive to any salient positive or negative space-related event or media display on a common basis. This presents public opinion as too variable for policymakers to reliably predicate their funding upon, as constituent preferences may shift before policy even reaches the implementation stage. Alternatively, even within cases of mass-publicized events, public opinion has sometimes been presented as comparatively unresponsive. In the wake of the 1957 Soviet launch of Sputnik, polled opinion was decidedly mixed, with most citizens simply lacking the classified context needed to make an informed appraisal and the much-reported public hysteria emergent more from a "media riot" than any self-derived broad outcry (McDougall 1997).

Former NASA Chief Historian Roger Launius has tracked public opinion polls for decades, criticizing the commonly-held myth that NASA funding evaporated post-Apollo due to any discrepancy in public support (Launius 2003). He demonstrates that the American populace is simply too insulated from NASA's structure to have a stake in its mission design beyond a generalized state of support. Public opinion failed to doom Apollo when concerns about costs went mainstream and has stayed positive for decades after the culmination of that national goal. Holman admits that both support for and opposition against the space program was largely diffuse for an extended period from its inception at least through the mid-1970s (the time of her publication) (Holman 1974). Any government employees taking part in organized-labor were "loosely-knit" and any businesses firms or related contractors, even if tied to trade organizations,

were relatively uncoordinated. These factors do not present the image of either a rapturous public ready to make or break any election over the issue of space policy or any monolithic syndicate ready to lobby and shape the space program's internal makeup. This current work builds upon this situational appraisal and examines whether, in the absence of any concerted domestic body of influence, international factors which might shape judgements of policymakers in its stead.

Alongside the interests of the American electorate, some have considered that the partisan composition of policymaking authorities could impact the direction of space policy. Previous study did find some relationship between presidential party and total funding, attributed to fiscal sensibilities or a partisan preference for military vs. fiscal investment (Smiley 2013). However, an alternative argument stems from examination of the transition between the presidencies, noting that the second Bush administration's belligerence outwardly overshadowed a fundamental retention of policies ranging as far back as the first Bush presidency due to the post-Cold War advent of unipolarity (Mitchell 2008, Launius 2009). This argument states that, to some extent, even decision-makers may be insulated from the direction of space policy by the fundamental realities of interstate conditions beyond their control. Further examination of this perspective is necessary to test its generalizability outside the era of unipolarity. Additionally, so is systematic testing to confirm whether, even if listed policy priorities remained intact, the actual programmatic distribution was likewise organized to reflect the foreign policy of a unipolar hegemon across the jurisdictions of many ideologically-opposed national administrations.

Economic factors have been found to play a key role in determining the overall funding available to NASA as an agency. Holman notes that the period surrounding NASA's foundation involved a confluence of economic conditions favorable to increased research and development while the decline of funding in the late 1960s matched competition for shrinking discretionary spending (1974, 28). The discretionary status of space spending has revealed sensitivity to the availability of funds and the risk of reappropriation, with a regression of budget totals demonstrating that a series of economic measures correlated strongly to NASA's annual budget (Smiley 2013). Measures of generalized economic health, such as unemployment or spending as a percent of GDP, were found to match accurately as recessions either limited available resources or obligated reappropriation outside of space spending. Likewise, military spending correlated negatively with budget totals, with either the costs of war drawing away spending or some degree of overlapping investments redirecting to the military during times of perceived need as possible explanations. Likewise, the study uses the period of the Space Race as a control to account for its disproportionate investment. These elements serve the current study as useful independent and control variables to account for changing economic and military influences. The Space Race control has been adapted for the current study controlling for the Cold War, as the space race is a symptom of competitive focus not an external cause. Furthermore, where many previous studies used the complete budget of NASA as the variable of study, an internal division of funding into competitive and cooperative spending may demonstrate the role of both domestic and foreign factors in determining specific types of spending.

3.4 Advancing Foreign Technology

Elsewhere, brought about by the massive cooperative boom surrounding the International Space Station, contemporaries and others since posited the shift in, primarily technological, capabilities of prospective contributors as a major influencing factor in the shift to cooperation (Williamson 1985, Pedersen 1986). These theorists observe that NASA had long-shaped its cooperation around limiting technology transfers, even to allies, until foreign programs independently caught up to American standards. Although, one should also consider that, when the United States truly sought to collaborate, cooperative endeavors such as the 1960s-present telecom syndicate INTELSAT emerged regardless of any technological gap or interstate concerns. There is also evidence that the United States both cooperates and/or competes with rivals simultaneously, as seen in the case of the American lack of cooperation with India and China in Asia even as it coordinates with Russia (Sheehan 2007). The competitive-cooperative distribution may not be just a natural consequence of technological capabilities. This question requires evaluation as to whether the balance is rather an intentional consequence of international competition, with the United States suppressing opportunities for cooperation until international conditions make collaboration a valid option. This thesis argues that cooperation is, to some extent, its own reduced form of competitive self-empowerment, with America always capable of collaboration but only participating when international tensions are reduced to the point where the absolute gains from a joint-project outweigh the relative cost of technological proliferation.

3.5 Foreign Policy

Even with those that attribute a critical role in shaping space policy to international factors, evidence is either incidental or too limited in scope. Attention has come to the role of international conditions in shaping space policy, whether by shaping the preferences of decision-makers or their available options towards pursuing their administration-specific goals. In focused case studies, the Apollo mission has been analyzed as a consequence of the Kennedy administration's intent to account for the failed 1961 Bay of Pigs Invasion of Cuba and the deviation from later cooperative overtures as a means of responding to foreign aggression in the 1962 Cuban Missile Crisis (Schauer 1976, Watanabe 2009). While the current thesis argues for a comparable responsiveness to signals of rivalrous interstate disputes that include martial flashpoints, the examination of one program (though a significant undertaking) over three years may be insufficient to confirm a generalizable systematic tendency. A more extended examination can track the degree of reactivity including Apollo but also programs beyond, in particular the designation of periods of foreign aggression as detrimental to cooperation (Sheehan 2007). This thesis reexamines the observed tensions, not only as qualitative case studies of competition but rather as consistent variables that influence the space program beyond incidental cases alone.

A more comprehensive survey and subsequent proposed model can be found in the work of Wang et al. (2013), where rationalist theories of international relations have been convincingly applied to the case study of transatlantic space cooperation. The model also applies rationalist conceptions of state actors, presenting the space policies implemented by states as

products of their strategic environment, accounting for state preferences and capabilities rather than any normative explanations. Here, the proposed model presents the cases of bilateral interstate interaction as subject to considerations of absolute and relative gains. Absolute gains involve how much a deviation from the status quo (pursuing goals alone) will benefit a participant, as opposed to the cost, while relative gains refer to concerns that those beneficial outcomes will allow partners in the current cooperative instance to use to their advantage in potential subsequent interactions. The importance of these gains to the pursuant interactional strategy is still noted to vary in different cases. Overall, however, this argument still suggests a uniform atmosphere of constant balancing of competition and cooperation within a continuous race to advance as spacefaring states and support terrestrial goals of dominance. For example, the model attributes the attainment of European lifter vehicle capabilities as the source of new competition with the Space Shuttle as the members of the European Space Agency's search for launch capability independent of American support drew both sides into market and strategic competition.

Under the realist conception, the struggle emerges from the continuous conflict between American goals of space dominance and European goals of freedom from that dominance, with cases of competition and cooperation following from analysis of costs relative to the pursuit of those goals. This provides a strong model for determining the expected considerations made by transatlantic space powers, but also necessitates greater analysis within the current research; both to confirm the proposed relationship and test its applicability within the broader relationship of the American space program and global politics. Expanding analysis beyond the transatlantic space relationship also accounts for relevant cases of competition and cooperation with

non-european partners such as Japan and the Soviet Union. With their competitive interactions with the United States no less strict and their joint-endeavors no less productive, a globally-applicable design can provide a fuller picture of the underlying mechanisms at hand. In addition, Wang et al. provides excellent qualitative case study analysis of interactions, and supports the current quantification of the theorized behaviors across the space program's lifetime. The rationalist model should allow for accurate measurement of the scale of international considerations' effect on subsequent strategic policy.

The goal of this thesis is to attain a more comprehensive understanding of the role of foreign policy in shaping the space program's evolution throughout its lifetime. Military tensions and economic competition are believed to play important roles in determining which programs advance to implementation and which are precluded. Alternative explanations likely play some role in programmatic design, but justifications for both international and domestic explanations remain too limited in observations, and predicated on anecdotal and qualitative assessments. Program-wide examination may better reveal tendencies in place of era-specific assessments. Measurement of factors influencing decision making is expanded to the martial and economic tensions present across the space program's entire timespan. Rather than incidental cases, accounting for standardized measures present during all past, present, and likely future policy considerations may provide a new basis towards understanding and predicting future space policy.

4.0 Theory

Within the context of the current inquiry, the examined question is: To what degree did the foreign policy of the United States shape the reactive distribution of funding to competitive and cooperative projects within the national space program? The U.S. space program presents itself simultaneously as a leader in scientific development for the benefit of all mankind and as a resource capable of enhancing the strategic position of the nation, inevitably relative to actual and potential competitors on the international stage. With the stated goals of "Fostering New Discoveries and Expanding Human Knowledge, Global Engagement and Diplomacy, Interactions with the Nation's Security and Industrial Base Posture, Economic Development and Growth, Addressing National Challenges, Leadership and Inspiration" (NASA 2018), this seemingly-dichotomous mission of simultaneous global cooperation and interstate competition is for the most part identical to NASA's position at inception. While the mission of the space program has remained intact for decades, the schedule and structure of implementation of these priorities has shifted over time.

Functionally, the American space program has been funded continuously, and overall increasingly, since its inception. Individual programs come and go, serving a variety of functions, but the reason for why these projects are initiated and appropriated may be more complex than capability alone. The guiding element behind these shifts is predicated on observation by past theorists that international events have influenced policymakers towards shaping the structure and schedule of American space project priorities (Holman 1974, Schauer 1976, McDougal 1995, Bencke 1997, Watanabe 2009). This thesis proposes that the state of

international relations at any given point during the space program's history offers a potentially important indicator of the subsequent direction of the space program by shaping the risks of investing in competitive or cooperative projects.

4.1 Policy Formation

By admission of space policy experts, domestic interest groups were historically dispersed, their bargaining power diffused (Holman 1974), therefore limiting the influence of domestic pressures on the space program. As such, there may not have been enough of a concentrated domestic constituency invested in space policy to influence project distribution towards specific programs. In parallel, the attestably top-down decision-making format amongst space policymakers suggests that executive and congressional officials determine a national strategy and then select the option best suited to achieve those goals, rather than a contest of policies emerging from bottom-up from policy entrepreneurs (Breaux 2020). Therefore, I argue that foreign policy, whose salience directly reaches the highest offices rapidly by its nature, is likely to influence legislative and executive politicians towards directional investments.

Due to democratic accountability, American policymakers are driven to select short-term goals that befit their contemporary situation and can be claimed as public victories to meet public pressure and provide electoral advantages (Organski 1968, 81). As such, one can expect that policymakers will not select policies that run completely counter to their standing policy stance. In conjunction, the space program is planned serially as individual technological achievements that reflect the short-term strategy in place at the time, in distinct contrast to the example of long-term planning in Soviet space program made possible by its autocracy and the desirability

of vague, opaque goals for broad appeal without concentrated public pressure. There is then an interaction between the specific short-term goals of the national leadership, matching their personal ideology and intentions, with the policy formation format of space policy. At this point environmental circumstances shape the salience of specific needs and therefore the available selection of options to address these concerns.

4.2 Competitive Investments: Maintaining the Lead

At any given planning phase during the space program's lifetime, policymakers are confronted with a choice of what type of investments to pursue. They can commit to competitive programs that provide benefits or products exclusive to American utilization, but require investment costs fully paid by the United States alone. Such projects allow the maintenance of a relative lead in the global power balance without need for active suppression of the competition, relying solely on the advancement of domestic capabilities. This study assumes such projects are the norm, with the space program itself originating from competitive considerations and early deviations requiring extraordinary opportunities to justify. The circumstances catalyzing greater investment into competitive projects become evident to policymakers through indicators of the need for a new advantage against international rivals. In order to maintain a sufficient gap between the American lead and the next several strongest powers, the United States must maintain an advantage in military and economic fields as to dissuade either armed usurpation or the economic costs of interstate bargains favoring a rival. From here emerges the first hypothesis:

As international competition with the United States increases, the degree of American investment into competitive programs will also increase.

The United States requires some means of gauging the state of international competitiveness as to decide where its resources are best allocated. There are numerous means of measuring the strength of countries, but for our purposes the most relevant are military and economic strength. Military strength is likely to play a role within allocation, having been the basis for many early competitive projects meant to provide advantages during direct conflict and simultaneously suppressing the prospects for productive, but security-sensitive, cooperation (Logsdon 1988). As such, indications that outside parties are capable of, or are investing in, challenging American military advantages should spur greater investment into assets which extend American dominance. These should preserve the power gap to prevent conflict and provide an advantage in the event that war erupts regardless. Previous study found that American military spending correlated highly negatively to NASA's total budget (Smiley 2013). The current study suggests some variation in subcategorized spending depending on the relationship between the competitive/cooperative-specific budget variables and the number of American conflicts. Signals of military challenge may also be found externally in the involvement of perceived rivals in their own military endeavors. For this reason, due to the distribution of power during the time period in focus, the Cold War through the 1990s, military conflicts involving the USSR (later Russia) and China may serve as additional indicators of rising threats obligating a response.

Economic dominance is a pillar of equal importance in the globalized state of commerce, allowing the leading power to pursue and maintain favorable conditions during interstate interactions. Some theorists use domestic productivity as measures of state power, often measured by total national GDP (Organski and Kugler 2015), but here the measure of a foreign economic threat to American dominance is gauged through international trade. Factors making up the balance of payments and parallel trade measures indicate the level of the American economy's dependence on external actors who might use such leverage in interstate bargains, relative to American capacity to exert influence outward. Therefore, this thesis uses indicators of trade strength to determine when the United States may seek to empower its economic competitiveness by introducing new and improved goods and services to domestic and international markets.

4.3 Cooperative Investments: Efficiency and Managed Competition

Otherwise, planners can support cooperative programs, utilizing the shared experience of skilled partners and dividing the burden of opportunity costs paid. However, such programs also result in a division of the joint-project's products between contributors. Historically, such collaborative endeavors have produced some of the most impressive undertakings of human history, from the first global telecommunications system to orbital experiments aboard the International Space Station. So initially, the case for cooperation looks like the archetypical "Stag Hunt" game theory exercise. Both sides of a joint space project would benefit greatly from employing their combined resources towards a common goal. Each could pursue a project on their own, though the product would likely achieve lesser results. As such, there should exist a

Pareto-efficient option for both parties to cooperate in pursuit of the productive joint project. Where the space application deviates from this model, however, is when we consider that in reality each faction actively intends for the other side to receive minimal benefits while maximizing their own. In the context of the archetype: What if each of the stag hunters wanted the other to go hungry? For each of the United States' great cooperative ventures, its partners advanced as well; an important distinction considering the demonstrated potential for terrestrial applications of joint experimentation products in emerging scientific fields and commercially-profitable goods and services (Amesse et al. 2002, Evans et al. 2009, Szalai and Peeters 2012). Therefore, concerns over technology transfer accompany all cooperative undertakings. Prospective projects must allay a vast array of security and commercial considerations to convince hesitant legislators to approve even a portion of possible cooperative programs (Lambright and Schaefer 2004).

Logically, proponents have several paths to support a cooperative program. They can dilute sensitive program components until technology transfer is no longer a concern, but these restrictions may limit overall productivity. Alternatively, advocates and policy entrepreneurs can make the case that the benefits of cooperation outweigh the dissemination of useful technologies. However, partners capable of this level of supplementary investment are rare and may be concerned with their own risk of technology transfer to the United States. This thesis argues that cooperation advocacy is most easily achieved simply by lowering the bar for meeting security concerns. In the absence of a close competitor, the gains of partners should be considered unlikely to put them in the position to overtake the United States, making technology transfer less relevant. Likewise, the safety net of a wider relative power gap should imbue leaders with

confidence that cooperative overtures will produce true collaborative efforts with mutually-beneficial outcomes. If cooperative products cannot significantly shift the balance of power, leaders should be less fearful of incentives for strategic behavior that might otherwise endanger and dissuade cooperation. As such, the absence of competition frees the United States to fund cooperative programs without fear that such overtures will overly empower prospective and actual rivals. Here emerges the second hypothesis:

As international competition with the United States decreases, the degree of American investment into cooperative programs will increase.

It is important to note that competitive and cooperative programs are not necessarily mutually-exclusive or that programmatic distribution is automatically a zero-sum system, as programs can be both competitive and cooperative to some degree. In parallel, it is essential to distinguish international competition, or its absence, as sufficient to induce the theorized spending trends but not absolutely necessary as additional factors may still play a parallel role in different circumstances.

4.4 Relative and Absolute Gains: Shifting Power Distributions and Strategies

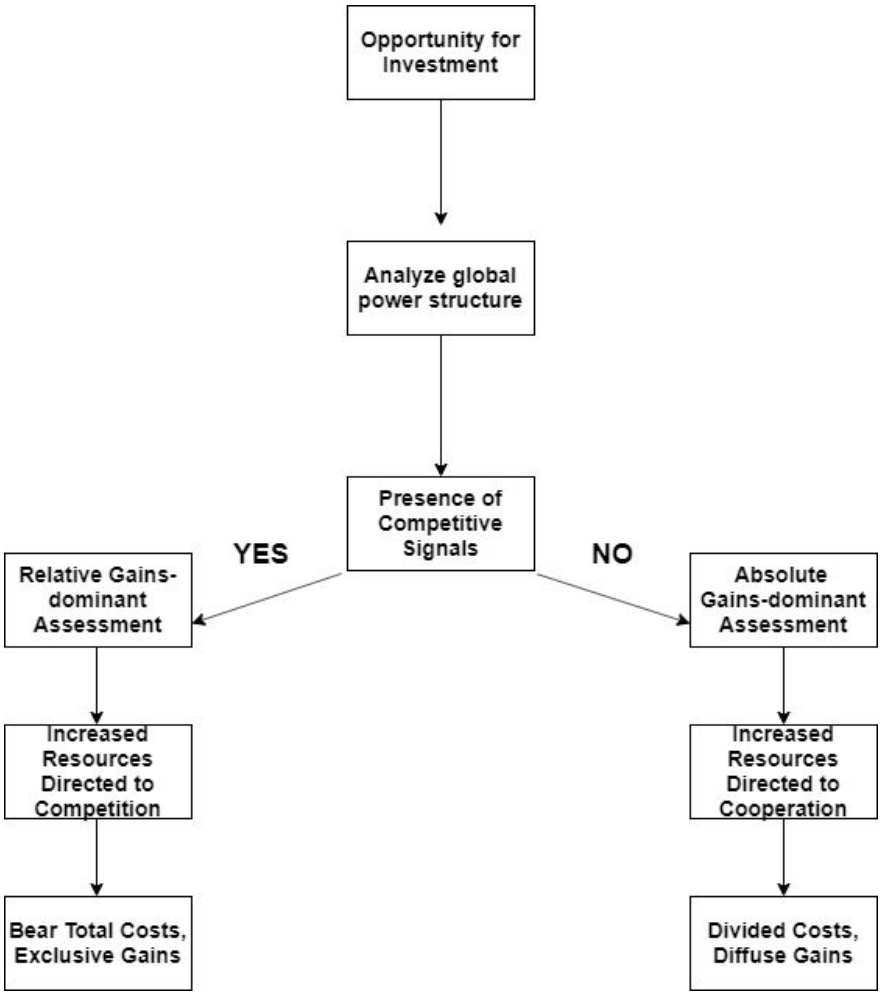
Wang et al. (2013) argues from a rationalist theoretical position that prospective cooperators consider the bilateral relative and absolute gains from particular cooperative overtures. Absolute gains involve the direct cost-benefit assessment of a particular project, while relative gains compare the potential benefits accrued domestically versus the predicted gains a partner, who is also a competitor, might achieve. The current study modifies this system

according to the bar set by the perception of global conditions. Game theoretic models by Duncan Snidal (1991) have suggested that states decide which type of gains to pursue depending on the power distribution. A relative gains-based strategy only precludes cooperation during the specific case of a bipolar rivalry, while the prospects for international cooperation greatly increase with a greater number of actors, as might be found in a more multipolar setting. In parallel, Robert Powell (1991) has modeled the strategies for gains as tied to the cost of conflict between factions, with higher costs of war promoting an absolute gains-seeking approach. These structure the proposed model, with a bipolar power distribution and low cost of war promoting relative gains as the primary consideration and a multipolar situation with high costs of war supporting absolute gains instead.

In current implementation, the United States must concern itself not only with the relative position of its partner but also the dispersion of useful findings to third parties whose relative position may be far more competitive. When competition is high, the United States must account for relative gains first, as a close competitor might benefit enough to challenge American interests or bargain from a stronger position in subsequent interactions. Even collaboration with partners who are not close competitors risks proliferating their technologies or benefits to parties which are. Absolute gains remain, but short of benefits deemed necessary to the national interest, relative gains should dominate considerations during times of perceived competition. When competition subsides, or the United States perceives its leading position as sufficiently advanced, relative gains lose relevance and assessment can instead predicate on the actual absolute material assessment of an individual cooperative venture. Cooperative projects can still fail to secure support in the absence of tensions if their absolute gains are seen as too costly to achieve, even

with assistance. However, they are still predicted to find approval at a higher rate than when otherwise suppressed by dominant technology transfer concerns.

Figure 1: Space Budget Competitive-Cooperation Decision Flowchart



From a geopolitical perspective, the lifetime of NASA offers an opportunity to test the gains-seeking behavior at work, as there should be a discernible change with the end of the Cold War. During the period, power was distributed in a bipolar structure between the superpowers,

while the costs of war might have been lower relative to the potential reward of unipolar hegemony. With the fall of the Soviet Union and the rise of economic competition from an increasing number of states, including in space, a more multipolar setting could have restructured the basis for gains-seeking. The bipolarity and low costs of the Cold War should have promoted a relative gains-based strategy that would have limited cooperation and left competitive investments to dominate while the rise of additional spacefaring states should have supported an absolute gains-seeking strategy conducive to more cooperative programs.

5.0 Research Design

Within the current project design, the purported relationship theorized functions as follows: Governing decision-makers are tasked with determining the structure of investments into the space program, including whether to pursue competitive programs that provide benefits while bearing the full cost of investment, or else cooperate on investment while sharing benefits. In doing so, they must consider not only the utility of each approach, but also the costs of alternative distributions of funding to available program options. This calculation is predicted to follow from the state of international competition, specifically the relative lead of the United States versus actual and prospective aspirants that may threaten its leading military and economic advantages. In the event that such a threat is determined to be sufficiently prominent, these policymakers will prefer to limit project benefits to American use despite subsequently paying for all investments. Alternatively, in the absence of indicators of strong international competition, it becomes viable to divide the costs of investment internationally since the diffused benefits are deemed insufficient to catalyze any rival's competitive position.

5.1 Data Analysis

Figure 2: Data Summary

VARIABLES	N	mean	sd	min	max
Calendar Year	62	1988	18.04	1957	2018
U.S. Defense Expenditures, % GDP	62	5.776	2.234	3.100	10.60
Unemployment Rate, % Population	62	5.979	1.584	3.400	10.80
Current Account Balance	58	-1.568	1.852	-5.834	1.075
Net Capital Inflow	54	95.79	128.6	0.186	516.3
Exports, % GDP	58	8.822	2.619	4.809	13.54
U.S. Annual Conflicts	52	5.327	2.167	1	12
Inflation Rate	40	3.531	1.886	1.431	6.591
Competitive Spending	40	4028	2477	125.7	9361
Cooperative Spending	40	1356	1212	16.75	3747
Spending Ratio	40	5.836	4.847	1.837	17.37
Cold War Years	62	0.565	0.500	0	1

The judgement of a foreign competitive threat is predicated on two possible groups of indicators which serve as the independent variables within analysis: either 1) military conflicts communicate a need to counter a concerted aggressive effort to impose costs in favor of a rising competitor, or 2) economic indicators communicate a weaker relative American position within international trade as successful alternatives reduce trade dominance and/or capital income from interstate transactions. These conditions are predicted to be sufficient enough to motivate a distinct funding redirection towards competitive and/or cooperative space programs, the dependent variables. For the dependent variables, given these qualifications, the first hypothesis

predicts that the higher the indications of an international military and/or economic threat, the greater funding will be towards competitive programs. Alternatively, the reduction of signals will result in an increase in cooperative spending. This dynamic is qualified by control variables that account for background factors affecting the data measured, specifically the calendar year and inflation rate, and the overall availability of discretionary funds for distribution, using the unemployment rate. The relationship can be computed through the following OLS regression model:

$$\text{Nasa Spending} = \alpha + \beta_1 X'_1 + \beta_2 X'_2 + e$$

Alternatively, the equation can be listed as:

NASA Spending = ß(Current Account Balance) + ß(Net Capital Inflow) + ß(Exports as % GDP) + ß(American Militarized Interstate Disputes) + ß(American Defense Expenditures as % of GDP) +ß(Cold War) + ß(Cold War*American Defense Expenditures as % of GDP) + α(Calendar Year) + α(Inflation Rate) + α(Unemployment Rate) + *e*

5.1.1 Dependent Variables

To test these hypotheses, several measures of the space program are operationalized as dependent variables to allow regression and subsequent analysis. Primary statistics are drawn from the 8-volume series of Data Books published by NASA (Van Nimmen et al. 1988, Ezell 1988, Gawdiak and Fedor 1994, Garber 1997, Rumerman 1999, 2009, 2012). Included within this series is the yearly fiscal budget of NASA available under several organizational formats. The current work specifically makes use of the raw yearly appropriations by projects as the

evident output of the purported foreign policy to space policy relationship. Data is available by project from 1959 through 1998, allowing for four decades of individual project categorization. However, measures from 1979-1980 are listed as undistributed, with funds not allocated by program (Rumerman 1999). Likewise, data from 1959-1979 is drawn entirely from the Research and Development sections, where projects fulfilling specifically competitive or cooperative functions are found. Entries from the mid-1980s and 1990s also include funding of projects from the Space Flight Control and Data Communication section, which split from R&D in 1984 but includes programs falling within the same principles.

Data for these four decades is approximated from the appropriated spending for projects during these years, rather than funded programs reflecting the money spent in practice (except in 1979-1980 where funded data is used). These sums reflect the intended use of government resources as per national policy, as opposed to the project's spending eventually recorded as specific engineering changes deviated from the appropriated sum. For each decade, programs are qualitatively characterized as either "Competitive" or "Cooperative" programs. "Neutral" spending, serving no direct competitive or cooperative goal (e.g. administrative and facility upkeep) is omitted. Within each spending category, projects are assigned a "high", "low", or "none" value indicating the assessed ordinal degree to which any specific project fulfills one of the three functions. Each qualitatively-assessed program is collected into both an individual variable of spending, as well as a combined measure of each program's overall approximate ratio of competitiveness/cooperation.

5.1.2 Qualitative Dependent Variable Categorization: Competitive Value

Determination of both categorical and level ranking is conducted on the basis of a series of measures relating to the functional use or output of each project. For competition, measures include several key indicators, with the foremost being projects geared specifically towards international competition. These categories all serve to provide indirect functions outside those of the specific project itself, namely security advantages during conflicts, the soft power provided by a prestigious public image, and the accruement of profits that feed back into the national economy. Strategic and military applications provide a prospective offensive capability or support efforts within the armed forces and intelligence services to provide an advantage against rivals during military conflict or through espionage. For example, the Gemini low earth orbiter program served as a coordinated effort between NASA and the Defense Department, simultaneously testing manned spaceflight for both civilian and military applications (Levine 1982, 231-232). These programs represent the highest level of competitiveness, with the ability to impose damages on foreign rivals indicating the expectation of the type of power struggles which Power Transition Theory predicts will emerge when two powers approach parity. A militarized investment is a clear attempt to maintain the gap in martial capabilities to preclude conflict and provide enough of an advantage to survive if the engagement still comes to pass.

Pride and prestige also play a key role in motivating NASA endeavors, as programs providing a public relations advantage improve the positive image of the space program and of the United States as a leader in scientific advancement. Strengthening the global image of the United States was historically seen as key in shaping perceptions in the ideological dichotomy

against communism (Von Bencke 1997, pg. 29, McDougall 1985, Pg. 302-305, Sheehan 2007, pg. 10). The Apollo lunar landing program is the most famous example of this type of effort, investing billions over a decade for a much-publicized effort to outdo the Soviet Union before reappropriation towards more practical investments.

Commercialized projects or technology offer a profitable and marketable good/service, either as a government-run amenity, like the INTELSAT telecommunications system, or as product of affiliated American corporations. NASA's Technology Transfer has long supported private industry and the development of numerous commercialized "spinoff" products for public consumption and foreign export (Gall and Pramberger 1992, Baker 2000). NASA projects often take the form of scientific explorations or practical implementation of developed products.

Investments toward research and tests showcase a more generalized form of competitiveness, supporting long-term domestic development instead of directly opposing a foreign rival. Research projects push the frontiers of knowledge, allowing unprecedented scientific or applied capabilities. A program in this vein provides the advantage of a comparative lead in useful advanced knowledge, allowing for progress which prospective rivals may take years to become aware of and decades to replicate for themselves. Mission demonstrations form the other type of experimental investment, testing previously posited new fields or types of missions. These serve to prepare experimental competitive assets, often the products developed through frontier research, for the active deployment. Fulfilling this role also denotes that a program has survived funding pressures and remained a sufficient spending priority until field-testing of a prototype or operational end product is possible.

5.1.3 Qualitative Dependent Variable Categorization: Cooperative Value

Cooperative measures are organized to reflect the clearest indicators of a willingness to incur risks and costs that can undermine the relative lead of the United States. Both types of cooperation involve the distribution of benefits, but vary significantly in scale. The first form, multinational projects, involves direct cooperation with foreign partners, including any combination of coordination, research-design, joint application, and support of ongoing foreign missions (either towards an international partner or else directed inward towards assisting an American project). This is the single greatest indicator of a tendency toward cooperation, as partners can access experimental designs and may share the joint benefits of the end products. NASA historically limited foreign cooperation to states with a technological and expertise base capable of contributions on-par with NASA's own. This same capability for support enables partners to learn from their interaction with NASA and replicate products or achieve a degree of utility closer to what the United States attains. Foreign participants can also potentially disseminate key components of advances to which they are exposed to third-parties with whom the United States may be in closer competition. Allowing foreign participation therefore shows either a significant degree of trust between partners and a willingness to incur the risk of shrinking the comparative lead over allies and hostile rivals alike.

A smaller-scale alternative to working directly with partners involves making the products of a specific investment available for public utilization. Making the results of a project open source and publicized provides informational or other supportive benefits to any interested parties. Released products may augment or inform foreign space programs, industries, or

prospective competitive parties, requiring enough of a comparative lead to justify. An example of this format includes NASA's Supporting University program, where sponsorship of advances in public education forums demonstrate the valuation of technological advances over the cost of allowing these same advances to be publicized through the work of nongovernmental officials.

Each of these seven measures is coded as a dummy variable, all used cumulatively to characterize the project as a whole in a new variable. Programs fulfilling no functions within a single spending category are coded as zeros for that type of spending. Those meeting less than half of their category's conditions, either two of five competitive conditions or only one of the two cooperative variables, are assigned a "low" value (1) and those fulfilling more than half are assigned a "high" value (2). In addition, the presence of either of two specific conditions (Strategic/Military for competitive and Multinational Inclusivity for cooperative) will automatically assign a "high" (2) value to their respective program. Strategic/Military programs are the only options capable of imposing direct costs on competitors, and therefore signal an especially significant degree of competitive focus. Multinationally Inclusive programs provide the greatest degree of access for external actors to American investments, and therefore signal the greatest degree of cooperative interest. Next, high/low/none values are categorized into a ratio of the competitive-cooperative ratio, which is then applied to internally divide each program's yearly spending as a multiplicative weight. For example, a program with a "High" competitive rating (2) and low cooperative rating (1) would receive a 66% competitive and 33% cooperative spending weight to the division of its yearly funding.[1] This allows a trace of the

[1] For a complete annual example of the qualitative assessment and spending-division processes see Appendix Section 1.

overall shifts in competitiveness and cooperation within the space program itself and then application of independent variables to determine the validity and scale of their connection.

Once these variables are operationalized, they are organized into several dependent variables for quantitative measurement. First, a measure of the total of each type of spending each year serves as the basic measurement of funding trends. Then, in a related measure, competitive and cooperative programs are summed and then organized into a variable showing the annual ratio of competitive to cooperative spending. This measure will depict the proportional changes to programs as they respond to external stimuli. These variables are run in time-series regressions to account for the interdependence of observations. Third, a pair of dummy variables will be coded noting each year where competitive and cooperative spending rose above the average for their decade, respectively. This measure assists the later qualitative case studies, helping identify both periods of notable trends and anomalous instances that require further exploration.

5.1.4 Independent Variables: Military Tensions

For the independent variables within the relationship, the two subcategories of military and economic competition are examined. Military competition is measured firstly through the Militarized Interstate Dispute-Correlates of War dataset (MIDS-COW v.4.3), which "provides information about conflicts in which one or more states threaten, display, or use force against one or more other states between 1816 and 2010" (Maoz et al. 2019, Palmer et al. 2019). Within this dataset, the current thesis collects yearly instances of all recorded conflicts involving the United States as a participant. Fluctuations in this scale should indicate the number of perceived

threats the United States faces which might inform a decision to pursue militarized space capabilities or complementary technologies. A subset of this data is also collected as a new variable indicating the yearly number of high-intensity conflicts, drawn from all instances where the MIDS-COW variable for hostility level was 3 or higher, indicating the actual deployment of force and extending to actual wars (Kenwick et al. 2013). A greater number of wars is expected to correlate to a higher degree of competitive spending and a lower number of wars should be conducive to higher cooperative spending.

A variable for American defense expenditures as a percentage of GDP is collected to represent the actual degree of investment into military-oriented competitive investment as part of the broader response to a perceived threat. This variable correlated significantly and negatively to NASA's total budget in past research, suggesting that wars draw funds away from discretionary spending (Smiley 2013). In the current study the variable may support two different possibilities. A positive relationship to competitive spending or the ratio of spending may indicate that wars support the relative share of competitive spending after a threat and a negative relationship may support past total-spending findings of reducing overall funds. Likewise, reduced defense expenditures should correlate to increased cooperative spending by indicating the lack of a threat and drawing away less discretionary funds, although there is a possibility that lowered defense spending may signal a reduction in the availability of funds in general and see less opportunity for cooperative spending.

The period of the Cold War (1958-1991) is used as a dummy variable to account for the period of heightened competition with the Soviet Union as the primary rival. Despite waxing and

waning tensions, the USSR was consistently viewed as a dangerous competitor throughout this period to be countered as a policy standard. As such, competitive spending is expected to be higher throughout this period than during the 1990s, when the United States achieved relative geopolitical unipolarity. An interaction variable is also coded, combining defense expenditures and the Cold War to account for their joint effects and to confirm a tangible and consistent influence. This variable allows a clearer division of NASA's budgetary relationship to defense spending between eras of relatively higher and lower tension, respectively.

5.1.5 Independent Variables: Economic Health and Trade

The parallel category of economic competition is measured by several indicators of American international trade strength. First, Current Account Balance is measured as a percentage of GDP from 1958-present, indicating balance of payments (net exports) of the United States[2]. A reduction in exports may signal a weakening of American trade dominance, or at least a threat to export-dependent domestic industries, and should indicate a need for improved goods/services to restore competitiveness. Second, the other major measure of national foreign trade, the Net Capital Inflow (U.S. Bureau of Economic Analysis), is measured in billion $USD from 1960-present, as measurements allow and significant fluctuations begin to appear. This measure, consisting of the amount of capital invested by the United States into foreign recipients relative to the sum invested by the rest of the world into it, should indicate whether the United States feels that the domestic market is powerful enough to draw investment or must be catalyzed to restore foreign confidence. Third, a measure of U.S. exports as a percentage of the fiscal year's gross domestic product (GDP) will indicate the overall strength of American trade,

[2] Data is drawn from the OECD's "Main Economic Indicators: Balance of payments BPM6 dataset".

as well as the level of dependence on, and therefore the importance of, trade to the national economy at a given time[3].

5.1.6 Control Variables

Testing of the theorized relationships includes control variables to manage the data used and account for background economic factors. Data is collected in nominal-year dollars from the period in which appropriation occured, so the inflation rate up to 2018 $USD (used in the most recently reviewed Presidential Aeronautics and Space Report) is applied to account for this difference. Then, as NASA's total budget has grown over time, and therefore likely made room for a greater number of projects, the calendar year is used to control for progressive growth independent from policy-driven changes. Lastly, to account for the effect of alternative priorities for discretionary spending seen in past research (Smiley 2013), the unemployment rate is used to control for redirection of funds during periods of economic hardship.

5.2 Qualitative Case Studies

Post-measurement qualitative case studies analyze notable and/or sudden shifts to study the specific contemporary events which might explain the trend or timely international factors that could have influenced budgetary considerations. Supportive factors are drawn from the annual Aeronautics and Space Reports of the President from 1958-2018. These reports will serve to both characterize individual programs within assessment of the previous NASA-specific dependent variables, as well as provide broader data on the space program as a whole. Several

[3] Data is drawn from the World Bank's "World Bank national accounts data, and OECD National Accounts data files" dataset.

periodic case studies have been preselected for analysis due to the expectation that notable foreign concurrences should have played a significant role in shaping subsequent budgetary distribution. All such cases are independent of the space program. For instance, it is unlikely that changes within the space program are singularly responsible for the end of the Cold War, it instead being far more likely that the cessation of strong competition should have noticeable effect on the subsequent budgetary distribution.

5.2.1 Detente

The first area of focus involves the period of Detente, ranging approximately from 1970, with early elements beginning in 1968, until the early 1980s with the election of president Ronald Reagan (Westad 1997). This period emerged from the pursuit of a new international regime characterized by stability and utilizing common values and interests as the basis for a sustainable relationship between the superpowers (Litwak 1986). Even before analysis, this period contains some of the most notable instances of American-Foreign cooperation, both with close allies to conduct groundbreaking new research and even rarer demonstrations of cooperative resurgence: the U.S.-Soviet Apollo-Soyuz Test project with the first American-Soviet joint space flight and 1977 bilateral agreement (Ezell and Ezell 1978, Bencke 1997). As such, this period is expected to have motivated an observable and sustained increase in cooperative spending and possibly a simultaneous overall reduction or stagnation in the rate of competitive project funding.

5.2.2 Reagan Administration and the "Second Cold War"

The second period of focus is the advent of the so-called "Second Cold War" of 1979-1985, in which the resurgent tensions between the superpowers reinstigated the arms race and reintroduced the risk of war during multiple flashpoints of conflict (Subrahmanyam 1983). This era is analyzed whether the observed increase in tension resulted in a clear rise in competitive spending as well. Competitive projects, particularly those with strategic-military dual-use applications, could easily fit into the return to the arms race dynamic as the United States sought technologies that would either deter the encroaching Soviet challenge or offer an advantage in the event of direct conflict. Assessment of this era may struggle with the partially-absent appropriations data from 1979-1980, but may be experimentally approximated by the programs funded within this period, as it is unlikely that NASA would intentionally deviate from primary national interests or that governing authorities would allow such a divergence to proceed uncorrected.

5.2.3 Post-Cold War

Thirdly explored is the state of space funding in the period surrounding the end of the Cold War, approximately around the 1991 dissolution of the Soviet Union. This period saw the collapse of the Soviet challenge to American dominance and a reorientation from international bipolarity to a unipolar hegemonic power structure (Gaddis 1994, Lemke 1997). As such, an increase in cooperative spending is expected within this period as the United States reasserted its leading position and could, with confidence, conduct joint projects with reduced concern of proliferation of useful technologies. In parallel, as initially evidenced by the entrance of the

Russian Federation in the International Space Station program, the United States was even comfortable with the inclusion of recent rivals in emerging space applications. This suggests a reduced need for competitive investment as inclusion of rivals superseded deterrence as the policy focus during this period.

5.3 Qualitative Interview:

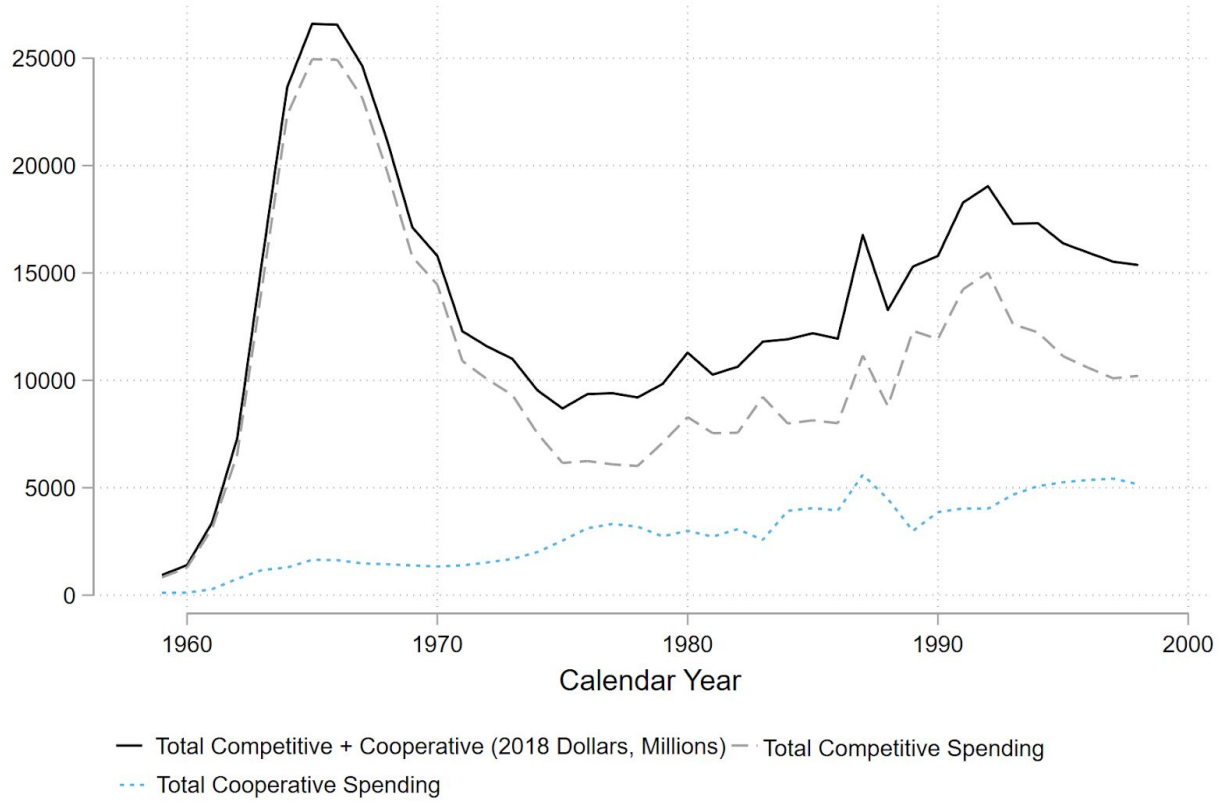
This thesis includes a series of qualitative interviews conducted with a space policy expert to explore and confirm underlying assumptions of the presented theory. Kris Breaux is a topical authority on military experience in space operations, asset acquisition, and management, and has served in government as an aide to the United States Congressional House Intelligence Committee specializing in space investment policy. Interviews sought to explore this primary source's insight into the process of space policy formation and budgetary considerations. Interview products have been incorporated into the theory and analysis to contextualize the proposed policymaking dynamic. Discussed topics include the structure of spacy policy-setting and budget formation, as well as the factors which influence these processes. This consultation highlighted the top-down structure of space policymaking, wherein a strategy is determined and a space program selected to support that policy. Such a dynamic supports the Rational Decision model considered in this thesis, with a problem identified and solution selected for its preferential cost-benefit output, as opposed to the alternative of an Incremental Bargaining model (Logsdon 1984). Likewise, space policy was noted as important for strategic and technological interests, tying into foreign policy as the United States considers the objectives of other states. Especially important, Mr. Breaux observed that space is viewed differently in

modern conditions, where the increasing space launch and technological capabilities of ever more states has driven cooperation where previously America faced fewer challenges or opportunities for collaboration (Breaux 2020). This observation supports the observations of Duncan Snidal (1991), with a greater number of players supporting absolute gains-seeking instead of the relative gains which might limit cooperation.

6.0 Results and Analysis

6.1 Spending

Figure 3: Historical Competitive, Cooperative, and Total Spending



Weighted budgetary categorization produced the above graph, demonstrating that competitive spending dominated NASA spending for the first three decades of the organization's

operation, with the gap only narrowing in the 1990s and beginning to widen again preceding the turn of the century. This trend portrays NASA as firstly a competitive organization, and by a vast margin. Competitive spending's trend most closely matches that of overall spending, which shows that competitive programs account for the broader trends while cooperative spending operates separately with slow and more consistent growth. As cooperative programs were rarely the focus for NASA in early years, competitive spending only deviates from overall spending once cooperative programs emerge as a priority. While cooperation was initially depressed by restrictive policy, its spending was likely artificially insulated from budgetary trends, with total funding instead demonstrating the government's prioritization of different large-scale competitive programs. Once more opportunities for cooperation arose, however, by availability and/or policy, its spending category also became large enough where cooperative programs displayed a tangible relationship to the total funding allocated, appearing to occur in the 1970s.

6.2 Regression Models

6.2.1 Regression Model: Competitive Spending

VARIABLES	(1) Model 1	(2) Model 1	(3) Model 1	(4) Model 2	(5) Model 2	(6) Model 2	(7) Model 3
Lag Competitive Spending				0.266	0.311	0.280	0.259
				(0.191)	(0.195)	(0.187)	(0.197)
Current Account Balance	-1,110***			306.3			12.14
	(279.4)			(211.8)			(367.4)
US Militarized Interstate Disputes	-39.75	-2.966	183.7	114.7*	129.1*	153.1**	148.0*
	(150.7)	(129.9)	(137.9)	(67.30)	(68.66)	(66.54)	(77.62)
Defense / Int'l Expenditures, % GDP				2,568***	2,364**	2,964***	2,778***
				(780.1)	(866.0)	(815.9)	(912.3)
Cold War Years				12,102***	12,097**	14,612***	13,338**
				(3,923)	(4,509)	(3,931)	(4,829)
US Defense Expenditures - Cold War Interaction Variable				-2,417***	-2,398**	-2,879***	-2,638**
				(834.1)	(941.3)	(835.8)	(989.2)
Inflation Rate 2018 Constant				2,683**	3,158***	3,378***	3,331**
				(980.9)	(948.8)	(915.8)	(1,202)
Calendar Year				661.0***	685.4***	698.1***	711.5***
				(178.5)	(185.4)	(176.8)	(188.9)
Unemployment Rate				15.64	126.2	78.98	58.90
				(141.6)	(119.9)	(117.6)	(152.6)
Net Capital Inflow		40.79***			-3.983		-5.081
		(6.991)			(8.616)		(9.051)
Exports, % GDP			856.3***			311.9	313.0
			(151.2)			(186.0)	(324.2)
Constant	3,678***	2,834***	-3,352**	-1.327e+06***	-1.377e+06***	-1.408e+06***	-1.433e+06***
	(910.5)	(813.0)	(1,577)	(359,314)	(372,703)	(355,987)	(381,114)
Observations	39	39	39	39	39	39	39
R-squared	0.307	0.487	0.472	0.948	0.945	0.950	0.950

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Time series regressions of competitive spending (in nominal-year dollars) against a selection of the independent variables was theorized to relevantly impact the budgetary decision-making process. In this model these consist of the current account balance, net capital income, and exports as a percentage of GDP as measures of the health of American foreign trade, and previous-year conflicts involving the United States and defense expenditures as a percentage of GDP. Due to high collinearity, the economic variables were regressed separately in models 1 and 2, before combination in model 3 as the common regression.

All three economic variables are only significant for the first model and see much-reduced coefficients in model 3, though collinearity with simultaneous economic variables very likely depressed these relationships. Starting with the current account balance, this may

initially signal that spending is reactive to trends in foreign trade. However, the coefficient is very negative, with spending reduced by over a billion dollars as the current account balance increases. In opposition, later models depict a variable increase for every GDP-percentage of growth.[4] Model 1's fall in competitive spending as the current account improves is compatible with the proposed theory, as there would mainly be a need for competitive investments during trade deficits, but the rise in later models suggests a possible alternative reason for growth. Current account balance may simply affect the overall funding available towards discretionary spending, with an increase in funds from foreign trade allowing for more simultaneous competitive programs.

Net Capital Inflow saw a similar coefficient sign flip between models 1 and 2 and relative stability between models 2 and 3. The negative relationship seen in the latter two models suggests that as foreign investment increased, competitive spending was reduced at a rate of around $5 million for every billion dollars invested into the U.S. This aligns with the theorized relationship, as increased inward investment from foreign sources should testify to a strong economy and relative lead. However, much as with Current Account, foreign investment could also simply help provide additional discretionary funds for competitive programs.

Exports as a share of the national GDP corresponded to a significant rise in competitive spending, potentially denoting the importance of products from competitive space investments to emerging or expanding international markets. Applying controls to the model demonstrated a reduced role for exports in latter models, but also a similar coefficient. Cumulatively, these economic variables show inconsistent significance and/or coefficients across models due to the

[4] In an alternate model leaving out the Cold War, interaction term, and unemployment rate there was actually a stable coefficient of a third of a billion dollars for the current account across model 3. Future work will explore whether this relationship is more accurate.

limited number of observations. Additional decades could improve coefficient stability and further research may help distinguish between the role of economic variables as indicators of a need for investment or practical determinants of the actual resources available for spending.

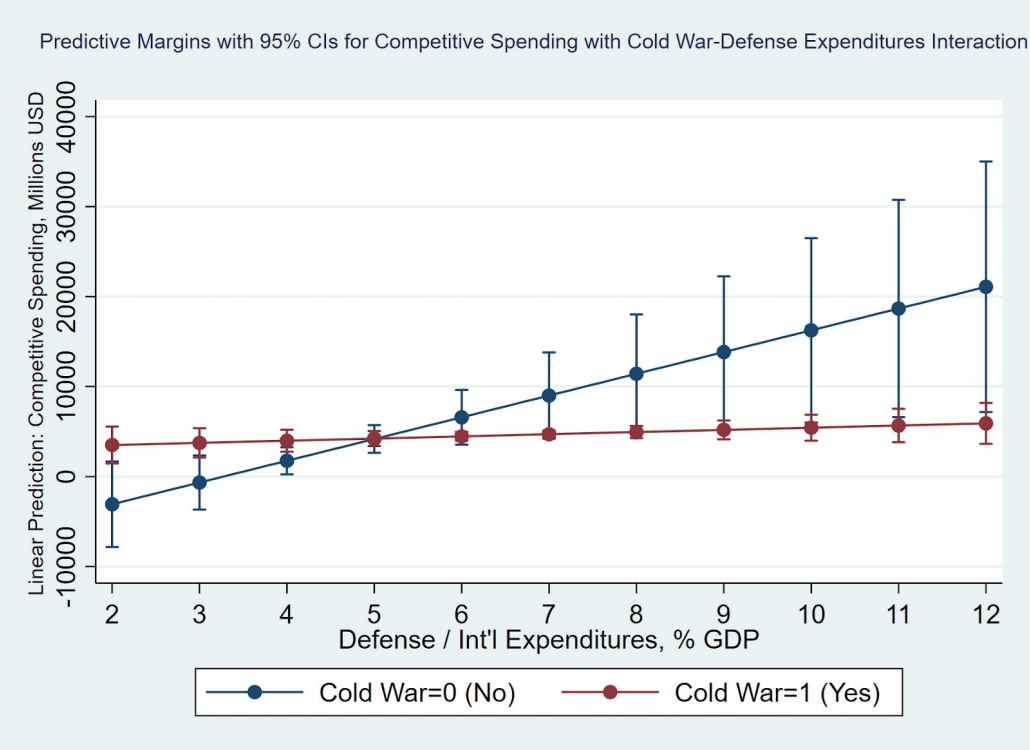
The role of same-year conflicts is significant in later models and, with a rise of over a hundred million dollars per conflict, showcase a relevant coefficient. A prioritization of competitive investment during and around wartime aligns with the theorized relationship, signalling a threat to the power distribution and the need to pursue new advantages. However, this result also reflects a need in future work for a specialized variable to reflect the role of wars as indicators. Even with the use of a high-intensity conflicts subset, not all wars are equal in scale and/or salience for American policymakers. As such, predicating regressions on the sheer number of conflicts in general may be more effective in capturing this relationship if accounting for the relevance of concurrent conflicts to budgetary policy-making. This possibility is explored qualitatively in the case study series, but should be incorporated into improved regressions in the future.

Defense expenditures provided an alternative variable to depict the role of conflicts on competitive expenditures, with low collinearity with MIDS conflicts to prevent overlap. More consistently, the coefficients signalled a rise in billions of dollars of competitive spending as defense expenditures increased as a percentage of GDP. This aligns with the simultaneous period of massive investment in both defense expenditures and NASA projects during the space race; when defense expenditures constituted their largest historical share of GDP. Likewise, competitive spending traces the chronological trends of defense expenditures fairly closely as well. This appears plausible, as defense expenditures took the largest share in the 1960s,

concurrent to the Space Race, and the 1980s, concurrent to the Reagan administration and Second Cold War period. If accurate, this may signal that rising defense expenditures reflect the simultaneous prioritization of NASA's competitive space investments. It is important to consider here the past-proposed reallocation of discretionary spending and the avoidance of funding NASA programs similar to defense research during wartime (Smiley 2013). With competitive investments tracking defense expenditures, the funding category is either sensitive to the impacts on discretionary spending observed in past studies or else reflects the prioritization of competitive spending even if total available funds decrease during conflicts. Future work should seek to disaggregate forms of competitive spending to observe whether specific subtypes benefit or suffer during wartime.

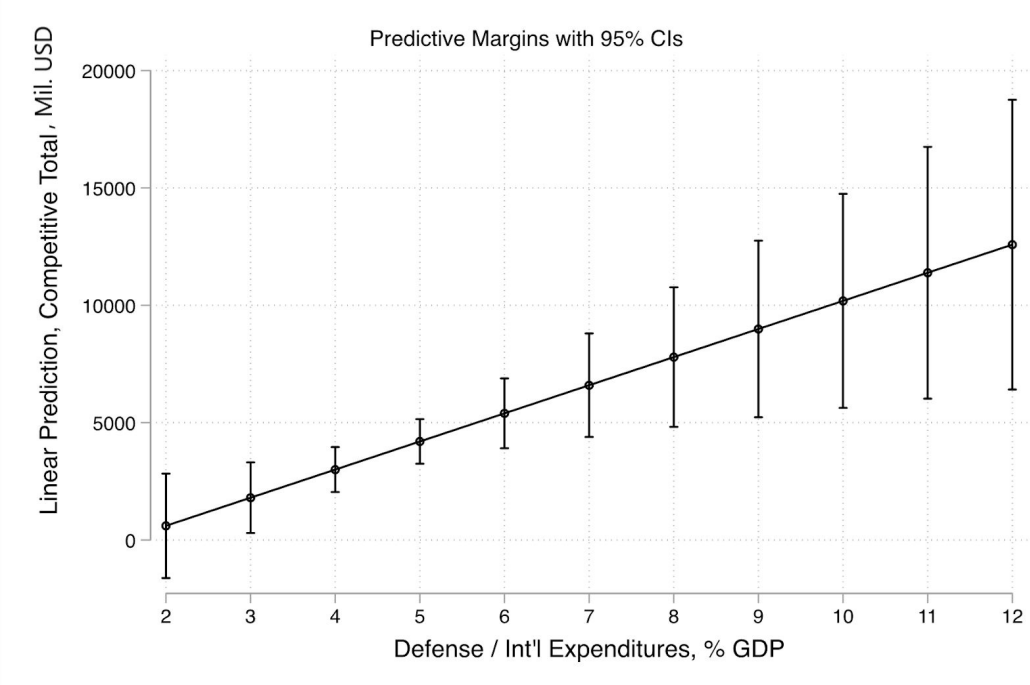
The cold war dummy variable signalled a dramatic difference in competitive spending of $12-14 billion. While showcasing the 1990s as the first major fall in competitive spending since the post-Apollo drop of the 1970s, this effect seems overemphasized as the actual size of the fall from 1992-1998 was only around $5 billion. In the future an improved model, and especially additional observations, should help manage this disparity and provide clearer estimates of the Cold War's effect versus the long-term behavior afterward as major tensions and defense expenditures return in the early 2000s.

Figure 4. Predictive Margins for Competitive Spending and Interaction Variable



The interaction variable, utilizing the Cold War and defense expenditure variables displayed significance. Plotting actually displayed a more positive projected growth rate for competitive spending as defense expenditures increased after the Cold War than during the era. Although, since post-1991 Defense expenditures only fell from a relative height of 5% this may still suggest lower post-Cold War competitive reactivity to defense expenditures. However, the large confidence intervals found in non-cold war spending show a need for more post-1999 data to further test this relationship.

Figure 5. Predictive Margins for Competitive Spending by Defense Expenditures at Mean Cold War Value



A plot of predictive margins for competitive spending by defense expenditure at the mean value of the Cold War variable still shows a strong positive relationship, supporting the proposed theory and suggesting the Cold War played an important role in moderating the salience of defense expenditures as a measure of a competitive environment.

Both the inflation rate and calendar year displayed significance, likely accounting for the overall increase of competitive spending across the timeframe, but may be exaggerated due to the initial jump during the space race. Inflation rate is not considered an economic factor that should affect considerations surrounding competitive spending appropriations, but like the calendar year has been progressing steadily in the same direction. The significance seen here

suggests that these controls should at least see continued use in future models to account for the over-time trends associated with competitive spending.

6.2.2 Regression Model: Cooperative Spending

VARIABLES	(1) Model 1	(2) Model 1	(3) Model 1	(4) Model 2	(5) Model 2	(6) Model 2	(7) Model 3
Lag Cooperative Spending				0.457***	0.362*	0.593***	0.258
				(0.152)	(0.184)	(0.160)	(0.185)
Current Account Balance	-770.8***			-179.6**			-268.0**
	(105.0)			(74.51)			(122.6)
US Militarized Interstate Disputes	-53.94	-30.94	81.88	9.448	-1.507	0.733	15.43
	(56.61)	(37.91)	(49.48)	(20.72)	(21.08)	(22.28)	(21.76)
Defense / Int'l Expenditures, % GDP				-40.86	65.13	17.61	18.92
				(61.91)	(54.16)	(75.16)	(68.62)
Inflation Rate 2018 Constant				507.6***	138.4	244.5	561.2**
				(180.0)	(150.4)	(153.1)	(236.3)
Calendar Year				112.8***	79.57**	89.03**	113.8***
				(33.19)	(32.43)	(34.42)	(34.30)
Unemployment Rate				96.14**	32.57	46.69	87.02*
				(46.63)	(40.80)	(47.44)	(46.95)
Net Capital Inflow		26.24***			5.593*		2.009
		(2.041)			(2.844)		(3.195)
Exports, % GDP			524.6***			-37.97	143.2
			(54.24)			(77.95)	(111.9)
Constant	1,223***	717.8***	-3,024***	-224,575***	-157,805**	-176,534**	-228,219***
	(342.0)	(237.3)	(565.7)	(66,210)	(64,636)	(68,500)	(68,795)
Observations	39	39	39	39	39	39	39
R-squared	0.605	0.824	0.726	0.967	0.965	0.961	0.970

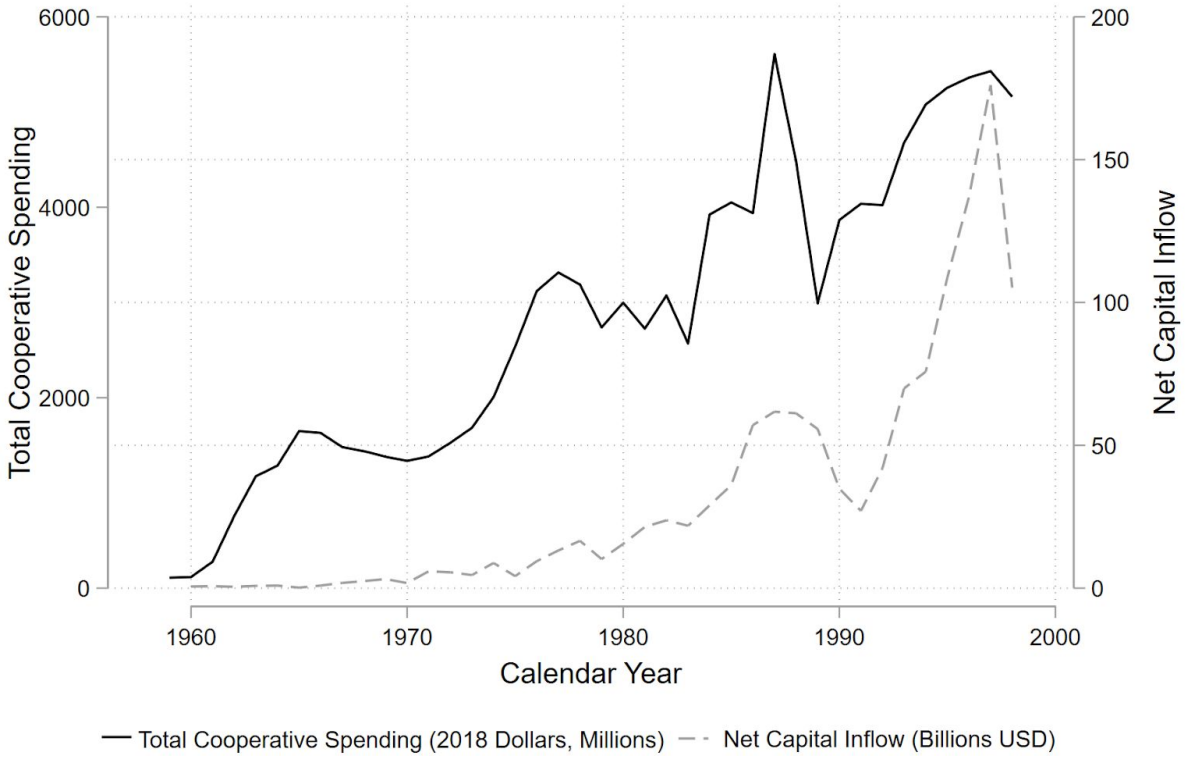
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results across nominal-year cooperative spending were also somewhat unstable, similarly to regressions of competitive spending. The current account correlates significantly and negatively to cooperative spending, which falls as the current account rises. However, the historical overall decreasing trend in current account from 1960 onwards, and especially its near-uninterrupted fall since 1989, may instead simply indicate that cooperative spending has in fact risen while current account has fallen[5]. Most large and costly cooperative efforts occurred during the two periods of greatest current account deficit, the 1980s and 1990s. If accurately depicting this relationship as a contradiction of the proposed theory, a current account surplus

[5] See Appendix

may not necessarily indicate a freedom to fund more cooperative programs. Here, an alternative explanation offers another option. With NASA's policy of limiting cooperation to partners capable of contributions on par with the U.S., as well as the operation of cooperative efforts when favorable bilateral politics allows (i.e. the Apollo-Soyuz mission of 1975), the health of the economy may fall behind other considerations during cooperative appropriation. This aligns with observation of policy-driven funding of programs (Breaux 2020), which may extend to the selection of a program befitting a timely diplomatic interest rather than the constant generalized conditions.

Figure 6. Cooperative Spending-Net Capital Inflow Comparison



Net Capital Inflow lost significance after early models but the coefficient stayed positive overall. This aligns with the upward trend of cooperative spending over time and matches the proposed theory that indications of a strong economy would signal a comparative lead and free

American policymakers to allow joint projects despite the spread of results. Rising investment into the U.S. may itself indicate not only a healthy economy, but also cooperative economic attitudes conducive to attracting foreign partners. Alternatively, as considered with competitive spending, foreign investment into a healthy economy may be an indicator of increased available funding, rather than a causal factor for greater investment.

Exports displayed a coefficient of an increase of hundreds of millions for cooperative spending, though this relationship lost significance and turned negative in the intermediate model 2. In terms of the common historical trends with cooperative spending, similarly to Net Capital Income, while exports have inclined upward, overall exports rapidly fell as a percentage during two periods where cooperative spending saw major increases: the early 1970s and 1980s[6]. Depending on whichever regression model more accurately captures the relationship, the rise of exports may signal that there exist sufficient markets for American goods, precluding fears of falling behind economically.

Among defense-related variables, the lack of significant or consistent correlation to American conflicts or defense may call into question wars themselves as the generalizable indicators of military prioritization over cooperative endeavors, although some models do suggest some cuts following militarized disputes or defense funding expansions. Because neither relationship is uniformly positive, varying in the ordinational direction and scale attributed by the regression, it is difficult to determine the effect of a military threat on cooperative spending. Together, these suggest that cooperative spending may only change conditionally. Decreases may still emerge when security needs take precedence in national policy, but cooperative

[6] See Appendix

programs may also benefit simultaneously with security investments when discretionary funding is available. As with competitive spending, analysis of these variables should improve as more annual budgetary data becomes available to improve the stability of the model.

Among the more timing-related variables, the Cold War variable did not achieve significance and experienced a major coefficient sign change, but appears best represented in model 3, as funding did increase during the cold war. However, much as with wars and defense spending, it is difficult to determine a precise and constant influence. The significance of calendar years is tied to cooperative spending's relatively consistent rise over time, lacking the more drastic funding cycles of competitive spending. As such, it is difficult to tie individual factors to cooperative spending, especially due to the low level of spending in early years which may hide what reactivity there is. With cooperative spending increasing post-cold war, the addition of observations from 1999 can vitally help test the variables used here during periods of reduced cooperative spending to account for over-time growth.

6.2.3 Regression Model: Ratio

VARIABLES	(1) Model 1	(2) Model 1	(3) Model 1	(4) Model 2	(5) Model 2	(6) Model 2	(7) Model 3
Lag Ratio, Competitive:Cooperative				0.373**	0.405**	0.408***	0.404**
				(0.146)	(0.151)	(0.143)	(0.156)
Current Account Balance	2.471***			0.561			0.0915
	(0.483)			(0.469)			(0.850)
US Militarized Interstate Disputes	0.745***	0.700**	0.259	0.273*	0.314**	0.334**	0.326*
	(0.260)	(0.288)	(0.220)	(0.148)	(0.149)	(0.144)	(0.169)
Defense / Int'l Expenditures, % GDP				1.870	2.118	2.563**	2.531
				(1.161)	(1.447)	(1.200)	(1.577)
Cold War Years				7.544	10.97	11.83*	11.53
				(6.835)	(8.322)	(6.405)	(9.331)
US Defense Expenditures - Cold War Interaction Variable				-1.326	-1.999	-2.125	-2.072
				(1.364)	(1.654)	(1.276)	(1.829)
Inflation Rate 2018 Constant				3.366	4.474**	4.474**	4.302*
				(1.992)	(1.816)	(1.752)	(2.443)
Calendar Year				0.509*	0.590**	0.562**	0.550*
				(0.274)	(0.273)	(0.263)	(0.294)
Unemployment Rate				-0.175	0.0650	-0.0554	-0.0763
				(0.321)	(0.270)	(0.265)	(0.355)
Net Capital Inflow		-0.0601***			0.00200		0.00126
		(0.0155)			(0.0193)		(0.0204)
Exports, % GDP			-1.865***			0.592	0.525
			(0.242)			(0.413)	(0.749)
Constant	3.195**	3.881**	18.47***	-1,026*	-1,193**	-1,145**	-1,120*
	(1.573)	(1.803)	(2.519)	(554.1)	(550.5)	(531.1)	(595.2)
Observations	39	39	39	39	39	39	39
R-squared	0.493	0.382	0.670	0.937	0.934	0.938	0.938

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

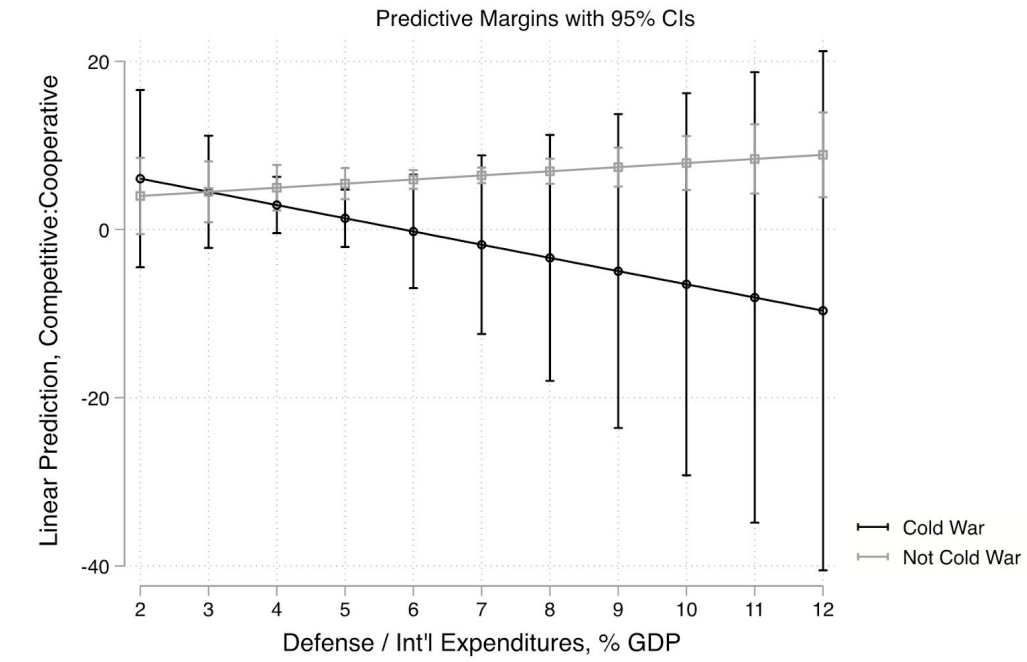
No economic independent variables maintained significance through the third model for the ratio between competitive and cooperative spending, though collinearity could play a role. However, the model presents all three with positive relationships to the ratio, seeing the disparity between spending types increase. This could be due to a simultaneous increase and decrease by either combination of the spending types. As such, variables with opposing effects for different spending types, such as the current account, may play a role here.

American conflicts correlated significantly to a widening gap in favor of competitive spending, as predicted. A greater number of costly conflicts demonstrates a heightened need for advantageous investments, leading to the relative height of the competitive-cooperative gap in the 1960s.[7] Defense expenditures only achieved significance in model 2 but consistently correlated to an overall increase of the ratio, with graphical representation showing the patterns

[7] See Appendix

tracking[8] and a similar model 3 coefficient as well. A comparable case can be found in the cold war dummy variable, losing significance after model 2 but keeping a close coefficient. These may depict elements of a composite relationship between the ratio and periods of heightened tension, growing during the wartime expansion of mostly competitive spending.

Figure 7. Predictive Margins for Spending Ratio and Interaction Variable



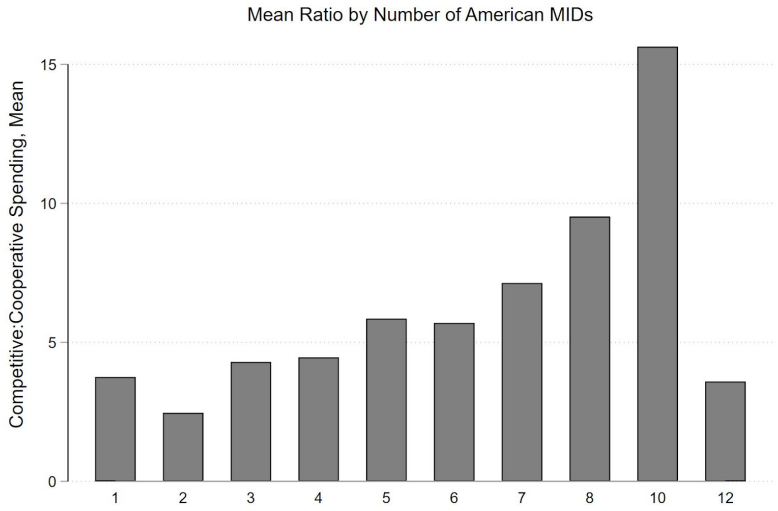
The interaction term did not achieve significance, but a plotted projection of the ratio during and outside the Cold War depicts a falling raio as defense expenditures rise during the during the period and a relatively constant ratio outside the era. This suggests a greater reactivity to defense expenditures during the Cold War, although the confidence intervals are very broad in higher percentages, as seen in the interaction variable plot for competitive spending. More

[8] See Appendix

post-Cold War data may help test the stability of this model and improve the accuracy of the confidence intervals.

6.3 Ratio Analysis

Figure 8. Average Spending Ratio at U.S. Conflicts per Year



A representation of the average ratio of competitive to cooperative spending demonstrates a distinct upward trend, allowing for the possibility that proportional spending is reactive even where budget totals or regression coefficients on their own may not be. This reflects the hypothesis that conflict demonstrates a need for greater investment into competitive-oriented research that can preserve American advantages despite strain. The drop-off at twelve simultaneous conflicts may be explained by a threshold to the ability to invest, where the costs of commitment significantly reduces discretionary spending available for NASA, in line with past research (Smiley 2013).

Figure 9. Average Spending Ratio at Soviet Union/Russian Conflicts per Year

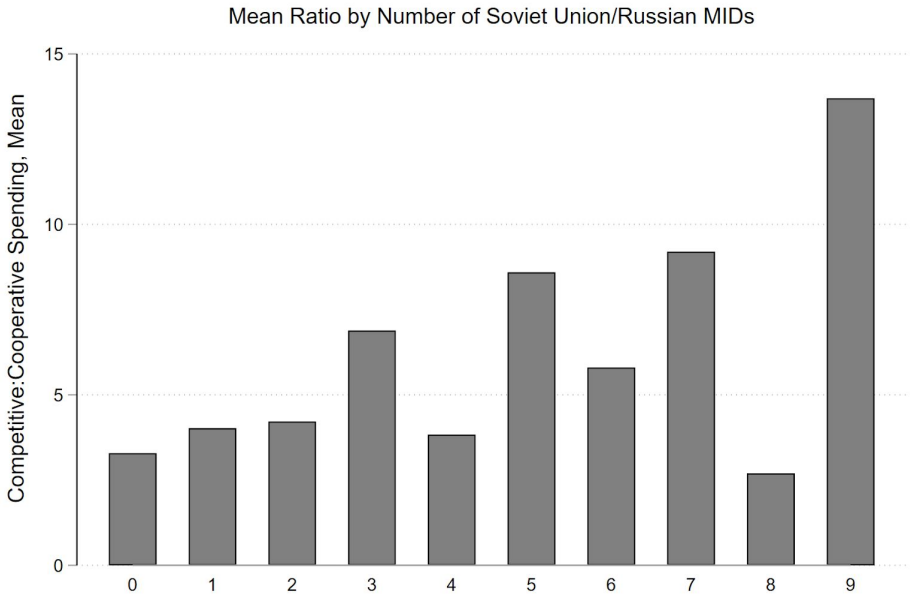
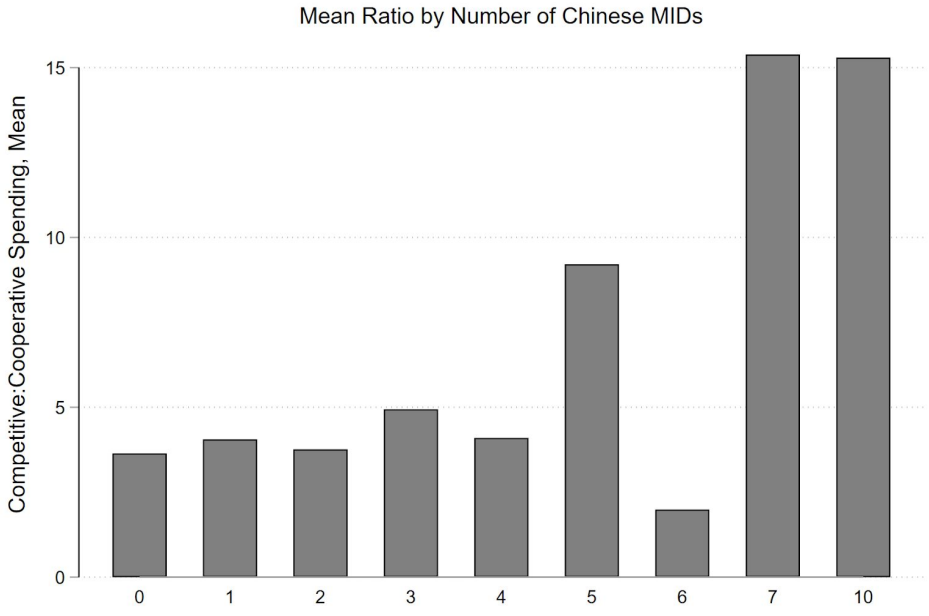
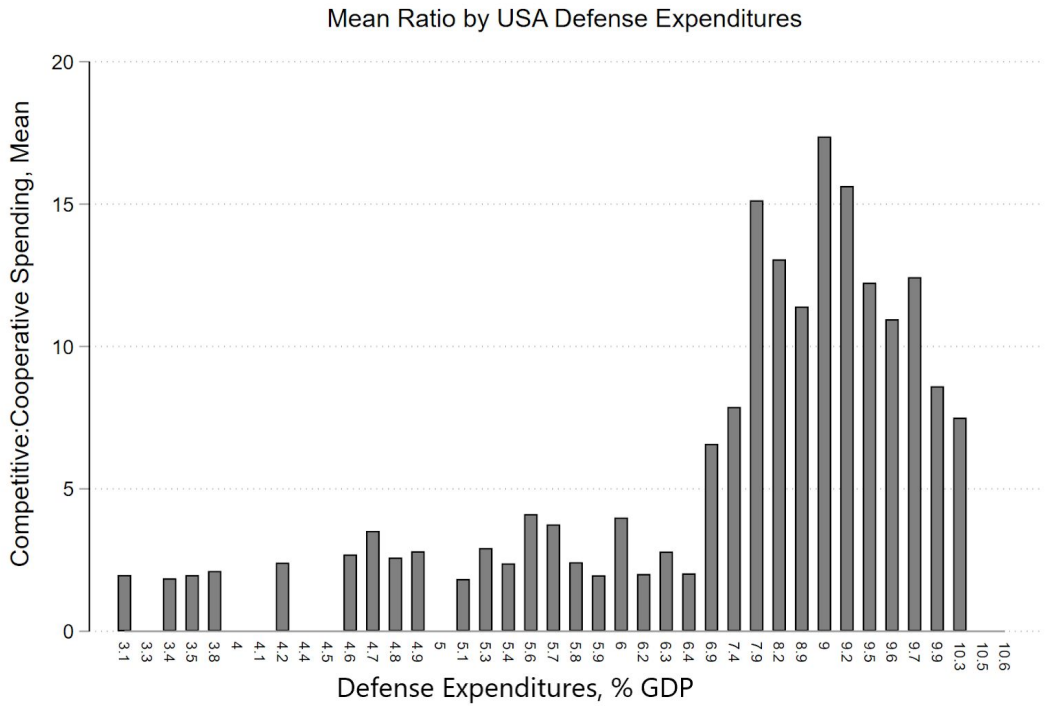


Figure 10. Average Spending Ratio at Chinese Conflicts per Year



Applying the same modeling to foreign conflicts likewise demonstrates an overall upward trend, though less distinct than American-specific wars. This may reflect an increased sensitivity to direct threats to American dominance, whereas foreign conflicts may demonstrate a willingness to engage aggressively, but not necessarily with the United States specifically. Of the two measures, reactivity appears greater with Soviet conflicts, corresponding to the USSR's role as the perceived primary threat for the majority of the explored period. Perceptions of China as a major rival to the United States may be frontloaded due to direct engagement during the Korean War. Generalized reactivity to Chinese capabilities may fall outside the timeframe, with the Chinese National Space Administration only created in 1993 and reformed for revised management in 1998.

Figure 11. Average Spending Ratio at Defense Expenditures per Year

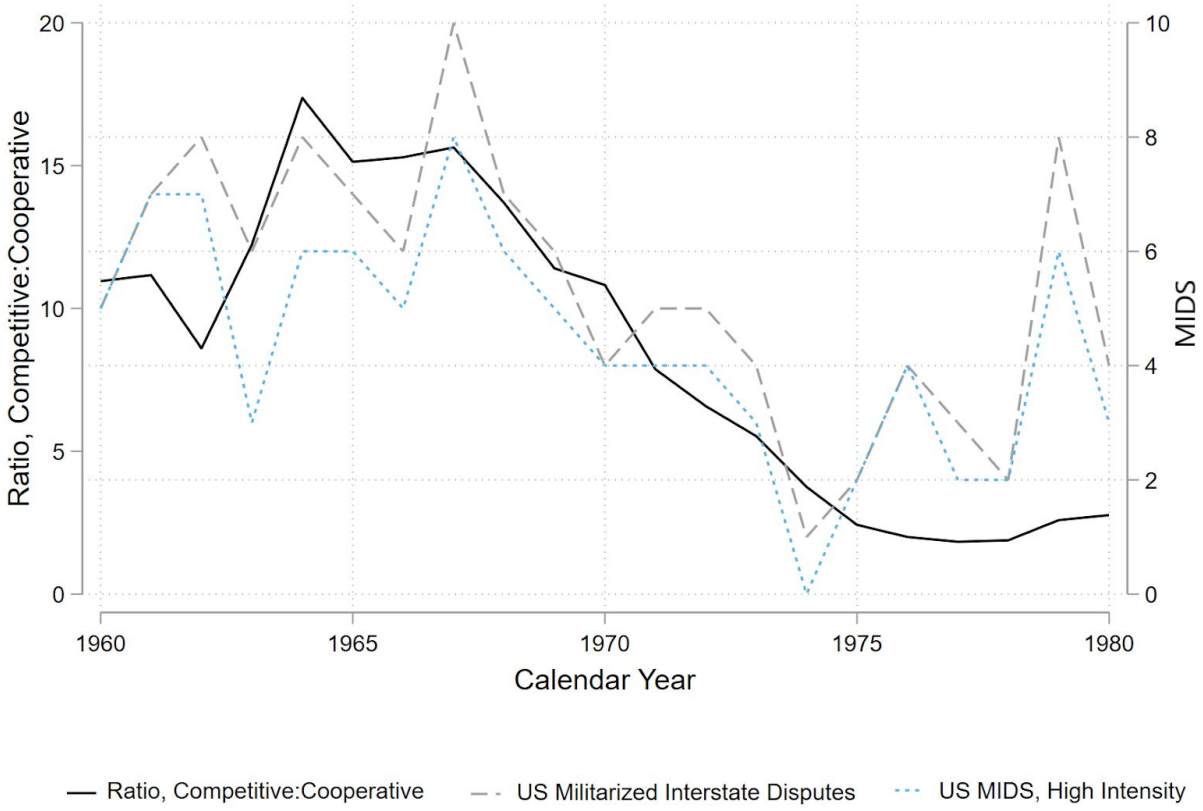


The average competitive-cooperative spending ratio is demonstrably higher when military expenditures make up a higher percent of American GDP. This supports the previous finding that a high-competitive ratio matched greater MIDS, as defense expenditures understandably rise during wartime. Likewise, this finding may corroborate the hypothesis that a focus on maintaining military dominance involves the prioritization of competitive space investments. However, this period also overlaps with the duration of the space race. Although this is the only time within the analyzed period where defense expenditures rose beyond 6.5%, militarized space projects emerged alongside civil competitive applications such as Apollo, making a direct relationship between military need and investment unclear. Defense expenditures were also heightened during the Reagan Administration, but the average ratio does not stand out there. As such, future work should differentiate between types of competition to determine whether investments during militarily-competitive periods favor programs applicable towards military use.

6.4 Qualitative Case Studies

6.4.1 Case Study 1: Detente

Figure 12. Spending Ratio-U.S. Annual Conflicts Comparison, 1960-1980



The late 1960s saw a renewal of bilateral diplomacy between the United States and Soviet Union under the incoming presidential administration of Richard Nixon. At the beginning of this period, the superpowers negotiated several agreements and arms control treaties with significant relevance for the applicability of competitive and cooperative investments. The Outer Space Treaty of 1967 had precluded all prospective claims of territorial sovereignty, lunar militarization, and atmospheric deployment of weapons of mass destruction (Gorove 1968,

1973). While the treaty did not explicitly ban militarization of space, the inability to claim exclusive rights or base strategic positions on the sole celestial object in reach would have limited political and economic motivations for competitive investment on the scale of Apollo. In parallel, formal ratification of the SALT I arms control agreement both limited the acceptable number of nuclear weapons and drastically minimized the use of anti-ballistic missile defenses (Galtung 1972). The opportunity for orbital deployment of nuclear weapons was constrained and the ceiling of a single Safeguard site to defend existing ground-based nuclear weapons would hardly attract policymakers to military-oriented investments. By the early 1970s, the United States established meaningful diplomatic relations with the People's Republic of China and simultaneously negotiated an end to the Vietnam War. From a distributional perspective, discretionary spending consumed by the nine-year conflict was now free for reappropriation and the Mao administration transitioned from an assumed enemy to a trade partner and co-belligerent balance against the Soviet Union. Together, these could serve as signals of a reduced military threat to the international status quo favored by the U.S..

The annual Aeronautics and Space Reports of the President from this era reflect these reduced concerns of conflict and the correspondent shaping of the space program to match. The incoming administration of Richard Nixon explicitly noted the importance of presenting a peaceful national image and the intent of pursuing global peacemaking achievements; especially notable considering this policy is stated in the national security section of the report (Nixon 1969). In the same report, security investments were solely oriented towards status-quo maintenance and reactive capabilities, funding Vela satellites capable of detecting nuclear detonations, and noting the growing civil applications of the Titan-III lifter vehicle. There was a

clear push for nonaggressive strategic spending and the search for broader nonmilitary uses for NASA products. Interest in military applications in general did not disappear during Detente, with military aviation still incorporating NASA research, in particular still preserved as priority throughout. However, international cooperation achieved its own section for the first time under the Nixon administration where its predecessors in the Johnson administration sequestered international relations to more utilitarian assessments of prospective opportunities for primarily coordination agreements rather than actual joint technical projects. The period of 1970-1972 saw a significant increase in joint projects, both with emergent European coordination, Canada, and Japan for the first time and, most anomalously, with the Soviet Union to set the foundation for the 1975 Apollo-Soyuz Test Project (ASTP) (Nixon 1972, 1973). This era is therefore unsurprisingly coincident with the beginning of the rapid increase of cooperatively-coded spending.

The cooperative spending growth-rate skyrocketed from 1973 onward, as the launch of the Skylab orbital laboratory and the designation of the Space Shuttle as the post-Apollo priority brought a flurry of foreign participation, though limited to the close allies. From the beginning, both programs were built with foreign participation in mind. Skylab hosted European and Japanese experiments for shared results and the Space Shuttle committed to compatability with the European research through the Spacelab module (Nixon 1973). After President Nixon's resignation, the Ford administration at first primarily continued existing cooperative commitments, most notably the 1975 mission with the USSR. However, upon ASTP's completion the new administration also began to emphasize the development of new military

satellites in 1975 and acknowledged only informational transfers with the Soviet Union instead of joint projects or technology-sharing (Ford 1975, 1976).

Through 1977-1979, there is no longer a section dedicated to foreign cooperation or the State Department's activities and the European Spacelab project becomes the only major international technical project, itself now vastly reduced despite American promises during the height of Detente to purchase a full series (Carter 1977, 1978, 1979). These point to a rare focus on cooperation in the wake of the Outer Space Treaty and the steady increase in joint projects until the completion of the Apollo-Soyuz Test project, then coincident with the victory of communist factions in Vietnam, Laos, and Cambodia and the eruption of civil war involving the leftist MPLA faction in Angola. By the Carter administration, cooperation appears to have slowed before 1979 in favor of a return to unilateralism.

From a historical outlook, spending in this period supports the hypothesis that eras of peace allow for greater cooperative spending. Throughout this period, cooperative spending saw rapid growth, in contrast to stagnation earlier in the 1960s amidst five-ten major conflicts-per-year. There were no more than four American-involved conflicts-per-year until 1979, when the Soviet invasion of Afghanistan signaled the end of Detente and the Iran Hostage Crisis demonstrated a renewed challenge to the Carter Doctrine and its system of pro-American regimes in the Middle East. In parallel, cooperative spending's growth slowed and decreased following a spike in conflict in 1976, dropping more steeply with greater conflicts in 1979.

Although competitive spending saw a dramatic fall concurrent with detente, this may be attributed to the termination of the expensive space race rather than any active competition with cooperative options. However, competitive spending continued a more moderate decline while

wars remained low, breaking into a new climb simultaneous to cooperative spending's fall at the end of the decade. This suggests the prioritization of competitive spending in the presence of conflict, as theorized, but also the comparative deprioritization of cooperative spending during wartime, not simply subordination to competitive spending. The spending-type ratio likewise supports this dynamic to an extent, tracking but falling in reactivity in the latter half of the decade. There is the possibility that the salience of war itself as a motivator for budgetary apportionment changes separate from the actual number of conflicts.

6.4.2 Case Study 2: The Second Cold War and the Reagan Administration

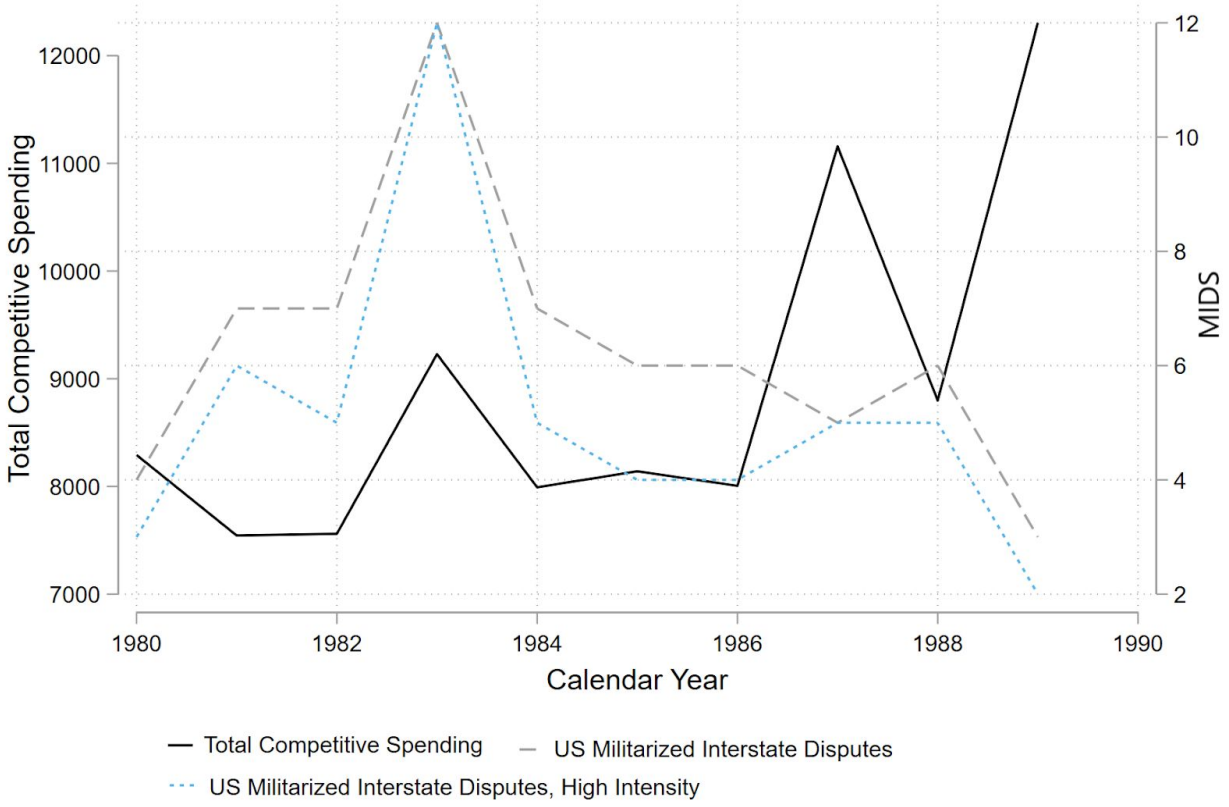
The election of the administration of Ronald Reagan saw renewed tensions with the Soviet Union, but also increased cooperation on larger projects with foreign allies. Tensions were understandably increased at the opening of the 40th presidency, with the Soviet invasion of Afghanistan marking the termination of Detente and the Iranian Revolution showcasing a renewed willingness to challenge American regional interests. The brief return of State Department-led activities in 1980 may at first appear to contradict the return of competition, but the section is once again gone by Reagan's first two years and the only remnant cooperation limited to rule-setting agreements through the United Nations, not any new joint projects (Reagan 1981, 1982). Despite the advent of the "Second Cold War", it appears to have taken the Reagan administration several years to formulate a new policy path. Early years don't deviate heavily in rhetoric from those of the Carter Administration, with attention dedicated to the completion of existing long-term commitments (STS/Space Shuttle and Spacelab). Only once

these pre-set priorities are completed is thera resurgent interest in cooperative investments, but actually as a supplement to competitive efforts.

1983's report returns the first lengthy dedicated cooperative section, promising a new emphasis on "openness and cooperative spirit", but these efforts are divided between true joint scientific projects, made possible by the operational status of the new Space Shuttle, and a sudden rush to more commercialized endeavors centering around communications and technology transfers supporting foreign satellites and launch vehicles (Reagan 1983). However, the true standout year is 1984 where the Reagan administration publicly committed to the construction of a manned space station with the invitation of foreign participation. Undoubtedly a vast leap in cooperation, the entire endeavor is depicted primarily in terms of renewed competition with the Soviet Union, promising to put "the West in the forefront of space developments" and "give a solid leadership advantage to the United States" (Reagan 1984). Although the relationship with the Soviet Union remained antagonistic since the fall of Detente, with the USSR attempting to block American space cooperation proposals in the UN General Assembly (Reagan 1985), the American response increasingly took the form of a multilateralist united front with its international allies. The split between scientific cooperation and foreign involvement in space commercialization is elaborated upon as well. Foreign commercial cooperation is lauded as a functionally competitive effort "to create an international environment in which United States commercial space activities can compete effectively" (Reagan 1984). The clearest example is the privatization of existing programs like Landsat, as well as the promotion of commercial equivalents to state-developed assets like launch vehicles. Thus, it is more difficult to distinguish between competition and cooperation in this period, with the increasing

profitability of space combined with the developing capabilities of space programs outside the superpowers to drive an increasingly hybridized space program.

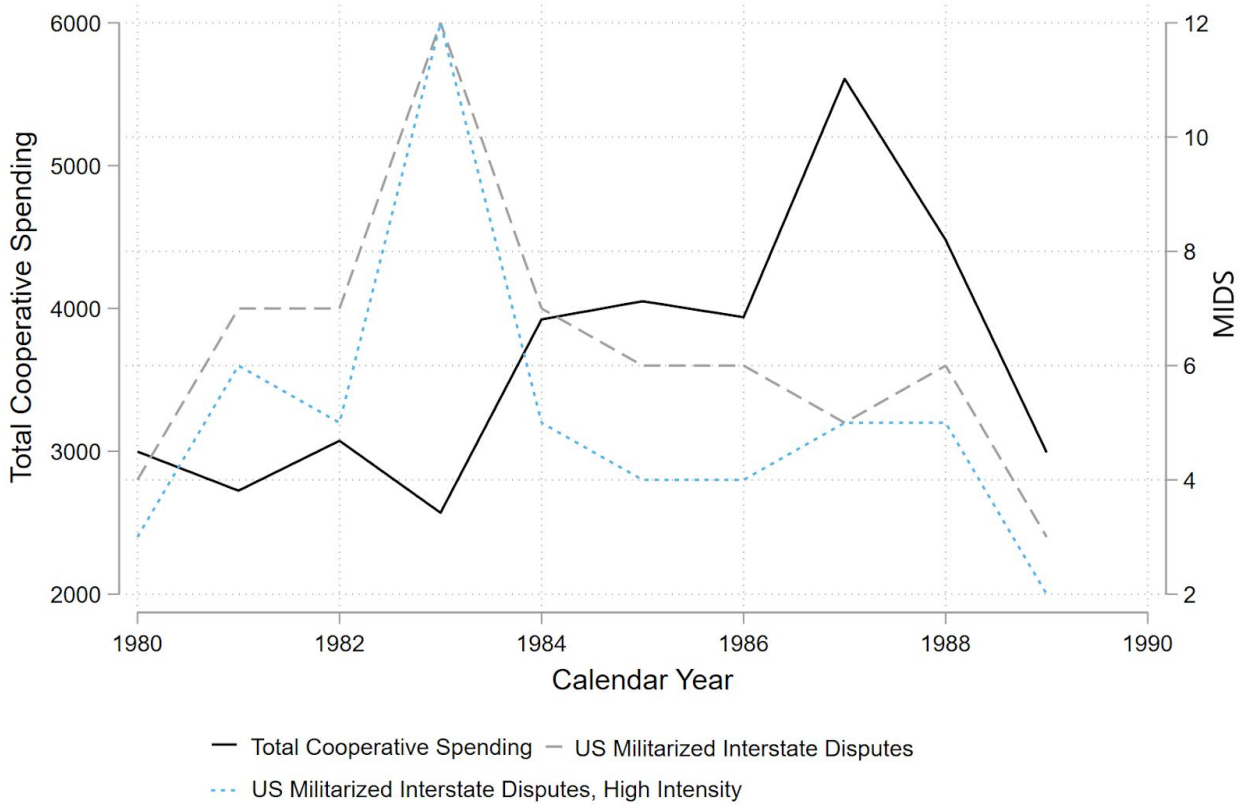
Figure 13. Competitive Spending-U.S. Annual Conflicts Comparison, 1980-1989



For the competitive end of the spectrum, while competitive spending does trend upward overall throughout the decade, the Reagan administration's competitive spending ends relatively close to the budget at its beginning. In terms of the relationship to conflicts, competitive spending actually fell after the 1980 election despite an increase in MIDS. The first upward spike was in 1983, in the same year as the Beirut Marine Barracks attacks and the high-tension Able Archer NATO exercise. While these events could have signalled a renewed military challenge, competitive spending actually dropped in the following year. It is possible that the spending

increase is instead due to the beginning of operational flights of the Space Shuttle with STS-5, although testing had been ongoing since 1981. Competitive investment also increased significantly in 1987, with most new funding going to the Space Transportation Capability Development (STCD) funding subcategory to build a replacement shuttle following the Challenger disaster. The subsequent 1988 "decrease" has been attributed as a recompensation back to normal spending after the preceding investment into a new shuttle (Rumerman 2000), and should therefore be considered as more of an increase from 1986's budget. It is therefore more difficult to tie NASA's competitive spending in the 1980s to perceptions of a military threat. The major competitive investments of the era, such as the Space Shuttle were long-term projects that did not provide immediate strategic/military benefits. Inclusion of military-specific investments, such as research toward the anti-ballistic missile Strategic Defense Initiative, may improve future analysis. Overall, competitive investments in the 1980s can be summed up as the continuation of existing project commitments, a transitional push towards more commercialization, and preparation for upcoming competitive endeavors for the Bush and Clinton Administrations to fulfill.

Figure 14. Cooperative Spending-U.S. Annual Conflicts Comparison, 1980-1989



For cooperation, the rate hovers during the high-tension years following the Soviet invasion of Afghanistan and the election of the Reagan Administration and rises as conflicts fall from 1984 onwards. The latter half of the 1980s saw a distinct rise in both cooperative spending and policy, with the Space Shuttle incorporating foreign components and experiments while 1987 saw a new space cooperation agreement signed with the Soviet Union. However, the anomalous jump in 1987 is again attributable to the cost of a replacement Space Shuttle after the Challenger disaster of the previous year (Reagan 1987). Interestingly, cooperative spending falls despite the ongoing dissolution of the Soviet Bloc around 1989. The dual-year presidential report for 1989-1990 however demonstrates a focus of international cooperation through policy coordination, consultation conferences, and measures conducted through the United Nations

which are not visible in a purely budgetary representation. There are still strong signals of cooperation in this period, both in terms of policy-setting and actual missions, most notably with the launch of the new INTELSAT telecommunication satellites by not only NASA but also European participants (Bush 1989-1990). However, much like competitive spending, cooperative spending in this decade is also explicitly presented as supportive of competitive interests, furthering "broader acceptance of the U.S. policy and opening new markets for U.S. commercial participation" (Bush 1989-1990). Finally, the period also saw the continued planning of the Space Station Freedom, the precursor which became the International Space Station, with the full incorporation of partners in Europe, North America, and East Asia, although still limited to close allies (Logsdon 1998). As such, cooperation in the latter part of the decade still very much reflects the Reagan Administration's competitive leanings but, through policy more than budgetary investments, set a foundation for the coming increase in cooperation in the next decade.

6.4.3 Case Study 3: The End of the Cold War

The collapse of Soviet bloc following the revolutions of 1989 and ultimately the dissolution of the USSR itself in 1991 removed both the main geopolitical rival to the United States and the second most-developed space program in the world. President George H.W. Bush had promised a grand expansion of space investments, but mostly focused on managing priorities of his predecessor like the Space Shuttle and Space Station. Much like the Reagan administration's maintenance of commitment to the Space Shuttle, these existing commitments had to be met, with cooperation dedicated to the continuation of these programs. However, 1992

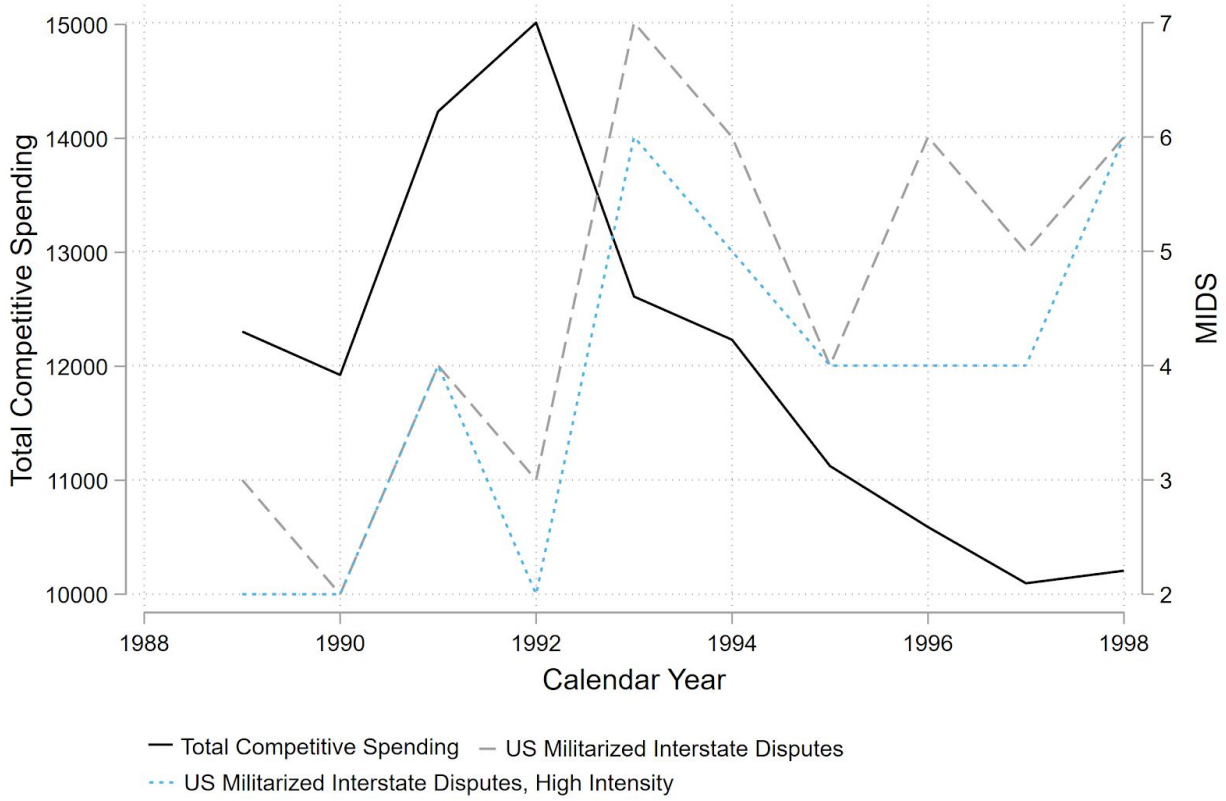
saw a much faster reaction to the fall of the Soviet Union than Reagan's to the end of Detente, with "Cooperation with the Former Soviet Union" getting its own section (Bush 1992), heralding the opening of programs funded under the new "U.S.-Russian Cooperative Program" category (Rumerman 2012). This may, in part perhaps be attributed to Reagan's remaining commitments being incompatible with Soviet participation, whereas President Bush successfully incorporated the non-hostile nascent Russian Federation into the American space agenda.

The Washington Summit of the same year organized a slew of the first large-scale joint technical programs between the superpowers since 1975. Cooperative missions between the Space Shuttle and Russian station Mir evoked the similar Apollo -Soyuz Test Project, but also provided for the first time mutual access to the internal technical working of each country's major projects. (Bush 1992). American assessors were allowed to gauge the resources of the Russian space program, providing deep insight into the remnant inventory and capacity for further mutual assistance. In return, Russian corporations were contracted to provide key components for U.S. space infrastructure.

It was with newly-elected President Clinton however, that Russia was allowed a coequal position within the largest program of the era: the International Space Station. Allowing the former rival to take part in the single largest space project in history was unprecedented, and Russian access and construction seems to disperse technical knowledge and capital that could have gone to American firms. These compromises were acceptable because they formed part of a larger strategy by the United States to manage the fall of the USSR for efficiency, stability, and security. The Space Station program had incurred significant costs, obligating the pursuit of efforts to split costs with capable partners (Clinton 1993). In parallel, Russian scientists engaged

with American projects could not lend their expertise to third-party missile programs (Abelman 1996). As such, it was within American interests to use cooperation as both a cost-efficiency mechanism and a means of de-facto arms control.

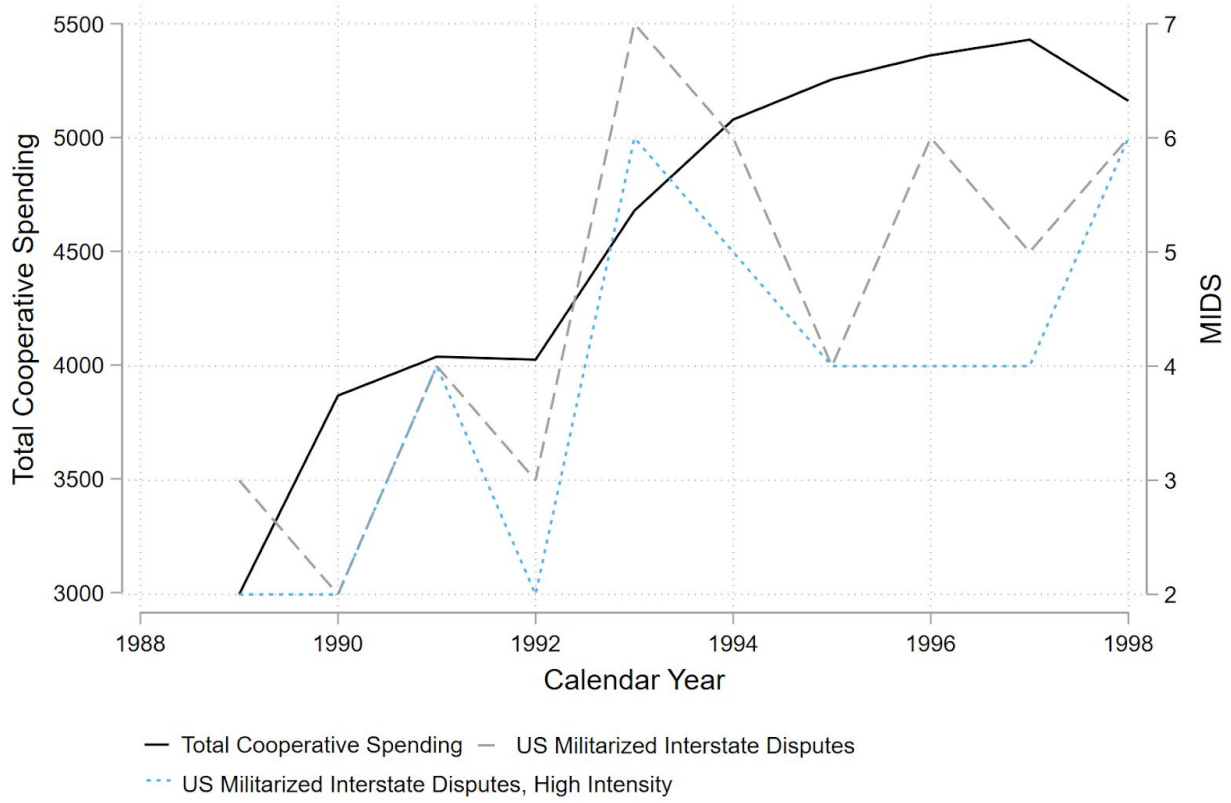
Figure 15. Competitive Spending-U.S. Annual Conflicts Comparison, 1989-1998



As visible in the above figure, competitive spending reflects these priorities across administrations. Competitive investment drops amidst the revolutions in Eastern Europe, but rises in subsequent years due to a vast increase in spending on the Space Station and a rapid increase in funding for Aeronautical Research and Technology and its hypersonics program. These follow the Gulf War against Iraq, widely acknowledged as the first "space war" where

advanced air and space assets played a vital role in planning and conducting operations to retake Kuwait (Anson and Cummings 1991, Sheehan 2007, pg. 98-100). Funding for experiential aeronautics in particular, now under the "Aeronautics and Space Transportation Technology" continues across the decade and only falls several in 1995, just as MIDS dip, before continuing an upward trend.

Figure 16. Cooperative Spending-U.S. Annual Conflicts Comparison, 1989-1998



Cooperative spending demonstrates a strong upward trend throughout the decade in two different phases of growth. Through the late 1980s, funding for the Space Station and support for European, Canadian, and Japanese participation grew, alongside new U.S.-Soviet cooperation following the 1987 agreement and additional bilateral accords with Senegal, the Gambia and Australia (Reagan 1987). Stagnation in 1990-1992 may be due to the Gulf War's prioritization of

discretionary spending, as no program is outright reduced in spending, only slowed into more limited growth. Greater expansion begins in 1993, with the Gulf War ended and post-Soviet cooperation negotiated, and the cooperative portion of the "Space Flight, Control, and Data Communications/Human Spaceflight" triples in size in a single year due the transition of the Space Station from a Research and Development category to active funding under the aforementioned Spaceflight category. The rest of the decade appears mostly insulated from changes in MIDS, with steady growth coming from the construction of the Space Station through its 1998 launch. The slow of the overall growth rate due to both the reduction of Space Shuttle funding from 1997 onward and the termination of the U.S.-Russian Cooperative Program after its largest year in 1997 upon completion of Russian contracts to provide components for the International Space Station. As such, cooperative programs in the 1990s mostly draw from the post-Soviet opportunity for cooperation, which as a priority for the Clinton administration could commit to a sustained effort regardless of simultaneous military and peacekeeping commitments in Somalia and Yugoslavia.

7.0 Discussion

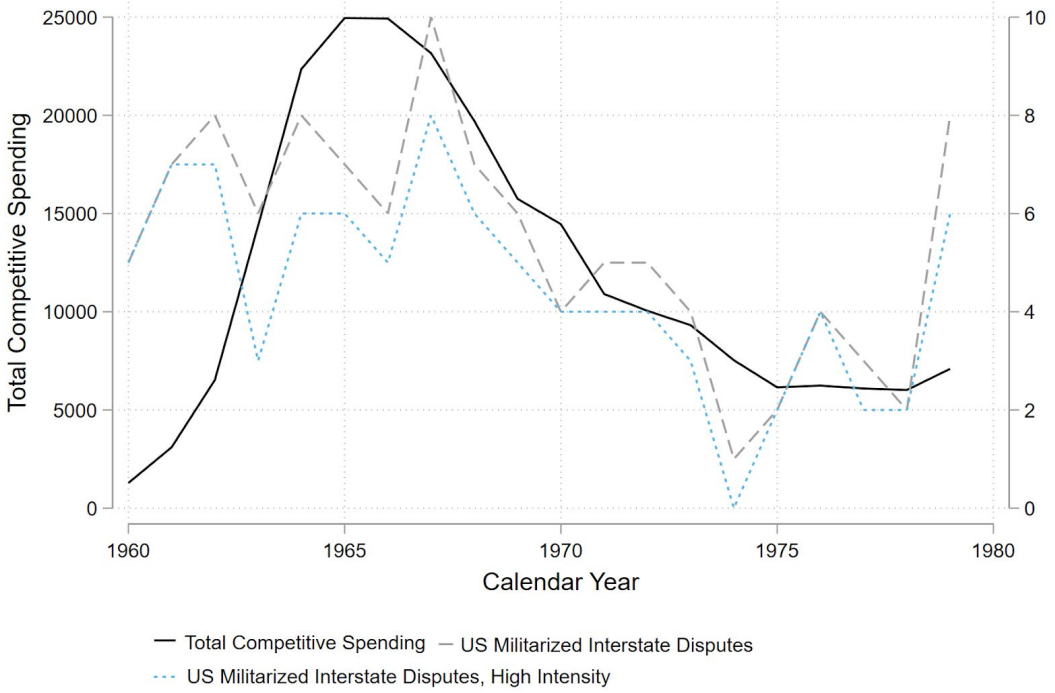
With the current low number of observations it is difficult to determine the actual correlation between the dependent and independent variables. Significance was inconsistent between models and coefficients were variable, including some sign changes denoting opposite relationships. In addition, there was collinearity between, mostly economic, independent variables which may have skewed overlapping effects. As such, it is best to view the current

results as the foundation of further research through the determination of the initial trends in the explored relationships.

Economic variables appear to have different effects on determining the amounts of appropriated spending for both competitive and cooperative investments. The current account seems to have the opposite effect on competitive and cooperative spending, but due to limited statistical significance identifying the variable as a determinant is difficult. The positive effect on the former could be due to the greater availability of funds while the latter's negative relationship, which registered as significant, may be because the current account has historically trended downward while cooperative spending has mostly grown. Both net capital inflow and exports usually had comparable effect on spending types, but also were subject to variability and sign changes. Past research on NASA budget data has noted the passive effects of economic factors on available funding, but these may simply be insufficient or limited in their capacity to trigger conscious reorganizations of the space budget.

Variables indicating a more direct threat appear to have produced the more direct changes, but only for competitive spending. Military oriented variables also showcased important effects on spending, most notably in the cases of competitive spending and therefore the ratio between spending types.

Figure 16. Competitive Spending-U.S. Annual Conflicts Comparison, 1959-1998



In third models, making use of all variables, militarized interstate disputes tended to raise competitive spending by indicating a need for greater investments without significantly affecting cooperative spending. Likewise, while defense expenditures aligned with an overall rise in both competitive and cooperative spending, the positive coefficient in widening the gap between competitive and cooperative spending suggests that heightened defense investments also demonstrated the periods of greatest investment in competitive investments. The Cold War dummy variable and its interaction with defense spending demonstrated significance for competitive spending, characterizing the period of the Cold War as sufficient enough to induce large competitive investments. The capability to impose costs by force may be the most salient signal of a need for competitive investments.

Cooperative spending may be less clearly reactive to the theorized relationship than competitive spending. Regression displayed only significance of the calendar year, most likely due to the spending categories general upward trend over time, and the current account, which dropped significantly since 1989 but is unlikely to have driven the concurrent investment into the International Space Station that probably accounts for the negative relationship. In sharp contrast to competitive spending, regression showed insignificant and highly inconsistent relationship to security-based variables. This suggests that some degree of insulation from security considerations. However, historical analysis of the major periods of expanding resource-intensive cooperative investment, the 1970s and 1990s, showcases the proximity of large-scale endeavors to geopolitical considerations such as maintaining Detente or guiding post-Soviet peaceful relations. Larger programs here look like investments genuinely oriented at fostering improved relations. It is also important to note the alignment of the competitive-cooperative ratio in the 1970s with the reduction of MIDS. It may be worth considering space cooperation as more reactive to hierarchical multi-year periods of tension that are not visible from regression against annual conflicts or defense spending alone. Likewise, annual cooperative spending may not account for the sunk costs of negotiated programs, continuing despite tension between participants. Events outside the investigated timeframe offer this as a possibility, most notably with the continuation of Russo-American cooperation onboard the International Space Station. The ill-fated Russian 2014 announcement of separation from the ISS reflected the Russian assertion of power during tensions over its annexation of the Crimean peninsula but did not account for the actual difficulty of removing fundamental internal components of the space station at great expense, preventing a separation despite geopolitical

shifts (Schmidt 2019). Searching for such cases may help better determine the actual degree of reactivity of cooperative spending.

Historical analysis may indicate changing salience of factors over time. There are periods where spending appears to track more closely with the proposed indicators of international competition, such as the Space Race of the 1960s or the cooperative flourishing of the 1970s and 1990s. While the race to maintain the lead and avoid a power transition is constant, space may not always be the forum of choice for expressing the preferences of national leadership. Prospective investments available at the moment may not match the specific foreign policy needs of the administration. Likewise, there may be cases of sunk costs bias or similar factors that distort the influence of international factors. As previously mentioned, it is not always feasible to stop an ongoing sufficiently expensive project, or start a new one, even if international factors might induce a shift in the absence of the existing investment. Likewise, newly available technology may combine with political circumstances heighten interest, as seen with economic competitiveness. Where previously military investments might take precedence during the bipolar rivalry with the Soviet Union, the ever-increasing opportunity for commercial programs may especially fit the needs of an administration concerned with economic competition, as observed with Presidents Reagan and Bush. It is important to consider such constraints and analyze their expression in later decades to test the generalizability of international influences across the entire lifespan of the space program versus perhaps a more segmental periodic analysis.

8.0 Future Work

Future work should introduce improvements to robustness, granular purpose-specific funding analysis, and historical analysis. First, the current study was limited to 39 observations from 1959 through 1998, limiting the power of regression analyses. More observations will provide a regression more accurately measuring the scale of economic and military effects. There are not yet any published official data books for 1999-2020, but more granular data may exist in alternative unpublished records. More data will also allow for historical analysis of the both continued tracking of competitive and cooperative spending and an improved comparison of spending during and after the Cold War. The 2000s saw heightened military tensions during military interventions in the Middle East, while the subsequent decade saw the reemergence of salient rivals to the post-Cold War unipolar power distribution. As such, this period forms an important asset for understanding the generalizability of the current study's findings, as well as a valuable opportunity to test the contemporary impact of the theorized mechanisms.

Funding categorization in the current study aggregated programs into competitive and cooperative spending types. Subcategorization of spending types may allow for specific determination of the relationship between, for example, economic variables and commercial programs or military tensions and strategic/military programs. Cooperative spending can also benefit from disaggregation, with cooperation with allies or major rivals potentially emerging from different conditions. Close allies may be the only option for cooperation when security concerns exclude major competitors from participation. Alternatively, those same rivals who are close to matching American capabilities may actually be preferable cooperative partners to allies

further behind, who may benefit relatively more from a joint-project than coequal participants. Combining the disaggregation of projects and targets of cooperation could allow for improved qualitative analysis that accounts for which variables induce which competitive programs, as well as when cooperation is technically feasible but politically restricted.

Additional regressions may be helpful in producing new useful results or confirming existing findings. The Aeronautics and Space Report of the President records several aggregated funding measures which were excluded from the current study due to the NASA-specific focus.. The annual space-focused expenditures of the Department of Defense (DOD) could serve as one of the strongest indicators of international competition, providing a large-scale example of reactive competitive investment in parallel to disaggregated strategic/military NASA projects. Then, an aggregate measure of funding to non-NASA/DOD federal departments and executive agencies can provide an indication on applied civil space spending and therefore a concentrated example of attempts to catalyze domestic industries.

Additional independent variables may be introduced for use in regression analysis to provide alternative measures of international competition that might drive the competitive-cooperative distribution. J. David Singer's Composite Index of National Capability (CINC) measures the power of nations relative to the global distribution on the basis of population demographics, industrial output, energy consumption, and military expenditure/magnitude. Accounting for power from other consistent state factors may help provide an accurate assessment of the indicators of the rise of a potential competitor who might trigger anxieties within the leading power without actively demonstrating intent to replace their

leading position. Further measures of competitiveness may be applied to analysis as well, depending on availability. For example, the annual aeronautic-astronautic patents filed and/or approved in the United States may facilitate examination of intellectual property and scientific advancement and productivity as another dimension of international competition accompanying military and economic considerations.

Further topical authorities specializing in advisory space policy and relations of space policy to the Department of Defense may also take part in further interviews to confirm proposed elements and explore relevant relational characteristics and aspects in need of further analysis. Source communications are currently in progress, and a new series of qualitative questions about the existence of the purported relationship, followed by queries pertaining to aspects of its mechanics and its conditionalities is currently being compiled.

9.0 Conclusion

This study sought to explore the connection between foreign policy and space policy concerning investments into aeronautic and space activities. The budget of NASA appears divided between programs that seek to directly empower the United States through scientific or practical accomplishments and those willing to share the benefits of such efforts with foreign powers in return for their expertise and support. When contextualized through the lens of Power transition theory, this distribution appears connected to considerations of the relative advantage provided by programs when conducted in either format. The first category constitutes the majority of investments, eschewing multilateralism and efficiency to maintain exclusive access to the cutting-edge of research and development. However, the latter has seen increasing support

throughout NASA's first four decades of operation amidst both the rise of new contributors among the United States' and a growing pool of military and economic competitors that can sometimes overlap with the potential allies capable of meaningful joint-projects. Faced with the decision on how to act, the United States is theorized to make a geopolitical assessment to determine if its economic and strategic-military position is secure enough to allow partners to collaborate for proliferated gains, or else if a risky power distribution requires investment to maintain a leading international role.

The current study made important steps towards exploring this dynamic. NASA's Cold War era and 1990s budget was digitized for granular analysis of the internal makeup of annual spending. Each year's programs were categorized into competitive and cooperative investments meeting the different needs and formats. These categorizations were compared to the indicators of the international power distribution theorized to inform American investment strategy, including factors indicating a military threat and economic factors measuring the nation's financial health. Regressions and historical assessment revealed the important factors, such as the positive effect of salient conflicts on increasing competitive investments. Analysis has also suggested the shifting salience of influences on spending over time and supported the concept of distinct phases of competitive-cooperative distributional policy, in particular the difference between investments during and after the Cold War.

Much further work is still necessary to confirm the current findings, as well as test their broader applicability. Regressions were limited in observations, requiring more data to test the robustness of current results and investigation of the additional two decades since for anomalous

trends. Future work may also benefit from modifying the current dependent variables, the funding of each type of spending, into subcategories demonstrating the ties between specific geopolitical indicators and their precise policy outputs. Likewise, additional and/or alternative variables may help account for collinearity and issues which may have limited the current analysis. In particular, modified or new variables of military challenges should account for the variable size and political salience of different conflicts. Variables tracking the rate of scientific productivity, such as annual aeronautic-astronautic patents, may also demonstrate another important dimension to the race to prevent a power transition.

Should the proposed theory be confirmed, this may help understand not only why space policy has proceeded as observed historically, but also the current state of the field. The United States is in the midst of a renewed focus on space investments, whether exclusively civil like the Artemis program's new moon landing, or military like the newly-established Space Force as a branch of the armed services. Understanding how geopolitics is directing these investments can allow researchers to better establish causal links between the national foreign policy and these resource-intensive and potential-rich projects. Finally, as we observe the evolution of modern international politics, we may also improve our predictions of where space policy is going and potentially help those with policymaking authority determine the best option to meet national and global needs. Competitive and cooperative investments alike have produced some of humankind's most meaningful accomplishments and with a deepening comprehension of the mechanisms at work we may yet determine what goals we need to pursue next.

Appendix

Section 1: Annual Programmatic Funding Division:

	1969	Mililitary/Strategic	Pride/Prestige	Commercial	Frontier Research	Mission Demonstration	Multinational	Open-source
Apollo	2025.0	0	1	0	1	1	0	0
Spaceflight Operations	150.0	1	1	1	1	1	0	0
Space Shuttle	0.0	1	1	0	1	1	1	0
Advanced Missions	2.5	0	1	0	1	1	0	0
Physics and Astronomy	128.9	0	0	0	1	1	1	0
Lunar and Planetary Exploration	87.9	0	1	0	1	1	0	0
Bioscience	37.9	0	0	0	1	1	0	0
Launch Vehicle Procurement	99.9	0	1	1	0	0	0	0
Life Science	0.0	0	0	0	1	1	0	0
Space Applications	98.7	1	1	1	0	0	1	0
Aeronautical Research and Technology	0.0	1	1	1	1	1	0	0
Space Research and Technology	0.0	0	1	0	1	1	0	0
Energy Programs	0.0	0	0	0	1	1	0	0
Nuclear Power and Propulsion	33.5	0	0	0	0	1	0	0
Basic Research	20.2	0	0	0	1	1	0	0
Space Vehicle Systems	31.3	1	1	0	0	1	0	0
Electronics Systems	34.5	0	0	0	1	1	0	0
Human Factor Systems	19.4	0	1	0	1	1	0	0
Space Power and Electric Propulsion Sy	38.8	0	0	0	0	1	0	0
Chemical Propulsion	25.8	1	1	0	1	1	0	0
Aeronautical Vehicles	74.7	1	1	0	1	1	0	0
Tracking and Data Acquisition	279.7	1	0	0	1	0	1	0
Technology Utilization	3.8	0	0	1	0	0	0	0
University Affairs	9.0	0	0	0	1	0	0	1
Total	3201.4							

Competitive Value	Cooperative Value	Competitive Ratio	CM69	Cooperative Value	CO69
2	0	1	2025	0	0
2	0	1	150	0	0
2	2	0.5	0	0.5	0
2	0	1	2.5	0	0
1	2	0.33	42.537	0.66	85.074
2	0	1	87.923	0	0
1	0	1	37.9	0	0
1	0	1	99.9	0	0
1	0	1	0	0	0
2	2	0.5	49.3325	0.5	49.3325
2	0	1	0	0	0
2	0	1	0	0	0
1	0	1	0	0	0
1	0	1	33.502	0	0
1	0	1	20.22	0	0
2	0	1	31.349	0	0
1	0	1	34.46	0	0
2	0	1	19.402	0	0
1	0	1	38.787	0	0
2	0	1	25.752	0	0
2	0	1	74.748	0	0
2	2	0.5	139.836	0.5	139.836
1	0	1	3.8	0	0
1	1	0.5	4.5	0.5	4.5
			2921.4485		278.7425

To exemplify the process of qualitatively defining a year of programs, projects from 1969, the year of the Apollo 11 moon landing, are used to illustrate. First, the absolute appropriated spending is listed in the year column (1969) in millions of nominal year $USD.

Then, each program is qualitatively assessed for its fulfillment of competitive national priorities. For example, the largest investment is the Apollo Program itself. The mission to the moon served no military purpose, as previous manned missions such as Gemini had already tested the role of potential soldiers in space. Likewise, the Outer Space Treaty of 1967 had already disallowed the militarization of the moon, so any singular mission visiting there would be incapable of establishing a strategic advantage in potential military conflicts. Instead, the mission was fundamentally a fulfillment of pride and prestige, as President John F. Kennedy had publicly committed to send astronauts to the moon within the decade. The announcement deliberately contested the Soviet Union's space program, symbolically contrasting American and Soviet political ideologies through advanced high-profile achievements. Commercial applications had not yet been considered in 1969, only achieving funding with the later Apollo Applications program. For research purposes, Apollo was a groundbreaking scientific mission for both scientific advancement and a practical proof-of-concept demonstrator. The mission was the first to visit another celestial body, returning with unprecedented material samples and gathered data. In parallel, the mission set the format for further manned missions to the moon, through Apollo 17, establishing procedural precedent and facilitating improvements for future missions. Fulfilling ⅝ competitive conditions, the program achieves a "high competitivity" value of 2. As a program in competition with the USSR, Apollo components were naturally confidential and foreign participation excluded, resulting in a "no cooperation" value of 0. The composite ration is therefore 100% competitive. Multiplied by the 1969 spending, all $2 billion is weighted towards the Competitive spending total for 1969.

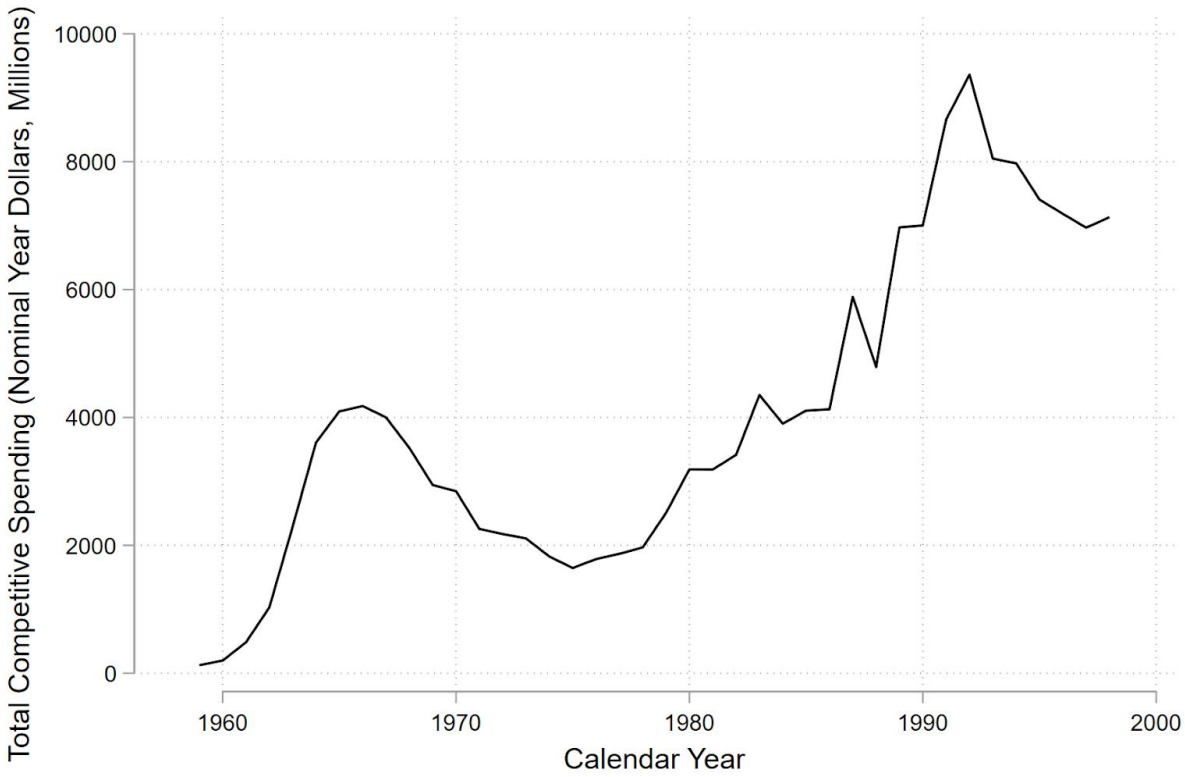
Not all programs were weighted entirely towards one spending type. The Physics and Astronomy program encomposses a diverse range of programs, from continued projects to new additions. Projects were not military or commercial in nature, limited to data gathering about natural processes like " particles and fields in the near interplanetary space reaching about halfway to the lunar orbit" (Nixon 1969). However, in addition to these research-oriented efforts, projects also "supplied information needed to assure astronaut safety" (Nixon 1969), supporting future missions by testing the human sustainability of manned programs. Fulfilling both scientific and mission-demonstration goals, ⅝ of the competitive objectives, the programs receive a "low competitiveness" rating. However, Physics and Astronomy spending also supported extensive cooperative projects, launching three international joint-project satellites in 1969 alone. ISIS-I supported Canadian-American atmospheric measurements, Borealis utilized European-American support to study ionospheric phenomena and the aurora borealis, and West German-American AZUR studied "magnetic fields, protons, electrons, and a band of ultraviolet radiation between 3,000 and 3,900 angstroms" (Nixon 1969). These projects shared advanced scientific data broadly, and, with the aforementioned relevance of such programs to parallel priorities like astronaut safety, dispersed a relative advantage to outside parties. As such, Physics and Astronomy achieve a "high cooperation" rating of 2. The emergent ratio of 1:2 leads to a ⅓ weight towards competitive spending and ⅔ weight towards competition, splitting the 1969 Physics and Astronomy budget into $42.5 million and $85 million competitive and cooperative dollars, respectively.

Certain listed programs serve as broad groupings, encompassing a large group of programs that individually reflect different combinations of the objectives. Space Applications

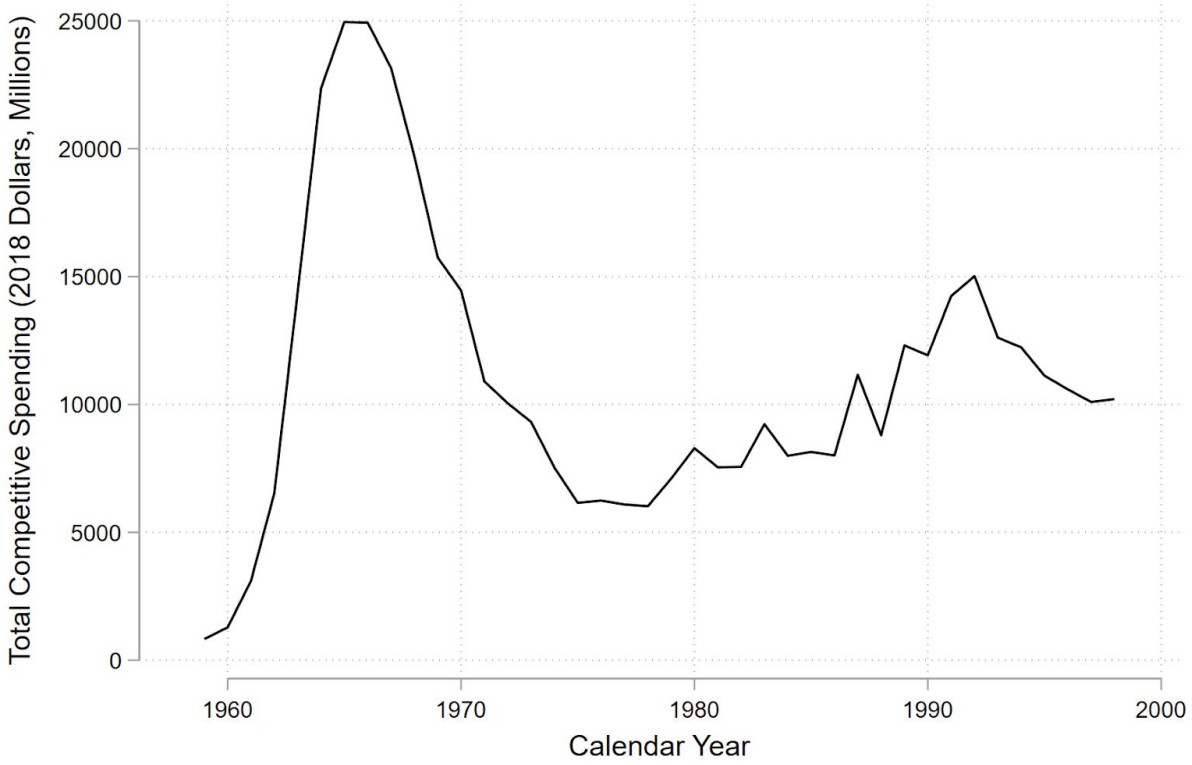
include military-aligned projects, such as geolocational data tracking ships and aircraft for the Department of Defense, economic projects like INTELSAT telecommunications, and research projects like the OSO observatory satellite series. Likewise, only some included programs were international, with OSO for example carrying British and Italian experimental equipment for joint research. As such, the category is listed as fulfilling all seven program types, even if its subdivisions may only meet some combination, providing an aggregated ½ competitive-cooperative split of spending for the category as a whole. This process continues through all of the year's programs, splitting each until the categories are summed into a combined value of $2921.44 million competitive dollars and 278.74 cooperative dollars for 1969.

Section 2: Spending Graphs

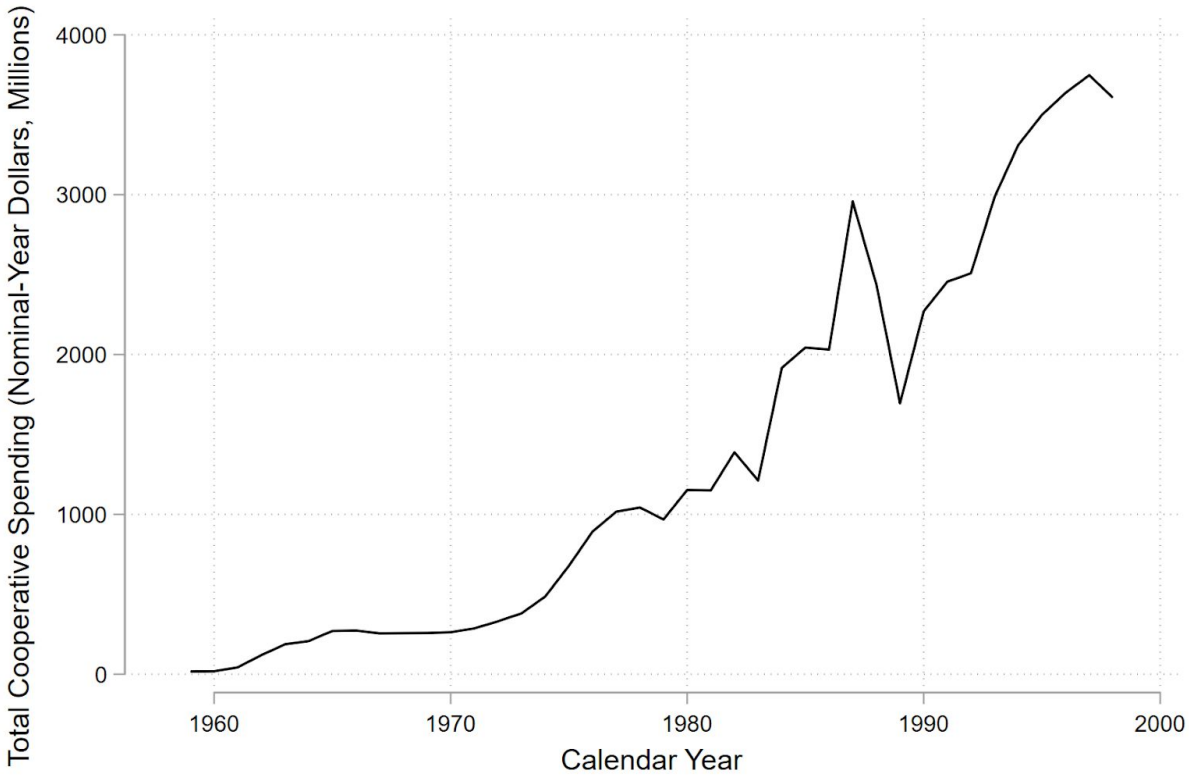
Competitive Spending



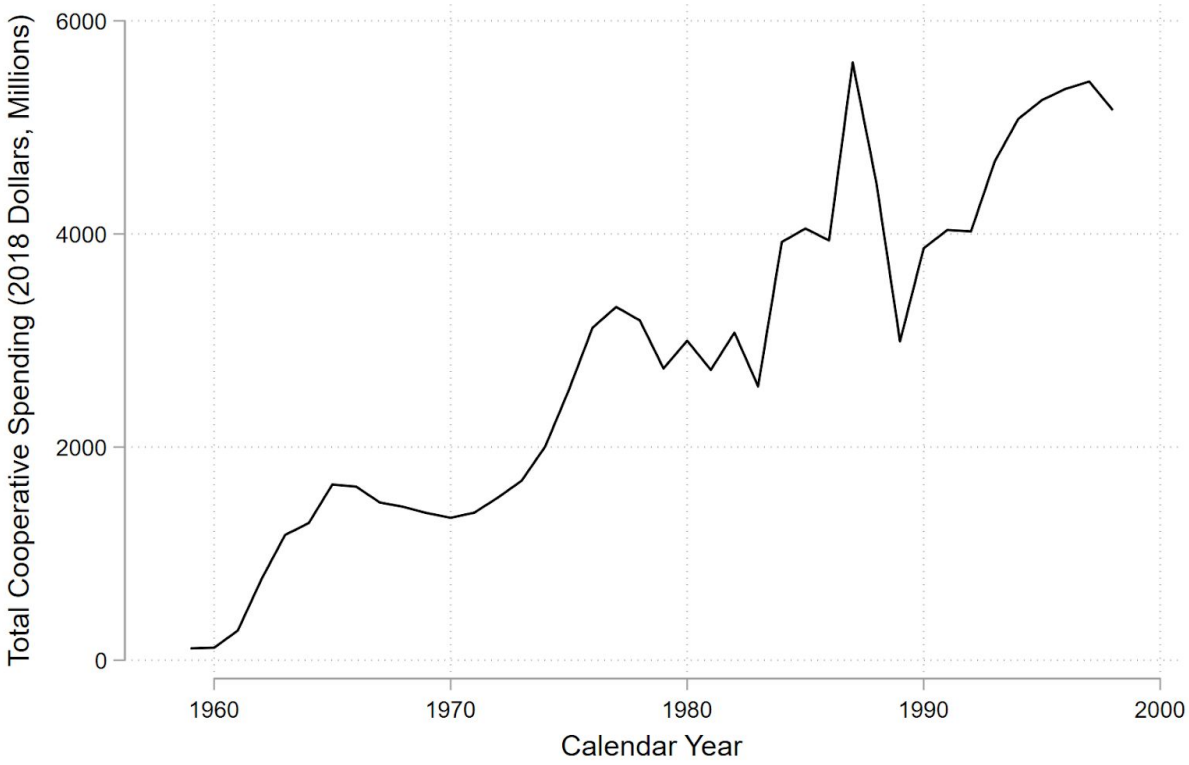
2018 USD Competitive Spending



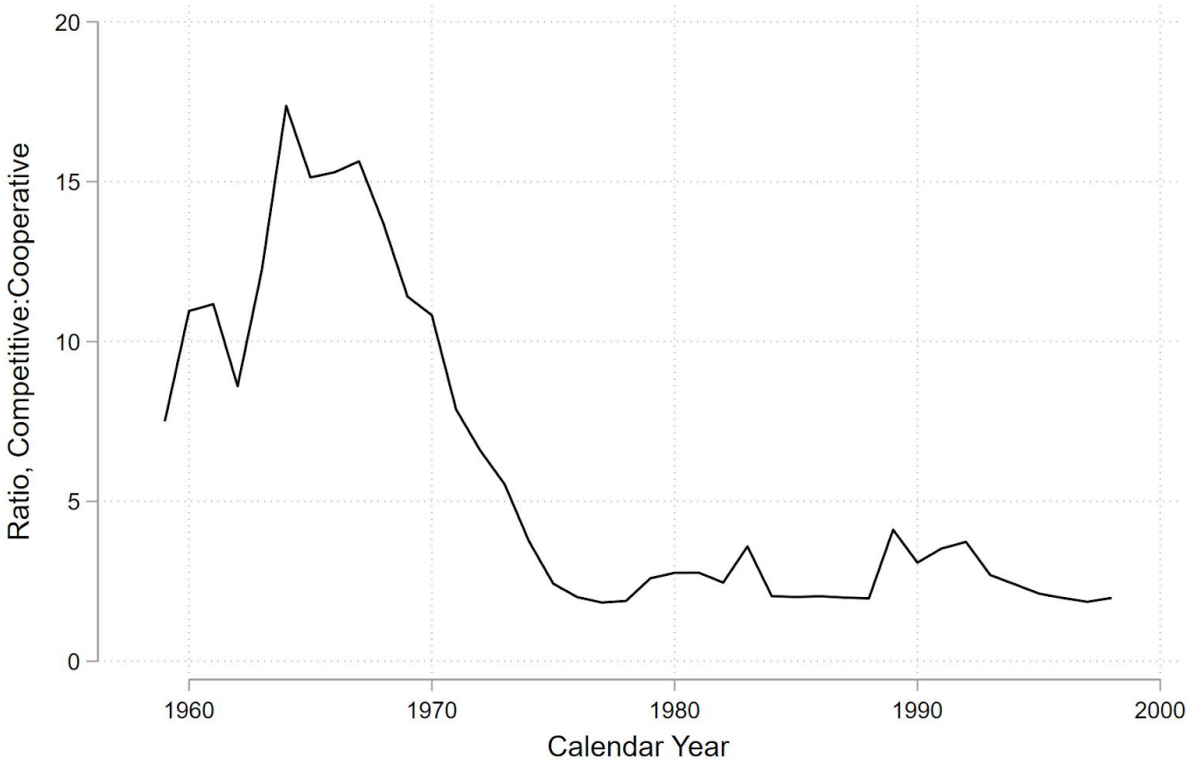
Cooperative Spending



2018 USD Cooperative Spending

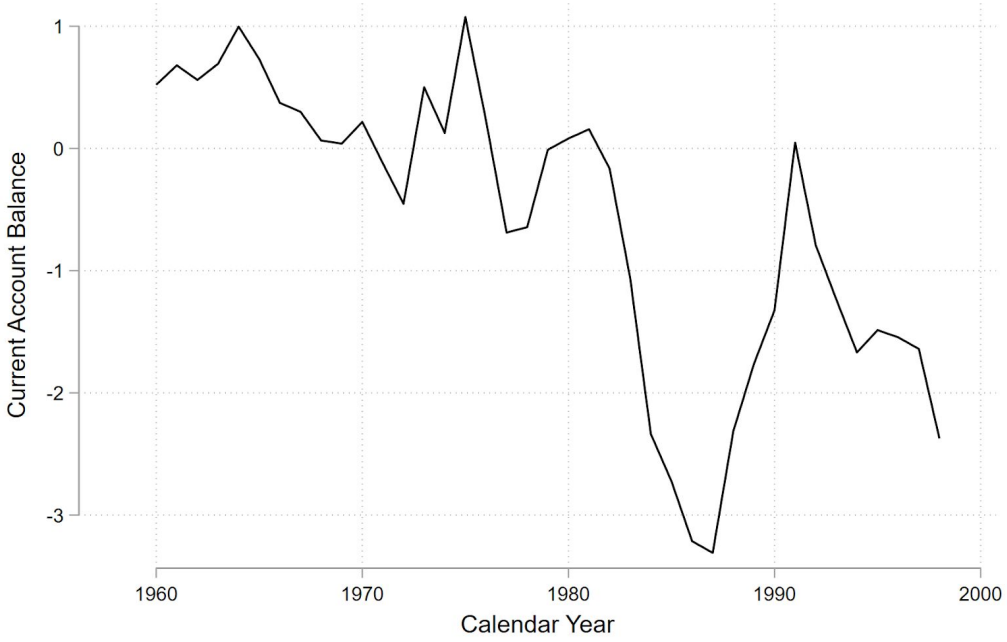


Ratio

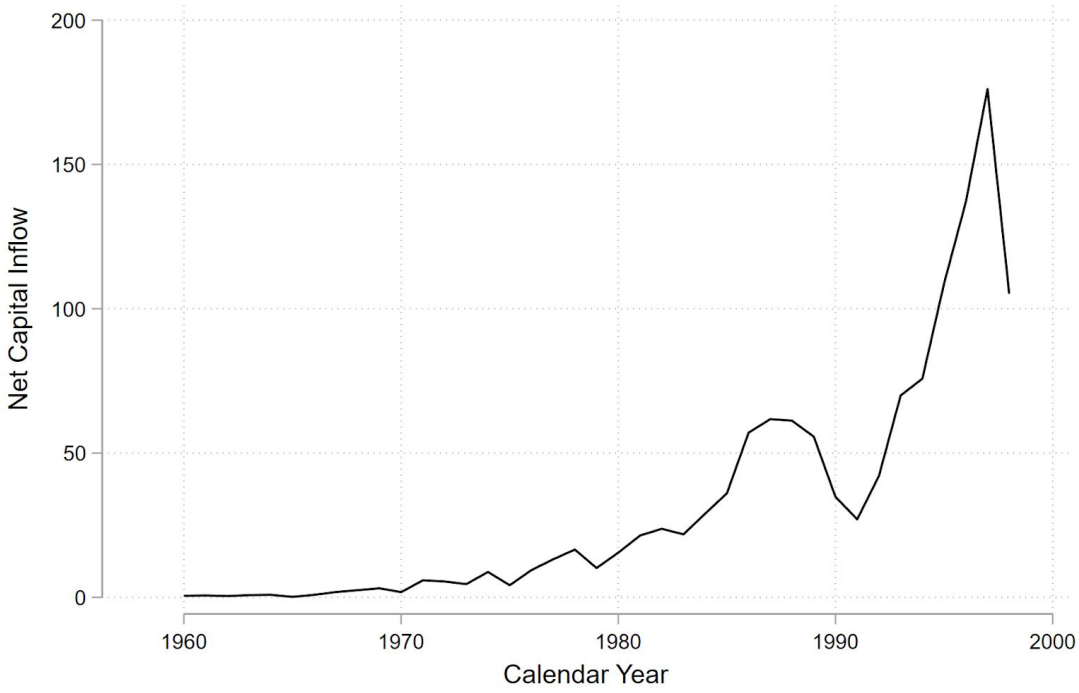

Ratio, Competitive:Cooperative
20
15
10
5
0
1960
1970
1980
1990
2000
Calendar Year

Section 3: Independent and Control Variables

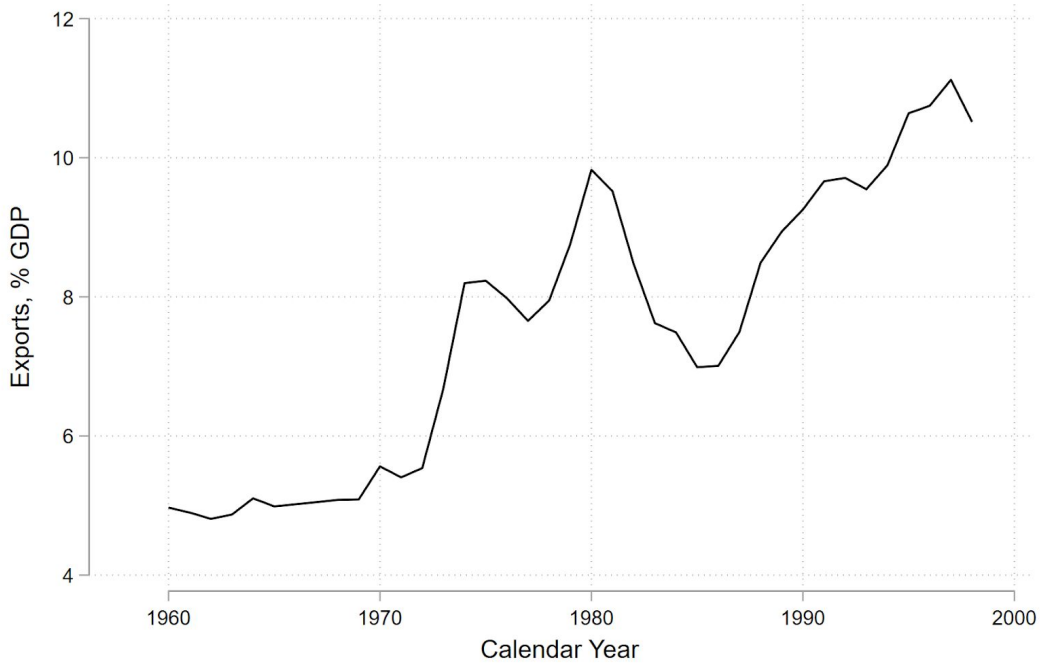
Current Account Balance:



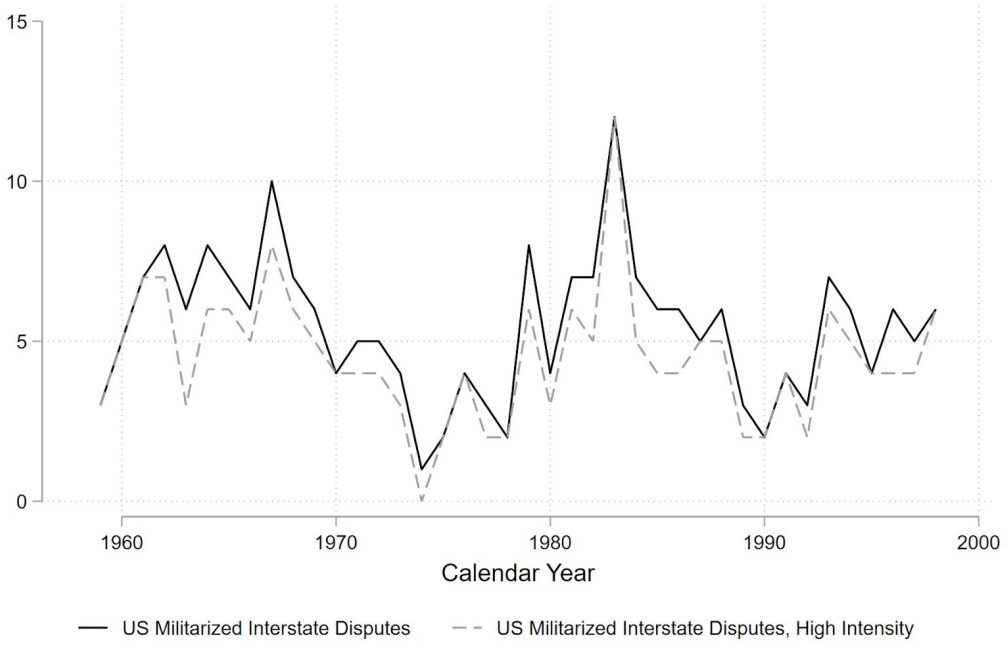
Net Capital Income:



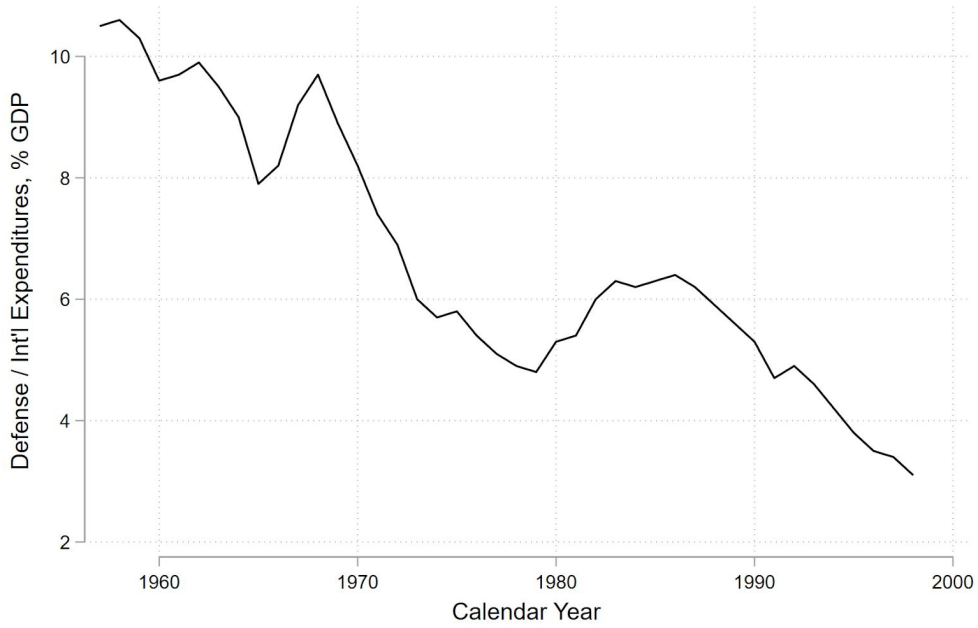
Exports:



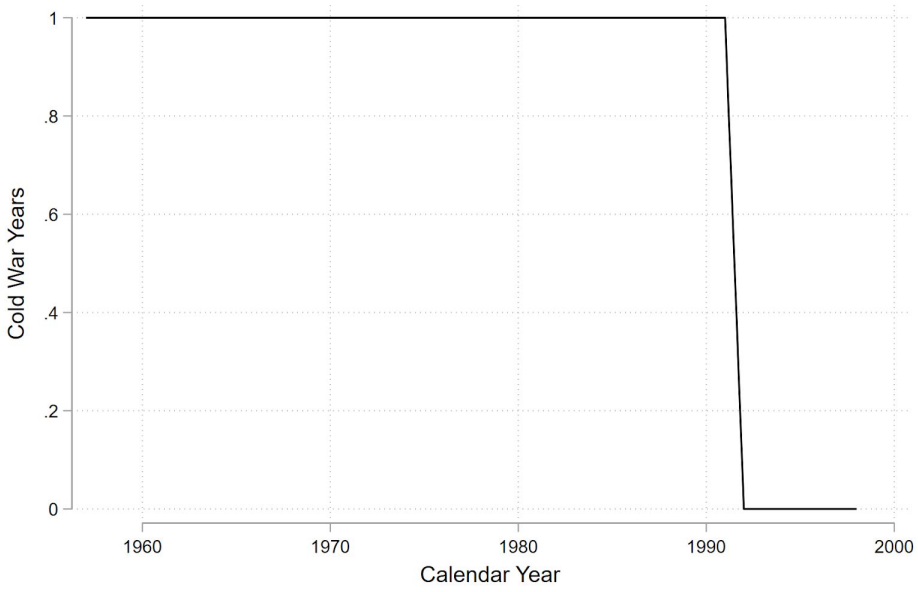
American MIDS (Annual Conflicts) and High-Intensity MIDS Subset:



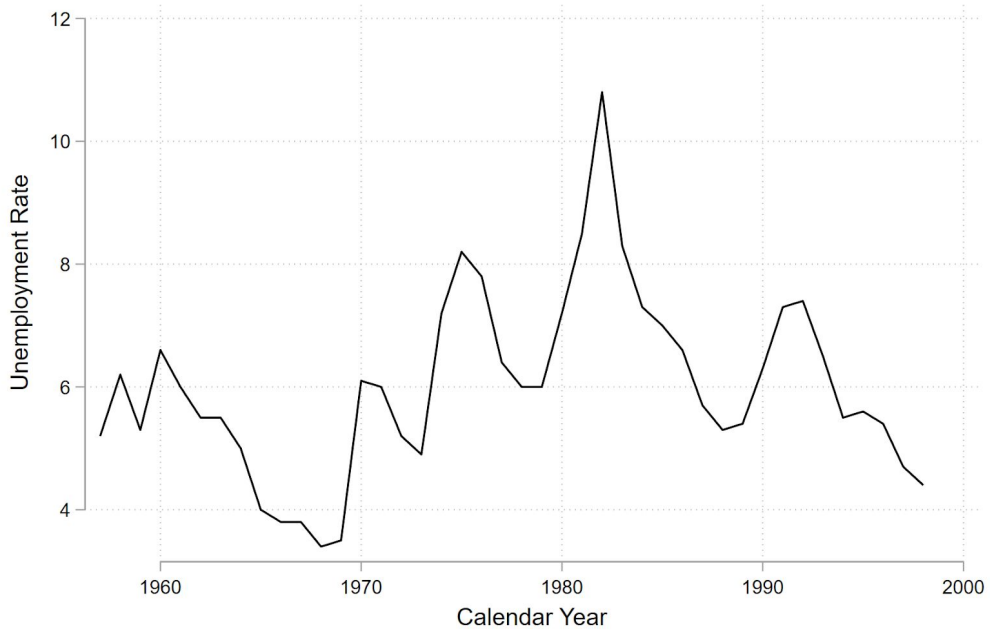
U.S. Defense Expenditures:



Cold War:


1
.8
.6
.4
.2
0
Cold War Years
1960
1970
1980
1990
2000
Calendar Year

Unemployment, %:



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