Geopolitical Competition and Air Power Acquisition

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Abstract

This thesis examines the impact of geopolitical competition on the acquisition of air power. The thesis is a replication and extension of Markowitz and Fariss' article on geopolitical competition and the acquisition of naval power projection capabilities (Markowitz & Fariss, 2018). Using new data on air power (Saunders & Souva, 2019) I test the proposition that geopolitical competition positively impacts air power acquisition, using Markowitz and Fariss' novel methodological approach of operationalizing geopolitical competition.

The results do not offer convincing support for the hypothesis that geopolitical competition caused air power acquisition in the 1974-2013 period. The hypothesis is tested using count models for the disaggregated measure, and OLS models with and without fixed effects for the aggregated measure of air power. Even though the statistical models featuring disaggregated air power as dependent variable reveal mixed support for the hypothesis, these estimates are not triangulated with an aggregated approach towards air power, which also lack explanatory power towards acquisition of air power.

The action-reaction theory has also been tested as an alternative to the geopolitical competition theory, using the same methodological framework. I have not found convincing evidence for such dynamics. I suggest that future studies of geopolitical competition incorporate alternative measures of interest compatibility between states to enhance its validity.

Acknowledgements

This thesis is the result of a process that started two years ago, when I stumbled across Markowitz and Fariss' article while writing a term paper in Tore Wig's Causes of War course. The article sparked an interest in geopolitical competition and how such an abstract concept might affect our lives.

First, I would like to thank Johanna for her unwavering support and for her endless patience the last years. I dedicate this thesis to her and our son Elias.

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Any mistakes are my own.

Contents

1 Introduction

In 2008, the Norwegian government decided to acquire 56 new F-35 combat aircraft[1] (Regjeringen, 2017). This decision is not unique in a historical perspective since development, production and acquisition of combat aircraft has been an ongoing endeavor since WWI. The context and one of the factors that cause these types of decisions is the topic of the thesis. In this thesis I test the argument that geopolitical competition contributes to states' acquisition of combat aircraft.

Recent papers describing the foreign policy and military strategies of Russia, USA and China may serve as indicators of increasing geopolitical competition, especially between these major powers (Russian MFA, 2016; The White House, 2017; SCIO PRC, 2019). Even though these papers are indicative of increasing geopolitical competition, they do not explain why it has emerged. This thesis will seek to understand geopolitical competition in structural terms, by looking at what specific characteristics within and between nations are associated with competition. This follows the theoretical understanding of geopolitical competition developed by Markowitz and Fariss (2018). The thesis contributes with an empirical examination of the consequences increased competition has on air power acquisition, which serves as a test of the theoretical framework provided by Markowitz and Fariss.

The thesis is a replication and extension of Markowitz and Fariss' article (2018) that addressed geopolitical competition's effect on states' acquisition of naval power, which this thesis will extend to acquisition of air power. Air power has been central to warfare since at least WWII, and air power is associated with a higher likelihood of succeeding in inter-state disputes (Saunders & Souva, 2019). The thesis has two stages. First, to discuss the concept of geopolitical competition in a quantitative model, and second, to apply this model to address national acquisition of air power. The first part of this two-stage process will provide an understanding of geopolitical competition, provide its definition, and explain its relationship with air power. The second stage involves applying the resulting model, which will shed light on what role geopolitical competition plays in air power acquisition. The thesis will also seek to explain how air power may be utilized under conditions of warfare and coercive

[1] Later adjusted to 52 aircraft.

interactions between states, which should serve as a further illustration of the relationship between geopolitical competition and air power.

Following Markowitz and Fariss (2018), **geopolitical competition is defined by the potential for coercive bargaining interactions between states,** a potential which increases under conditions of interest incompatibility**.** This incompatibility is defined by the lower levels of trust afforded to non-democratic regimes, their relative economic power, and the geographical distance between potential competitors. Higher levels of interest incompatibility entails that there is a higher likelihood that disputes are solved by military means, rather than through dialog and compromise. There is an alternative school of thought that defines geopolitical competition as a competition for influence over third-party states. Both approaches are discussed in the literature review, but only the interest incompatibility approach to competition will be analyzed in this thesis.

Air power has been a central component in inter-state conflicts since WWII and achieving air superiority against opponents has been a critical objective in conflicts since military operations rely on air superiority for success (Saunders & Souva, 2019:1-2; Warden, 1988:13). Markowitz and Fariss argue that a competitive environment increases the potential of coercive bargaining interactions (Markowitz & Fariss, 2018). The inherent risk of escalation in such interactions entails that acquisition of air power with the goal of attaining air superiority becomes desirable to avoid coercion or defeat in a military conflict. The conditions under which states acquire air power is important to predict and prevent the potential for both arms races and conflicts. The centrality of air power in conflicts since WWII entails that states will seek to acquire air power if they expect attempts to either coerce their neighbor or be coerced by a neighbor. Markowitz and Fariss argue that gunboat diplomacy requires actual gunboats (Markowitz & Fariss, 2018), and this thesis extends this reasoning, by arguing that air power is a necessity to credibly enter coercive bargaining interactions with other states in the post-WWII era.

There are several alternative theories that may explain air power acquisition, including the action-reaction model, the domestic structure model, technological development and its diffusion through arms trade, and symbolic politics. These theories will be discussed in later chapters. Due to data availability issues and time constraints, only the action-reaction model will be tested as an alternative to the main hypothesis that geopolitical competition causes air power acquisition. The action-reaction theory posits that states' arming decisions are informed by arms acquisition in potentially hostile states (Richardson, 1960), a theory that has served as the basis of most arms race theories. I will test the action-reaction theory by adapting the geopolitical competition variable developed by Markowitz and Fariss to the theory developed by Richardson.

The thesis applies quantitative methods to determine the effect geopolitical competition has on air power acquisition, and the research design involves an estimation of both count models with aircraft generations as dependent variables and of panel data models using a measure of air power developed by Saunders & Souva (2019). This closely replicates the research design adopted by Markowitz and Fariss. Using both count models and linear panel models enables triangulation of the statistical estimates, and interpretation based on a larger pattern compared to research designs featuring only one type of model. The same approach is adopted for testing of action-reaction dynamics' effect on air power acquisition.

The operationalization of the geopolitical competition variable follows Markowitz and Fariss. The variable consists of three components: a latent threat component, a preference component, and a distance component. These components are measured between all dyads (pairs of countries) before they are summed into a single measure for each country-year, resulting in monadic data. This enables analysis of country-level characteristics rather than dyadic characteristics, for example the effect regime types, GDP, or other national characteristics have on acquisition of air power (Markowitz & Fariss, 2018; Markowitz & Fariss, 2018b). The action-reaction variable conceptually overlaps with the competition variable, in that it is constructed by altering the latent threat component while retaining the other components. The operationalization and validity of these variables is discussed in the research design chapter.

The results obtained from the models do not support the extension of Markowitz and Fariss' theory from acquisition of naval power projection capabilities to air power acquisition. The estimates are subjected to a range of robustness checks and are generally found robust. There is also a lack of support for the alternative hypothesis that action-reaction dynamics cause states to acquire air power. I end the thesis with a discussion on the potential theoretical and methodological issues that may explain the lack of support for the main and the alternative hypothesis, and how these issues may be addressed in future studies.

1.1 Contributions to the literature

The main contribution of this thesis is a new argument linking geopolitical competition to air power, using quantitative tests on new data on both geopolitical competition and air power. To the best of my knowledge, the association of between geopolitical competition and air power has not been tested before. According to Keohane, Verba and King, testing new implications of theories is an important task within the social sciences, since it examines the leverage of a given causal variable, either by improving upon the underlying theory, the data, or the use of that data (Keohane et al., 1994). For the purposes of this thesis, leverage refers to a causal variable's ability to explain other phenomena than initially envisioned. In sum, this thesis contributes to the study of geopolitical competition and arms procurement theories in general, with an emphasis on air power.

2 Literature review

In this chapter I will outline how this thesis relates to the existing research and how it is positioned in relation to the other theories in the field. This will provide a background for the thesis and give an overview of the related issues and debates in conflict studies and should provide a justification for the research question by demonstrating a gap in the previous research that needs to be filled. Additionally, the literature review will also delineate the scope of the thesis, by explicitly omitting or including existing research as relevant. Each source will be evaluated on its premise, methodology and conclusion. Inconsistencies, omissions, and errors will be addressed to determine each source's accuracy and depth. Each source will also be evaluated on its relevance to this thesis' research question, and whether it addresses it directly or impacts this thesis indirectly. The source selection for the literature review is conducted mainly through a snowballing method, where the starting point is the article by Markowitz and Fariss and its sources, supplemented with systematic searches through materials in the university library. I will synthesize conclusions from the existing research, which hopefully will demonstrate the gaps in existing research that this thesis will address.

2.1 Geopolitical competition

Quantitative studies on geopolitical competition and conflict studies more broadly have identified enduring rivalries and dangerous dyads (Bremer, 1992; Huth, Bennett & Gelpi, 1992; Goertz & Diehl, 1993, 1995; Thompson, 2001) and interest incompatibility as indicators of geopolitical competition between states (Markowitz & Fariss, 2018; Anders, Markowitz & Fariss, 2020). These studies are inspired by or a part of the broader field of conflict research that has sought to identify causes of war. This thesis will adopt the approach of interest compatibility to establish the level of geopolitical competition each state faces, which in turn is a refinement of Bolks and Stolls (2000) article on international and domestic causes for arms acquisition.

Within the study of geopolitics and geopolitical competition in a broader sense there are two main approaches to how the terms are studied, and how to define geopolitical competition. I will outline these approaches in the following sections of the chapter, which also seeks to provide context and reasoning behind choices that were made when I define geopolitical competition for the thesis, and what limitations the reader should be cognizant of with regards to that definition and the conclusions that can be drawn. These limitations are mainly a result of the research design's inability to handle all forms of geopolitical competition.

2.1.1 Geopolitical competition as interest incompatibility

Markowitz and Fariss' (2018) contribution to the study of geopolitical competition is the starting point of the thesis, which warrants a thorough examination of their understanding of geopolitical competition. Markowitz and Fariss make a three-part contribution to the field: First, they develop a state-level theory of why states find their environment threatening and how they respond to competition. Second, they have constructed a unique measure of the level of geopolitical competition each state faces. And third, they apply the new measure to explain why some powerful states invest in power projection capabilities, while other states do not. Markowitz and Fariss define power projection capabilities as the military force structures necessary to use military power at distance, such as navies (Markowitz & Fariss, 2018:1-4).

Markowitz and Fariss seek to explain why states choose to build power projection capabilities that may be used coercively in bargains over foreign policy issues. Credible commitment and information are posited as two central causes for war (Fearon, 1995), but these mechanisms only come into play once states have entered coercive bargaining interactions (Markowitz & Fariss, 2018). Coercive bargaining is politics with the threat of war, and to credibly threaten war a state needs to invest in the capabilities to project power. They argue that states that operate within a competitive geopolitical environment are incentivized to build power projection capabilities, whereas states within cooperative geopolitical environments can safeguard their interests and bargain effectively without relying on power projection capabilities. They posit that economically powerful states situated in a competitive environment are even more likely to build power projection capabilities. The competitiveness of the environment is be exacerbated by the proximity of economically powerful, non-democratic states. Markowitz and Fariss argue that a state's choice to build the capabilities necessary for coercive bargaining has three causal components: the relative geographic position of the interacting states, their relative economic power, and the degree to which their interests are compatible. The higher the level of geopolitical competition a state faces, the greater its incentive to invest in power projection capabilities. States expect that unless they invest in these capabilities, they will be outgunned by other states during bargaining interactions (Markowitz & Fariss, 2018:2-4).

When Markowitz and Fariss outline the context of their work, and which other theories exist to explain why states acquire power projection capabilities, they refer to two competing schools. The first contends that projection of military power is obsolete because wars of conquest are no longer economically viable (Rosecrance, 1986), that public opinion in developed states has turned against war to such a degree that its initiation is unthinkable (Mueller, 2009), or that the world has become more peaceful because of increased importance of human rights, normative resistance to violence, and trade (Pinker, 2011). Markowitz and Fariss contend that the first school of thought does not explain why rising states have started to develop power projection capabilities, especially blue water navies. The second school is structural realism, which argues that investments into power projection capabilities can be explained by shift in the distribution of power, by either hegemonical power preponderance ensuring stability, or by hegemonic guarantees which allow smaller states to rely on the hegemon for security through free-riding mechanisms (Gilpin, 1981). However, Markowitz and Fariss contend that a major weakness of structural realism is that the measure of the distribution of power often conflates economic and military power, obscuring the role of consciously choosing to invest in power projection capabilities. They argue that this choice is dependent on the degree to which they find other states threatening, while structural realists claim that all states find each other threatening (Markowitz & Fariss, 2018:5-6). The measure in question, the CINC, and the reasoning for choosing air power as a dependent variable will be discussed further in section 2.3.

This thesis relies on the same theory and methodology as Markowitz and Fariss. Fearon's (1995) bargaining theory is fundamental in both by assuming that a competitive political environment encourages acquisition of coercive capabilities. Both their article and this thesis draw on the democratic peace theory by assuming that interest compatibility is affected by political regimes, and on structural realism by assuming that geographical proximity and the distribution of power influences the level of geopolitical competition. While Markowitz and Fariss tested the link between geopolitical competition and acquisition of naval power projection capabilities, this thesis tests a new implication of this theory, by linking geopolitical competition to acquisition of air power.

While Markowitz and Fariss (2018) rely on joint democracy between states to determine the level of interest compatibility, there are alternative approaches to defining interest compatibility. Anders, Markowitz and Fariss examine a range of alternative determinants of interest compatibility or incompatibility, including defense pacts and alliances, UN voting similarity, rivalries, bilateral trade, diplomatic exchange, and shared intergovernmental organization membership. They also refine the measurement of potential threat each state faces, by introducing the surplus domestic product (SDP), which allows identification of states with economic surplus which they can invest in power projection capabilities (Anders, Markowitz & Fariss, 2020).

2.1.2 Geopolitical competition for influence or integration

The second approach to geopolitical competition may be called a competition for influence or integration, which is a wider approach compared to the narrower focus of the interest incompatibility approach. These approaches often take account of several forms of power and influence, including the activities that are required to transform latent power into active influence.

Spaiser provides an explanation of what geopolitics is and what form geopolitical competition may take, in her book on the EU's influence in Central Asia. Geopolitics is concerned with "sources, practices, and representations that allow for the control of territory and the extraction of resources", that is complemented by a consideration of the geopolitical agent's identity and normative belief. Geopolitical competition is therefore a situation where claims of control and interpretations of the world collide in an environment where several actors are present and interact. Geopolitical competition is a competition for leadership, making the actor capable of influencing events in a specific territory and to provide a "big idea" for how countries should exist and interact with each other (Flint, 2012:33-35,199; Modelski, 1987, in Spaiser, 2018:xi). The thesis does not engage with the aspects of territorial control and resource extraction, nor does it engage with the aspects of international leadership or the ability to influence events.

Spaiser elaborates on the nature of power and influence, referring to three different types of power: the power to win conflicts, the power to limit alternatives, and the power to shape normality. The power to shape normality differs from the classical understanding of power and best reflects the noncoercive view of power, drawing on the influence of discourses on normality in the shaping of identities and rules. This contrasts sharply with the power to either win conflicts or limit alternatives, with which powerful actors may shape the preferences or interests of others. She prefers the term "influence" to describe the EUs external actions in Central Asia, which generally aim to consensually change opinion, attitudes, and values, prior to a strictly behavioral change. She posits that influence is not dependent on a hierarchical distribution of coercive capabilities (Spaiser, 2018:3-4).

Another arena for geopolitical competition can be found in Southeast Asia, where China and Japan compete to provide infrastructure investments for the smaller states. One can argue that these investments are designed to enhance Japan's or China's influence in the countries they invest in (Zhao, 2019). This competition is not limited to the competition between China and Japan. The centrality of the Association of Southeast Asian Nations (ASEAN) is challenged by the Belt and Road Initiative (BRI), which is China's framework in the endeavor to bilaterally establish agreements and provide loans for infrastructure development in the ASEAN member states. The Chinese loans and investments could fill an investment gap that ASEAN member states are incapable of addressing by themselves, in addition to contributing to much needed development in the less wealthy ASEAN states. ASEAN has functioned as a linchpin of regional cooperation on trade, security, and diplomacy by engaging the major powers in Southeast Asia so they can counter-balance each other. This stable balance of power in the Southeast Asia is now threatened by the unravelling of the regional order. The United States has economically and diplomatically withdrawn from Southeast Asia. The economic cooperation between ASEAN and India has also diminished. China, on the other hand, is solidifying its economic footprint through the BRI. This movement from a multipolarity to unipolarity creates challenges for ASEAN since it is no longer able to counter-balance the major powers in the region. China faces growing suspicion regarding the BRI, which may be perceived as an attempt to carve out Southeast Asia as its exclusive sphere of influence, by using the BRI as geopolitical leverage. This suspicion is borne out of a fear that the BRI could deepen the asymmetric economic dependence on China, prompting the ASEAN countries to pursue a pro-China policy and concede on issues of national interest (Rana & Ji, 2020:93-108). This form of geopolitical competition takes place mainly within the framework of international political economy and illustrates how economic competition may be a part of broader geopolitical competition. This form of competition falls outside the scope of the thesis, as I do not examine trade- and financial relationships between countries, and how for example foreign investments may influence states.

There is yet another form for geopolitical competition, which may manifest itself in the structure of international organizations. There are elements of competition in the relationship between Russia and the EU, particularly with regards to former Soviet states and their relationship to Russia and the EU. Following the end of the Cold War, the EU chose to pursue an integrationist strategy towards former Soviet states involving an indirect approach through encouragement of democratization, human rights, good governance, market economy, in addition to various partnership programs and agreements. Russia, on the other hand, adopted an antagonistic stance towards the partnership programs and launched competing intergovernmental organizations aimed at a reunification of the post-Soviet space in the political, economic and military domains, while rejecting the values promoted by the EU in Russia's 'traditional area of privileged interests', where Russia also exerted diplomatic and economic pressure on the states that demonstrated ambitions for EU and NATO membership. When this approach yielded inconclusive results, Russia switched to a multilateral approach with economic fundamentals and mutual interests as perceived by its partners, involving common markets, joint projects, and a strengthening of security ties with members of the newly created organizations. A lack of compatibility between the two forms of integration pursued by the EU and Russia stems from the mechanisms for setting external tariffs and the competition between different standards and regulations. An earlier cause of the emerging competition between the EU and Russia may be found in the Russian disappointment of the post-Cold War rapprochement with the West, which did not result in a smooth integration into the Western community, nor the expected economic growth. In addition, a fear of political isolation stemming from the expansion of the EU and NATO bore witness of increased Western influence in the post-Soviet space, exacerbating the logic of geopolitical competition (Moga & Alexeev, 2013). The lack of compatibility between the European and Russian-led organizations and their competing ambitions for the post-Soviet space may be an indicator of competitive integration. Competitive integration may serve as a complementary component in future studies of geopolitical competition, by extending the definition of interest incompatibility between states beyond Markowitz and Fariss' definition.

The view of geopolitical competition in terms of influence or integration raises the possibility that the research design and operationalization of the thesis has limitations in its ability to account for all forms of geopolitical competition. Furthermore, this definition of geopolitical competition implies competition of either power or influence over a third party, an aspect which would require a more complex model to quantify and measure. The scope of the thesis is therefore limited by not being able to capture the third-party dimension at all, and not being able to capture influence or its direction. Competitive integration of third-party states into economic, political, or military arrangements as a form of geopolitical competition also escapes the scope of this thesis.

2.2 Air Power

Previous studies of air power have examined bombing campaigns, the use of drones, air superiority, and air power's role and effectiveness in coercive bargaining (Saunders & Souva, 2019; Byman et al, 1999; Post, 2019). I have not been able to find any studies that specifically address acquisition of air power beyond aerial arms races, but there are several studies on acquisition of naval power with relevant theoretical approaches that may prove useful for the study of air power (Markowitz & Fariss, 2018; Anders, Markowitz & Fariss, 2020; Bolks & Stoll, 2000; Crisher & Souva, 2014).

Air power is used in conventional warfare to neutralize an adversary's air power, with a secondary objective of supporting operations on the ground or at sea. Air superiority is nearly a requirement for successful military campaigns since it enables air support to ground- and sea operations, while denying the adversary air force the capability to support its operations in the other domains. As stated by Saunders and Souva: "Air power is the ability to inflict damage on an adversary through the air, and its successful application depends on achieving air superiority. Air superiority enhances both offensive and defensive military operations, improves an actor's ability to mass firepower against an adversary and is often a central aspect of combined arms operations." (Saunders & Souva, 2019:2). Achieving air superiority entails that the opposing force does not have the ability to prohibitively interfere in military operations using air power. As such, air superiority is a critical objective for military operations, and it is primarily achieved by employing fighter aircraft, designed to combat other aircraft (Saunders & Souva, 2019:2-3).

2.2.1 Air power and coercion

In this section I will clarify what strategies may be pursued by states that are able to gain air superiority over an adversary in a bargaining situation. This also serves as a partial explanation of what underlying mechanisms increase the likelihood of success in coercive bargaining, and how air superiority enables exploitation of those mechanisms.

A central finding regarding air power is made by Saunders and Souva, who identify that air superiority increases the likelihood that a state achieves its goals in coercive bargaining (Saunders & Souva, 2019). This is a core finding for the thesis, as it provides an empirical foundation for the advantages a state can expect to attain in bargaining interactions through acquisition of air power. This finding also illustrates the relationship between geopolitical competition and air power and provides the reasoning behind acquisition of air power in a competitive environment. Saunders and Souva's finding that air superiority increases the likelihood of success in coercive interactions fits neatly with Markowitz and Fariss' definition of geopolitical competition, where competition is defined as an increased potential for coercive interactions.

According to Byman et al., the success of coercive operations is often a product of one or more of the following three factors: Achieving escalation dominance, threatening to defeat an adversary's military strategy, and/or by magnifying third-party threats. Air superiority increases the likelihood of succeeding with these coercive approaches (Byman et al.,1999:29), which may partially explain Saunders and Souva's finding that air superiority increases the likelihood of succeeding in coercive interactions more generally.

Air power is particularly useful in achieving escalation dominance in bargaining interactions by reducing the adversary's ability to escalate further. Air superiority enables destruction of the adversary's forces, reducing the opportunities for further adversary military operations. Escalation dominance requires both capacity and will to employ force, the ability to prevent an adversary from escalating, and the ability to neutralize the adversary's counter-coercive measures. Achieving escalation dominance gives control over future costs associated with non-compliance and allows the coercer to manipulate imposed costs at will (Byman et al., 1999:30-36). Threatening to defeat an adversary's military strategy entails rendering the adversary's victory impossible. This decreases the expected benefits of continued non-compliance and reduces the incentives of continued hostile behavior. While such a "denial" strategy is often directed at military targets, it is aimed at making the opponents overall strategy unable to achieve victory. While air power is particularly useful in achieving strategy denial against opponents engaging in conventional warfare, it is less effective against opponents that have adopted an asymmetric guerilla strategy (Byman et al., 1999:37-39). While coercion often relies on direct military action, magnifying future third-party threats also shape an adversary's expectations of costs. These third-party threats can be either internal or external, and successful coercive strategies may magnify these threats by reducing the adversary's ability to handle them. This approach is often effective against regimes that rely on the repressive capability of the state to maintain power (Byman et al., 1999:39-43). The relationship between air superiority and these avenues for manipulating costs and expected benefits highlights the relevance of air power in bargaining interactions. They serve as the underlying mechanisms states could exploit using air power and explain why air superiority is associated with a higher likelihood of achieving success in bargaining situations.

Air power is rapidly deployable, which is especially important for major powers that have regional or global interests that need protection, and air power makes rapid response to crisis situations possible (Khalilzad et al., 2002:33). In a bargaining theory perspective, air power gives decision-makers options in coercive bargaining, options that are available early and can be deployed rapidly. This point is important for major powers like the U.S. who have global interests but cannot have permanently deployed forces everywhere. Air power enables the state to respond rapidly with signals – such as major deployments of aircraft – to either coerce or avoid coercion in bargaining situations.

Post's work on air power and crisis bargaining tempers the alleged effectiveness of air power in bargaining situations. Aircraft deployments can be cheaper than deploying land forces or naval forces when considering financial costs and especially when considering potential human costs. This also reduces the political costs of using air power. The relatively low cost of using air power can be a detriment for signaling in coercive bargaining interactions, since it can convey a lack of resolve compared to using land or naval forces. Since deployments of land forces or naval forces often entail a higher financial cost and generally risk the lives of more personnel such deployments may be considered stronger signals than deploying aircraft. Signaling with air forces display a lack of resolve compared to signaling with land or naval forces and are less likely to produce compliance with coercive threats (Post, 2019). The fact that air power is less effective in coercive bargaining situations implies that rational states would not acquire or deploy air power alone to prevent or conduct coercion.

Air power – and other forms of national power – serves as a measure of relative power between states. This thesis tests the proposition that states seek to shift this balance of power in their favor, especially under conditions of geopolitical competition.

2.3 The CINC and disaggregated military power

Earlier studies have often used the Composite Index of National Capability (CINC) to measure national power. The CINC measures national strength within three categories: military, economy, and demography. The two military variables included in the CINC are the number of military personnel and the military expenditure of the state. CINC measures economic power by measuring iron and steel production and energy consumption, while demographic measures include the total population and the urban population (Singer et al., 1972). There are a few issues regarding the CINC that may be alleviated by using more direct measures of military power, such as air power. First, the CINC is a measure of *potential* military power, as it includes a set of variables that capture broader capacities of a state which do not directly reflect national military power but can be transformed into military power. The second issue is that military expenditure does not always allow for direct comparison between states. Some states include for example pensions for military personnel in their budgets, while other states do not, which may serve as an illustration that an increase in military expenditure does not always result in an increase in national military power. Using a direct measure of military power may increase the validity of the study (Bolks & Stoll,2000:583). Third, using a raw measure of military personnel or expenditure does not account for the technological developments in the post-WWII period. Comparing these does not necessarily reflect the military capabilities of armed forces, since one state may have equipment that acts as force multipliers, such as modern combat aircraft, that another state may not have access to. The main benefit of using a disaggregated measure of military power is that it does not conflate measures of economic, demographic, and military power.

I argue that air forces, like navies, are less suited for repressing domestic insurgencies or rebellions compared to armies (Markowitz & Fariss, 2018b). Air power may be used to support for example counter-insurgency operations, but they are primarily intended to fight external military forces. While autocracies may maintain standing armies intended to repress potential unrest, I argue that this is not the case for air power. Air power is mainly intended to either demonstrate power or sovereignty, or to defeat external military threats. Therefore, the relationship between geopolitical competition and air power is likely more relevant than the relationship between geopolitical competition and military personnel and/or military expenditure more generally, which may include standing armies and other security forces. Using air power as a dependent variable therefore enhances the validity of the study, compared to using either the CINC or the latent power-variables that are part of the CINC.

2.4 Research gaps and the role of this thesis

To summarize, this thesis tests a new implication of Markowitz and Fariss' theory that geopolitical competition leads to acquisition of naval power projection by extending it to the acquisition of air power. To the best of my knowledge, this is the first study of the relationship between geopolitical competition and acquisition of air power, either quantitatively or qualitatively, and the thesis seeks to fill that gap in the literature. It is also one of very few quantitative studies of air power, while most other studies are qualitative in nature. I seek to strengthen Markowitz and Fariss' argument that states acquire power projection capabilities by narrowing the time period from 1865-2011 to 1974-2013 and testing their proposition on a different form of power projection capability. By examining disaggregated military capacities, the thesis also seeks to circumvent the issues related to the CINC index, such as the conflation of economic and military power.

3 Theory

In this chapter I will introduce the theoretical framework for the thesis, starting with a discussion of the relationship between air power and geopolitical competition, and how bargaining theory provides a causal mechanism for the dynamics between competition and air power acquisition. I will then present the main hypothesis. The chapter ends with a discussion of alternative explanations for air power acquisition, and presentation of the alternative hypotheses.

3.1 Geopolitical competition and air power

Geopolitical competition is defined as the potential for coercive bargaining interactions between each state and the other states in its geopolitical environment. For each state, as the potential for coercive bargaining increases, so does the level of geopolitical competition (Markowitz & Fariss, 2018:4).

Interest compatibility defines the potential for shared interests between states, which theoretically reduces the potential for escalation of disputes, and is operationalized primarily through regime type. One of the underlying theories is the democratic peace theory, which posits that democracies tend to not fight one another, Numerous studies show this to be true, especially for the post-WWII period (Gartzke, 2007:168), which supports the expectation that democracies are more likely to share interests. This allows Markowitz and Fariss to theorize that dyads where at least one party is non-democratic are less likely to share interests, and that democratic dyads are more likely to have shared interests. They cite two sets of explanations for this. The first relies on democratic political institutions that constrain incentives to pursue private goods such as rents and territory by force (Lake, 1992, in Markowitz & Fariss, 2018). The second explanation relies on shared norms between democracies, which shift the states' preferences towards public goods such as civil liberties, political rights, transparency, prosperity, and (most importantly) peace (Bueno de Mesquita et al., 2003, in Markowitz & Fariss, 2018). This second school also includes public opinion as a constraint in democracies regarding potential conflict with other democracies, and that this opinion largely is shaped by perceptions of threat and morality rather than expected costs associated with war (Tomz & Weeks, 2013). Both the constraints and preferences of democratic executives reduce the probability of militarized disputes between democracies, which in turn allows Markowitz and Fariss to theorize that there is a lower probability of coercive interactions between democracies and therefore lower levels of geopolitical competition (Markowitz & Fariss, 2018). It is unlikely that for example Sweden and the Netherlands will escalate disputes to the level of militarized coercive interactions. Both the constraints on the executives and the preference for public goods – such as peace – in both countries serve to reduce the likelihood of escalation. These restraining factors do not necessarily apply when one or both countries are non-democracies, because one or both executives do not face the same constraints nor preferences that a democratic dyad would. As a sidenote, findings on executive constraints in various authoritarian regime types (Weeks, 2012) may also be relevant since they also can explain differences that regime types may generate in interstate coercive behavior and conflict.

Joint democracy is not a perfect proxy for interest compatibility. Democracies may have diverging interests with other democracies and non-democracies may share interests with other non-democracies or democracies. Gartzke finds that capitalist states are more likely to settle disputes with other capitalist states peacefully (Gartzke, 2007). Similarly, Mazumder finds that autocracies are more likely to settle disputes peacefully if they are embedded in preferential trade agreements (Mazumder, 2017). These findings indicate that there are alternative avenues of interest convergence beyond joint democracy. While democracies are less likely to fight one another that does not equate to having perfectly aligned interests, as may be illustrated in disputes between democracies, such as between Norway and Finland in 1976-77 regarding German NATO forces in Norway (Gleditsch, 1992). In sum, joint democracy does not provide a comprehensive guide for interest compatibility, which may weaken the validity of this study.

The operationalization of interest compatibility also includes measures of geographical distance and economic power. The closer states are, the higher the potential for coercive interactions. Geographical distance limits how threatening states perceive each other by limiting the opportunities for interstate interaction, and thus the potential for coercive interaction, although states with sufficient resources and technology have the capability to act far beyond their borders (Boulding, 1962, in Gleditsch & Ward, 2001:754). For instance, if South Africa were inclined to exert military pressure on Mongolia that would require a force structure capable of transporting, supplying, and conducting military operations on or over Mongolian territory in a coercive bargaining interaction. South Africa does not have this capability, due to the distance between the two states and the lack of power projection capabilities. Geographical distance also gives reason to include the economic power of states when considering the potential for coercive interactions. Economic power can potentially be transformed into military power, making states with major economies more threatening to other states, especially when there is a lack of interest compatibility and even over greater distances (Markowitz & Fariss, 2018). This may be exemplified by the US military operations in both Afghanistan and Iraq, where the US (and NATO) deployed military forces across great distances. This would not be achievable without costly power projection capabilities, such as navies and air forces, which highlights the interaction of economic capacity and distance in the estimation of the potential for coercive interactions. Operationalizing interest compatibility in this manner allows the research design to distinguish between states that are threatening and those that are not, which is a departure from structural realisms view that all states are threatening to each other. More on the operationalization of geopolitical competition will follow in a later chapter.

The thesis relies on bargaining theory as an underlying mechanism, by assuming that states wish to improve their chances of winning wars by acquiring air power, thereby improving their position in current and future negotiations. Interest incompatibility with economically powerful, proximate states is the second mechanism that drives states’ acquisition of combat aircraft since it creates a competitive environment in which coercive bargaining interactions are more likely to occur.

3.1.1 Bargaining theory

Bargaining theory posits that war is irrational and inefficient in terms of costs and benefits, and that rational leaders with full information therefore should seek negotiated agreements in pre-war bargaining. There should always exist a bargaining space for negotiated settlements, and war is a sub-optimal solution in terms of cost-benefit calculations. Central considerations in bargaining theory are the costs and risks associated with war, the expected benefits associated with war compared to negotiated settlements, and under what circumstances war may be rationally preferable to a negotiated settlement. The states will consider the costs, benefits, and the probability of achieving a military victory which may yield the desired benefits. The probability of victory is determined by the relative strength between the opponents, in addition to the relative resolve or willingness to fight. Fearon posits that wars are inefficient due to the costs associated with war, and that wars are the result of lack of information or miscalculation about the adversary's willingness to fight or the likely outcome of war, or lack of credible commitment to a negotiated settlement. Leaders may be unable to reach a negotiated settlement due or private information about relative capabilities or resolve, and leaders may be incentivized to misrepresent such information to gain a better deal. A lack of credible commitment to a negotiated settlement occurs when one or both parties have incentives to renege on the terms of the settlement (Fearon, 1995).

The thesis is drawing on bargaining theory as a causal mechanism, especially regarding the likely outcome of war and the willingness of states to engage in conflict. Higher levels of geopolitical competition entail that states face a higher potential for coercive bargaining interactions with other states. States that face a higher potential for such bargaining interactions are therefore incentivized to acquire air power to strengthen their position in bargaining interactions, thereby avoiding being coerced, or enabling themselves to coerce the other party by shifting the balance of military power and increasing the likelihood of winning a potential war. The acquisition of aircraft may thus serve as a deterrent, to ensure that other states do not achieve power preponderance and become able to defeat the state in a military contest or become able to impose costs on the state with impunity. The incentive to acquire combat aircraft is moderated by the financial costs of acquiring enough aircraft to credibly establish or contest air superiority over the adversary. The financial cost of acquiring aircraft may be justified by the risks associated with being coerced or the cost of losing a war if one did not invest in combat aircraft. In other words, any state in relative vicinity of an economically powerful, non-democratic state is incentivized to acquire sufficient air power to avoid coercion.

I argue that the operationalization of geopolitical competition as interest incompatibility is able to account for interstate relationships where at least one of the parties has a relatively higher willingness to fight due to having a non-democratic regime type. This entails that the non-democratic state is more willing to enter coercive bargaining interactions and faces less constraints when deciding to escalate such interactions to military action which necessitate military power, and air power in particular.

3.1.2 Hypothesis

Markowitz and Fariss posit that states need power projection capabilities to engage in coercive bargaining with other states. They define power projection as the deployment of military force beyond a state's borders or territorial waters and power projection capabilities as the force structure required to deploy military force over distance. Coercive bargaining is politics with the threat of war. To credibly threaten war, states must be able to project power, which requires investment into power projection capabilities (Markowitz & Fariss, 2018). For the thesis this entails that potential belligerents will evaluate relative air power, in particular the capability to achieve air superiority when considering the credibility of conventional military threats and the expected outcome of conflicts. The underlying mechanism driving states' acquisition of military power is that states acquire military power to either coerce or avoid being coerced in bargaining interactions with other states (Diehl, 1985:250), and that this mechanism extends to air power. The thesis relies on the same set of theory and methodology as Markowitz and Fariss (2018). Fearon's (1995) bargaining theory is fundamental in both by providing the causal mechanism for Markowitz and Fariss' theory that a competitive political environment encourages acquisition of military capabilities. Both their article and this thesis draw on the democratic peace theory by assuming that interest compatibility is affected by political regimes, and on structural realism by assuming that geographical proximity and the distribution of power influences the level of geopolitical competition (Markowitz & Fariss, 2018).

To test these assumptions regarding the interaction between geopolitical competition, bargaining theory, and air power the hypothesis is as follows:

H_1: An increase in the level of geopolitical competition a state faces will lead to an increase in the state's acquisition of air power

3.2 Alternative explanatory theories

Geopolitical competition is only a partial explanation of why states choose to acquire military power, and I will give a short overview of the theories on arms procurement and arms races. This will provide alternative explanations and hypotheses as to why states may choose to acquire military capabilities or armaments. The alternative theories presented here are largely complementary between themselves and to the theory that geopolitical competition leads to air power acquisition. None of the theories are exclusive in the sense that they preclude explanations derived from other theories, including geopolitical competition.

3.2.1 Action-reaction model

The action-reaction model serves as the basis of most theories on arms races. It posits that states acquire armaments because of the threats the states perceive from other states. Arms acquisitions in potentially hostile states is the primary cause for states' arms acquisitions. This interaction is most clearly exemplified by the naval arms race between Great Britain and Germany prior to WWI. Germany decided to invest in a fleet capable of projecting power across oceans and Britain reacted to this by introducing a more powerful type of warship, and later by producing a higher number of those warships relative to Germany. Britain's naval construction program was linked to the rate of shipbuilding in Germany. Buzan and Herring argue that the action-reaction model is not dependent on technological innovation which causes continual improvement in military technology. But if such innovation exists, it becomes part of the action-reaction process. (Buzan & Herring, 1998:83-84) This is applicable to the development of new generations of combat aircraft, where states may compete to acquire a relative advantage over an adversary in qualitative terms, in addition to a relative advantage in quantitative terms. Glaser argues that arms races are a result of repeated cycles of arms buildups, which may continue indefinitely. Arms buildups and arms races may also occur because of “greedy” states, and not because of security concerns. A greedy state may seek to acquire the capability to compel or coerce concessions in armed conflict, while the other state acts in reaction to such an arms buildup which may lead to an arms race. (Glaser, 2000:253-256) Saunders and Souva identified two likely aerial arms races following the action-reaction approach; the first between the US and the USSR, and the second between India and Pakistan, both in the 1980s. (Saunders & Souva, 2019:15-17) This makes it likely that the action-reaction model is able to explain at least these situations. It is also possible that the action-reaction model can explain less dramatic increases or decreases in the states’ inventories of aircraft, outside of arms races. Arms races occur at certain junctures of rivalries, and arms races probably do not occur outside of rivalries, even though not all rivalries will involve arms races. (Goertz & Diehl, 1993:155-156) The action-reaction model and arms race theories rely on the interaction between two potentially hostile states, and in particular their arsenals and inventories of weapons systems. I will test the theory that the action-reaction model causes acquisition of combat aircraft, and the theory will serve as the foundation for an alternative hypothesis. I will return to how I will test this alternative hypothesis in the research design chapter.

The action-reaction theory differs from the geopolitical competition theory in two ways: First, the threat component is defined by changes in relative military capabilities rather than economic capacity. This is illustrated by the Anglo-German naval arms race which was symmetrical in the sense that the competition was responded to within the same domain i.e., Great Britain responded to German shipbuilding efforts and vice-versa. This direct relationship is not defined as geopolitical competition, which defines threat within the economic sphere, which naturally is not directed towards a potentially hostile state. This leads into the second difference between geopolitical competition and the action-reaction theory, namely that geopolitical competition explicitly defines potentially hostile states while the action-reaction theory does not. Even though Richardson posited that action-reaction dynamics should only take place between potentially hostile states, he did not provide a means of identifying such states (Richardson, 1960). This shortcoming is theoretically addressed by the geopolitical competition theory by operationalizing interest incompatibility through regime type and the absence of joint democracy between two states.

By examining the relationship between geopolitical competition and air power acquisition this thesis will contribute to arms procurement and arms race theories indirectly, by stepping away from the notion that arms buildups are exclusively dependent on a potential adversary's buildups or drawdowns in armaments inventories. Interactions of this kind do not explain why the states choose to react to changes in some states' inventories, while arms buildups or drawdowns in other states do not warrant a reciprocal buildup or drawdown.

3.2.2 Domestic structure model

The domestic structure model presents arms acquisition as something caused by forces within the state, and Buzan and Herring argue that the domestic structure model does not replace the action-reaction model, but rather complements it. The domestic structure model posits that arms acquisition processes become deeply institutionalized within the state, and that these institutions over time become insensitive to current interstate action-reaction considerations. Interstate hostility and rivalries still provides motivation for continued arms acquisition, but when the "reactions" become anticipatory of arms build-ups in hostile states, the state has structured itself for arms acquisition. Under such conditions, the state may also acquire military capabilities for prestige or to reinforce the government's hold on the country, rather than responding to external threats (Buzan & Herring, 1998:101). These institutions may also have an interest in promoting military research and development and can therefore become a driving force in arms acquisition. The military may also have an interest in maintaining production capability, and may therefore support research, development, and production of arms to ensure future production capability (Glaser, 2000:257).

Domestic politics may explain acquisition of combat aircraft, especially when considering the potential for continuation of aircraft development and production as a lingering effect of the Cold War. The domestic structure model posits that arms acquisition processes become institutionalized, and that the institutions become more autonomous, self-interested, and able to influence arming decisions. In other words, the structure of the state facilitates arms acquisition (Buzan & Herring, 1998). An explanation within the framework of the domestic structure model would entail that the development and production of combat aircraft would be less sensitive to external threats, and that the process of air power acquisition is driven by the structure of domestic institutions. These institutions could include the military-industrial complex, the military, and other entities that have organizational or economic interests in continued air power acquisition. Governments themselves may also seek to further domestic economic interests, like as Truman did following the end of WWII, when he exaggerated the threat of a Soviet invasion of Europe to secure congressional funding of the U.S. aircraft industry (Kofsky, 1995, in Buzan & Herring, 1998:107). Buzan and Herring also found that there was a dramatic cut in global arms research and development spending following the end of the Cold War, which is incongruent with the theory (Buzan & Herring, 1998:105-107). One could potentially test this hypothesis using this research design, by measuring military-industrial complexes influence on states' arms procurement processes. However, this falls outside the scope of the thesis, mainly due to a lack of data on such procurement processes.

In their article on internal and external constraints on naval arms race dynamics, Bolks and Stoll found that internal factors influenced armament decisions, but that these effects were limited compared to external competition and hostility between states (Bolks & Stoll, 2000:581). For this reason I have chosen to focus on external causes of arms procurement.

3.2.3 Symbolic politics

Buzan and Herring argue that acquisition of weapons systems is not always dependent on the military utility those weapons may serve, but rather their symbolic utility. The USAs and the USSRs acquisition of vast nuclear arsenals serve as an example, where there were no obvious gains in the ability to use force or threats beyond that offered by far smaller nuclear arsenals. This dynamic has been observed in other countries with different types of weapons as well, such as the oil-producing states in the Gulf acquiring high-technological military equipment following the invasion of Kuwait by Iraq. The Gulf states did so, even though small and high-technological militaries have proven ineffective at deterring or providing denial capabilities against states like Iraq. These types of arms dynamics show that states acquisition may be explained by other things than the weapons' military utility. Buzan and Herring argue that these arms acquisitions were cases of symbolic politics, where the US and the USSR sought to establish symbolic superiority over each other, while the Gulf states sough to symbolize their sovereignty. Even though the weapons were less useful at achieving their military objectives, they were effective at achieving their symbolic purposes. (Buzan & Herring, 1998:179-180) Arms acquisition may also play a symbolic role during disputes, where the acquisition of arms may be used to signal resolve, such as the U.S. did during the Berlin Crisis in 1961 (Buzan & Herring, 1998:88-89). Arms acquisition in coercive bargaining interactions to signal resolve may serve a complementary role to the theory of geopolitical competition. Extending this argument, symbolic politics may serve as a means of communication and mode of bargaining while geopolitical competition serves as a foundational or structural explanation of why such interactions occur in the first place. While both theories may provide insights regarding bargaining interactions they operate on different levels of analysis, with symbolic politics often examining political actions such as armaments acquisition, narratives, and their causes on a case-by-case basis. Geopolitical competition posits that these interactions occur due to institutional incompatibilities between states, approaching a systems-level theory that does not account for case-by-case studies. In this sense, geopolitical competition and symbolic politics (when applied to inter-state bargaining) are complementary.

Symbolic security politics is often founded on a need to reassure the population, such as when fear of nuclear attack may spur the development of anti-ballistic missile (ABM) systems that are designed to prevent such attacks. The actual capability of the system to prevent such attacks may be questionable, but the symbolic effect depends on the system's capability to provoke feelings, rather than on the capabilities of the system. This dynamic also takes place between countries, where military activities such as demonstrations or displays of capabilities may serve to reassure allies or to increase the credibility of one's threats to opponents (Buzan & Herring, 1998:182-183). These dynamics may contribute to states' acquisition of air power, not because of the military utility of air power or for other purposes, but because of the symbolic utility of acquiring combat aircraft. Examples of modern combat aircrafts' symbolic utility may include demonstrating that the state is technologically and economically advanced, that the state is capable of maintaining its own sovereignty and independence, or to demonstrate superiority over a competing state. It is important to note that the demonstration of superiority does not necessarily imply military superiority, but rather technological and technical superiority that enables development and acquisition of qualitatively superior aircraft compared to the competitor. Given air power's importance in interstate warfare, demonstrations of superiority within the field of air power may contribute more to symbolic utility relative to land and possibly sea power. Acquisition of air power requires considerable economic capacity and technological capability, and acquisition of advanced combat aircraft may serve as symbols for that capacity and capability. Acquisition of air power as a consequence of symbolic politics will not be tested empirically in the thesis, but I will assume that it is an active causal mechanism in some cases, such as in the example of the Gulf states acquiring high-technological armaments following Iraq's invasion of Kuwait.

3.2.4 Military application of civil technology and the international arms trade

Buzan and Herring argue that general advancement of technology of both civil and military application and its diffusion through the international arms trade has accelerated the need to develop weapons systems. For instance, development of new generations of combat aircraft and their diffusion through international arms trade may incentivize states to develop and acquire newer generations of combat aircraft. Arms producing states only rarely have a sufficiently large domestic market to make large-scale production of increasingly advanced weapons systems economically viable, and that this results in a need to export advanced weapons systems to countries that do not have the capability to produce those weapons systems. There may also be political reasons to export advanced weapons systems. This arms trade has consequences for competing states of the countries that import advanced weapons systems, and for the states that are exporting weapons systems. The competitor states of an arms importer are incentivized to acquire weapons systems that are competitive and are in most cases reliant on importing such weapons systems themselves. As a result of this diffusion through the arms trade, the arms producing countries are incentivized to develop ever more advanced and expensive weapons systems to ensure a qualitative advantage in military technology against potential rivals. This dynamic of development and exporting of advanced weapons systems may result in a self-reinforcing cycle of demand and supply for advanced weapons systems (Buzan & Herring,1998:29-52). As an example, the diffusion of the 4.5 generation F-35 aircraft may incentivize states outside NATO to develop and acquire combat aircraft that are able to credibly challenge it in combat. The diffusion may also incentivize the USA to retain the fifth-generation aircraft F-

22 for exclusively domestic use, or to develop an even more capable aircraft to ensure the continued qualitative advantage when competing states develop their own fifth generation aircraft. The effect of the arms trade on technological development and acquisition of air power will not be empirically tested in this thesis due to data availability issues. If data on aircraft transfers becomes available, it could be possible to test the theory quantitatively.

3.2.5 Alternative hypotheses

	Causal mechanism	**Indicators**
Action-reaction model	Arms procurement as a reaction to arms procurement in potentially hostile states	Interactions between the arms inventories of potentially hostile states
Domestic structure model	Domestic institutions associated with arms acquisition able to influence arming decisions	Domestic arms acquisition processes, and which institutions are influencing the results of the processes
Symbolic politics	States acquire arms for symbolic purposes, such as demonstrating superiority or parity with a competitor, or to demonstrate sovereignty	Arms acquisition and their narrative framing
Technological development and arms trade	Diffusion of military technology through arms trade incentivizes further arms development	The effect of arms trade on the development of increasingly capable weapons systems
Geopolitical competition	Arms acquisition as a result of proximity to economically powerful non-democratic states that are likely to engage in coercive bargaining	GDP, regime type, distance

Table 1: Summary table for the theories on armaments acquisition

There are two alternatives to the hypothesis that geopolitical competition leads to acquisition of combat aircraft, based on the theories in the table above:

H_{A1}: Action-reaction dynamics i.e., acquisition of air power by potentially hostile states cause states to acquire air power.

H_{A2}: The domestic structure model, symbolic politics and/or technological development and arms trade cause states to acquire air power.

H_{A1} is intended to test the action-reaction model’s effect on acquisition of air power and is directly testable within the chosen research design and with the available data. I will present how I test this hypothesis in a later chapter. Unfortunately, the other three theories, the domestic structure model, symbolic politics and technological development and arms trade face challenges both in data availability and feasible incorporation into the research design. Therefore, I have chosen to gather potential hypotheses derived from these theories into a single alternative hypothesis *(H_{A2})*. Determining which of the alternative theories in H_{A2} is best able to predict acquisition of air power is not testable with this research design, but I assume that the unexplained variance within the geopolitical competition model and/or the action-reaction model is explained by one or more of these theories. This is not a strong assumption, and future studies on these theories may shed light on this issue.

4 Research design

The research design in this thesis is a quantitative study of most countries in the world, with the goal of determining the effect geopolitical competition has on acquisition of air power, using different types of statistical models to estimate the effect. The study is a large-n study a measure of the priority afforded to acquisition of air power as dependent variable, and an variable over geopolitical competition as independent variable.

I will test the alternative hypothesis that action-reaction interactions between states' level of air power cause acquisition of air power using the same method.

This rest of the chapter will cover the data, a discussion on the statistical models I use, the operationalization of air power and geopolitical competition, in addition to control variables. I will then present the operationalization of the action-reaction model.

4.1 Data

The main dataset is compiled from three sources covering air power (Saunders & Souva, 2019), geopolitical competition, regime type, GDP (Markowitz & Fariss, 2018), and geographical distance between states (Gleditsch & Ward, 2001). The dataset is monadic, with country-years as the unit of analysis, and include 4510 observations from 1973 to 2013. Less than 7 % of the observations are missing and will most likely not pose any major issue for the model estimations. The analysis builds on a dataset that is unbalanced, consisting of observations of 157 states over 40 years, with varying degrees of coverage per state.

4.2 Statistical models

I use two different types of models to test the association between geopolitical competition and acquisition of air power. The first set of models are binomial count models over different generations of combat aircraft. The second set of models are regressions with fixed effects on countries and years, in addition to pooled OLS-models. These models combined should be capable of establishing the relationship between geopolitical competition and acquisition of air power. In this section of the research design chapter I will give a short discussion of the models, the assumptions they make, and what measures I will take to accommodate those assumptions.

4.2.1 Negative binomial count models

Markowitz and Fariss apply negative binomial models to estimate the effect geopolitical competition has on the number of different types of warships (Markowitz & Fariss, 2018). I will apply the same method on the number of aircraft of different generations. The naval power data Markowitz and Fariss use is similar to the air power data provided by Saunders and Souva in that they are structured as count data. As an example, this sort of data may count number of items or events occurring within a period of time or over a number of periods (Hilbe, 2014:2).

The model used to produce estimates on count data are dependent on the distribution of the data, typically either the Poisson distribution or the negative binomial distribution. A Poisson-distribution assumes that the data is not overdispersed, i.e., that the variance does not exceed the mean. The data I analyze do not meet this requirement, which is confirmed by formal overdispersion-tests. This may be remedied by applying a negative binomial model, which includes an estimate of the overdispersion, and is able to adjust for Poisson overdispersion (Hilbe, 2014:7-16). Since Markowitz and Fariss apply negative binomial models on their count data, and that the data I analyze is overdispersed I choose to conduct negative binomial regression for the analysis of the count data.

As a part of the robustness checks I will omit the USA from the analysis, and I will conduct analyses within certain time periods to account for specific aircraft generations' technological primacy or obsolescence. For example, aircraft of generations 3 and 3.5 were mostly withdrawn from service in large numbers by the mid-1990s, and thus an analysis with generation 3 and 3.5 will be conducted from 1973 up until the mid-1990s. Aircraft of generation 4 were introduced in substantial numbers by 1980, and thus an analysis of generation 4 will be conducted from 1980 up until the introduction of generation 4.5 in substantial numbers in 1993. A further analysis will be conducted with data ranging from 1990 until 2013.

To replicate Markowitz and Fariss' work as diligently as possible and to triangulate the estimates from the negative binomial models I also estimate panel models, featuring ordinary least squares estimators with and without fixed effects.

4.2.2 Regression with panel data

Fixed effects regression is a method that controls for omitted variable bias when the omitted variables vary across countries and/or time. For country fixed effects these may be unobserved variables that are constant over time but vary across states. Year fixed effects control for omitted variable bias that arises from unobserved variables that are constant across states but vary over time (Stock & Watson, 2012:396-403). The country fixed effects models I will use will control for unobserved variables that cause omitted variable bias, such as attitudes that do not change over time towards geopolitical competition and/or air power that are based on culture, history, or traditions. Year fixed effects will control for unobserved variables that vary over time, for example global geopolitical or economic shocks. Omitted variable bias will remain an issue within the models, even after fixed effects are applied.

Four issues need to be handled when applying OLS on panel data: Endogeneity, autocorrelation, trends, and heterogeneity. The OLS models I use are autoregressive, include a lagged independent variable, and feature clustered standard errors. These measures combined should – at least to some degree – handle the issues of autocorrelation, contemporaneous correlation, and heteroscedasticity (Christophersen, 2018:168-171).

I will perform robustness checks on the panel models by using an alternative dependent variable, alternative control variables, using a reproduced independent variable and by excluding extreme outliers, such as the USA.

4.3 Operationalization of geopolitical competition

The geopolitical competition variable has three components: First, a preference component which determines whether the states can cooperate on common interests or whether they are likely to engage in coercive behavior over diverging interests. As noted above, this is proxied by democracy. Interest incompatibility is present when one or both states are non-democracies, and therefore are more likely to engage in coercive behavior. The second component is a measure of the state's economic power, its gross domestic product (GDP). The GDP determines what level of latent threat the state can pose to other states, by converting its economic power into military power. The higher the GDP of the state, the higher potential threat it is capable of projecting towards other states. The third component is the distance between capitals. Distance limits the potential threat states pose to each other. The farther the distance between the countries, the less capable they will be at employing military power, which reduces the potential threat they pose to each other (Markowitz & Fariss, 2018; Anders, Markowitz & Fariss, 2020).

$$Competition_{it} = \frac{\Sigma_j \left(\frac{g_{jt}}{\Sigma_j g_{jt}} \times \ p_{ijt} \times w_{ijt} \right)}{\Sigma_j w_{ijt}}$$

The equation above developed by Markowitz and Fariss is used to determine the level of geopolitical competition state *i* faces in year *t*. The geopolitical competition variable's interest incompatibility component *(p)* is modelled when at least one state in the dyad is non-democratic, operationalized with a Polity score below 6, resulting in *p = 1* in the equation above, whereas joint democracy would result in *p = 0.* The economic capacity component *(g)* of the other state *j* is measured by its GDP, which is then divided by the sum of all states' GDP in year *t*, yielding state *j*'s relative economic capacity. The inverted distance component *(w)* is expressed as $\frac{1}{\ln{(km)}}$, where *(km)* is the distance in kilometers between the capitals in the dyad. The sum of these components is then divided by the sum of distances between all capitals in that year, yielding the sum of competition a state faces per year (Markowitz & Fariss, 2018).

Markowitz and Fariss constructed the variable in a dyadic dataset according to the equation above. This approach provides an aggregated figure for the sum of competition a state faces in a year, which enables analysis of country-level characteristics, and their effect on air power acquisition (Markowitz & Fariss, 2018; Markowitz & Fariss, 2018b).

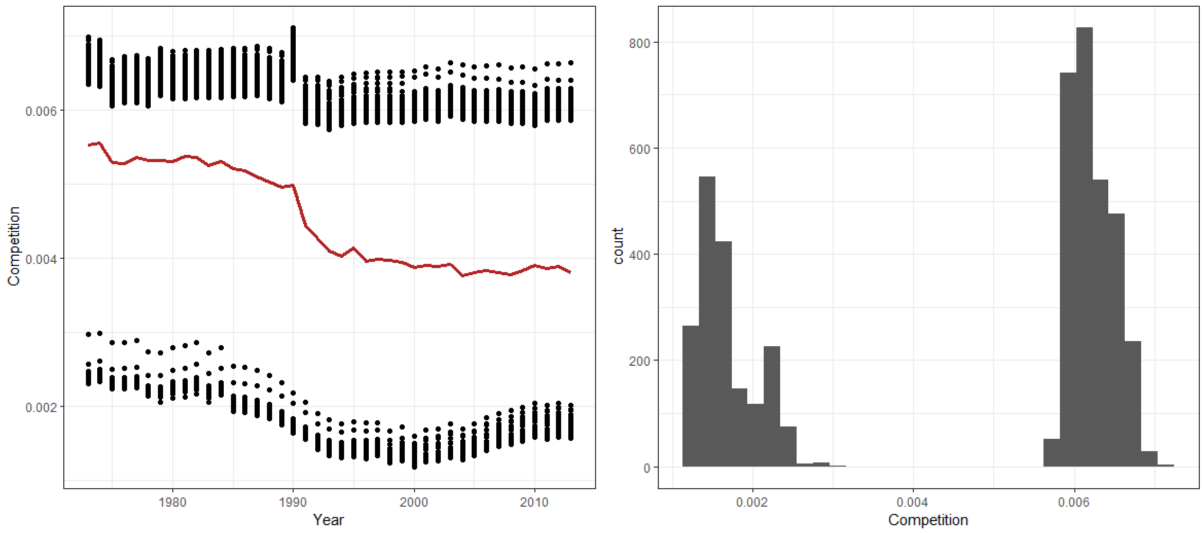

Figure 1: The independent variable geopolitical competition over time on the left, with point plot and mean per year (red line). Histogram on the right. (Markowitz & Fariss, 2018)

As can be seen from the graph above, the geopolitical competition variable is sensitive to the reduction in geopolitical competition associated with the end of the Cold War around 1990, which lends the measure face validity (Markowitz & Fariss, 2018). Technically, the reduction in competition is most likely a result of the "third wave" of democratization that took place between 1974 and 1990 (Huntington, 1991). The histogram indicates that there is bimodality in the level of competition states face, with the states facing higher levels of competition being proximate to economically powerful, non-democratic states, while the states facing lower competition are geographically distant from those states, or that the non-democratic states they are proximate to have less economic power. The validity of the competition variable will be discussed later in section 4.8.1.

4.3.1 Reproduced geopolitical competition

The operationalization of geopolitical competition above was produced by Markowitz and Fariss. As part of the robustness checks, I reproduced the geopolitical competition variable using data collected from Markowitz and Fariss, Gleditsch and Ward, in addition to data from Saunders and Souva. The reproduced geopolitical competition variable is computed in the same manner as Markowitz and Fariss' original variable, but the new variable includes states that were not part of the original variable. This should alleviate potential sampling issues associated with the original competition variable.

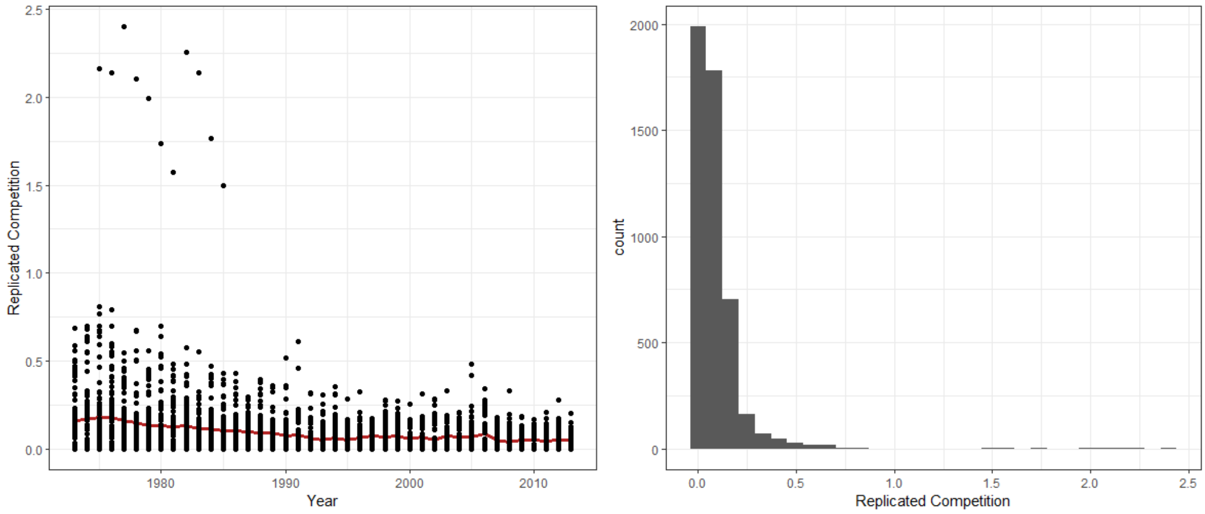

Figure 2: Replicated geopolitical competition variable over time on the left, with point plot and mean per year (red line). Histogram on the right. Constructed using data from Markowitz and Fariss (2018), Gleditsch and Ward (2001), Saunders and Souva (2019)

The evolution of the reproduced geopolitical competition variable does not reflect the reduction in geopolitical competition associated with the end of the Cold War in the same way that Markowitz and Fariss' variable does. The reproduced variable does not feature a sharp decline in competition around 1990, or any other point in time. There is a gradual decline in the average competition from the mid-1970s until it stabilizes around 1993. This may be a result of differences in sampling, i.e., which countries are included. The reproduced geopolitical competition variable is constructed around Saunders and Souva's dataset which was intended to account for air power in the period 1973-2013 (Saunders & Souva, 2019). Markowitz and Fariss' data was intended to account for geopolitical competition's effect on acquisition of naval power projection capacities in the period 1865-2011, which may explain the differences in sampling. The distribution is right-skewed, rather than bimodal as the original variable.

Yugoslavia is an outlier in the replicated geopolitical competition variable, and all observations with values above 1 belong to Yugoslavia, and I will exclude Yugoslavia from the analysis due to these extreme values.

4.4 Operationalization of air power

Saunders and Souva have specified six distinct generations of combat aircraft, ranging from generation zero to five. Each generation is defined by prominent characteristics that heavily influences the combat effectiveness of aircraft. These characteristics include the sophistication of the aircraft's avionics equipment, the top speed of the aircraft, the presence and sophistication of radar systems, the range and sophistication of weapons systems, and the level of stealth technology employed. Each generation represents a significant improvement in one of these characteristics compared to earlier generations, which is reflected in combat records. The expanded typology includes "half-steps" in generations (1.5, 2.5, 3.5 and 4.5) to identify aircraft with characteristics that straddle generations and have limited or partial implementation of later-generation characteristics (Saunders & Souva, 2019:5-9).

The number of aircraft within each generation per country-year will be used as dependent variables in the count models presented later.

Generation	**Example**	**Characteristics**
0	P-51D Mustang, A-1D Skyraider	Piston-driven engines, propellers. Armed with cannons, free-falling bombs, unguided rockets
1	F-80 Shooting Star	Early turbojet engines. Not supersonic speeds. No radar. Armed with cannons, unguided weapons. Major improvements in speed and maneuverability compared to generation 0
1.5	A-37, J-5, L-59	
2	MiG-15, F-86	Swept-wing design. Not supersonic speeds. Range-finding radar. Short-range guided missiles. Major improvements in weapons systems compared to generation 1
2.5	MiG-19, F-5E/F	
3	F-104, MiG-21	Sustained supersonic speeds. Missiles capable of beyond visual range (BVR) engagements. Missile illumination radar. Not capable of reliable below-the-horizon engagements
3.5	F-4 Phantom II	
4	F-16, F-15, MiG-29	BVR capable. Fly-by-wire avionics and computer-integrated flight control systems. Advanced pulse-Doppler radar allowing reliable below-the-horizon engagements
4.5	F-15E, F/A-18E/F, Su-35, F-35	Active electronically scanned array (AESA) radar. Limited supermaneuvrability. High speed agility. Limited sensor fusion and limited stealth capabilities
5	F-22	All-aspect "active stealth" technologies, internal weapon bays. Supercruise capabilities

Table 2: Typology of aircraft generations and their distinguishing characteristics. Non-exhaustive examples. (Saunders & Souva, 2019:5-9)

The year of introduction of new generations may have an impact on the results, so I will discuss it here. 4th generation aircraft were first introduced in 1977 and approx. 500 aircraft were produced by 1980. Generation 4.5 was introduced in 1990 and 250 aircraft were produced by 1993. The 5th generation of aircraft were introduced in 2000, and approx. 200 aircraft were produced by 2010. The year of introduction do not render previous generations obsolescent immediately since there most likely will be a substantial number of earlier-generation aircraft available. This is exemplified by the number of aircraft in generations 3 and 3.5, which were present in large numbers until the early 1990s even though the 4th generation had reached substantial numbers by 1980 (Saunders & Souva, 2019). It is worth noting that the abrupt removal from service of large numbers of aircraft in generation 3 and 3.5 roughly coincides with the steep decline in geopolitical competition associated with the end of the Cold War. Aircraft of older generations (0, 1, 1.5, 2 and 2.5) remained in service throughout the period, and especially generation 2.5 aircraft were represented with a substantial number in service in 2013 (Saunders & Souva, 2019). Maintaining older aircraft in service may be dictated by the economic capacity of states since modern aircraft almost always are associated with high costs, or by a need to fulfill secondary functions such as education and training of pilots. It is therefore reasonable to assume that states without sufficient economic capacity to acquire newer-generation aircraft will satisfy the need for air power by acquiring older-generation aircraft. A set of graphs covering each generation of aircraft is available in the appendix.

Air power is defined as the material capacity to achieve air superiority using aircraft designed to combat other aircraft. This is operationalized using a dataset containing the number of aircraft within each generation to create a weighted air power score (CAP2), which will be presented in more detail later. The inclusion of weighted scores allows consideration of technological development and its effects on the capability to achieve air superiority. If one were to use a raw count of aircraft, it would not necessarily give an accurate representation of air power, as exemplified by Israel's ability to achieve air superiority in the 1973 Yom Kippur war against numerically superior – but technologically inferior – adversaries (Saunders & Souva, 2019: 10-11).

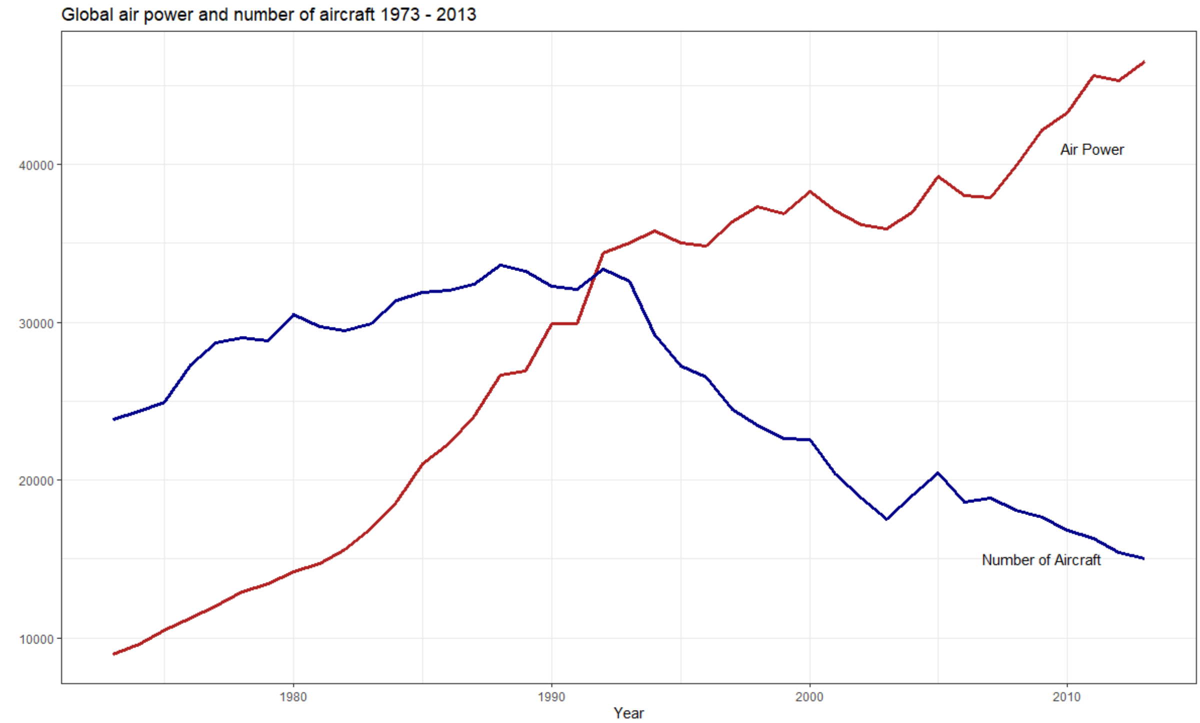

Figure 3: Air power has increased despite a decline in the raw number of combat aircraft due to the introduction of increasingly capable generations of aircraft. Air power is a measure of combat capability based on number of aircraft, weighted by their generation. (Saunders & Souva, 2019)

As Figure 3 demonstrates, the number of aircraft does not necessarily reflect the state's actual air power. Air power will therefore be used as the dependent variable in the panel models, rather than the number of aircraft a state possesses.

While this thesis measures air power in terms of fighter aircraft, there are several other types of specialized aircraft capable of conducting missions other than air-to-air combat. Reconnaissance aircraft, bomber aircraft, electronic warfare aircraft, transport aircraft, tanker aircraft and anti-submarine aircraft are examples of the type of aircraft that are not included in the analysis. A state's ability to conduct missions other than air-to-air combat is not included in the analysis, which is focused on the capability to achieve air superiority. While this may seem to be a flaw in the operationalization of air power, air superiority achieved using fighter aircraft is a prerequisite for successful military operations, and I argue that the measure is an adequate proxy for a more comprehensive measure of air power.

4.4.1 Air power as a share of GDP

It may be prudent to measure air power as a share of GDP (CAP2/GDP), to account for the increases in both the high costs associated with acquisition of newer-generation aircraft and the growth of GDP throughout the period. This is also the approach that most closely resembles Markowitz and Fariss' dependent variable, which was a measure of naval tonnage as a share of GDP. Measuring air power as a share of GDP will emphasize the level of priority afforded to the acquisition of air power and may to some degree alleviate the impact of major economic and military powers. However, differing rates of growth in GDP may have an impact on the figures. Slow or no growth of the figure in a rapidly growing economy may disguise a considerable expansion in aircraft acquisition (Buzan & Herring, 1998:89). It is worth noting that the mean GDP of some countries grew at astounding rates in the period 1973-2013, and that this may distort the measure of air power as a share of GDP. Other models with a measure of air power (CAP2) will be used to alleviate this potential issue.

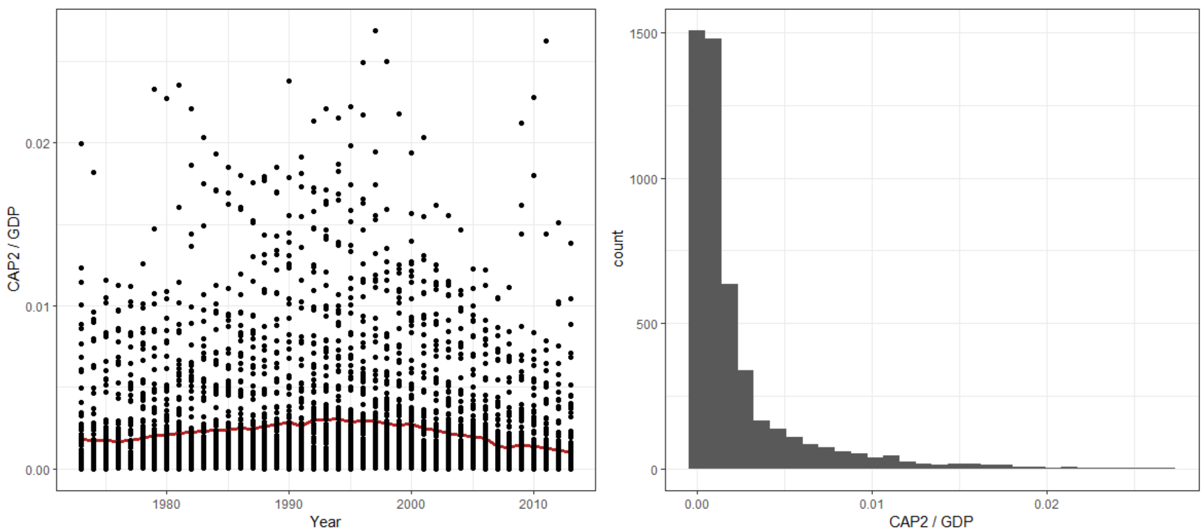

Figure 4: The dependent variable CAP2 / GDP over time on the left, with point plot and mean per year (red line). Histogram on the right. (Saunders & Souva, 2019; Markowitz & Fariss, 2018)

The graphs above indicate that the mean priority given to acquisition of air power increased from 1976 to around 1994, and that this priority has decreased steadily since then until 2013. This lag in the four-year period following the end of the Cold War may be consistent with the domestic structure model's prediction that aircraft-producing countries structure their states to producing weapons systems, and that institutions were able to influence arming decisions, despite a decrease in competition.

4.4.2 Alternative operationalization – Country Air Power 2 (CAP2)

The air power of each state is measured through the variable *Country Air Power 2 (CAP2)*, which is calculated for each country-year in the analysis. Each generation of aircraft is weighed according to the equation below (Saunders & Souva, 2019).

$$Country\ Air\ Power\ 2\ (CAP2) = \ln(number\ of\ gen\ 0\ aircraft + 1) + \ln(number\ of\ gen\ 1\ aircraft + 1) + \ln(number\ of\ gen\ 1.5\ aircraft + 1)^{1.5} + \ln(number\ of\ gen\ 2\ aircraft + 1)^{2} + \ln(number\ of\ gen\ 2.5\ aircraft + 1)^{2.5} + \ln(number\ of\ gen\ 3\ aircraft + 1)^{3} + \ln(number\ of\ gen\ 3.5\ aircraft + 1)^{3.5} + \ln(number\ of\ gen\ 4\ aircraft + 1)^{4} + \ln(number\ of\ gen\ 4.5\ aircraft + 1)^{4.5} + \ln(number\ of\ gen\ 5\ aircraft + 1)^{5}$$

This equation results in a measure of a state's air power which also discounts the value of older-generation aircraft, resulting in data that reflects the value afforded by newer-generation aircraft.

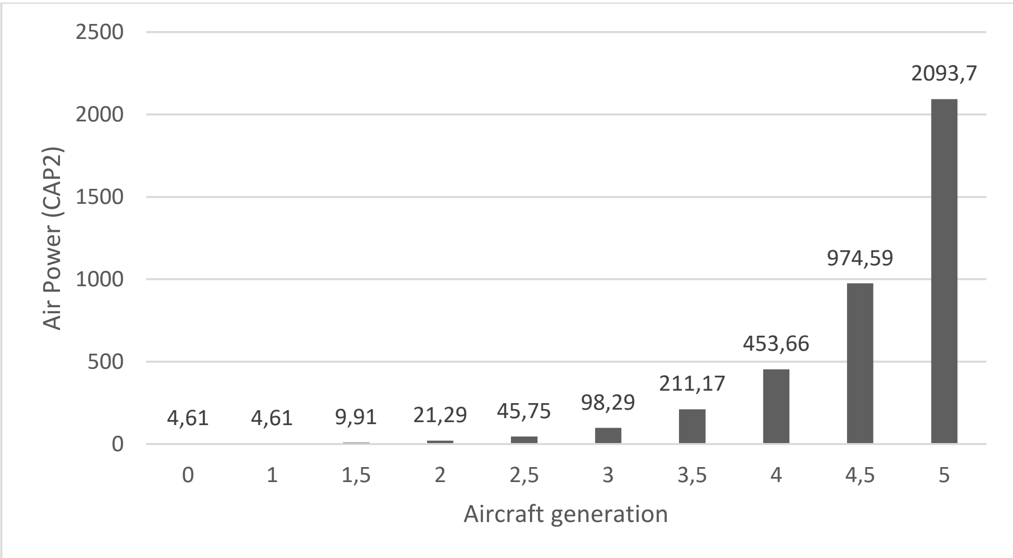

Figure 5: Amount of air power (CAP2) yielded by 100 aircraft per generation.

The figure above illustrates the value of acquiring newer-generation aircraft, by showing the amount of air power (CAP2) is gained by acquiring 100 aircraft within each generation. 100 5^{th} generation aircraft (by themselves) yield over 2000 CAP2. The variable developed by Saunders and Souva enables comparison of air power across generations by accounting for the relative advantage provided by technologically advanced aircraft (Saunders & Souva, 2019).

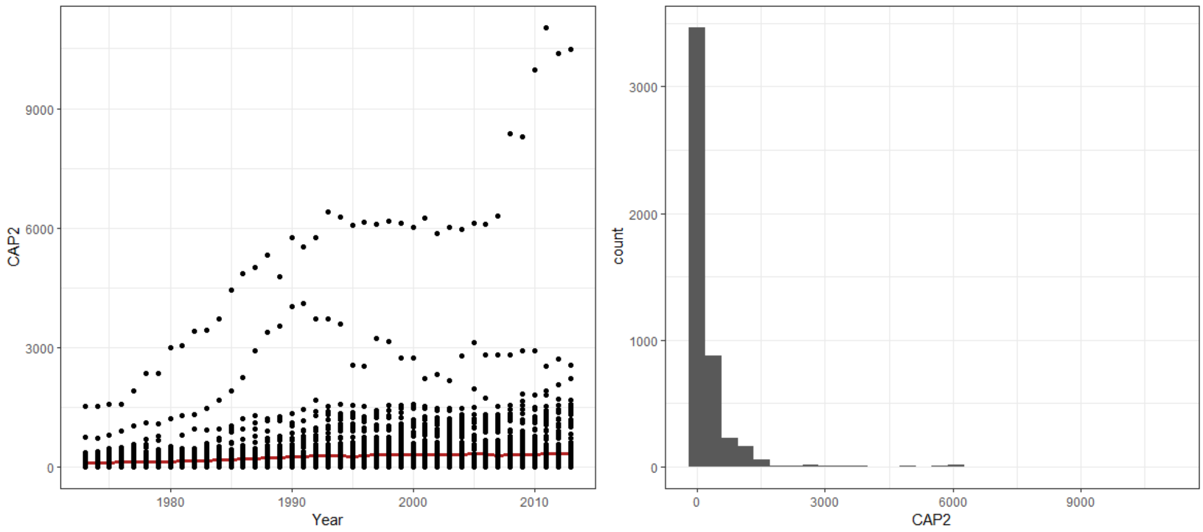

Figure 6: The alternative dependent variable CAP2 (air power) over time on the left, with point plot and mean per year (red line). Histogram on the right. (Saunders & Souva, 2019)

Observable from the graphs above is that there are clear outliers, where one or more states possess significantly more air power than the other states. First among these is the USA, which had the most air power throughout the period. The second observation is that the average air power has increased slowly throughout the period, mostly due to the introduction of newer-generation aircraft.

4.5 Control variables and their operationalization

This section is about the control variables and their operationalization. The variables are the same variables Markowitz and Fariss use to test their hypothesis. I will also conduct robustness tests with alternative control variables, which will be covered in the next section.

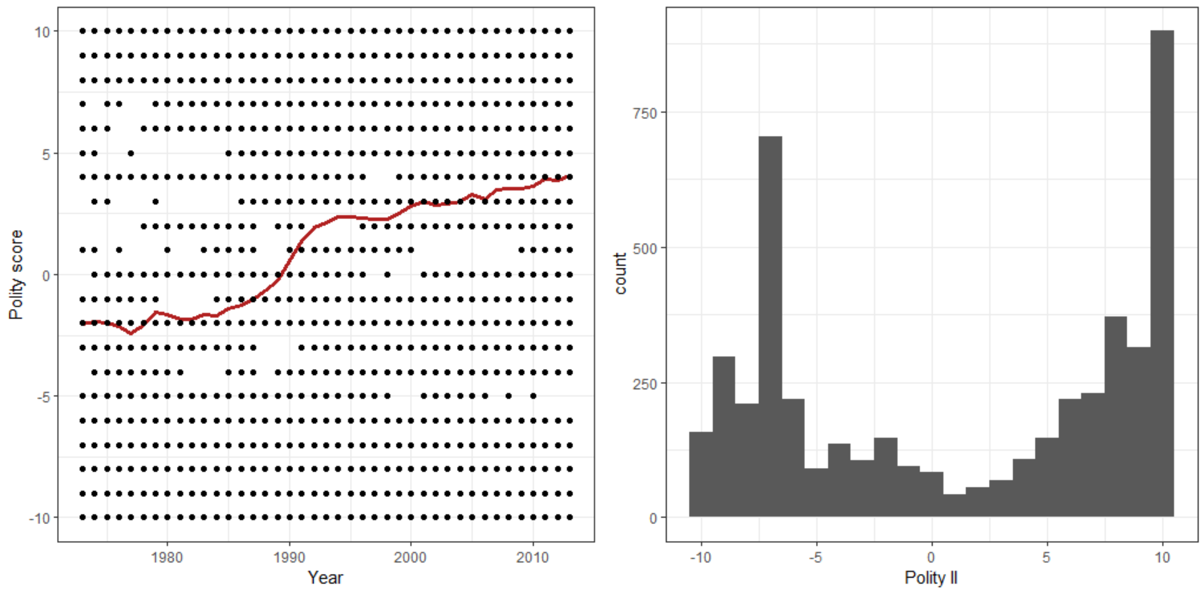

Figure 7: Polity score is used as a control variable, its evolution over time is on the left, with point plot and average Polity score per year (red line). Histogram on the right.

The Polity score measures how democratic or autocratic regimes are. It ranges between -10 and 10, where -10 is the most authoritarian, and 10 is the most democratic. Values above 6 indicate that the regime type is a democracy, while values below -6 are given to autocratic regimes. Values between 6 and -6 are mixed regime types or anocracies (Marshall, Gurr & Jaggers, 2014). As seen in the graph on the left, the mean Polity score has increased throughout the period, in what Huntington terms the "third wave" of democracy (Huntington, 1994). As previously mentioned, this contributes to decreasing levels of geopolitical competition.

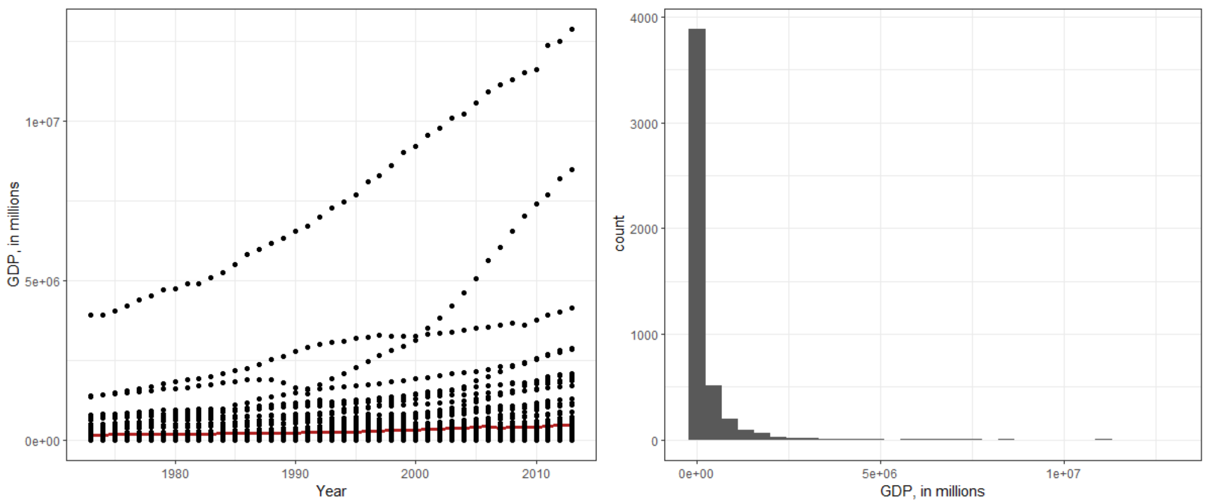

Figure 8: The control variable GDP (in millions), its evolution over time is on the left, with point plot and mean per year (red line). Histogram on the right. (Markowitz & Fariss, 2018)

The natural logarithm of GDP, in millions of constant US dollars, will be used as a control variable in the negative binomial models. Using GDP as a control variable allows the model to account for the economic power of a state, and the effect economic capacity has on acquisition of air power. Like the case with air power, the USA is an outlier throughout the period, having the highest GDP by a large margin.

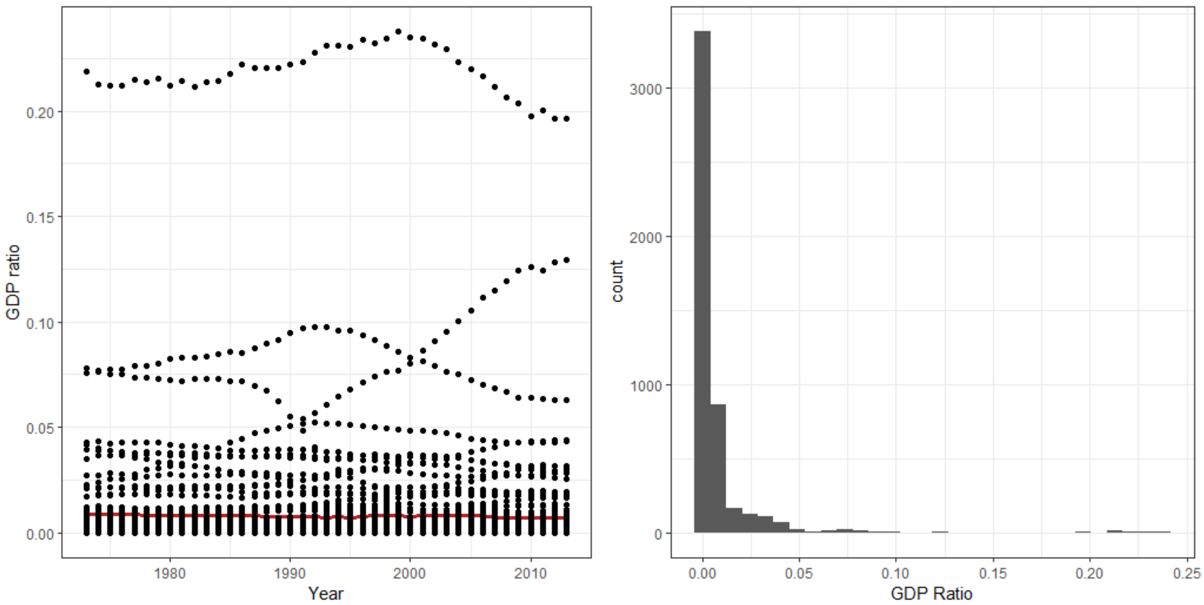

Figure 9: The control variable GDP Ratio, its evolution over time is on the left, with point plot and mean per year (red line). Histogram on the right. (Markowitz & Fariss, 2018)

GDP Ratio and the natural logarithm of GDP Ratio will be used as control variables in the panel regressions. The GDP Ratio is a measure of how much of the world's GDP is held by the state. The GDP Ratio is calculated by dividing a country's GDP by the sum of all countries' GDP in that year. This control variable was used by Markowitz and Fariss in their models and will therefore be a part of my replication of their work (Markowitz & Fariss, 2018).

While both the Polity and GDP variables are part of the geopolitical competition variable, the operationalization of competition captures the relative conditions between states. The application of GDP ratio and Polity as control variable measure the states' independent values and are therefore applicable as control variable since they do not measure the same as the competition variable.

4.6 Alternative control variables

As a part of the robustness checks, I will examine the relationship between geopolitical competition and air power using alternative control variables. The variables included in this section will be used in the panel regressions to ensure that the original control variables do not produce biased estimates.

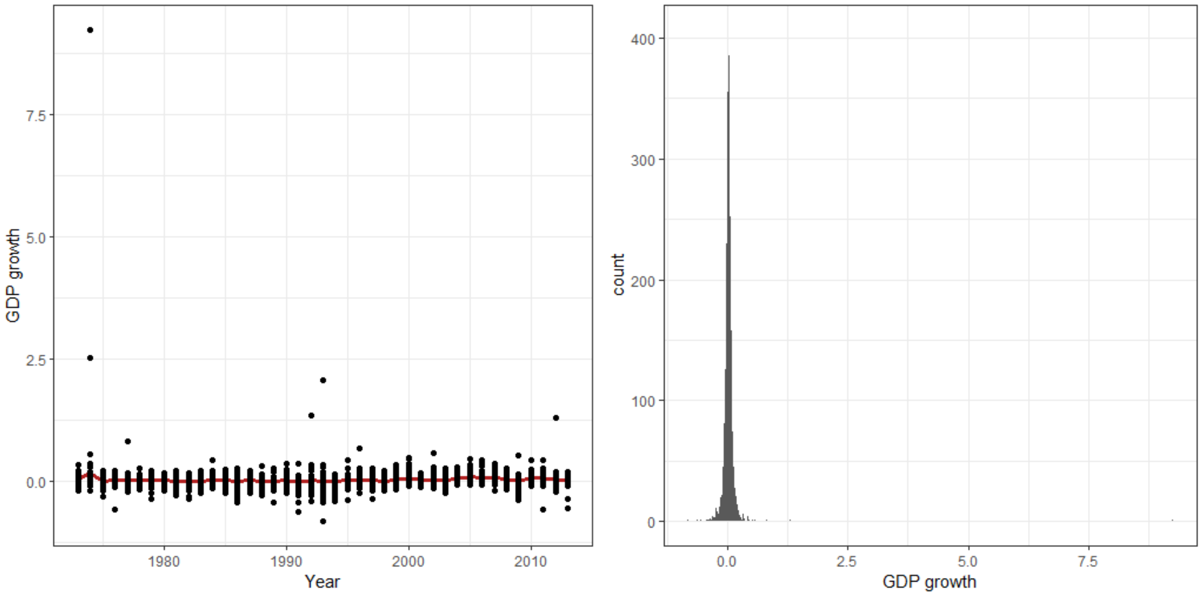

Figure 10: The alternative control variable GDP growth, its evolution over time is on the left, with point plot and mean per year (red line). Histogram on the right.

The alternative control variable GDP growth from the V-Dem dataset (Coppedge, et al., 2020) will be used in the panel regressions. I have chosen to use GDP growth as an alternative to the control variables GDP ratio and its natural logarithm, since it features fewer consistently extreme outliers, such as the GDP ratios for USA, China, and Japan. Even though it does not capture the economy in absolute terms and hence exactly how much air power the state can afford, it gives the state a sense of what its economic capacity will be in the future, which may inform future decision-making processes regarding acquisition of air power.

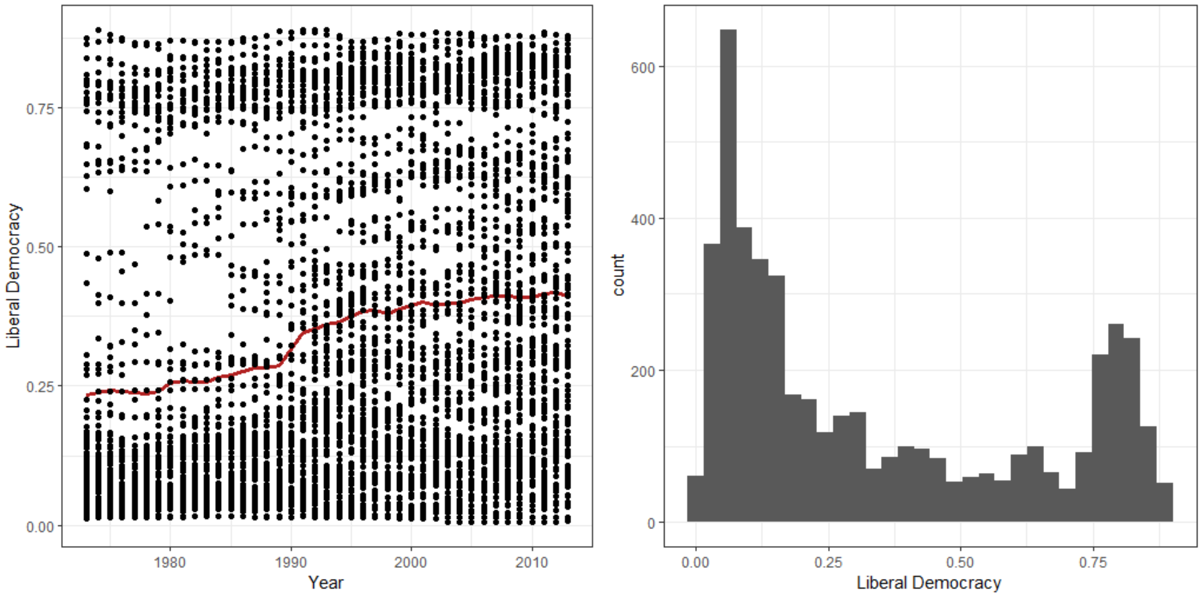

Figure 11: The alternative control variable Liberal Democracy, its evolution over time is on the left, with point plot and mean per year (red line). Histogram on the right.

The second alternative control variable also originates from the V-Dem dataset (Coppedge, et al., 2020). The liberal democracy measures to what degree the state in question has a regime that lives up to the ideal of liberal democracy. It is discrete variable that ranges between 0 and 1. The Liberal Democracy variable replaces Polity scores as a control variable in the models with alternative controls as part of the robustness checks. The variables are strongly correlated and feature similar evolutions over time, so I do not expect major differences in their association with acquisition of air power.

4.7 Operationalization of the action-reaction model

To test the alternative hypothesis that action-reaction dynamics cause acquisition of air power, I combined the theory (Smith, in Gleditsch, 2020:25-33) with Markowitz and Fariss' (2018) methodology. To reiterate the theoretical foundation, the action-reaction model posits that arms acquisition by potentially hostile states informs the arming decisions of states (Buzan & Herring, 1998). This operationalization does not seek to identify arms races, traditionally defined by action-reaction dynamics between states' military capabilities or expenditures (Mahnken et al., 2016), but rather a slightly more subtle military competition between states.

The *Action-Reaction* variable consists of the same three types of components as the geopolitical competition variable: a threat component, a distance component, and a preference component to determine which states are potentially hostile, which is similar to the interest incompatibility component in the geopolitical competition variable. I developed the action-reaction variable by altering the threat-component in the geopolitical competition variable developed by Markowitz and Fariss (Markowitz & Fariss, 2018; Anders, Markowitz & Fariss, 2020).

The development of the action-reaction variable was done in two stages: First, a replication of Markowitz and Fariss' geopolitical competition variable using data collected from other sources than the original. The replicated competition variable was then compared to the original competition variable to determine whether the method of replication was correct. Second, the threat component in the replicated competition variable was replaced with the action-reaction component, defined by the sum of changes in potentially hostile states' air power.

The action-reaction variable is defined by the equation below, with almost the same notation as the geopolitical competition variable presented earlier. The main difference is that states' air power *(a)*, measured in CAP2, replaces GDP as the threat component. The level of potential threat is measured in potentially hostile states' *(j)* relative change in air power from year *t-2* to *t-1*. Like the geopolitical competition variable, this is then multiplied by the interest compatibility component, which is coded $p = 1$ if one or both states are non-democratic, or $p = 0$ if both states are democracies. This is then multiplied by the inverted distance between states *i* and *j*, before the sum of these components is divided by the sum of inverted distance between all states in year *t*, which yields the sum of changes of air power state *i* faces in its environment in year *t*. This should capture state *i's* fear of falling behind in air power acquisition relative to proximate and potentially hostile states. Conversely, if the state faces negative values in the action-reaction variable, that should incentivize it to acquire less air power. The action-reaction variable could also be called the action variable, since it depends on a reaction from state *i*, which in this thesis will be an increase in the priority of air power acquisition.

$$Action\text{-}Reaction_{it} = \frac{\Sigma_j \left(\frac{a_{jt-1} - a_{jt-2}}{a_{jt-2}} \times p_{ijt} \times w_{ijt} \right)}{\Sigma_j w_{ijt}}$$

This operationalization is not completely consistent with the action-reaction theory since it lacks a ‘fatigue’ factor, which is a negative reaction within the state to its own level of air power (Smith, in Gleditsch, 2020:27-28). It does allow for negative action-reaction dynamics, where decreases in the air power of potentially hostile states may lead to decreases in state *i’s* air power.

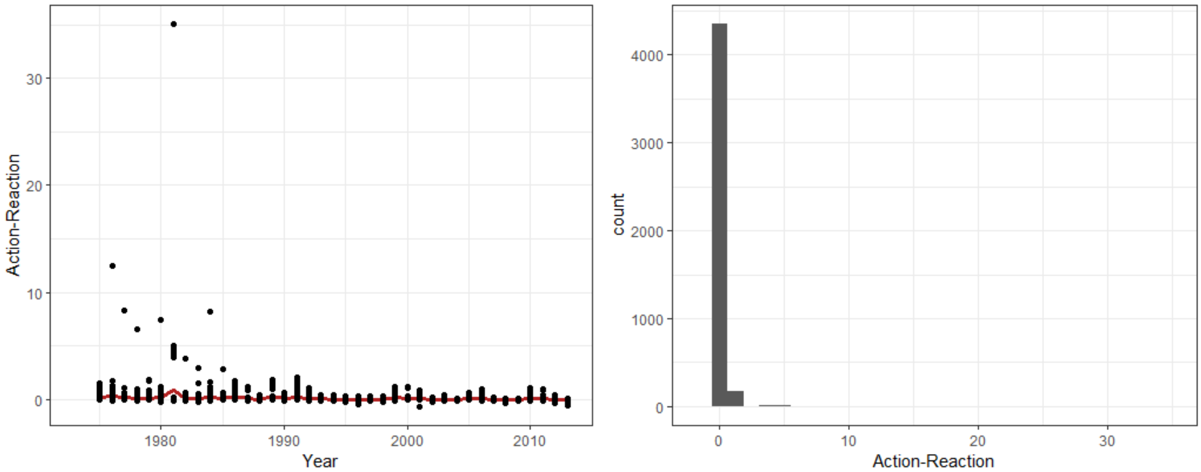

Figure 12: The Action-Reaction variable with its evolution over time is on the left, with point plot and mean per year (red line). Histogram on the right. (data from: Saunders & Souva, 2019; Markowitz & Fariss, 2018)

Yugoslavia has the six highest action-reaction values throughout the dataset, making it a candidate for removal as an influential outlier in the analysis. Aside from the top six observations there is an additional cluster of outliers in 1981, with values around 5. This cluster serves as an example of action-reaction dynamics. The countries within the cluster are mostly located in the Middle East and Northern Africa and most are a result of Yemen’s expansion of their air force from three 2nd generation fighter aircraft to the equivalent of 40 3rd generation fighter aircraft from 1979 to 1980. Yemen’s expansion of its air force was not large in absolute terms, but in relative terms CAP2 increased by approximately 2500 %, which explains why there is a cluster of outliers in 1981.

The operationalization of the action-reaction variable includes a two temporal lags, which results in a slightly higher percentage of missing values. The years 1973 and 1974 are omitted from the analysis because of this, and the variable therefore ranges between 1975 and 2013.

Numerical descriptive statistics

Statistic	Min	Median	Mean	Max	St. Dev.	N
Competition	0.001	0.01	0.004	0.01	0.002	4,714
Replicated Competition	0.00	0.06	0.09	2.40	0.13	4,827
Action-Reaction	-0.66	0.00	0.10	35.07	0.68	4,551
Polity	-10.00	3.00	1.15	10.00	7.44	4,695
Liberal Democracy	0.005	0.22	0.34	0.89	0.29	4,812
GDP (in millions)	216.35	49,926.57	282,892.70	12,862,317.00	901,121.00	4,865
GDP Ratio	0.0000	0.001	0.01	0.24	0.02	4,865
GDP Growth	-0.82	0.03	0.03	9.25	0.17	4,706
CAP2	0.00	58.11	244.41	11,025.34	641.50	4,868
CAP2 / GDP	0.00	0.001	0.002	0.03	0.003	4,865
Generation 0	0	0	3.18	129	10.68	4,868
Generation 1	0	0	6.02	330	22.30	4,868
Generation 1.5	0	0	2.13	220	9.40	4,868
Generation 2	0	0	19.93	2,100	68.64	4,868
Generation 2.5	0	0	40.18	4,690	289.87	4,868
Generation 3	0	7	79.53	6,595	365.99	4,868
Generation 3.5	0	0	15.47	2,126	109.21	4,868
Generation 4	0	0	44.95	2,829	196.86	4,868
Generation 4.5	0	0	2.07	269	17.86	4,868
Generation 5	0	0	0.28	275	7.63	4,868

Small numbers rounded to zero.

4.8 Validity and reliability

With regards to reliability, the thesis and its sources use frequently cited and peer-reviewed data sets, and reliability issues are more likely to be found in my coding efforts, rather than in the data.

4.8.1 Geopolitical competition

There are three potential issues regarding the research design's validity. First, the operationalization of geopolitical competition does not account for all forms of geopolitical competition, such as a competitive integration or influence over third-party states. As an example, the Cold War's effect on acquisition of air power is not reliably accounted for since the research design does not include the increased potential for hostility between the Western and Eastern blocs resulting from ideological differences and other political issues.

This leads us into the second potential issue, which is that the operationalization of geopolitical competition may place disproportionate emphasis on the role of the democratic peace theory in predicting peaceful relations between states. The variable does not include other measures of interest compatibility than joint democracy. While joint democracy may be an effective predictor, there are other potential indicators of interest compatibility which may affect acquisition of air power, such as shared IGO-cluster membership, defense pacts and alliances or United Nations voting similarity (Anders, Markowitz & Fariss, 2020). These potential indicators of interest compatibility are not accounted for. This may result in false positives, where dyads with at least one non-democratic state is coded as a potentially hostile relationship with increased risk of coercive interactions. Non-democratic states and democratic states may – at least to some degree – have compatible interests, which may be reflected more accurately in for example a shared IGO cluster membership or alliance structure. An example of this may be modern day Turkey, which in 2018 was coded as a closed anocracy (with a Polity score of -4). Despite this, Turkey is not necessarily considered threatening to NATO members since Turkey is a NATO member state. This is only an example, but there are almost certainly several such cases included in the estimated levels of competition states face.

It may be that the model captures the degree of spatial clustering of air power, and while this clustering is contingent upon proximity to non-democratic states that are economically powerful relative to the state that is analyzed, it is not necessarily the same as geopolitical competition. If the model is interpreted in its most rigid sense, one could imagine circles around non-democratic capitals, where one expects decreasing levels of priority afforded to air power the longer the distance between capitals is, adjusted by the level of economic capacity in the neighboring states, and their level of democracy. The most obvious shortcoming of this model is that rigidity, and that it disregards other forms of geopolitical competition and any form of cooperation between democratic and non-democratic states which may accelerate or moderate the need for air power.

The third issue is that the level of potential threat is measured in GDP, which may yield biased estimates. Countries with large and relatively poor populations, for example India and China, are considered disproportionally threatening, even if they do not have sufficient surplus to invest heavily into air power. Anders, Markowitz and Fariss address this issue, by introducing the surplus domestic product, which is a modification of GDP which accounts for population size and subsistence costs, which yields a more accurate measure of potential threat (Anders, Markowitz & Fariss, 2020).

4.8.2 Action-Reaction

The most serious challenge to the validity of the action-reaction variable is that it may inadvertently capture acquisition of air power that is caused by other mechanisms, such as developments in military technology and the diffusion of air power through international arms trade, symbolic politics, the domestic structure of states, or geopolitical competition. A potentially hostile state could acquire air power due to the abovementioned mechanisms, while the action-reaction theory inherently assumes that any acquisition of air power is caused by action-reaction dynamics, and that they warrant a response in kind.

The action-reaction variable shares a validity-related issue with the geopolitical competition variable due to its definition of potentially hostile states, which is identical to the definition of interest incompatibility in the geopolitical competition variable. The action-reaction variable overlaps conceptually with the competition variable since both variables rely on joint democracy for the definition of potentially hostile states. This may result in an overestimation of potentially hostile states in the action-reaction variable, as is the case with the competition variable. However, it may be a more accurate measure of the threat component since it directly measures symmetric military capabilities rather than conflating economic capacity with potential threat.

5 Results

In this chapter I will present the results from all the statistical models, including negative binomial count models and panel data regressions. This includes models with an alternative dependent variable, models with alternative control variables, and models with an alternative independent variable.

5.1 Results: Negative binomial count models

The first models I present are negative binomial count models for different generations of combat aircraft, using geopolitical competition, the natural log of GDP, and a lagged dependent variable as controls. The negative binomial models do not feature fixed effects.

This model specification enables analysis of disaggregated air power, rather than measuring air power as a sum of inventory across generations as I will do in the panel analysis. Temporally, the models range from 1974 to 2013 and include approx. 157 states.

	Dependent variable:									
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$	Generation $4.5_{i,t}$	Generation $5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Geopolitical competition$_{i,t-1}$	-34.52***	51.84***	-109.89***	152.61***	291.75***	138.46***	143.82***	100.70***	93.01***	-3,246.54
	(4.34)	(3.14)	(5.02)	(1.75)	(1.68)	(0.98)	(2.13)	(1.17)	(7.15)	(2,441.58)
ln GDP$_{i,t-1}$	-0.01*	0.17***	-0.02***	0.36***	0.50***	0.40***	0.77***	0.62***	0.85***	16.39***
	(0.01)	(0.004)	(0.01)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.01)	(2.63)
Generation $0_{i,t-1}$	0.04***									
	(0.0002)									
Generation $1_{i,t-1}$		0.02***								
		(0.0001)								
Generation $1.5_{i,t-1}$			0.03***							
			(0.0002)							
Generation $2_{i,t-1}$				0.002***						
				(0.0000)						
Generation $2.5_{i,t-1}$					0.001***					
					(0.0000)					
Generation $3_{i,t-1}$						0.001***				
						(0.0000)				
Generation $3.5_{i,t-1}$							0.002***			
							(0.0000)			
Generation $4_{i,t-1}$								0.001***		
								(0.0000)		
Generation $4.5_{i,t-1}$									0.01***	
									(0.0001)	
Generation $5_{i,t-1}$										0.003
										(0.003)
Constant	0.95***	-0.89***	1.09***	-1.93***	-4.17***	-1.17***	-7.80***	-4.43***	-10.81***	-255.56***
	(0.07)	(0.06)	(0.07)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)	(0.15)	(40.23)
Observations	4,529	4,529	4,529	4,529	4,529	4,529	4,529	4,529	4,529	4,529
Log Likelihood	-18,475.10	-32,233.45	-16,899.31	-99,798.50	-141,548.60	-247,043.30	-66,070.77	-126,659.90	-10,568.76	-71.46
Note:										*p<0.05; **p<0.01; ***p<0.001

Figure 13: Negative binomial count models over different generations of combat aircraft.

The results of these models lend support to the hypothesis that geopolitical competition is associated with an increase air power acquisition. All generations of combat aircraft except generations 0, 1.5 and 5 are associated with statistically significantly higher counts of combat aircraft, all else equal.

GDP matters when states make decisions regarding acquisition of aircraft and GDP's explanatory power increases along with the development of new generations of aircraft. This is likely due to increasing costs in development, acquisition and maintenance associated with newer-generation aircraft.

Only the USA had a limited number of fifth-generation aircraft by 2013, explaining the lack of statistical significance. The USA also had the highest GDP and the most air power throughout the period, which justifies removing the USA as an outlier.

	Dependent variable:								
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1,5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$	Generation $4.5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Geopolitical competition$_{i,t-1}$	-33.23***	53.38***	-116.45***	147.80***	300.43***	145.28***	-22.55***	-26.15***	47.04***
	(4.32)	(3.11)	(4.95)	(1.71)	(1.76)	(1.03)	(2.53)	(1.35)	(7.98)
ln GDP$_{i,t-1}$	-0.004	0.20***	0.01	0.39***	0.49***	0.34***	0.71***	0.58***	0.90***
	(0.01)	(0.004)	(0.01)	(0.002)	(0.002)	(0.001)	(0.004)	(0.002)	(0.01)
Generation $0_{i,t-1}$	0.04***								
	(0.0002)								
Generation $1_{i,t-1}$		0.02***							
		(0.0001)							
Generation $1.5_{i,t-1}$			0.04***						
			(0.0002)						
Generation $2_{i,t-1}$				0.002***					
				(0.0000)					
Generation $2.5_{i,t-1}$					0.001***				
					(0.0000)				
Generation $3_{i,t-1}$						0.001***			
						(0.0000)			
Generation $3.5_{i,t-1}$							0.004***		
							(0.0000)		
Generation $4_{i,t-1}$								0.002***	
								(0.0000)	
Generation $4.5_{i,t-1}$									0.04***
									(0.0003)
Constant	0.84***	-1.13***	0.80***	-2.28***	-4.02***	-0.63***	-6.59***	-3.61***	-11.87***
	(0.07)	(0.06)	(0.07)	(0.03)	(0.03)	(0.02)	(0.05)	(0.03)	(0.19)
Observations	4,489	4,489	4,489	4,489	4,489	4,489	4,489	4,489	4,489
Log Likelihood	-18,396.61	-31,929.29	-16,392.37	-97,393.87	-136,870.80	-240,301.30	-52,934.27	-99,191.32	-6,175.14
Note:									*p<0.05; **p<0.01; ***p<0.001

Figure 14: Negative binomial count models over different generations of combat aircraft, excluding the USA.

Excluding the USA had a major impact on the models, which seems to confirm the USA as an influential outlier. The models now estimate a negative association between geopolitical competition and generations 3.5 and 4. This comes in addition to generations 0 and 1.5 which already were negatively associated with geopolitical competition in the models that included the USA. Geopolitical competition is positively associated with generations 1, 2, 2.5, 3 and 4.5. These findings do not unambiguously support the hypothesis that geopolitical competition leads to acquisition of combat aircraft, since it is reasonable to assume that competition ought to be positively associated with all generations of aircraft.

The control variable ln GDP still has a strong and positive association with newer-generation aircraft, and the removal of the USA from the analysis did not significantly impact this relationship.

5.1.1 Negative binomial models: Subsets

The next set of models are part of a robustness check, where I divide the data into three subsets: the first subset ranging from 1974 to 1980, the second from 1977 to 1990, and the third from 1990 to 2013. These subsets are determined largely on the introduction of specific aircraft generations. The 1974 to 1980 subset is determined by the introduction of substantial numbers of fourth generation aircraft into service, indicating a forward leap in technology that may render previous aircraft generations obsolete. The same logic applies to the other two subsets, which are determined by the introduction of generation 4.5 aircraft around 1990. These subsets enable successive analyses of geopolitical competition’s effect on the most modern aircraft generations and older-generation aircraft that were nominally obsolete within each period. The USA is excluded from all the following models.

The first subset (1974-1980) includes all aircraft generations up until generation 3.5.

	Dependent variable:						
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Geopolitical competition$_{i,t-1}$	285.69^{***}	85.53^{***}	78.05^{***}	26.00	288.74^{***}	95.01^{***}	-143.07^{***}
	(21.38)	(6.38)	(18.46)	(41.80)	(4.84)	(2.62)	(5.99)
ln GDP$_{i,t-1}$	-0.10^{***}	0.28^{***}	0.22^{***}	0.18^{***}	0.59^{***}	0.53^{***}	0.38^{***}
	(0.01)	(0.01)	(0.02)	(0.05)	(0.01)	(0.004)	(0.01)
Generation $0_{i,t-1}$	0.04^{***}						
	(0.0004)						
Generation $1_{i,t-1}$		0.01^{***}					
		(0.0001)					
Generation $1.5_{i,t-1}$			0.04^{***}				
			(0.001)				
Generation $2_{i,t-1}$				0.01^{***}			
				(0.0005)			
Generation $2.5_{i,t-1}$					0.001^{***}		
					(0.0000)		
Generation $3_{i,t-1}$						0.001^{***}	
						(0.0000)	
Generation $3.5_{i,t-1}$							0.02^{***}
							(0.0002)
Constant	0.26	-1.57^{***}	-2.46^{***}	0.40	-5.07^{***}	-2.30^{***}	-2.49^{***}
	(0.20)	(0.12)	(0.30)	(0.67)	(0.07)	(0.05)	(0.11)
Observations	695	695	695	695	695	695	695
Log Likelihood	-3,269.31	-6,778.07	-2,397.49	-2,668.29	-28,544.43	-32,786.10	-4,576.73
Note:							$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Figure 15: Negative binomial count models over different generations of combat aircraft between 1974 and 1980, excluding the USA.

The first subset estimates a statistically significant and positive association between competition and generations 0, 1, 1.5, 2.5 and 3, and a negative association between competition and the number of aircraft in generation 3.5. There is no statistically significant relationship between competition and the number of aircraft in generation 2.

The second subset (1977-1990) includes all aircraft generation up until generation 4.

	Dependent variable:							
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Geopolitical competition$_{i,t-1}$	59.66***	33.08***	-18.38	-14.86***	259.30***	111.46***	-127.52***	-216.01***
	(8.51)	(4.83)	(60.96)	(2.93)	(3.57)	(1.73)	(4.64)	(4.89)
ln GDP$_{i,t-1}$	0.05***	0.24***	0.32***	0.21***	0.37***	0.42***	0.67***	0.58***
	(0.01)	(0.01)	(0.07)	(0.004)	(0.004)	(0.002)	(0.01)	(0.01)
Generation $0_{i,t-1}$	0.04***							
	(0.0003)							
Generation $1_{i,t-1}$		0.02***						
		(0.0001)						
Generation $1.5_{i,t-1}$			0.25***					
			(0.02)					
Generation $2_{i,t-1}$				0.005***				
				(0.0000)				
Generation $2.5_{i,t-1}$					0.001***			
					(0.0000)			
Generation $3_{i,t-1}$						0.001***		
						(0.0000)		
Generation $3.5_{i,t-1}$							0.004***	
							(0.0000)	
Generation $4_{i,t-1}$								0.01***
								(0.0000)
Constant	0.11	-1.20***	-4.17***	0.70***	-2.42***	-1.03***	-5.17***	-3.84***
	(0.12)	(0.09)	(0.96)	(0.05)	(0.05)	(0.03)	(0.10)	(0.10)
Observations	1,486	1,486	1,486	1,486	1,486	1,486	1,486	1,486
Log Likelihood	-7,072.18	-12,256.39	-1,384.74	-29,701.66	-45,305.18	-81,862.88	-18,009.97	-16,629.40
Note:								*p<0.05; **p<0.01; ***p<0.001

Figure 16: Negative binomial count models over different generations of combat aircraft between 1977 and 1990, excluding the USA.

The second subset estimates a statistically significant and positive association between competition and generations 0, 1, 2.5 and 3, and a negative association between competition and the number of aircraft in generations 2, 3.5 and 4. There is no statistically significant relationship between competition and the number of aircraft in generation 1.5.

The third subset (1990-2013) includes all aircraft generation up until generation 4.5.

	Dependent variable:								
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$	Generation $4.5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Geopolitical competition$_{i,t-1}$	-58.16	-2.81	-36.21	3.82	209.24***	125.50***	-10.76**	34.00***	84.34***
	(32.28)	(5.18)	(36.09)	(2.82)	(30.74)	(1.39)	(3.42)	(1.39)	(7.75)
ln GDP$_{i,t-1}$	-0.06	0.09***	0.31***	0.20***	0.41***	0.27***	0.79***	0.54***	0.84***
	(0.04)	(0.01)	(0.05)	(0.004)	(0.04)	(0.002)	(0.005)	(0.002)	(0.01)
Generation $0_{i,t-1}$	0.19***								
	(0.01)								
Generation $1_{i,t-1}$		0.02***							
		(0.0001)							
Generation $1.5_{i,t-1}$			0.30***						
			(0.01)						
Generation $2_{i,t-1}$				0.01***					
				(0.0001)					
Generation $2.5_{i,t-1}$					0.02***				
					(0.0002)				
Generation $3_{i,t-1}$						0.001***			
						(0.0000)			
Generation $3.5_{i,t-1}$							0.004***		
							(0.0000)		
Generation $4_{i,t}$								0.002***	
								(0.0000)	
Generation $4.5_{i,t-1}$									0.04***
									(0.0003)
Constant	0.15	-0.16	-4.73***	-0.27***	-4.12***	0.08***	-7.86***	-3.03***	-10.85***
	(0.53)	(0.09)	(0.61)	(0.05)	(0.51)	(0.02)	(0.07)	(0.03)	(0.18)
Observations	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,825
Log Likelihood	-2,969.75	-15,369.60	-2,327.23	-35,435.37	-5,893.81	-137,136.10	-29,128.30	-66,705.90	-5,426.38
Note:							*p<0.05; **p<0.01; ***p<0.001		

Figure 17: Negative binomial count models over different generations of combat aircraft between 1990 and 2013, excluding the USA.

The third subset estimates a statistically significant and positive association between competition and generations 2.5, 3, 4 and 4.5 and a negative association between competition and the number of aircraft in generation 3.5. There is no statistically significant relationship between competition and the number of aircraft in generation 0, 1, 1.5 and 2.

1974-1980	0	1	1.5	2	2.5	3	3.5		
1977-1990	0	1	1.5	2	2.5	3	3.5	4	
1990-2013	0	1	1.5	2	2.5	3	3.5	4	4.5
1974-2013	0	1	1.5	2	2.5	3	3.5	4	4.5

Figure 18: Comparison of the estimates per generation yielded by the negative binomial models within each subset and the full model. Negative associations in red, positive associations in blue, statistically insignificant associations in grey. The USA is omitted from all models.

The estimates are fairly consistent with the full model ranging from 1974-2013, especially regarding generation 2.5 and above. Generations 2.5, 3 and 4.5 are statistically significant and positive across all models and subsets where they are available, while generation 3.5 is consistently negatively associated with competition. Estimates for all other generations are not robust to the subsetting of data. This suggests that aircraft generations up to and including generation 2 became less relevant in coercive bargaining situations by the 1990-2013 period. It is somewhat surprising that aircraft in generations 2.5 and 3 remained relevant in the 1990-2013 period, since they were outdated by that time. This may indicate that states satisfice their air power needs by acquiring outdated aircraft to either coerce or avoid coercion in bargaining situations. This may be dictated by the economic capacity of these states, given the costs of modern combat aircraft, or by other political considerations that make acquisition of newer-generation aircraft less likely.

5.1.2 Negative binomial models: Additional control variable

As part of the robustness checks for the negative binomial models, I introduce Polity scores as an additional control variable into the analysis.

	Dependent variable:								
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$	Generation $4.5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Geopolitical competition$_{i,t-1}$	-55.01^{***}	123.43^{***}	99.81^{*}	79.91^{***}	121.32^{**}	-187.70^{***}	183.00^{***}	-33.45^{***}	107.93^{***}
	(6.91)	(5.45)	(50.22)	(3.16)	(43.18)	(2.32)	(4.72)	(2.71)	(17.53)
ln GDP$_{i,t-1}$	0.005	0.20^{***}	0.22^{***}	0.35^{***}	0.43^{***}	0.32^{***}	0.33^{***}	0.58^{***}	0.92^{***}
	(0.01)	(0.005)	(0.04)	(0.002)	(0.03)	(0.001)	(0.004)	(0.002)	(0.01)
Democracy$_{i,t-1}$	-0.01^{***}	0.02^{***}	0.03^{*}	-0.02^{***}	-0.03^{*}	-0.10^{***}	0.13^{***}	-0.001	0.01^{**}
	(0.002)	(0.002)	(0.02)	(0.001)	(0.01)	(0.001)	(0.002)	(0.001)	(0.005)
Generation $0_{i,t-1}$	0.04^{***}								
	(0.0002)								
Generation $1_{i,t-1}$		0.02^{***}							
		(0.0001)							
Generation $1.5_{i,t-1}$			0.27^{***}						
			(0.01)						
Generation $2_{i,t-1}$				0.002^{***}					
				(0.0000)					
Generation $2.5_{i,t-1}$					0.02^{***}				
					(0.0002)				
Generation $3_{i,t-1}$						0.001^{***}			
						(0.0000)			
Generation $3.5_{i,t-1}$							0.01^{***}		
							(0.0001)		
Generation $4_{i,t-1}$								0.002^{***}	
								(0.0000)	
Generation $4.5_{i,t-1}$									0.04^{***}
									(0.0003)
Constant	0.86^{***}	-1.50^{***}	-4.19^{***}	-1.56^{***}	-3.72^{***}	1.06^{***}	-3.71^{***}	-3.51^{***}	-12.33^{***}
	(0.08)	(0.06)	(0.53)	(0.03)	(0.45)	(0.02)	(0.06)	(0.03)	(0.20)
Observations	4,470	4,470	4,470	4,470	4,470	4,470	4,470	4,470	4,470
Log Likelihood	-18,351.99	-31,683.79	-3,708.16	-94,965.30	-9,599.45	-207,799.90	-34,355.86	-97,306.46	-6,092.23
Note:									*p<0.05; **p<0.01; ***p<0.001

Figure 19: Negative binomial count models over different generations of combat aircraft, with Polity scores introduced as a control variable. Excluding the USA.

Base	0	1	1.5	2	2.5	3	3.5	4	4.5
Polity	0	1	1.5	2	2.5	3	3.5	4	4.5

Table 3: Comparison of the estimated effect of geopolitical competition per generation yielded by the negative binomial models excluding and including Polity scores as a control variable. Negative associations in red and positive associations in blue. The USA is omitted from all models.

Including Polity scores *(Democracy)* yielded estimates that are mostly consistent with the base model seen in Figure 14. There are differences in estimated direction seen in generations 1.5, 3 and 3.5. This indicates that countries with higher Polity scores were more likely to acquire aircraft of generation 3.5, while countries with lower Polity scores were more likely to acquire aircraft of generation 3. The direction also changed in the relationship between geopolitical competition and the number of aircraft in generation 1.5, which went from a negative to a positive association.

The control variable Democracy shares a statistically significant relationship with the number of aircraft across all generations, except for generation 4. Perhaps the most relevant insight the Democracy variable gives us is that lower scores on the Polity scale makes it more likely that the state acquired generation 3 aircraft, while states with higher scores were more likely to acquire generation 3.5 aircraft.

5.2 Results: Panel regression models

The first set of panel models is specified in a manner that closely resembles Markowitz and Fariss' specification. CAP2 as a share of GDP is used as the dependent variable, the natural log of competition is used as the independent variable, while Polity score *(Democracy)*, GDP ratio and the natural log of GDP ratio are used as controls, in addition to a lagged dependent variable for the OLS models. The panel models also include fixed effects on country or on country-years, in addition to a set of pooled OLS models that do not feature fixed effects.

	Dependent variable:											
	$CAP2 / GDP_{i,t}$											
	panel linear								*OLS*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ln $Competition_{i,t-1}$	0.05	-0.07	-0.07	-0.09^{**}	0.03	-0.05	-0.05	-0.06	0.02^{***}	-0.02^{**}	-0.02^{**}	-0.02^{**}
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.005)	(0.01)	(0.01)	(0.01)
$Democracy_{i,t-1}$		-0.02^{***}	-0.02^{***}	-0.02^{***}		-0.01^{**}	-0.01^{**}	-0.01^{**}		-0.004^{***}	-0.004^{***}	-0.004^{***}
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)		(0.001)	(0.001)	(0.001)
GDP $ratio_{i,t-1}$			-2.22				-2.09				-0.05	
			(1.52)				(3.22)				(0.04)	
ln GDP $ratio_{i,t-1}$				-0.49^{***}				-0.38^{***}				-0.003
				(0.13)				(0.14)				(0.002)
$CAP2 / GDP_{i,t-1}$									0.95^{***}	0.95^{***}	0.95^{***}	0.95^{***}
									(0.01)	(0.01)	(0.01)	(0.01)
Constant									0.11^{***}	-0.09^{**}	-0.09^{**}	-0.11^{**}
									(0.03)	(0.04)	(0.04)	(0.05)
Fixed effects	C	C	C	C	C-Y	C-Y	C-Y	C-Y	None	None	None	None
Observations	4,529	4,510	4,510	4,510	4,529	4,510	4,510	4,510	4,529	4,510	4,510	4,510
Adjusted R^2	-0.03	-0.02	-0.02	0.03	-0.04	-0.04	-0.04	-0.01	0.92	0.92	0.92	0.92
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$. C denote country, and C-Y country-year fixed effects.											

Figure 20: Replication of Markowitz and Fariss' linear regression models (1974-2013)

The results of the first set of panel models are contradictory to what one might expect, with geopolitical competition being statistically insignificant in many of the models and associated negatively with air power in most of the models that are statistically significant.

Adjusted R^2 is only 0.03 in the statistically significant fixed effect model (model 4), indicating that the model only explains 3 % of the variance. The remaining fixed effects models have negative adjusted R^2, which I interpret as zero. The OLS-models have high R^2 values, but those R^2 values can generally be disregarded since they are autoregressive OLS models (Christophersen, 2018:170). Democracy is statistically significant and negatively associated with air power acquisition across all models, indicating that the more democratic a nation is, the less of its GDP is spent on air power. The same applies to GDP ratio and the log transformed GDP ratio. Ln GDP ratio has a moderate and negative association with air power acquisition in the fixed effects models, indicating that prosperous nations spend less of their GDP on air power.

The next model is one of the robustness checks I will conduct, where the USA is removed from the analysis due to its extreme values in both GDP and air power. The geopolitical effect of the USA is still estimated for other countries i.e., the competition the USA poses to for example China is still included in the analysis.

	Dependent variable:											
	$CAP2 / GDP_{i,t}$											
	panel linear								*OLS*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ln $Competition_{i,t-1}$	0.05	-0.13***	-0.14***	-0.14***	0.01	-0.15***	-0.15***	-0.14***	0.02***	-0.02**	-0.02**	-0.02**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.005)	(0.01)	(0.01)	(0.01)
$Democracy_{i,t-1}$		-0.03***	-0.03***	-0.03***		-0.02***	-0.02***	-0.03***		-0.004***	-0.004***	-0.004***
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)		(0.001)	(0.001)	(0.001)
GDP $ratio_{i,t-1}$			-6.26***				-3.74				-0.27***	
			(1.52)				(3.22)				(0.04)	
ln GDP $ratio_{i,t-1}$				-0.20				-0.19				-0.003
				(0.13)				(0.14)				(0.002)
$CAP2 / GDP_{i,t-1}$									0.95***	0.95***	0.95***	0.95***
									(0.01)	(0.01)	(0.01)	(0.01)
Constant									0.11***	-0.09**	-0.09**	-0.12**
									(0.03)	(0.04)	(0.04)	(0.05)
Fixed effects	C	C	C	C	C-Y	C-Y	C-Y	C-Y	None	None	None	None
Observations	4,489	4,470	4,470	4,470	4,489	4,470	4,470	4,470	4,489	4,470	4,470	4,470
Adjusted R^2	-0.03	-0.02	-0.02	0.01	-0.05	-0.03	-0.03	-0.01	0.92	0.92	0.92	0.92

Note: *p<0.1; **p<0.05; ***p<0.01
C denote country, and C-Y country-year fixed effects.

Figure 21: Replication of Markowitz and Fariss' linear regression models (1974-2013), excluding the USA.

Excluding the USA had a major impact in the panel models and geopolitical competition becomes statistically significant in most models, with most being significant at the 1%-level. It resulted in an average association of -0.14 in the fixed effects models, and an average association of -0.01 for the OLS models.

Even though geopolitical competition has statistically significant associations with air power in most of the models, the adjusted R^2 is low or negative across all models, suggesting that the models do not explain air power acquisition adequately. Only one fixed effects model (model 4) had a positive adjusted R^2, with a value of 0.01, indicating that the model explains 1 % of the variance. This indicates that geopolitical competition is not able to explain air power acquisition adequately, even after the USA is omitted from the analysis.

The control variable democracy retains its statistically significant and negative association with acquisition of air power from the previous models where the USA was included. GDP Ratio becomes statistically significant in one of the fixed effect models, rather than the natural logarithm of GDP Ratio which was statistically significant in the analysis that included the USA. In all models both the economic control variables remain negatively associated with air power acquisition, most likely due to the operationalization of air power as a share of GDP, where richer states spend less of their GDP on air power, in relative terms.

5.2.1 Alternative dependent variable: CAP2

	Dependent variable:											
	$CAP2_{i,t}$											
	panel linear								*OLS*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ln $Competition_{i,t-1}$	-0.07**	-0.08**	-0.08**	-0.08**	0.03	-0.03	-0.03	-0.03	-0.001	-0.003	-0.0004	0.003
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.003)	(0.004)	(0.004)	(0.004)
$Democracy_{i,t-1}$		-0.002	-0.002	-0.001		-0.01***	-0.01***	-0.01**		0.0001	-0.0001	-0.0001
		(0.003)	(0.003)	(0.003)		(0.003)	(0.003)	(0.003)		(0.0004)	(0.0004)	(0.0004)
GDP $ratio_{i,t-1}$			24.69***				21.65**				1.40***	
			(9.16)				(9.22)				(0.31)	
ln GDP $ratio_{i,t-1}$				0.11***				0.05				0.01***
				(0.04)				(0.04)				(0.002)
$CAP2_{i,t-1}$									1.00***	0.99***	0.97***	0.98***
									(0.01)	(0.01)	(0.01)	(0.01)
Constant									0.001	-0.01	-0.005	0.08***
									(0.02)	(0.03)	(0.02)	(0.02)
Fixed effects	C	C	C	C	C-Y	C-Y	C-Y	C-Y	None	None	None	None
Observations	4,489	4,470	4,470	4,470	4,489	4,470	4,470	4,470	4,489	4,470	4,470	4,470
Adjusted R^2	-0.03	-0.02	0.05	0.02	-0.04	-0.04	0.03	-0.03	0.97	0.96	0.96	0.96

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
C denote country, and C-Y country-year fixed effects.

Figure 22: Replication of Markowitz and Fariss' linear regression models (1974-2013), with an alternative dependent variable (CAP2), excluding the USA.

A further robustness check involves changing the dependent variable to a direct measure of air power (CAP2), rather than air power as a share of GDP (CAP2 / GDP). This does not change the overall results of the models. Geopolitical competition remains negatively associated with air power in all statistically significant models, and the adjusted R^2 remains low or negative. At best, the model explains 5 % of the total variance, which is not a major improvement over the previous models.

The interpretation of the economic control variables is more intuitive using CAP2 as dependent variable, with a positive relationship between air power and economic capacity.

5.2.2 Results: Alternative controls

Another robustness check involves using alternative control variables. The variables I have chosen still reflect regime type and economic capacity, as in the previous models. Both variables are from the V-Dem dataset (Coppedge et al., 2020), and replace Polity and GDP ratio as control variables. Liberal Democracy replaces the Polity score, while GDP growth replaces GDP ratio.

	Dependent variable:								
	$CAP2 / GDP_{i,t}$								
	panel linear						*OLS*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Competition_{i,t-1}$	0.04	-0.05	-0.04	0.02	-0.05	-0.03	0.01^{***}	0.003	0.004
	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.003)	(0.01)	(0.01)
$Liberal\ Democracy_{i,t-1}$		-0.52^{**}	-0.48^{*}		-0.48^{*}	-0.43		-0.03^{*}	-0.02
		(0.24)	(0.25)		(0.28)	(0.30)		(0.02)	(0.02)
$GDP\ growth_{i,t-1}$			-0.24^{**}			-0.21^{**}			0.01
			(0.12)			(0.10)			(0.03)
$CAP2 / GDP_{i,t-1}$							0.95^{***}	0.95^{***}	0.95^{***}
							(0.01)	(0.01)	(0.01)
Constant							-0.002	0.01	0.001
							(0.004)	(0.01)	(0.01)
Fixed effects	C	C	C	C-Y	C-Y	C-Y	None	None	None
Observations	4,489	4,458	4,331	4,489	4,458	4,331	4,489	4,458	4,331
Adjusted R^2	-0.03	-0.03	-0.02	-0.04	-0.04	-0.03	0.92	0.92	0.93
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$								
	C denote country, and C-Y country-year fixed effects.								

Figure 23: Linear regression models with alternative controls. (1974-2013)

The results of the panel models featuring alternative controls further weaken the hypothesis that geopolitical competition leads to air power acquisition. None of the fixed effects models are show a statistically significant relationship between geopolitical competition and air power, and only the autoregressive OLS model without any controls (model 7) resulted in a statistically significant and positive relationship. These results differ markedly from the models with the original control variables, which featured a statistically significant and mostly negative associations between geopolitical competition and acquisition of air power. This weakens the support for hypothesis H_1 further since the original control variables were instrumental to the models' ability to estimate the statistical relationship between geopolitical competition and air power.

The alternative control variables themselves are statistically significant and show consistent results with the control variables they replaced. Both the liberal democracy and GDP growth variables are statistically significant and negatively associated with air power. Similar to the panel models featuring the original control variables, the fixed effects models feature negative adjusted R^2 values, indicating that the models are inadequate in estimating the association between geopolitical competition and acquisition of air power.

5.3 Results: Reproduced geopolitical competition

A further robustness check involves using a reproduced geopolitical competition variable to alleviate potential sampling issues related to Markowitz and Fariss' data. The reproduced geopolitical competition variable is constructed using Saunders and Souva's (2019) sampling of countries. In this section I will present the results of the negative binomial models and the panel models using the reproduced variable.

	Dependent variable:								
	Generation $0_{i,t}$	Generation $1_{i,t}$	Generation $1.5_{i,t}$	Generation $2_{i,t}$	Generation $2.5_{i,t}$	Generation $3_{i,t}$	Generation $3.5_{i,t}$	Generation $4_{i,t}$	Generation $4.5_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Replicated Competition$_{i,t-1}$	0.94***	2.31***	1.18***	0.50***	0.74***	0.67***	0.001	-0.92***	-1.54***
	(0.07)	(0.05)	(0.10)	(0.04)	(0.03)	(0.01)	(0.06)	(0.03)	(0.21)
ln GDP$_{i,t-1}$	0.0001	0.17***	0.03***	0.29***	0.38***	0.27***	0.72***	0.57***	0.81***
	(0.01)	(0.004)	(0.005)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.01)
Generation $0_{i,t-1}$	0.04***								
	(0.0002)								
Generation $1_{i,t-1}$		0.02***							
		(0.0001)							
Generation $1.5_{i,t-1}$			0.03***						
			(0.0002)						
Generation $2_{i,t-1}$				0.002***					
				(0.0000)					
Generation $2.5_{i,t-1}$					0.001***				
					(0.0000)				
Generation $3_{i,t-1}$						0.001***			
						(0.0000)			
Generation $3.5_{i,t-1}$							0.002***		
							(0.0000)		
Generation $4_{i,t-1}$								0.001***	
								(0.0000)	
Generation $4.5_{i,t-1}$									0.01***
									(0.0001)
Constant	0.50***	-0.92***	-0.02	-0.50***	-1.46***	0.82***	-6.56***	-3.28***	-9.85***
	(0.06)	(0.05)	(0.06)	(0.02)	(0.02)	(0.01)	(0.04)	(0.02)	(0.14)
Observations	4,585	4,585	4,585	4,585	4,585	4,583	4,585	4,585	4,585
Log Likelihood	-17,852.88	-30,460.56	-17,345.41	-103,973.20	-157,692.60	-253,776.40	-68,014.33	-129,238.40	-10,585.31
Note:									*p<0.05; **p<0.01; ***p<0.001

Figure 24: Negative binomial models for the reproduced geopolitical competition variable and generations of aircraft. Excluding Yugoslavia and the USA. (1974-2013)

The negative binomial model using the reproduced geopolitical variable estimate a statistically significant and positive association between geopolitical competition and the number of aircraft in generations 0, 1, 1.5, 2, 2.5 and 3. There is no statistically significant association between geopolitical competition and the number of aircraft in generation 3.5. The models estimate a statistically significant and negative association between competition and the number of aircraft in generations 4 and 4.5.

The negative binomial models using the original variable and excluding the USA estimated a statistically significant and negative association between the number of aircraft in generations 0, 1.5, 3.5, and 4. They estimated a positive association between competition and generations 1, 2, 2.5, 3, and 4.5.

Original	0	1	1.5	2	2.5	3	3.5	4	4.5
Reproduced	0	1	1.5	2	2.5	3	3.5	4	4.5

Table 4: Comparison of the estimates per generation yielded by the negative binomial models, using either the original competition variable or the reproduced variable. Negative associations in red, positive associations in blue, statistically insignificant associations in grey.

Using alternative data to construct the competition variable yielded estimates that differ markedly from estimates using the original competition variable. This suggests that sampling i.e., the selection of which states are included in the analysis had a substantial impact on the estimates.

The models using the reproduced variable estimate an insignificant or negative association between competition and aircraft in generations 3.5, 4 and 4.5. The aircraft of previous generations were mostly obsolescent throughout most of the period, in the sense that at least one state was in the process of acquiring substantial numbers of 4th generation aircraft by 1980 (Saunders & Souva, 2019). This may be an indication that states did not consider geopolitical competition as a decisive factor for acquisition of modern air power in the 1974-2013 period.

	Dependent variable:											
	$CAP2 / GDP_{i,t}$											
	panel linear								*OLS*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Replicated $Competition_{i,t-1}$	0.02	-0.20***	-0.20***	-0.17**	0.01	-0.06	-0.06	-0.02	0.01	-0.04**	-0.04**	-0.04**
	(0.08)	(0.07)	(0.07)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)	(0.01)	(0.02)	(0.02)	(0.02)
$Democracy_{i,t-1}$		-0.01**	-0.01**	-0.01**		-0.01*	-0.01*	-0.01*		-0.003***	-0.003***	-0.003***
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)		(0.001)	(0.001)	(0.001)
GDP $ratio_{i,t-1}$			-2.13				-2.06				-0.05	
			(1.44)				(3.16)				(0.04)	
ln GDP $ratio_{i,t-1}$				-0.48***				-0.38***				-0.002
				(0.13)				(0.14)				(0.002)
$CAP2 / GDP_{i,t-1}$									0.96***	0.95***	0.95***	0.95***
									(0.01)	(0.01)	(0.01)	(0.01)
Constant									-0.002	0.01	0.01	-0.01
									(0.004)	(0.005)	(0.005)	(0.01)
Fixed effects	C	C	C	C	C-Y	C-Y	C-Y	C-Y	None	None	None	None
Observations	4,620	4,473	4,473	4,473	4,620	4,473	4,473	4,473	4,620	4,473	4,473	4,473
Adjusted R^2	-0.03	-0.02	-0.02	0.02	-0.04	-0.04	-0.04	-0.01	0.91	0.92	0.92	0.92

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
C denote country, and C-Y country-year fixed effects.

Figure 25: Linear regression models featuring the reproduced geopolitical competition variable (1974-2013). Excluding Yugoslavia and the USA.

The estimates of the panel models using the reproduced variable are largely similar to the estimates produced using the original variable. The main difference is that the models with year fixed effects estimate statistically insignificant relationships between the reproduced competition variable and air power acquisition. Overall, the estimates are still negative, as was the case with the original variable. The control variable *Democracy* is statistically significant in all models, and is negatively associated with air power, which is consistent with the estimates of the original data and competition variable. The natural log of GDP is also statistically significant and negatively associated with air power in the fixed effects models, which is also consistent with the original models.

The adjusted R^2 values are mostly negative for the fixed effects models, indicating that the model does not fit the data, and that the reproduced competition variable is unable to explain air power acquisition adequately.

5.4 Results: Action-Reaction

To estimate the effect of action-reaction dynamics on states' acquisition of air power I have chosen to use the same models that were used for geopolitical competition. I will only present two sets of models, using the same control variables as Markowitz and Fariss' models, and both sets exclude Yugoslavia and the USA from the analysis.

The first set of models are negative binomial count models. The number of aircraft each state possesses within each generation is used as dependent variables, the action-reaction variable is used as independent variable, and log transformed GDP is used as a control variable. Each model also uses a lagged dependent variable as control to mitigate the impact of autocorrelation.

	Dependent variable:								
	Generation 0	Generation 1	Generation 1.5	Generation 2	Generation 2.5	Generation 3	Generation 3.5	Generation 4	Generation 4.5
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Action-Reaction$_{i,t-1}$	0.14***	0.24***	0.17***	0.15***	-0.42***	0.05***	0.20***	0.17***	-0.14**
	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.001)	(0.01)	(0.01)	(0.06)
ln GDP$_{i,t-1}$	0.01*	0.15***	-0.05***	0.18***	0.36***	0.25***	0.72***	0.57***	0.80***
	(0.01)	(0.004)	(0.01)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.01)
Generation 0$_{i,t-1}$	0.05***								
	(0.0002)								
Generation 1$_{i,t-1}$		0.02***							
		(0.0001)							
Generation 1.5$_{i,t-1}$			0.04***						
			(0.0003)						
Generation 2$_{i,t-1}$				0.01***					
				(0.0000)					
Generation 2.5$_{i,t-1}$					0.001***				
					(0.0000)				
Generation 3$_{i,t-1}$						0.001***			
						(0.0000)			
Generation 3.5$_{i,t-1}$							0.002***		
							(0.0000)		
Generation 4$_{i,t-1}$								0.001***	
								(0.0000)	
Generation 4.5$_{i,t-1}$									0.01***
									(0.0001)
Constant	0.46***	-0.54***	0.90***	0.46***	-1.17***	1.05***	-6.61***	-3.38***	-9.85***
	(0.06)	(0.05)	(0.07)	(0.03)	(0.02)	(0.01)	(0.04)	(0.02)	(0.14)
Observations	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315
Log Likelihood	-16,551.15	-28,454.74	-16,165.83	-75,312.33	-141,323.00	-240,906.10	-64,033.19	-122,922.20	-10,345.03
Note:							*p<0.1; **p<0.05; ***p<0.01		

Figure 26: Negative binomial count models over different generations of combat aircraft and action-reaction dynamics, excluding Yugoslavia and the USA. (1976-2013)

The negative binomial models estimate a statistically significant positive association between action-reaction dynamics and count of aircraft in generations 0, 1, 1.5, 2, 3, 3.5 and 4. The models estimate a statistically significant negative association between action-reaction dynamics and acquisition of aircraft in generations 2.5 and 4.5. GDP is statistically significant and positive across all generations and is a strong predictor for newer generations of aircraft, as was the case in the geopolitical competition models.

Even though the estimates of the negative binomial models largely show a positive correlation between action-reaction dynamics and acquisition of air power, they do not provide unambiguous support for the alternative hypothesis that action-reaction dynamics cause states to acquire aircraft across all generations.

	Dependent variable:											
	$CAP2 / GDP_{i,t}$											
	panel linear								*OLS*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$Action\text{-}Reaction_{i,t-1}$	0.02	0.01	0.01	0.01	-0.01	-0.01	-0.01	0.003	0.02	0.02	0.02	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)
$Democracy_{i,t-1}$		-0.02^{***}	-0.02^{***}	-0.02^{***}		-0.02^{**}	-0.02^{**}	-0.02^{***}		-0.003^{***}	-0.003^{***}	-0.003^{***}
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)		(0.001)	(0.001)	(0.001)
$GDP\ ratio_{i,t-1}$			-8.53^{***}				-6.57^{*}				-0.03	
			(3.22)				(3.40)				(0.04)	
$\ln GDP\ ratio_{i,t-1}$				-0.25^{**}				-0.22^{**}				-0.001
				(0.10)				(0.11)				(0.002)
$CAP2 / GDP_{i,t-1}$									0.96^{***}	0.95^{***}	0.95^{***}	0.95^{***}
									(0.01)	(0.01)	(0.01)	(0.01)
Constant									-0.004	-0.001	-0.001	-0.01
									(0.004)	(0.005)	(0.005)	(0.01)
Fixed effects	C	C	C	C	C-Y	C-Y	C-Y	C-Y	None	None	None	None
Observations	4,315	4,186	4,186	4,186	4,315	4,186	4,186	4,186	4,315	4,186	4,186	4,186
Adjusted R^2	-0.04	-0.02	-0.02	0.02	-0.05	-0.04	-0.04	-0.01	0.92	0.92	0.92	0.92

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
C denote country, and C-Y country-year fixed effects.

Figure 27: Linear regressions (1976-2013) on the action-reaction model, excluding Yugoslavia and the USA.

The panel regressions do not estimate any statistically significant association between action-reaction dynamics and acquisition of air power. The models do not have adequate explanatory power regarding acquisition of air power, given the mostly negative adjusted R^2 values of the fixed effects models. Model 4 has an adjusted R^2 value of 0.02, indicating that it can explain 2% of the total variance. The estimated direction of the control variables remains the same as in the geopolitical competition models, with statistically significant estimates showing a negative association between higher levels of democracy, GDP, and the natural logarithm of GDP. In sum, the panel models estimate a null-effect between action-reaction dynamics and acquisition of air power.

6 Discussion

In this chapter I will discuss the results of the statistical models, with a particular focus on potential theoretical weaknesses and biases within the research design.

I have not found convincing empirical support for the hypothesis that geopolitical competition causes acquisition of air power *(H_1)*. Even though most of the negative binomial models show statistically significant and positive association between geopolitical competition and acquisition of aircraft within certain generations (2.5), this is not sufficient to decisively determine a generally positive relationship between the two, especially given the estimates of generation 3 and 3.5, which are positive, negative or statistically insignificant, depending on which robustness check is applied. Additionally, the lacking explanatory power of the panel models, indicated by low or negative adjusted R^2 values, undermines the estimates yielded by the negative binomial models. The results of the panel models are robust to the use of an alternative dependent variable, using an alternative (reproduced) independent variable, using alternative control variables, and to omitting the USA from the analyses.

The results of the action-reaction models are similar to those of the geopolitical competition models. Some of the negative binomial models estimate a statistically significant relationship between action-reaction dynamics and acquisition of some generations of aircraft, while the panel regression models do not estimate any significant relationship between action-reaction dynamics and air power. Hence there is little empirical support for the hypothesis that action-reaction dynamics cause states to acquire air power *(H_{A1})*.

Geopolitical competition was not found to be decisive for states' air power acquisition decisions between 1974 and 2013. Geopolitical competition is not able to predict states' acquisition of air power throughout the period, which indicates that other considerations were prioritized in decision-making processes.

The likely reason for the unexpected results may be a consequence of the rigidity of the models, particularly in how interest incompatibility is defined. As mentioned in the discussion on the validity of the competition variable, the reliance on joint democracy for the definition of interest incompatibility disregards other forms of competition and cooperation. This is a source of bias in the study and including other sources of interest incompatibility would likely remedy the issue somewhat. The alternative sources of competition could include measures of influence or competitive integration (as described by Spaiser, 2018; Rana & Ji, 2020; Zhao, 2019). The inclusion of these sources of competition would allow the research design to overcome some of its rigidity. Even though the rigidity is necessary to accurately determine the effects of interest incompatibility, it is not sufficient to account for these alternative sources of competition. The operationalization of the geopolitical competition variable with alternative or added measures of interest compatibility such as joint IGO membership (Bearce & Bondanella, 2007), shared IGO cluster membership (Lupu & Greenhill, 2017), similarity in alliance portfolios, trade, financial integration and/or economic interdependence (Anders, Markowitz & Fariss, 2020; Markowitz & Fariss, 2018:11; Lupu & Greenhill, 2017) could also alleviate some of this issue. The inclusion of these alternative would reduce the risk of false negatives or positives, where dyads with at least one non-democratic state are considered as having no interest compatibility despite being members of the same alliance, IGO cluster or being economically interdependent. The same applies regarding the assumed interest compatibility between democracies. Development of a more extensive index of geopolitical competition is likely necessary to gain the ability to predict air power acquisition. Markowitz and Fariss state that interest compatibility between democracies is not an ironclad law, but rather a useful starting point for further development of a measure of interest compatibility (Markowitz & Fariss, 2018:11).

The unexpected estimates may also be a result of omitted variable bias. Alliance networks may be of particular importance, given Gilpin's argument that smaller states are able to rely on a hegemon for security through free-riding mechanisms (Gilpin, 1981). This, or other omitted control variables may have biased the estimates in their unexpected direction. Controlling for alliances with major powers may be a viable avenue for future research, given the preponderance of for example US air power in the data I analyzed, resulting in increased potential for free-riding mechanisms informing states' arming decisions, air power included.

The findings may also be a consequence of the research design and operationalization of geopolitical competition and action-reaction dynamics. It is possible that direct interactions between states are more informative than the sum of interactions, and that the sum of interactions conceal the direct interactions. As an example, the level of competition between the US and the Soviet Union was likely a major driver for both states' acquisition of air power, but this dyadic relationship is not given a special consideration in the research design. This may suggest a poor choice of research design to examine the research questions. This is surprising given the findings of Markowitz and Fariss, which suggest that geopolitical competition is associated with naval power projection capabilities using a nearly identical research design (Markowitz & Fariss, 2018).

On the other hand, it is likely the alternative explanatory theories, such as military application of civil technology and its diffusion through arms trade, symbolic politics and the domestic structure model may explain a greater degree of the air power acquisition than either geopolitical competition or action-reaction dynamics. While these theories are not tested in this thesis, there are several examples that appear to be a result of these theories, such as some of the Gulf states' acquisition of advanced military equipment as a part of demonstrating sovereignty (Buzan & Herring, 1998: 179-180). It is not inconceivable that the continued development of new generations of aircraft serves as an example of the diffusion of technology through arms trade, and future studies could benefit from examining this relationship.

It is unlikely that the results are a consequence of the different periods this thesis examines compared to Markowitz and Fariss. While Markowitz and Fariss' main models cover the 1865-2011 period they conduct robustness checks consisting of splitting the data into two separate periods. The first period ranges from 1865-1945, while the second covers the 1946-2011 period. The models of the 1946-2011 period yields estimates that support the hypothesis that geopolitical competition leads to acquisition of naval power projection capabilities (Markowitz & Fariss, 2018). It is still possible that the unexpected results obtained in this thesis are a consequence of the "missing" years between 1946 and 1974, but this can not be confirmed until data on air power in that period becomes available.

Another possible explanation may be that air power and naval power have a significantly different relationship to geopolitical competition, and that naval power is more relevant in a competitive environment. Naval power has a unique ability for power projection across the seas, a power projection capability that cannot be matched by fighter aircraft alone. It is therefore possible that states acquire naval power in order to project power at distant competing states, while fighter aircraft are acquired for other purposes. It is possible that competition incentivizes states to acquire naval power projection capabilities rather than the warfighting capabilities associated with air power.

7 Conclusion

The findings do not lend support to hypotheses that geopolitical competition (H_1) or action-reaction dynamics cause states to acquire air power (H_{A1}). The findings cannot rule out the second alternative hypothesis that the domestic structure model, symbolic politics and/or technological development and arms trade explains states' air power acquisition (H_{A2}).

7.1 Future studies

In this section I will discuss possible approaches to enhance the validity of future studies of air power acquisition and propose some avenues for future research. Provided there are no major flaws in this thesis, future studies should examine the relationship between air power acquisition and the alternative theories. Different research designs and/or operationalizations may be better suited to estimate the relationship between geopolitical competition and air power acquisition, or between action-reaction dynamics and air power acquisition. Future studies of geopolitical competition's relationship with air power should include alternative conceptualizations of competition, such as competition for influence or integration. Additionally, future studies built on the same theoretical foundation could benefit from including multiple indicators of interest incompatibility as well as compatibility. Future studies could also benefit from analyses of the functional difference between air power and naval power, and how their relationship with geopolitical competition differs.

As Anders, Markowitz and Fariss argue, using GDP as a measure of potential threat introduces bias to the models. High GDP does not necessarily enable states to invest into air power, because GDP only measures the total value of goods and services produced. The total value of goods and services does not equate into a surplus that is available for investments into military power. Anders, Markowitz and Fariss develop the Surplus Domestic Product (SDP), which accounts for population size and the costs of subsistence. The SDP enables measuring potential threat levels far more accurately, yielding more valid results (Anders, Markowitz & Fariss, 2020).

To test the domestic structure theory, one could conduct process-tracing studies on acquisition processes to determine the level of influence wielded by institutions associated with the arms industry, the military or other institutions with vested interests in arms production. This would require access to processes that may be considered sensitive by governments. To test the technological development and its diffusion through arms trade one could collate information on arms producing nations and arms importing nations, in addition to which aircraft they export or import. SIPRI has collected this type of information in their Arms Industry and Arms Transfers databases, and future studies could incorporate that data (SIPRI, 2021). Additionally, it is possible to estimate the effect of forward leaps in aircraft technology by constructing a variable that measures when states acquire newer-generation aircraft. This may enable quantitative studies of the effect of both exporting or importing aircraft has on other countries' air power acquisition, in addition to the effect of acquiring newer-generation aircraft, which amounts to a partial test of the technological development and arms trade theory. To test the effect of symbolic politics on air power acquisition, one could examine states' narrative framing of acquisitions and determine the effect of different types of symbolic framing, in addition to comparing these effects with the other theories.

7.2 Summary

In this thesis I have extended Markowitz and Fariss' (2018) proposition that geopolitical competition leads to state acquisition of naval power. I have extended this to state acquisition of air power. This has been a process involving reviewing the literature on both geopolitical competition and air power, in addition to air power's role in inter-state coercive bargaining. I have reviewed alternative theories that may explain air power acquisition, and the action-reaction theory has been empirically tested as an alternative theory. The research design consists of a multi-model approach, with the goal of triangulating estimates between negative binomial count models and panel linear models using both aggregated and disaggregated measures of air power as dependent variables, following Markowitz and Fariss' example. These estimates have been subjected to comprehensive robustness checks and have been found generally robust. I have discussed potential challenges to the validity of both theories tested in this thesis and highlighted the most likely theoretical and methodological sources of biases and errors. The results of the statistical models do not lend support to the hypothesis that an increasing level of geopolitical competition leads to states acquiring air power. Neither have I found convincing evidence that supports the alternative hypothesis that action-reaction dynamics cause states to acquire air power. This is mainly due to a lack of triangulation between the different families of statistical models, and the lacking explanatory power of the panel linear models which indicate that geopolitical competition and action-reaction dynamics are unable to explain air power acquisition adequately. Returning to the example of Norwegian acquisition of combat aircraft in 2008, I cannot conclude that this decision was caused by geopolitical competition or action-reaction dynamics. The theories I have tested in this thesis do not adequately explain air power acquisition, and I have proposed possible avenues for further research, and how one may handle some of the theoretical and methodological challenges that this thesis has encountered. The main theoretical issue is found in the operationalization of interest incompatibility relying solely on regime type, which results in a valid but incomplete measure of interest incompatibility. This theoretical issue may be mitigated by including alternative measures of interest incompatibility. There are two methodological issues that may reduce the validity of the thesis: First, the statistical models may be biased due to omitted variables, for example alliance structures and its potential impact on free-riding mechanisms between minor and major powers. Second, the research designs relies on summing dyadic characteristics into monadic data, which may obscure important dyadic relationships such as USA-USSR that may have a strong impact on geopolitical competition, even between third-party states, as seen during the Cold War.

Appendix

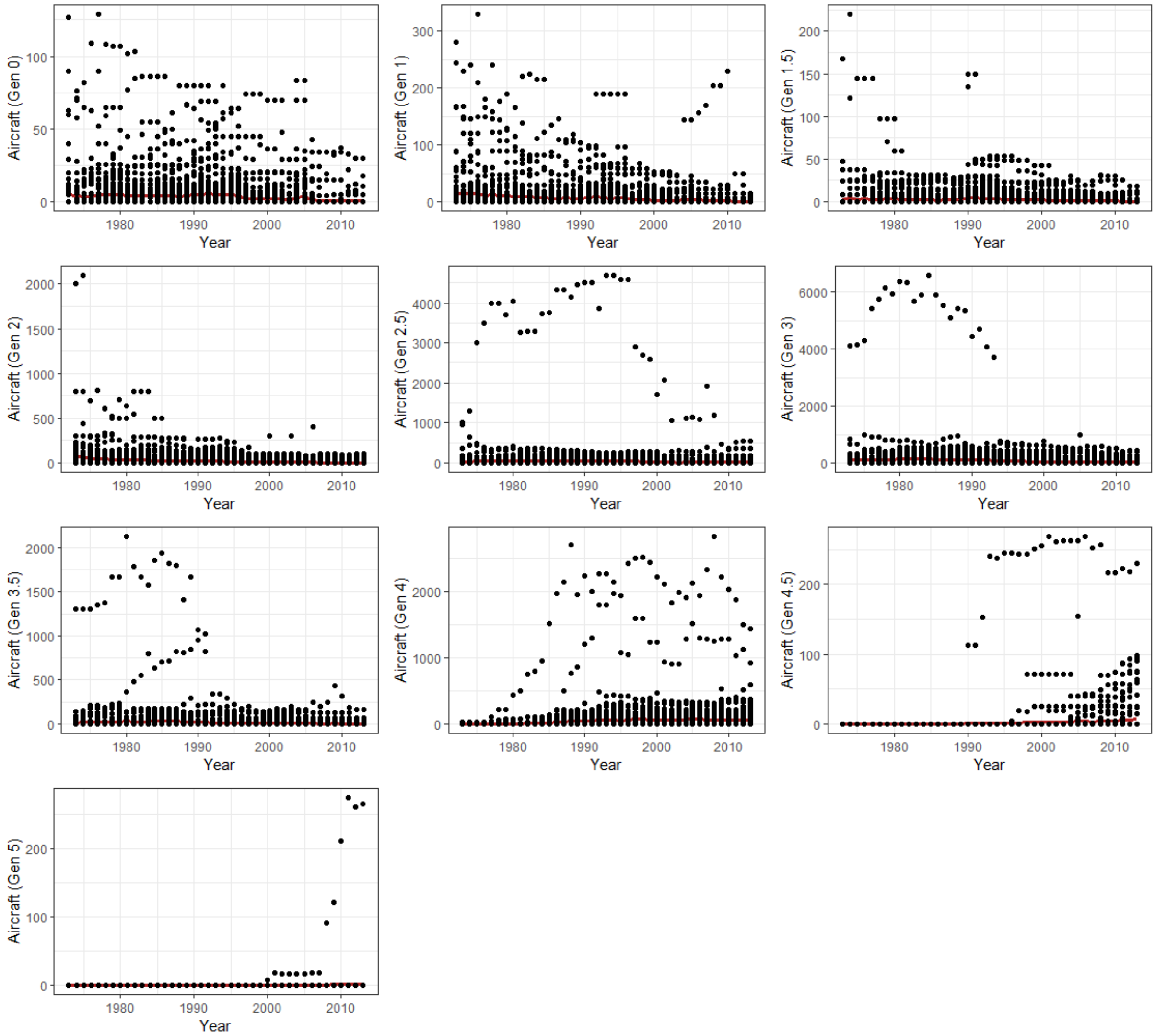

Figure 28: Number of aircraft within each generation, and their evolution over time. Average number of aircraft in red line (Saunders & Souva, 2019)

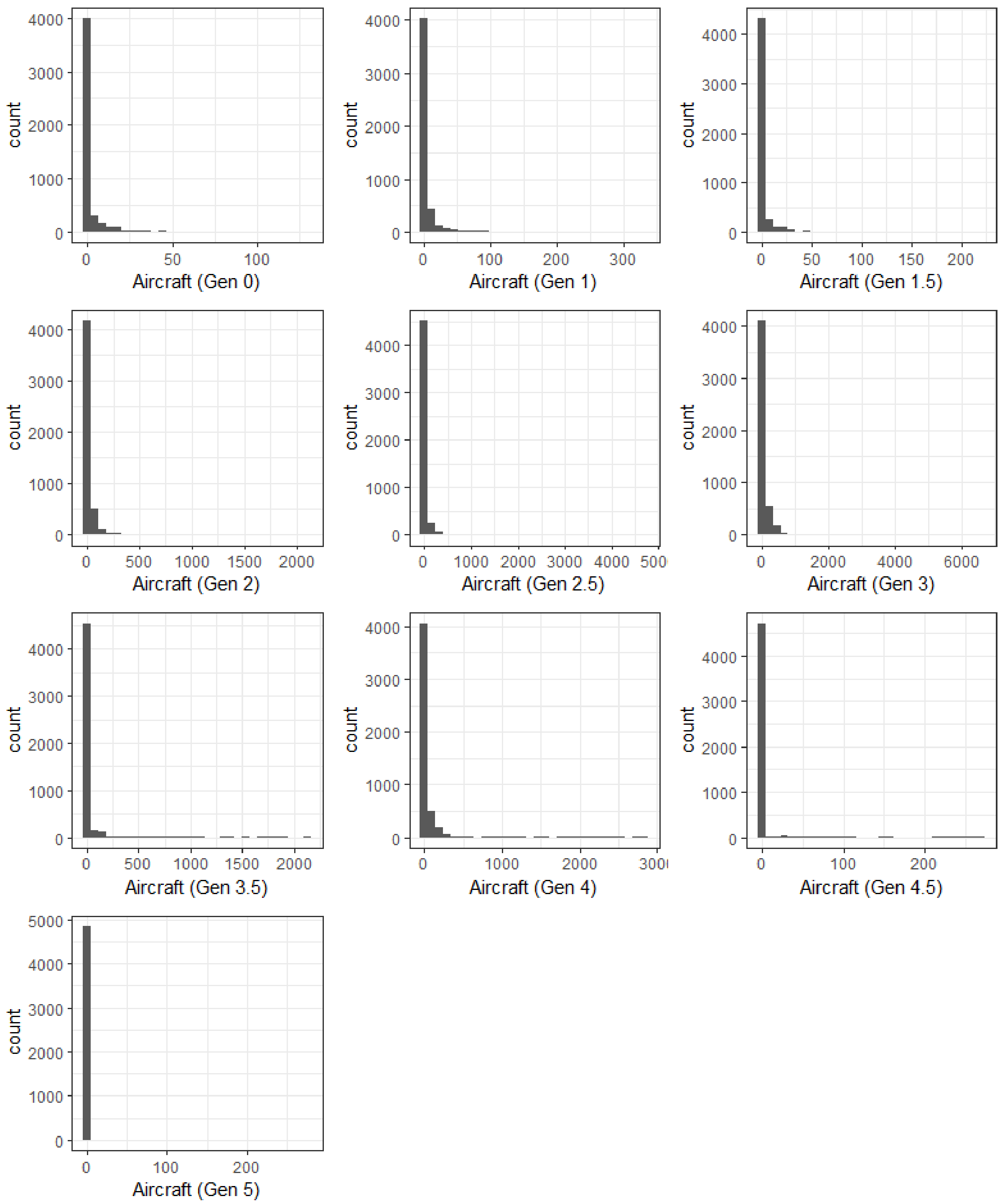

Figure 29: Histograms over number of aircraft within each generation (Saunders & Souva, 2019)

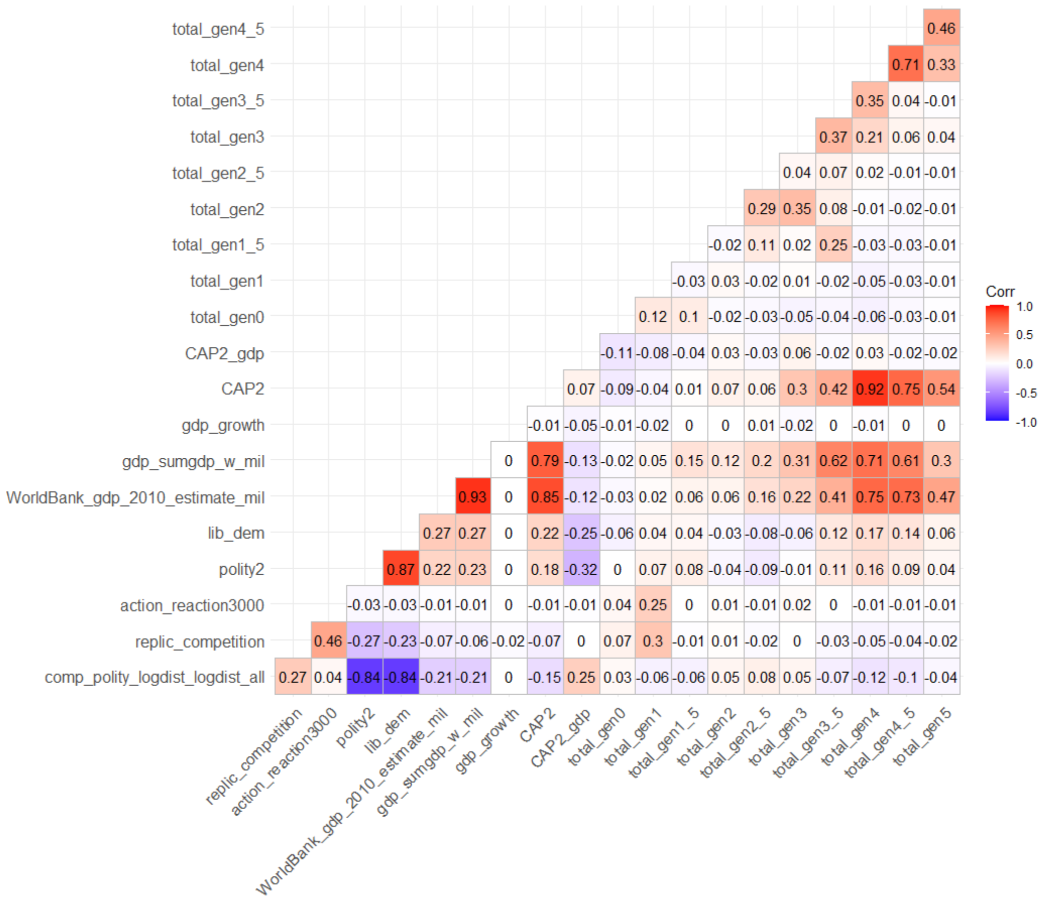

Figure 30: Correlation matrix

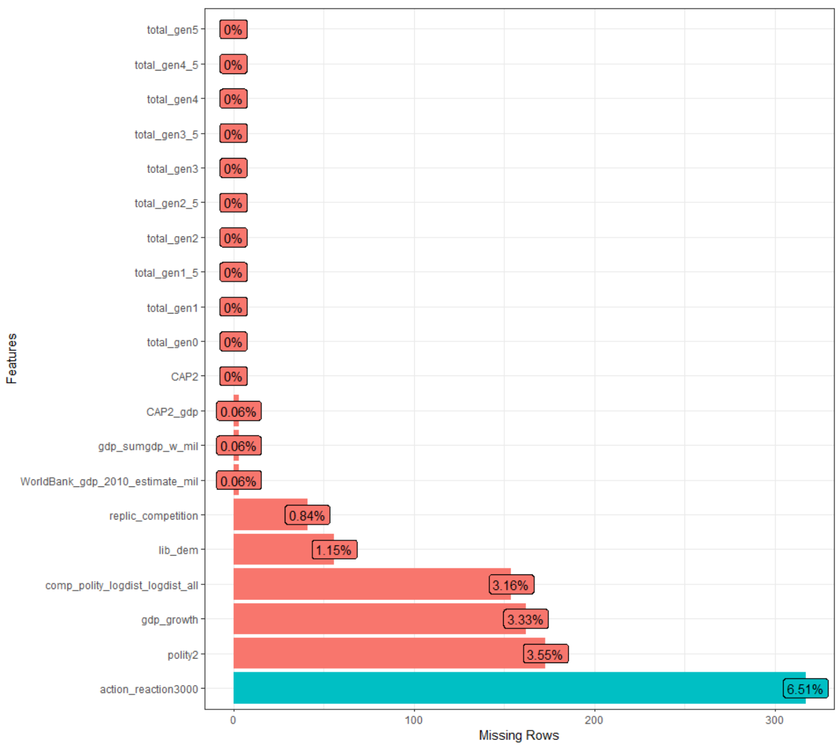

Figure 31: Missing values in percentages

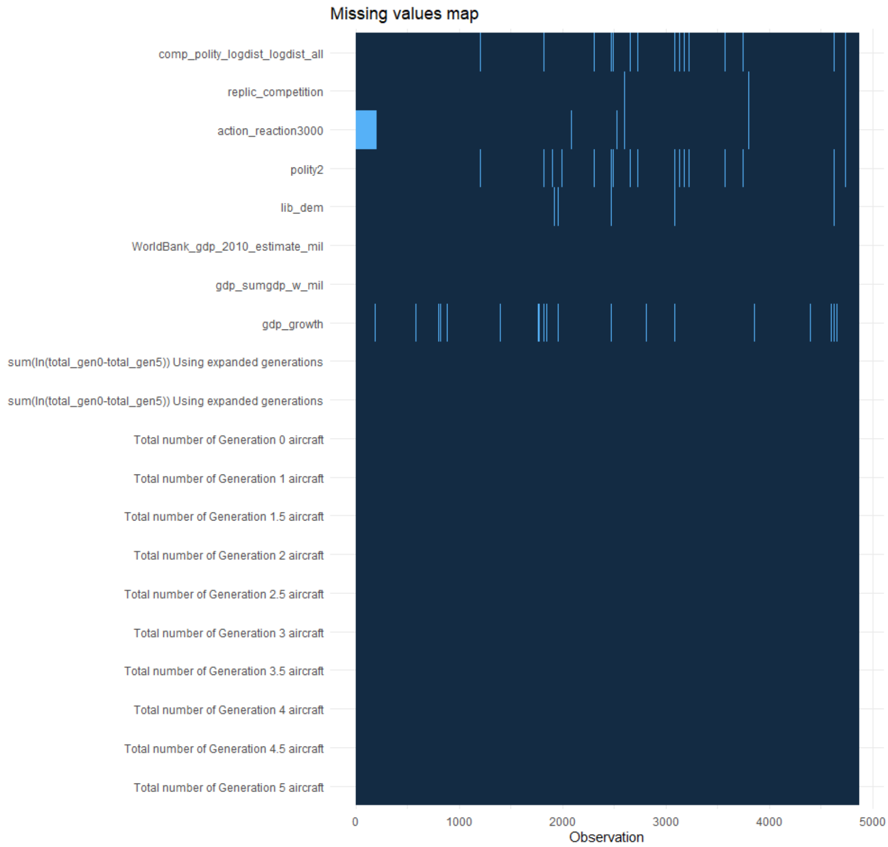

Figure 32: Missing values distribution. Missing observations in light blue.

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