Reactive Latency: An Analysis of the Diffusion of Nuclear Latency Between Neighboring States

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Definitions

Civilian nuclear cooperation: "The state-authorized transfer of technology, materials, or know-how intended to help the recipient country develop, successfully operate, or expand a civil nuclear program" (Fuhrmann 2012, 3). Concurrent with the language that Fuhrmann uses in his 2012 book, *Atomic Assistance: How "Atoms for Peace" Programs Caused Nuclear Insecurity*, the terms "civilian nuclear cooperation", "peaceful nuclear assistance", and "atomic assistance" are used interchangeably throughout this thesis.

Commercial-scale operation: "The facility or process line is being operated in commercial or industrial scale" (Nuclear Fuel Cycle Information System 2009, 5).

Enrichment: "Activities related to the isotopic enrichment of UF6 to obtain the appropriately enriched 235U concentration" (Nuclear Fuel Cycle Information System 2009, 10).

Laboratory-scale operation: "The facility or process line is being operated in a laboratory to examine the applicability of a process" (Nuclear Fuel Cycle Information System 2009, 5).

Pilot-plant operation: "The facility or process line is being operated as a precursor of a commercial or an industrial facility or process line" (Nuclear Fuel Cycle Information System 2009, 5).

Reactive Latency: When a state responds to a neighbor's acquisition of latent nuclear capabilities by becoming latent itself.

Spent fuel reprocessing and recycling: "Activities related to the special treatment of spent fuel to be able to extract the usable materials and to recycle them in the reactors" (Nuclear Fuel Cycle Information System 2009, 10).

Abbreviations

ACDA: Arms Control and Disarmament Agency
BRI: Belt and Road Initiative
ENR: Enrichment and Reprocessing
Euratom: European Atomic Energy Community
IAEA: International Atomic Energy Agency
INFCIS: Integrated Nuclear Fuel Cycle Information System
IR: International Relations
NNWS: Non-Nuclear Weapons State
NPP: Nuclear Power Plant
NPT: Treaty on the Non-Proliferation of Nuclear Weapons, or Non-Proliferation Treaty
NSG: Nuclear Suppliers Group
NWS: Nuclear Weapons State
PNNL: Pacific Northwest National Laboratory

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Abstract

The threat of a nuclear weapons cascade in the Middle East has perennially plagued US policymakers in their interactions with the region. Accordingly, Herculean efforts have been made to mitigate this threat, and its prevention has been studied extensively. However, Saudi Arabia's recent interest in pursuing indigenous enrichment capabilities begs a new question: should policymakers be concerned about Iran's latent status pushing its MENA neighbors to pursue similar capabilities? The threat of *reactive latency* between neighbors thus demands analysis. Such work is made possible by recent scholarship in the nuclear latency space that aims specifically to support quantitative analysis. In the following article, I contribute to a growing latency-focused literature through an analysis of whether states that have latent neighbors are more likely to become latent themselves. Through three phases of statistical modeling, I analyze the relationships between having a laboratory-scale, pilot-scale, or commercial-scale latent neighbor or neighbors and whether a state itself becomes latent. I find that having a neighbor that has achieved commercial-scale latent capabilities has a positive and nearly statistically significant relationship with whether a state itself becomes latent. This finding could indicate that states may explore nuclear options in response to more modest external proliferation stimuli than is currently believed. Additionally, in many of my models, I find a positive and statistically significant relationship between a state having a nuclear-armed neighbor or neighbors and a state itself becoming latent. This lends further support to the idea that the external proliferation stimuli that beget exploration of and investment in latency may be lower than we had previously thought.

Introduction

The year 1941 marked the advent of nuclear latency with the University of Virginia Centrifuge Testing Facility beginning operations in the US and the Dnepropetrovsk Physicochemical Institute and Ukrainian Physicochemical Institute beginning operations in what was then the Soviet Union (Fuhrmann & Tkach 2015). Since then, thirty-one states have developed latent nuclear capabilities, while only nine have ultimately developed nuclear weapons. Even though the states that have succeeded in developing weapons capabilities are few and far between compared to those that have achieved latency, the lion's share of scholarly attention has been weapons-centric. In order to contribute to efforts to plug this gap, the primary actors whose motives I explore through my thesis project are the thirty-one states that have achieved nuclear latency. What motivates states to become latent? This thesis explores this question with a particular emphasis on the interaction between a state's regional context and whether or not a state ultimately becomes latent. Broadly, I hypothesize that states will be more likely to become latent if they have neighbors that have achieved nuclear latency. More specifically, I posit that states with neighbors that have reached greater latency milestones or have proliferated will be more likely to achieve latency than states with neighbors whose capabilities are lower on the nuclear totem pole.

My results provide preliminary support for these hypotheses; there is a positive and nearly statistically significant relationship between a state having a commercial-scale latent neighbor and that state becoming latent. Additionally, many of my models show a positive and statistically significant relationship between a state having a neighbor or neighbors that have proliferated and a state itself becoming latent. These findings supplement existing work exploring the diffusion of nuclear capabilities between states, and this thesis proceeds as follows. I first provide the theoretical and empirical context for my research. In doing this, I discuss latency-specific scholarship, scholarship pertaining to the relationships between contiguous states, and scholarship exploring the mechanisms by which nuclear capabilities spread. I then argue that a state is more likely to become latent if it has latent neighbors. In constructing this argument, I first establish how other states, neighbors and otherwise, may impact a state's decision to become latent. I then utilize the opportunity and willingness conceptual framework to analyze the mechanisms that may contribute to and ultimately elicit reactive latency. Next, I present my research design as well as my findings. Finally, I discuss my findings as well as the opportunities that I envision for future research.

I. Literature Review

The scholarship that undergirds my argument that a state is more likely to become latent if it has a latent neighbor or neighbors can be divided into three categories: that which focuses on latency, that which focuses on the relationship between contiguity and conflict, and that which focuses on diffusion. In the following literature review, I consider each of these themes in turn and discuss how scholarship within each realm has contributed to my thinking regarding reactive latency.

1. Latency Scholarship

The body of scholarship exploring why states pursue latent capabilities has gained significant richness and policy relevance in recent years because of Matthew Fuhrmann and Benjamin Tkach's compilation of information about the history of each state's enrichment and reprocessing (ENR) capabilities in the 2015 Nuclear Latency (NL) dataset. Prior to the creation of the NL dataset, proxy indicators were used to assess each state's latent capabilities. However, reliance on these measures resulted in significant analytical errors that undermined the utility of the indirect approach to measuring latency. The NL dataset's inclusion of the history of each state's ENR capabilities allows for greater clarity of analysis of the factors that contribute to latency, as well as the impact that latent capabilities have on geopolitical status.

In the section that follows, I first acknowledge Scott Sagan's 2010 contribution to Volume I of *Forecasting Nuclear Proliferation in the 21st Century: A Comparative Perspective* in which he effectively chronicles the evolution of the latency literature and proposes avenues for future scholars to explore. I then briefly explore the influential technical latency literature, infusing my own commentary with that of Sagan. I next describe the evolution of the dataset of proxy indicators that previously served as the basis for analysis of the causes and consequences of nuclear latency. Finally, taking Sagan's direction into account, I then take a deep dive into recent developments in the scholarly pursuit of understanding of the causes and consequences of nuclear latency, and surface with a research question informed by the work of Rupal Mehta and Rachel Whitlark.

In his chapter in Volume I of *Forecasting Nuclear Proliferation in the 21st Century: A Comparative Perspective*, Sagan identifies what he calls "mirror image analytic failures" that plague the technical and academic literature that explores nuclear latency (Sagan 2010, 80). The academic scholarship at the time of Sagan's writing did not adequately assess or take into account the technical factors pertaining to the nuclear fuel cycle that dictate the speed at which a state can race to the bomb. On the other side of the coin, the technical scholarship prior to Sagan's writing did not adequately integrate the political factors that may expedite or impede a state's fissile material development. Sagan discusses three influential technical reports as well as the trajectory of the academic nuclear latency scholarship, and his discussion frames the course of this literature review.

A. Technical Latency Scholarship

In 1977, Albert Wohlstetter and colleagues published a seminal analysis of the capabilities of non-nuclear weapons states: *Swords from Plowshares.* Wohlstetter and his colleagues divided these states into three categories: states with advanced infrastructure and fissile material, states with a research or power reactor, and states with no nuclear experience whatsoever. While Wohlstetter and colleagues provided a helpful intellectual foundation for the study of nuclear latency, their analysis was limited by their exclusion of the internal and external dynamics that impact a state's nuclear development process. Additionally, the timelines that the authors proposed are based upon the nuclear development experience of the US. This is problematic because, since the US developed its nuclear capabilities during the Cold War period, the US experienced a unique level of urgency during its nuclear development process. Further, the US had and has a greater level of bureaucratic organization than most states, which assisted in streamlining its efforts to pursue nuclear weapons capabilities.

In 2005, the Pacific Northwest National Laboratory (PNNL), a US Department of Energy research laboratory, published a report titled the "Nuclear Proliferation Technology Trends Analysis" which Sagan describes as "the most detailed analysis, at least in the unclassified literature, of the history of successful efforts either to enrich uranium or reprocess plutonium" (Sagan 2010, 94). The PNNL report evaluated historical trends in nuclear technology development, and drew conclusions about "(1) the length of time it takes to acquire a technology", "(2) the length of time it takes for production of special nuclear material to begin", and "(3) the type of approaches taken for acquiring the technology" (Zentner et al. 2005, 1). Critiquing the PNNL report, Sagan argues that the first two points are so dependent on a state's specific context, that "calculations of 'average' times to pilot plants and 'average' times to production success… have a particularly ahistorical character to them" (Sagan 2010, 95). Sagan also criticizes the report for not accounting for the growing impact of international export controls on nuclear technology over time.

In 2006, Robert Harney and his Naval Postgraduate School colleagues produced a report— "Anatomy of a Project to Produce a First Nuclear Weapon"— in which they determined and detailed the "complex timeline of the 196 necessary tasks required to produce a uranium-based nuclear weapon by a state that has produced or acquired 120 metric tons of yellowcake" (Sagan 2010, 93). Harney and his colleagues assessed the time, money, labor, and energy required to complete these tasks under both "normal" and "crash" conditions. They concluded that under "normal" conditions, the earliest completion time for six weapons is around six and a half years and that the earliest completion time for six weapons under "crash" conditions is just under five years. Sagan highlights the same limitation here as in *Swords from Plowshares*: the accuracy of this study is limited by the authors' usage of US experience as their basis for estimation. Additionally, the study is further limited by the authors assumption that the government pursuing nuclear weapons capabilities "has not developed covert facilities to jumpstart the weaponization process" (Sagan 2010, 94).

B. Academic Scholarship that Relies on Proxy Measures of Nuclear Latency

In 1984, Stephen Meyer published a seminal study, *The Dynamics of Nuclear Proliferation,* in which he constructed a dataset that allowed him to assess each state's nuclear capabilities based upon a set of ten technical and economic variables: national mining activity, indigenous uranium deposits, metallurgists, steel production, construction work force, chemical engineers, nitric acid production, electrical production capacity, nuclear engineers, physicists, chemists, and explosive and electronic specialists. Since Meyer was not able to directly assess the acumen or number of a state's nuclear engineers or explosive and electronics specialists, he employed proxy variables in his analysis. To assess a state's nuclear engineers, Meyer determined whether a state had been operating a research reactor for three years. To assess a state's explosive and electronics specialists, he determined whether a state manufactured or assembled cars, or if a state manufactured or assembled radios or televisions. Meyer concluded that in 1982, thirty-four states had the latent capacity to manufacture nuclear weapons.

Richard Stoll updated Meyer’s data to include state-year information up to 1992 yet made a significant change to the coding rules pertaining to each state’s indigenous uranium deposits. In his analysis, Meyer measured each state’s indigenous uranium sources. Stoll, on the other hand, “dropped this requirement due to the ease with which any country may purchase a supply of uranium on the world market” for all years after 1970 (Stoll). Notably, Stoll continued to use Meyer’s two proxy indicators for the expertise and quantity of a state’s nuclear engineers and explosive and electronics specialists. Thus, Stoll concluded that in 1992, forty-eight states had latent nuclear capabilities. Sagan is critical of Stoll’s decision to classify all states as having the ability to access uranium from 1970 on. He argues that “Stoll’s hidden assumption that any state could acquire uranium on the open market, coupled with his use of research reactor experience as the measure of required nuclear engineering expertise” assumed away the two greatest technical constraints preventing states from achieving latency (Sagan 2010, 86).

In 2007, Erik Gartzke and Dong Joon-Jo picked up where Stoll left off yet made four main changes. First, they removed three variables— construction workforce, steel production, and previous mining activity. Additionally, Gartzke and Jo improved upon Stoll’s assumption that all states had access to nuclear materials from 1970 on by only coding a state as having access to nuclear materials if it had known uranium deposits on its territory or had somehow acquired produced uranium deposits already in a given year (Gartzke & Jo 2006). However, Sagan criticizes Gartzke and Jo for not “focusing [more of their] attention on enriched uranium and plutonium” and points out that their reliance on proxy measures results in peculiar findings. For example, Gartzke and Jo assessed Trinidad and Tobago to have a greater degree of nuclear latency than North Korea in 2001.

C. Academic Scholarship that Focuses on Enrichment and Reprocessing Capabilities

In 2015, Matthew Fuhrmann and Benjamin Tkach published a dataset that comprehensively and effectively captures the development of each state's latent nuclear capabilities based on its ENR capabilities between 1939 and 2012. As was discussed at length above, prior to Fuhrmann and Tkach's Nuclear Latency (NL) dataset, scholars relied on proxy measures to quantify states' latent capabilities. However, acquiring fissile material is believed to be the most challenging hurdle to surmount on the path to the bomb. Therefore, a measure of a state's access to fissile material is a more direct representation of a state's latent status. Since operational ENR facilities allow for countries to produce fissile material, it is thus believed that "possessing ENR technology is the most important feature of nuclear latency" (Fuhrmann & Tkach 2015, 444). The contents of the NL dataset reflect this conclusion— the dataset provides information regarding:

> "the operational history, size, and purpose (whether it served civilian or military functions) of each plant. The dataset also reveals whether facilities were subjected to safeguards administered by the International Atomic Energy Association (IAEA), and whether they were built covertly or with foreign assistance" (Fuhrmann & Tkach 2015, 445).

Questions swirl regarding the factors that contribute to a state's decision to become latent as well as about the utility of latent nuclear capabilities for states. The NL dataset provides a sturdy foundation for analysis of such questions.

Fuhrmann and Tkach provide guidance for how their dataset can be leveraged in the future: to help understand the deterrent effects of latency, the impact of a state's latent status on its dispute behavior, how latency influences world politics, and the causes of nuclear proliferation (Fuhrmann & Tkach, 2015). In order to demonstrate the value of the NL dataset, Fuhrmann and Tkach use it to "provide preliminary evidence that nuclear latency reduces the likelihood of [a state] being targeted in militarized disputes" (Fuhrmann & Tkach 2015, 445). This finding supplements literature that aims to determine the deterrent value of nuclear weapons capabilities.

In "Unpacking the Iranian Nuclear Deal: Nuclear Latency and U.S. Foreign Policy", Rupal Mehta and Rachel Whitlark utilize the information about states' ENR capabilities made available by Fuhrmann and Tkach to analyze the causes and consequences of nuclear latency, and how these causes and consequences may differ from those of nuclear proliferation. Mehta and Whitlark discuss these causes and consequences in the context of the debate that surrounded the Iran nuclear deal, or Joint Comprehensive Plan of Action (JCPOA). The contours of the debate prior to the signing of the JCPOA provide interesting insight into the widespread confusion surrounding the impact that latent nuclear capabilities have on a state's foreign policy behavior as well as why states pursue latency in the first place. Mehta and Whitlark note that "advocates of the deal said that Iran would not reap the benefits of a full nuclear weapons capability" in terms of geopolitical status and that "critics argued that Iran would be emboldened because of their capability retention" (Mehta & Whitlark 2016, 46). The yawning gap between the perceptions of these two foreign policy camps indicates that much work needs to be done to tease out the true causes and consequences of nuclear latency.

First considering the causes of nuclear latency, Mehta and Whitlark (2016) divide potential catalysts of nuclear latency into three categories: security-specific factors, energy-specific factors, and then *technological determinism*. The potential security-specific motivations for pursuing latency that Mehta and Whitlark outline include whether a state experiences a high instance of militarized interstate disputes, has persistent rivalries with nuclear-armed states, and or exists within a comparatively menacing security environment. If a state pursues latency in a tense security scenario, then the reasoning goes that the state wants to possess a "virtual deterrent". Mehta and Whitlark propose one energy-specific latency driver: whether a state is uncertain about the reliability of its access to energy markets. If a state is dissatisfied with its current access to energy markets or is concerned about its future energy prospects, it may invest in exploration of alternative energy sources, such as nuclear energy.

The idea that technological determinism may be a driver of nuclear latency is a troubling proposition for those who both see the spread of latency as a proliferation concern and support global technological advancement. In brief, proponents of hard technological determinism argue that technology "develops according to an internal logic independent of social influence" and that "technological change determines social change in a prescribed manner" (Kline 2001, 15945). Proponents of soft technological determinism, on the other hand, emphasize "the autonomy of technological change" and "the technological shaping of society" (Dafoe 2015, 1052). Since Mehta and Whitlark propose that states may become latent "as a natural byproduct of having the opportunity to do so", it seems that they were evoking a softer definition of technological determinism that still ascribes some level of agency to people and to states (Mehta & Whitlark 2016, 49). Still, the idea that development of nuclear latency may be a fait accompli for technologically advanced states remains troubling if we take the proliferation of latency to be a cause for concern.

Mehta and Whitlark conclude that latency has historically been driven more so by security-specific factors and technological determinism than by energy-specific factors. First, they find that if a state has nuclear-armed rivals, it is more likely to pursue latent capabilities. This finding added further affirmation to the body of nuclear proliferation literature that frames latency as a form of hedging. Interestingly, Mehta and Whitlark also find that security commitments from powerful allies “have a limited effect on the initial exploration into latency” and “do little to prevent states from progressing down the pathway to more substantial latent acquisition” (Mehta & Whitlark 2016, 50). Additionally, Mehta and Whitlark find a strong correlation between a state’s industrial capabilities and its latent status— “states may decide to acquire this technology simply because they have the resources and opportunity to do so” (Mehta & Whitlark 2016, 50). In regard to energy-specific factors that inform a state’s decision to pursue latent capabilities, Mehta and Whitlark find that “uncertainty of access to energy does not appear to drive decisions to pursue nuclear latency as a means of achieving energy independence”, yet also find “a positive relationship between large oil consumers, possibly seeking alternative energy sources, and the pursuit of latency” (Mehta & Whitlark 2016, 50).

In their 2017 study, “The Benefits and Burdens of Nuclear Latency”, Mehta and Whitlark further leverage Fuhrmann and Tkach’s NL Dataset to analyze how acquisition of latent nuclear capabilities “affects a state’s military security and bargaining power” (Mehta & Whitlark 2017, 517). They acknowledge two theories about the impact of latency on a state’s security status: virtual deterrence theory and latency provocation theory. Advocates for virtual deterrence theory argue that nuclear latency fortifies a state’s geopolitical status, while advocates for latency provocation theory posit that nuclear latency jeopardizes a state’s security (Levite, 2003; Sagan, 2010). More specifically, advocates for virtual deterrence theory maintain that nuclear latency can deter aggressor states, encourage risk-seeking foreign policy initiatives, drum up resource commitments from allies, and provide diplomatic advantages (Mehta and

Whitlark 2017: 519-520). On the other hand, advocates for latency provocation theory propose that nuclear latency can incentivize aggressor states to strike preventatively, increase the likelihood that other states engage in coercive pressure, and stifle the flow of resources from latent states' traditional allies.

Pushing back against Fuhrmann and Tkach's preliminary conclusion that nuclear latency reduces the likelihood of a state being targeted in militarized interstate disputes, Mehta and Whitlark's findings are more aligned with latency provocation theory than with virtual deterrence theory. Mehta and Whitlark find that relationships between the US and its latent allies tend to wither: latent allies are more likely to see a decrease in US aid and an increase in US nonproliferation sanctions. However, Mehta and Whitlark also find that latent non-allies gain "access to additional economic resources" from the US (Mehta & Whitlark 2017, 526). Finally, Mehta and Whitlark find that latency "does not decrease the likelihood of being targeted by fatal militarized disputes" and "is associated with a higher likelihood of initiating such fatal disputes" (Mehta & Whitlark 2017, 517).

2. The Contiguity Based Explanation for Conflict

The idea that contiguity increases the likelihood that states will engage with one in another in some capacity is not only intuitive, but also finds theoretical and empirical support in the political geography and international relations (IR) literature. This literature serves as the intellectual foundation of my contention that states are more likely to become latent if they have latent neighbors. Indeed, I use the opportunity and willingness conceptual framework of analysis, which was popularized by eminent political geography scholar, Harvey Starr, to structure my upcoming argument. A vast political geography literature exists that works to elucidate the relationship between proximity and armed conflict (Starr 2005). In the theoretical realm, contiguity— the most direct manifestation of proximity— is often operationalized within the opportunity and willingness framework (Starr 2005). The opportunity and willingness framework is an agent-structure model that was formulated by Harvey Starr in his 1978 path-defining article: "Opportunity and Willingness as Ordering Concepts in the Study of War". *Opportunity*, in the context of Starr's proposed framework, requires three related conditions: "(1) an environment that permits interaction between states, (2) states that possess adequate resources to be capable of certain kinds of actions, and (3) decision makers, or human agents of some kind, who are aware of both the range of interactions and the extent of capabilities available to them" (Starr 2005, 395). *Willingness* is based on "perceptions of the global scene and of domestic political conditions" and "deals with the goals and motivations of decision-makers" (Starr 2005, 395).

The idea of *interaction opportunity* situates proximity, and thus contiguity, within the opportunity and willingness framework: "proximity creates the possibility for conflict through increased possibilities for interaction (both positive and negative); thus, it raises the probability of interactions, both positive and negative" (Starr 396). In the quantitative IR literature, "opportunity has mainly been operationalized as physical proximity" (Furlong, Gleditsch, & Hegre 2006, 79). However, Senese advances a prominent criticism of contiguity-based explanations for conflict and cooperation between states: that "though interaction opportunity is posited as a necessary condition for conflict, either little is said, or a random process is assumed about conflict beyond that" (Senese 2005, 770). The "willingness" element of the opportunity and willingness schema aims to elucidate the impetus for conflict or cooperation between states beyond the objective opportunity that states are presented with.

It is important to emphasize that the interactions that contiguity permits to occur are not necessarily negative, indeed, through his social communication model of integration, Deutsch posits that "increased interactions, transactions, and interdependence make conflict less probable" (Starr 2005, 396). However, within the quantitative IR literature, contiguity is primarily employed as an element of models that aim to tease out what conditions increase the likelihood of armed conflict. In 1982, Allan Bremer's exploration of the conditions that were believed at the time to be the most characteristic of war-prone dyads cemented the role of contiguity in the quantitative IR scholarship for decades to come. Bremer found that the presence of contiguity was the most predictive condition of conflict between two states, and his finding has "been overwhelmingly confirmed by numerous conflict studies" (Brathwaite, 2005; Huth, 1996; Kocs, 1995). To be sure, from 1816 on, two-thirds of full-scale wars and more than half of all militarized disputes were initiated by neighbors (Hensel 2000). Moreover, from 1945 on, almost all full-scale wars were initiative by neighbors (Hensel 2000).

Two prominent explanations for why neighbors fight more than non-neighbors built upon Starr's "interaction opportunity" formulation. The more prominent of these is Vasquez's proposal that "human proclivity to territoriality leads neighboring states to use violence and aggressive displays to demark their territory, especially the areas contiguous to another state" (Vasquez 1993, 135). The alternate, less established, explanation is advanced by Robert Powell, who posits that "neighbors fight more because their expected value for conflict relative to the status quo is greater than it is for non-neighbors" (Reed & Chaiba 2010, 62). Vasquez's territorial explanation is of greater relevance to my thesis project because it notes that "neighbors are more likely to become rivals and become involved in a spiral of conflict" as well as that "neighbors tend to view the world in terms of a traditional realist security dilemma" (Reed & Chaiba 2010, 62).

The concept of reactive latency that I propose is a decidedly realist, long-term calculation, rather than the sorts of immediate, physical conflict that have been roundly established as more likely to occur between neighboring states than distant ones. However, findings regarding contiguity and physical conflict establish, at the very least, that tension is a common element of relationships between contiguous states. Such tension could result in a proclivity for reactive latency. Additionally, the opportunity and willingness framework advanced by proponents of the contiguity-based explanation for conflict provides a helpful logical architecture for the consideration of reactive latency.

Finally, it is interesting to consider the recent nuclear latency literature in conversation with the body of political geography scholarship that is woven together by the opportunity and willingness framework of analysis. According to proponents of the opportunity and willingness framework, for an event to occur, opportunity and willingness must occur in tandem: "simply being able to do something does not mean it will happen unless you have the will to take action" (Starr 2005, 395). The proposal that the currents of technological determinism drive nuclear latency should be considered in light of this element of the opportunity and willingness framework. While technology may provide a state with the adequate resources to become latent, the perceptions and motivations of a state's decision-makers, too, are key.

3. Diffusion Scholarship

Etel Solingen's 2012 article "Of Dominoes and Firewalls: The Domestic, Regional, and Global Politics of International Diffusion" has similar prescriptive and descriptive value to Sagan’s 2010 critique, only Solingen tackles the diffusion scholarship space. In “Of Dominoes and Firewalls” Solingen contextualizes the history of scholarship concerning international diffusion and provides recommendations for the future study of the phenomenon. Solingen notes the “centrality of diffusion to international studies”, puts forth a conceptual framework for discussion of diffusion, and identifies ways in which future diffusion models can improve upon past scholarship. Solingen argues that the literature has failed thus far to adequately define diffusion and has largely studied the concept tacitly rather than directly. Solingen sees David Strang’s conceptualization of diffusion as “any process in which prior adoption of a trait or practice alters the probability of adoption for remaining non-adopters” as a useful starting point for analysis (Strang 1991, 325).

Solingen identifies four elements of diffusion: (1) an initial stimulus, (2) a medium, (3) social agents, and (4) outcomes. The conductivity of a medium is impacted by its “firewalls”. In the nuclear proliferation context, the Treaty on the Non-Proliferation of Nuclear Weapons or Non-Proliferation Treaty (NPT) is a primary example of the firewall concept. Solingen also identifies possible classifications for a perceived diffusion process: (1) “spurious diffusion”, or “independent responses to similar or different domestic triggers”, (2) “independent reactions to a common global source”, (3) “interdependent regional contagion”, and (4) “globally interdependent copycat” (Solingen 2012, 633).

In her discussion of the extensive literature analyzing the international diffusion of nuclear capabilities, Solingen pushes back against over-reliance on mechanical, neo-liberal explanations for nuclear acquisition and calls for additional analysis of non-security-specific variables, such as regime type. In regard to the regional diffusion of nuclear weapons capabilities, Solingen notes that the relative regional incidence of inward-looking regimes is more predictive of a state's decision to nuclearize than a neighbor's acquisition of nuclear weapons. Indeed, Solingen states that "the latter did not lead inexorably to the reactive nuclearization of others as auto-pilot responses to presumed system-level diffusionary adjustments to changing levels of relative power" (Solingen 2012, 639).

In his 2010 dissertation, *Does Proliferation Beget Proliferation? Why Nuclear Dominoes Rarely Fall*, Philipp Bleek pushes back on the conventional wisdom that states are more likely to pursue nuclear weapons capabilities if a security rival has proliferated. He also considers what qualities of a state's security environment or of the state itself increase the likelihood that it "reactively proliferates", which adds to his dissertation's policy-relevance. To analyze whether states are more likely to pursue nuclear weapons capabilities if they have a weapons-capable security rival, Bleek employs hazard analysis. Hazard analysis is a statistical method that is "intended to explore the likelihood and timing of events of interest, while controlling for and exploring the importance of various factors" (Bleek 2010, 66). The 'event of interest' in Bleek's case is the year that a state proliferates, if it chooses to do so. Conventional regression analyses fall short of Bleek's research aims because they can "either code the United States as though it had re-acquired in each of those years, thereby explaining weapons possession rather than acquisition… or can code the United States as though it did *not* proliferate in each of those subsequent years, a cure that is worse than the disease" (Bleek 58).

Bleek adopts two identifications of rivalry and builds a reactive proliferation independent variable from there: his 'enduring rival' coding comes from D. Scott Bennett, and his 'lower rivalry' coding comes from James Klein, Paul Diehl, and Gary Goertz (Bennett, 1997; Klein, Goertz, & Diehl, 2006). Bleek finds that "…states whose security rivals proliferate consequently experience modest increases in proliferation motivation" (Bleek 2010, iii). More specifically, states whose security rivals proliferate are more likely to explore nuclear weapons options, but are not more likely to push over "the much higher thresholds to launching nuclear weapons programs or seeing such programs through to acquisition" (Bleek 2010, iii). In regard to relevant intervening variables, Bleek unsurprisingly finds that states without security guarantees from powerful allies are more likely to reactively proliferate and that states that have access to greater economic and technological resources are more likely to reactively proliferate as well. Bleek includes each state's latent nuclear weapons production capacity as a control variable in his study, and he utilizes Gartzke and Jo's 2007 dataset, which is limited by its reliance on proxy indicators of latent capabilities.

4. Gap in the Literature

In their 2015 paper, Fuhrmann and Tkach raise the concern that Iran's latent status could compel other states in the Middle East to pursue similar capabilities, bringing the region to the brink of the almost universally dreaded Middle East nuclear arms race. Tugging on this thread, Mehta and Whitlark suggest that future scholars should consider "the conditions under which states seek latent capabilities and the extent to which the pursuit of latency proves 'contagious'" (Mehta & Whitlark 2017, 526). Through this thesis, I respond to this suggestion and analyze whether having a latent neighbor increases the likelihood that a state itself will become latent. Solingen and Bleek's discussion and findings pertaining to the diffusion of nuclear weapons capabilities inform how I structure my statistical analysis as well as shape my expectations for my results. Bleek, in particular, finds that states with nuclear-armed security rivals are likely to explore nuclear options. Will states with latent neighbors show a similarly increased propensity to explore latent capabilities themselves? Through this thesis, I aim to contribute to the growing nuclear latency literature by providing a preliminary answer to this question.

II. Argument

In the following section, I introduce the concept of "reactive latency" and argue that a state is more likely to become latent if it has a latent neighbor or neighbors. Additionally, I argue that a state is more likely to become latent if it has a neighbor or neighbors who have achieved commercial or pilot-scale latency rather than a neighbor or neighbors who have achieved laboratory-scale latency. In constructing this argument, I first establish how other states, neighbors and otherwise, may impact a state's decision to become latent. I then utilize the opportunity and willingness conceptual framework to analyze the mechanisms that may contribute to and ultimately elicit reactive latency. In regard to the opportunity that a state may have to engage in the pursuit of reactive latency, I first briefly discuss the relationship between contiguity and opportunity. I then analyze the institutional environment in which states pursue and achieve varying latency milestones as well as the incentives that other states, neighbors and otherwise, may have to enable or block a state's path to latency. In regard to a states' willingness to become latent, I consider the incentives that states have to become latent. These considerations lead me to conclude that a state is more likely to become latent if it has a latent neighbor or neighbors, and that having a neighbor or neighbors who have made a considerable investment in latent capabilities is more likely to beget a state's own pursuit of latency than having a neighbor or neighbors who are in a more exploratory phase.

1. The Role of Other States: Neighbors and Otherwise

States cannot achieve latency in a vacuum. Therefore, when analyzing how and when the latency dominoes may fall, it is crucial to consider the role of outside actors: the other states in the international system. The traditional argument proceeds such that a state's pursuit of nuclear latency equates to that state adopting a nuclear hedging strategy in response to provocation. Recent empirical work reinforces the underlying logic of this argument: that states are more likely to become latent in tense security scenarios (Mehta & Whitlark 2016). This reasoning is also an implicit mainstay in contemporary discussions of the Iran- Saudi Arabia nuclear dichotomy: we are bombarded with press releases these days out of Riyadh regarding how it intends to match Tehran, latency milestone for latency milestone. However, latent nuclear capabilities do not simply appear at a snap of the fingers when a state finds itself in geopolitical hot water and is looking to hedge. Rather, because of the extensive nuclear nonproliferation and export control regimes that structure the exchange of nuclear material between states today, non-latent states must collaborate with latent or weapons states in order to develop the capabilities that they seek.

Some states may pique the interests of non-latent states in becoming latent. Others may actively or tacitly support non-latent states in their pursuit of nuclear latency. Others still may attempt to quash non-latent states' attempts to develop such capabilities. For the purposes of this analysis, I divide the outside actors that our protagonist states— or antagonist states depending upon perspective— interact with on their quests to becoming latent into three categories: catalysts, enablers, and blockers. *Catalysts* are the neighbors that may pique a state's interest in becoming latent itself. *Enablers* are any states, neighbors or not, that assist a state in its pursuit of latency. Conversely, *blockers* are the states that actively work to prevent a state from achieving latency. Of course, there are also states within the international system that remain on the sidelines, not contributing to catalyzing, enabling, or blocking another state's moves toward latency. Because of the gravity of additional proliferation and thus the extensive nature of the global non-proliferation and export control regimes, this cast of external actors interacts in some way with every step of a state's journey toward becoming latent.

2. Opportunity: Contiguity, Environment & the Incentives of Other States

Now that I have established the actors within the international system that play a role in each state's pursuit of latency, I will employ the opportunity and willingness conceptual framework to explore the concept of reactive latency. Recall that Starr divides the requirements of opportunity into three categories: "(1) an environment that permits interaction between states, (2) states that possess adequate resources to be capable of certain kinds of actions, and (3) decision makers, or human agents of some kind, who are aware of both the range of interactions and the extent of capabilities available to them" (Starr 2005: 395). I consider the *environment* element of the opportunity equation in the greatest depth. I explore the encouraging elements as well as constraints inherent to a state's environment through consideration of the balance of power between contiguous states and acknowledgment of the institutional environment dictated by the global nonproliferation and export control regime.

I then supplement my discussion of the environment piece by homing in on the *resources* element of opportunity. It is important to note that the legal exchange of the physical and technological resources necessary to achieve various latency milestones is governed completely by the institutional environment: the global nonproliferation and export control regime. My consideration of how resources contribute to opportunity is thus framed in the terms of how the incentives of a state's enablers and blockers manifest themselves within the institutional environment that I detail. Finally, seventy-four years after Hiroshima and Nagasaki and forty-five years after the establishment of the Nuclear Suppliers Group (NSG), it is hard to imagine that the third element of opportunity in this case— *awareness* of nuclear options— is not ubiquitous amongst decision-makers. Since awareness of options can be assumed to be nearly, if not completely, universal, awareness will not be discussed in an isolated manner within the context of this thesis.

A. Contiguity

Vasquez's notion that relationships between contiguous states are more prone to rivalry and to mutual perceptions that realism defines the relationship between them serves as the basis of my thinking regarding reactive latency. As was discussed in depth in my literature review, the correlation between contiguity and conflict is well-established, empirically speaking. Because of this, contiguity is commonly operationalized as a representation of opportunity within the quantitative IR literature. I am not, however, proposing that reactive latency would be form of conflict. I instead am proposing that reactive latency would be a behavior born out of strategic calculation. Strategic behaviors are necessarily responsive to the balance of power within a state's security environment. The introduction of nuclear latency to a dyad shifts the balance of power within that dyad. A state would not necessarily respond to this shift by becoming latent itself. However, it stands to reason that reactive latency would be a present, if not prominent, item on a state's menu of responses to this shift. Therefore, I argue that a state is more likely to become latent if it has latent neighbors because its incentive to do so increases as a result of a shift in the balance of power within a state's security dyad. Additionally, based upon the same line of reasoning, I posit that a state's likelihood of becoming latent increases as its neighbors achieve comparatively greater latency milestones or even proliferate.

B. Institutional Environment

A behemoth nonproliferation regime governs the exchange of nuclear materials and technology, and "proponents argue that today the NSG, NPT, and IAEA provide policymakers with confidence that the looming renaissance in nuclear power can unfold without contributing to the spread of nuclear weapons" (Fuhrmann 2012, 8). Because of the existence of dual-use nuclear technology, though, the idea that peaceful and military nuclear development are mutually exclusive is increasingly inapplicable. Indeed, Swedish Nobel Prize-winning physicist Hannes Alfvén described the peaceful atom and military atom as "Siamese twins" (Barnaby 2004, 68). In the following section, I outline the civilian nuclear cooperation agreements, nonproliferation regime, and export control regime that constitute the institutional context, or environment, that all states operate within when legally exchanging nuclear material and technology presumably intended for civil use. Reactive latency, legally pursued, would be in some ways enabled and in other ways constrained by the dictates of this environment.

i. Civilian Nuclear Cooperation

In a 1953 speech before the United Nations General Assembly, President Dwight D. Eisenhower pledged the United States' "determination to help solve the fearful atomic dilemma - to devote its entire heart and mind to finding the way by which the miraculous inventiveness of man shall not be dedicated to his death but consecrated to his life" (Eisenhower). President Eisenhower's speech, commonly referred to as the Atoms for Peace Speech, "helped set the stage for the nuclear marketplace to take off over the next several decades" because of the president's support of the exchange of civilian nuclear knowledge, materials, and technology (Fuhrmann 2012, 2).

The thinking undergirding Atoms for Peace still shapes popular thinking surrounding the exchange of civilian nuclear technology, knowledge, and materials today. Peaceful atomic assistance is widely believed to be a form of arms control. Indeed, Eisenhower "believed that sharing nuclear technology and know-how would reduce the likelihood of proliferation because foreign suppliers could obtain assurances from the recipient state that any assistance it provided would be used exclusively for peaceful purposes" (Fuhrmann 2012, 7). Additionally, foreign suppliers "could also gain a degree of control over the recipient's activities by enhancing its dependence on external technology" (Fuhrmann 2012, 7). When a state wants to pursue civilian nuclear capabilities, regardless of its true aims, it must receive assistance from a member of the NSG. Peaceful nuclear cooperation between states can be divided into six categories: safety, intangible transfers, nuclear materials, research reactors, power reactors, and fuel cycle facilities (Fuhrmann 2012). Civilian nuclear cooperation in regard to research reactors, power reactors, and fuel cycle facilities is of the most relevance to consideration of the institutional context in which nuclear latency may spread.

Research reactors are "used for training purposes or to produce isotopes that have medical applications and are often exported to states that are just beginning nuclear programs" (Fuhrmann 2012, 16). Power reactors are used to produce electricity, and transactions involving these reactors and their subcomponents constitute a large portion of civilian nuclear cooperation. The US, Russia, France, and Canada are the world's chief reactor suppliers. If construction of a reactor is not completed in one of these states, then foreign assistance is usually a necessary element of the construction process (Fuhrman 2012, 17). If a state only imports research reactors or power reactors, and not fuel cycle facilities, it must also import reactor fuel. States that aim to develop advanced civilian nuclear capabilities "often demand the capability to produce reactor fuel indigenously or with minimal dependence on foreign suppliers" (Fuhrmann 2012, 17). However, in recent years, the NSG has strengthened the guidelines that govern whether supplier states can export such ENR technology (Carlson, Goorevich & Jonas 2012). Exports of fuel cycle capabilities are thus less frequent than exports of research and power reactors.

US civilian nuclear cooperation agreements are governed by Section 123 of the US Atomic Energy Act of 1954 and are thus commonly referred to as "123 agreements". Section 123 of the Atomic Energy Act "establishes a legal framework for cooperation between the US and the partner nation and provides for strict nonproliferation commitments governing that cooperation" (Miller & Volpe 2018, 31). The stringency of 123 agreements, however, varies significantly. For example, the US-Japan, US-India, and US-Euratom 123 agreements allow for indigenous enrichment of uranium and reprocessing of used nuclear fuel using imported US materials and technology. These agreements are comparatively less stringent than the more common "standard" 123 agreements, all of which necessarily include a prior consent clause (U.S. Department of State 2017). Prior consent clauses require a state, or an organization of states, to obtain Washington's permission before they can engage in ENR activities with US-sourced nuclear material or technology. Finally, the class of 123 agreement that requires the greatest nonproliferation commitment is often colloquially referred to as the "gold standard" because of its wholesale prohibition of future acquisition of ENR technology. The 123 agreement that the United Arab Emirates concluded with the US in 2009 is the only gold standard 123 agreement that has been signed to date. However, calls for the 123 agreements that the US concludes with additional countries to adhere to the "gold standard" are increasingly prevalent in both houses of Congress (Lewis 2012).

ii. The Global Nonproliferation Regime

In 1968, when the US signed the Nuclear Nonproliferation Treaty (NPT), President Lyndon Baines Johnson declared that the treaty was "evidence that amid the tensions, the strife, the struggle, and the sorrow of [those] years, men of many nations [had] not lost the way — or… the will— toward peace" (Johnson). The NPT has been the centerpiece of global nonproliferation efforts since it entered into force in March 1970, and it is best conceptualized as two requirements that lead to an associated promise. Nuclear weapons states (NWS) NPT signatories have agreed to work towards disarmament, non-nuclear weapons states (NNWS) NPT signatories have agreed to cease their efforts to proliferate, and, in turn, all state signatories reap the rewards of peaceful nuclear energy. Today, the NPT is nearly universally adopted, with India, Israel, Pakistan, and South Sudan the only remaining non-signatories and North Korea existing in a state of NPT legal limbo. The NPT shapes the institutional context in which NNWS pursue civilian nuclear capabilities, and thus achieve varying degrees of nuclear latency.

Articles III, IV, and VII of the NPT are the most relevant to consideration of the institutional context, or environment, in which reactive latency may occur. Article III of the NPT establishes that each NNWS will accept IAEA safeguards and inspections "for the exclusive purpose of verification of the fulfillment of its obligations assumed under [the NPT] with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other explosive devices" (Treaty on the Nonproliferation of Nuclear Weapons). Article III requires that NWS parties to the Treaty not provide fissionable material or relevant equipment to NNWS that are not parties to the Treaty. Article IV affirms the "inalienable right of all the Parties to the Treaty to develop research, production, and use of nuclear energy for peaceful purposes" and enshrines support for the “fullest possible exchange” of NPT-appropriate information between NWS and NNWS (Treaty on the Nonproliferation of Nuclear Weapons). Finally, the NPT’s most succinct Article, Article VII, states that “nothing in [the NPT] affects the right of any group of states to conclude regional treaties in order to assure the total absence of nuclear weapons in their respective territories” (Treaty on the Nonproliferation of Nuclear Weapons).

In the early 1990s, due to the IAEA’s experiences in North Korea in Iran, it became clear that the NPT was effective “with regard to verification activities on declared material and facilities” but was not “well-equipped to detect undeclared nuclear material and activities” (International Atomic Energy Agency 2018). Therefore, in 1993 the IAEA commenced efforts to better detect undeclared nuclear materials and activities. These efforts culminated in the Additional Protocol to the NPT, which “is not a stand-alone agreement, but rather a protocol to a safeguards agreement that provides additional tools for verification”, in particular increasing “the IAEA’s ability to verify the peaceful use of all nuclear material in States with comprehensive safeguards agreements” (International Atomic Energy Agency 2018). The Model Additional Protocol was approved in May 1997 and as of December 2018, “Additional Protocols are in force with 134 States and Euratom” (International Atomic Energy Agency 2018).

Finally, there are four regional nuclear weapons free zones (NWFZs)— in Latin America, Africa, the South Pacific, and Southeast Asia— that are governed by NWFZ treaties that supplement the NPT regime. NWFZ treaties are a distinctly regional approach to nonproliferation, and they prevent signatories from acquiring, receiving, or supporting the acquisition or receipt of nuclear weapons. All NWFZ treaties include a protocol for NWS to sign indicating that they will neither house nuclear weapons within treaty-protected territory nor use nuclear weapons against a treaty’s NNWS signatories. However, it is important to note that NWFZ treaties do not prevent NWS from sharing fissile material or civil nuclear technology with NNWS treaty parties. These treaties exclusively govern the acquisition and receipt of nuclear weapons.

iii. The Global Export Control Regime

The Nuclear Suppliers Group, hereafter referred to as the NSG, is a multinational export control regime that supplements the global nonproliferation regime. It is made up of forty-eight states and it was founded in the wake of the May 1974 Indian nuclear test. The NSG's central aim is to prevent proliferation without hindering nuclear commerce. The NSG operates based upon two sets of Guidelines for nuclear exports and nuclear-related exports: the first set of Guidelines, published in 1978, "governs the export of items that are especially designed or prepared for nuclear use", and the second set of Guidelines, published in 1992, "governs the export of nuclear-related dual-use items and technologies"(Nuclear Suppliers Group (NSG)).

The Guidelines are "consistent with, and compliment, the various international, legally binding instruments in the field of nuclear nonproliferation: the NPT, the Treaty of Tlatelolco, the Treaty of Rarotonga, the Treaty of Pelindaba and the Treaty of Bangkok (Nuclear Suppliers Group (NSG)). The second set of Guidelines, which pertain to dual-use technology, was implemented in 2005 because of Iraq's success in leveraging dual-use items that were not governed by the Guidelines as they were at that point to pursue a covert weapons program. In 2011, the NSG revisited the dual-use problem and decided to enhance its guidelines pertaining to transfer of ENR technologies. Taken together, the civilian nuclear cooperation agreements concluded between NSG nations and NNWS, the global nonproliferation regime, and the global export control regime structure the environment in which states become latent.

C. Incentives of Enablers and Blockers

The second requirement of opportunity per Starr is that states must “possess adequate resources to be capable of certain kinds of actions” (Starr 2005, 395). Because of the extensive nature of the global nonproliferation and export control regime detailed above, NNWS must interact with members of the NSG in order to obtain the resources necessary to be capable of becoming latent: nuclear material and technology. In some cases, states are incentivized to enable another state’s pursuit of latency. In others, states are incentivized to block another state’s pursuit of latency. Either way, other states’ incentive structures directly impact a state’s opportunity to become latent.

Members of the NSG have much to gain in the civilian nuclear cooperation realm. A helpful way to conceptualize these trade practices is to frame them as “geostrategic nuclear exports” because exporting nuclear reactors is appealing on a number of levels (Hibbs 2017). First, Nuclear Power Plant (NPP) sales are more lucrative than transactions related to fossil fuels because they “are generally accompanied by a suite of services, including provision of nuclear fuel, training for engineers and regulatory consulting” (“The world relies on Russia to build its nuclear power plants” 2018). Additionally, beyond the commercial benefits of such cooperation, NSG members can also use transactions in the nuclear realm to “build political relations and acquire leverage over key countries” (Volpe & Miller 2018). Indeed, because of the longevity and complexity of such projects, states commit to decades of close collaboration with the NSG member or members that they ultimately conclude a treaty with.

Moves to block or temper a state’s efforts to achieve different latency milestones can also confer geopolitical gains as well as commercial gains on NSG members. NSG members have three main blocking tools at hand: diplomacy, technology denial, and sanctions. These options, of course, depend upon the context of a non-latent state's moves to become latent or a latent state's efforts to achieve different milestones. However, the acquisition of latency does not equate to an intention, or even ability, to proliferate. Therefore, the potential geopolitical gains of blocking latency are indeed more nebulous than the opportunity for a state to extend its global reach by enabling additional states to become latent. Commercial gains of blocking latency, too, are more nebulous.

However, members of the NSG certainly do engage in technology denial practices. The global nonproliferation and export control regimes are indeed predicated on technology denial. A mainstay example of technology denial on the part of the US that recently reemerged as a topic of debate is the US' refusal to consent to South Korean commercialization of its civilian nuclear capabilities. South Korea, which concluded a standard 123 agreement with the US in 1974, has repeatedly pushed for prior consent from Washington to enrich uranium and reprocess spent reactor waste at commercial scale, yet US presidents from both parties have perennially refused Seoul's requests (Miller & Volpe, 2018, 32; Varnum, 2012). The intersection between a state's pursuit of latency and the commercial and geopolitical incentives of members of the NSG that may either enable or block a state's path to latency is a ripe avenue for future study.

3. Willingness: Incentives of the State

Within the opportunity and willingness framework, an event of interest occurs at the nexus of opportunity and willingness. Now that I have explored how contiguity as well as the three requirements of opportunity— environment, resources, and awareness— affect a state’s path to latency, I pivot to analysis of the necessary willingness piece of the latency puzzle. A state may experience strong support in regard to potential pursuit of latency from enablers and have no blockers to speak of. However, a state’s impetus to act is dependent on the incentives attached to latency in its particular security environment. Recall that Mehta and Whitlark (2016) divide a state’s hypothetical motives to become latent into three categories: security-specific factors, energy-specific factors, and then the inertia characteristic of technological determinism. How is a state’s security, access to energy, and technological status impacted by its relationship with its neighbors? I consider each of these motivational categories in turn and conclude that security-specific factors are a logical driver of reactive latency, while energy-specific factors and technological determinism are not.

First, scholarship indicates that neighboring states engage in more frequent militarized interstate disputes than states that are far away from one another (Boulding, 1962; Bremer, 1992). If we take the comparatively greater instance of militarized interstate disputes between neighbors than between distant states to mean that there is, on average, more tension between neighbors than between distant states, then the idea that a state would reactively pursue latent capabilities in order to hedge against its neighbor makes sense. Nuclear latency is classically framed as a form of hedging, and Mehta and Whitlark’s (2017) findings support this formulation. Indeed, Mehta and Whitlark find that states are more likely to pursue latent capabilities if they have a nuclear armed rival. Of additional interest, the stringency of the civilian nuclear cooperation agreements that a state’s neighbors conclude may shift a state’s risk calculi, and therefore may catalyze reactive latency (Miller & Volpe, 2017).

While access to increased or consistent energy resources is certainly an integral element of many states’ decisions to pursue of latency, it does not appear that such concerns would impact the strategic behavior that I explore in my study: reactive latency. A short thought experiment helps to elucidate why this is. Say that a collection of states in a region began to explore latent capabilities as a result of concerns regarding continued access to energy resources. The potential for such a scenario is supported by the literature— Mehta and Whitlark (2017) find a positive relationship between large oil consumers, who are potentially exploring alternative sources of energy, and the pursuit of latency. However, this would constitute a regional response to a common shock— a current or potential future scarcity of hydrocarbons, in this case— rather than the sort of reactive latency that I aim to explore through this thesis.

Additionally, the theory that elements of technological determinism lead to acquisition of latency, which Mehta and Whitlark (2017) also find support for, does not contribute to reactive latency because technological determinism is fundamentally focused on state-level progress rather than how the relationship between neighboring states may culminate in the reactive acquisition of nuclear latency. Eliminating energy-specific motivations and technological determinism from consideration of why states may reactively pursue latent capabilities of their own, we are left considering the security-specific motivations that may drive such acquisition.

4. Summary of Argument

Given the above presentation and analysis of the actors, institutional structures, and incentives that impact a state's decision and ability to become latent, I argue that states are more likely to become latent if they have latent neighbors. I also find that Bleek's (2010) conclusion that states that have nuclear-armed rivals are more likely to explore nuclear-weapons options yet are not more likely to actually proliferate is relevant to my argument. Accordingly, I posit that if a state has a neighbor or neighbors with comparatively advanced latent capabilities, or even a neighbor or neighbors who have proliferated, then that state will be more likely to become latent than other states who have a latent neighbor or neighbors that are in more exploratory phases of their nuclear journeys.

III. Research Design

In the following section, I outline my research design. I first discuss the datasets that undergird my work. Next, I discuss how I went about constructing the explanatory and response variables utilized in my analysis. After that, I discuss the security-specific, economic, institutional, and domestic covariates that I included in all of my statistical models. Finally, I expand upon the method that I utilize to conduct my analysis.

1. Datasets

This article utilizes two datasets that each have a cross-section, time-series structure. In both datasets, the unit of observation is the state-year. As in Mehta and Whitlark (2017), state-year observations were drawn from the 1945-2000 period in both datasets rather than from the entirety of the 2015 NL dataset's 1939-2012 period because of "constraints on the availability of data" (Mehta & Whitlark 2017, 521). However, in the first dataset (hereafter referred to as Dataset I), all of the state-year observations after the first year that a state achieved laboratory-scale nuclear latency plus all of the state-year observations that a state possessed nuclear weapons were excluded from the dataset. In the second dataset (hereafter referred to as Dataset II), all of the state-year observations after the first year that a state achieved pilot-scale nuclear latency plus all of the state-year observations that a state possessed nuclear weapons were excluded from the dataset. Table I, included below, presents a record of which states have achieved laboratory and pilot-scale latency and the years that they had these capabilities. Table II, which is also included below, details the years that states possessed nuclear weapons.

State-year observations after the first year that a state reaches different latency milestones— laboratory-scale latency for Dataset I, and pilot-scale latency for Dataset

II— are excluded because this analysis aims to explore whether states that have latent neighbors are at a greater risk of becoming latent themselves. A state's decision to become latent is different than its decision to maintain its latency, and this study aims to tease out what variables impact motivation to explore and acquire rather than motivation to maintain. Also, following Mehta and Whitlark's (2017) precedent, if a latent state possessed nuclear weapons at any point, I censored all state-year observations for those years from both of my datasets. I made this decision because recent scholarship suggests that "the determinants of states' pursuit of nuclear latency are different from that which drives states toward *weapons* acquisition" (Mehta & Whitlark 2016, 46).

Some states have reached different latency milestones and then ultimately shuttered their ENR facilities, effectively forfeiting their latent capabilities beyond the technical know-how undergirding their efforts to construct and maintain the facilities that they previously had. Other states have repeated the nuclear latency acquisition-forfeiture cycle multiple times, fluctuating between levels of latency. In Dataset I, for states such as these, all state-years in which the state possesses laboratory-scale latent capabilities are censored out other than the first year of each instance of latency and all state-years in which the state does not possess laboratory-scale latent capabilities are included in the dataset. In Dataset II, for states such as these, all state-years in which the state possesses pilot-scale latent capabilities are censored out other than the first year of each instance of latency and all state-years in which the state does not possess pilot-scale latent capabilities are included in the dataset. It should be noted that all state-years between 1945 and 2000— minus the state-years in which a state either had proliferated or had achieved the latency milestone relevant to the dataset at hand— are included in Datasets I and II, not just the state-years corresponding to states that eventually became latent. It is just as important to include data concerning the states that did not explore or achieve latency as it is to include data concerning those states that did.

Datasets I and II include 6464 and 6701 state-year observations respectively. Dataset II includes more state-year observations than Dataset I because less states have achieved pilot-scale latency than laboratory-scale latency thus far. Accordingly, more state-year observations are censored from Dataset I because it excludes all observations after the first year in which a state has achieved laboratory-scale nuclear latency. The covariates that are included in these datasets are largely consistent with those included in Mehta and Whitlark (2017) and Gartzke Jo (2007). I expand upon the reasoning behind the inclusion of each below. The explanatory variables included in the datasets were constructed using information from the Correlates of War (COW) State System Membership (v2016) dataset, the COW Direct Contiguity dataset, and the 2015 NL Dataset. Response variables were constructed using the 2015 NL Dataset.

2. Explanatory Variables: Latent Neighbor(s)

To determine how to classify the geographic relationship between states for the purposes of my statistical models, I first had to find a comprehensive account of the history of the international state system. After all, even though the state system feels fairly constant today from an American perspective, it has changed dramatically since the Congress of Vienna. The COW State System Membership (v2016) dataset provided me with the information necessary to accomplish my goal. The COW Project was founded in 1963 by political scientist J. David Singer with the goal of "systemic accumulation of scientific knowledge about war" (Correlates of War Project). The State System Membership (v2016) dataset is one of the COW project's constituent datasets, and it contains information about all of the "states" in the international state system between 1816 and 2016. According to the facilitators of the Correlates of War project, to be considered a state before 1920, "the entity must have had a population greater than 500,000 and have had diplomatic missions at or above the rank of charge d'affaires with Britain and France" (Correlates of War Project). To be considered a state after 1920, "the entity must be a member of the League of Nations or the United Nations or have a population greater than 500,000 and receive diplomatic missions from two major powers" (Correlates of War Project).

To determine each state's neighbors, I looked to version 3.2 of the Correlates of War (COW) Direct Contiguity dataset, which was most recently updated by Dr. Paul R. Hensel in February 2017. The COW Direct Contiguity dataset is one of the COW Project's constituent datasets and "identifies all direct contiguity relationships between states in the international system from 1816 through 2016" (Correlates of War Project). The COW Direct Contiguity dataset includes five categories of contiguity, one for land contiguity and another four for increasingly distant water contiguity. Land contiguity is "defined as the intersection of the homeland territory of the two states in the dyad, either through a land boundary or a river" (Stinnett et al. 2017, 1). Water contiguity is classified by "whether a straight line of no more than a certain distance can be drawn between a point on the border of one state, across open water (uninterrupted by the territory of a third state), to the closest point on the homeland territory of another state" (Stinnett et al. 2017, 1).

The four different categories of water contiguity are divided as such: less than or equal to 12 miles, 24 miles, 150 miles, and 400 miles apart. The authors decided that 'less than or equal to 12 miles apart' should be the first category of water contiguity in accordance with Part II of the UN Convention on the Law of the Sea (UNCLOS), which states that "every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles" (United Nations Convention on the Law of the Sea). The second category of water contiguity, 'less than or equal to 24 miles apart' is also based upon the UN's 12-mile territorial milestone: two adjacent 12-mile territorial zones is equal to 24 miles apart. The 'less than 150 miles apart' water contiguity category is an artifact from an earlier version of the dataset that included information about contiguity between 1816 and 1965 and reflected "what was considered the average distance that a sailing ship could travel in one day" (Stinnett et al. 2017, 1). Finally, the 'less than 400 miles apart' water contiguity category is informed by Part V of the UNCLOS, which states that a state's "exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured" (United Nations Convention on the Law of the Sea). This final category of water contiguity thus encompasses the "maximum distance at which two 200-mile exclusive economic zones can intersect" (Stinnett et al. 2017, 1). I decided to incorporate all categories of land and uninterrupted water contiguity included in the COW Direct Contiguity Dataset into my definition of 'neighbor' for the purposes of my statistical models.

As was previously noted, Fuhrmann and Tkach's 2015 NL dataset provides the most comprehensive information available to date on the history of each state's latent capabilities, and therefore acts as the foundation for analysis of nuclear latency today. As such, I leveraged the information about the history of each state's ENR capabilities provided in the NL dataset and also utilized the data available in the COW Direct Contiguity (v3.2) and State System Membership (v2016) datasets to generate the explanatory variables for my models: laboratory-scale latent neighbor(s), pilot-scale latent neighbor(s), and commercial latent neighbor(s). From 1945 onward, for each state-year included in the State System Membership (v2016) dataset, I determined whether the state in question had any neighbors (classified according to the COW Direct Contiguity (v3.2) dataset) that had reached laboratory, pilot, or commercial-scale latency. I then created dummy variables and count variables for each state's laboratory-scale latent neighbor(s), pilot-scale latent neighbor(s), and commercial latent neighbor(s). The way in which I leveraged each of the explanatory variables that I constructed is detailed in Table III which is included at the conclusion of my research design section.

3. Response Variables: Nuclear Latency (Enrichment and/or Reprocessing Operation)

The question that I aim to answer with my statistical analysis is whether a state is more likely to become latent if it has a neighbor or neighbors that have achieved latency. My response variable in each regression of my statistical analysis thus is a state's latent capabilities. To determine each state's latent capabilities in a given year, I looked to Fuhrmann and Tkach's NL dataset, which classifies civilian nuclear facilities based upon their size: (1) laboratory, (2) pilot, and (3) commercial. Fuhrmann and Tkach drew from the IAEA Integrated Nuclear Fuel Cycle Information System (INFCIS) when categorizing ENR facilities (Nuclear Fuel Cycle Information System). The IAEA classifies a laboratory-scale facility as follows: "the facility or process line is being operated in a laboratory to examine the applicability of a process" (Nuclear Fuel Cycle Information System). Fuhrmann and Tkach clarify the contents of this category by stating that "one can think of laboratory-scale ENR facilities as those that enrich uranium or reprocess plutonium on a very small scale" (Fuhrmann & Tkach 2015). They also note that it is often hard to definitively differentiate between laboratory-scale ENR plants and research and development activities. Because of this, Fuhrmann and Tkach include a *facility ambiguity* variable in their dataset that indicates if they were uncertain about “whether small scale enrichment or reprocessing occurred at a site” when deciding upon its size classification for the purposes of the NL dataset (Fuhrmann & Tkach 2015).

Classifying pilot-scale and commercial facilities is much more straightforward, however. According to the IAEA, a facility is classified as pilot-scale if “the facility or process line is being operated as a precursor of a commercial or industrial facility or process line” (Nuclear Fuel Cycle Information System). Finally, a facility is classified as commercial if “the facility or process line is being operated in commercial or industrial scale” (Nuclear Fuel Cycle Information System). For the models that I run, I take Mehta and Whitlark’s (2017) decision to focus on the laboratory-scale versus pilot-scale dichotomy to be instructive. I thus focus on the laboratory versus pilot-scale dichotomy, excluding commercial-scale latency as a response variable in my analysis.

4. Covariates

In order to analyze whether the presence of a latent neighbor influences a state’s proclivity to become latent itself, it is essential to consider what other factors may impact a state’s latency. Identifying these factors and integrating them into my models will allow me to isolate the effect of having a latent neighbor. In order to determine what factors are necessary to include, I look to Mehta and Whitlark (2017), Gartzke and Jo (2007), and Bleek (2010) for guidance. Of these three formative studies, Mehta and Whitlark (2017) are the only duo that specifically explores nuclear latency. However, latency is one of many explanatory variables in their study, while latency is the response variable in mine. For the purposes of my study, it is important to home in on the factors that may contribute to a state’s pursuit of latency. Mehta and Whitlark were primarily concerned with determining which factors— along with latency— may contribute to a state’s military or diplomatic outcomes. This is where Gartzke and Jo (2007) and Bleek (2010) prove useful. In both of these studies, nuclear proliferation is the response variable rather than nuclear latency. However, the wealth of scholarship that explores the causes and consequences of proliferation should not be thrown out with the bath water when exploring the causes and consequences of nuclear latency. Indeed, Mehta and Whitlark (2017) indicate that they drew inspiration for their covariates from proliferation-focused studies such as Gartzke and Jo (2007). Bleek (2010) also drew much of the data for his covariates from Gartzke and Jo (2007). Researchers that aim to elucidate the causes and consequences of nuclear latency should take proliferation-centric scholarship to be informative rather than instructive, though, because latency-focused scholarship indicates motivations to pursue latency may diverge from those to pursue the bomb.

When determining which covariates from the Gartzke and Jo (2010) and Mehta and Whitlark (2017) studies to include in my analysis, I was faced with a challenge. The Mehta and Whitlark (2017) data for each covariate ends in 2000 while the Gartzke and Jo (2007) data ends in 1992. This discrepancy in timelines presents a tradeoff: to include more state-year observations, or to include more variables that appear to be relevant? Between 1941 and today, only thirty-one states have ever achieved laboratory-scale latency and only twenty-one have ever achieved pilot-scale latency. The limited number of cases that states have achieved latency limits the predictive power of any statistical model utilized to analyze the causes and consequences of said latency. Because of the limited number of cases of nuclear latency available for analysis, I ultimately decided to include more state-year observations and thus to use the Mehta-Whitlark (2017) replication dataset rather than to use the Gartzke-Jo (2007) replication dataset which included more variables. I separate my covariates into four categories: (A) security, (B) economic, (C) institutional, and (D) domestic. In an ideal world where the Gartzke-Jo (2007) data extended to 2000, I would have included their nuclear threat, nuclear defense pact, diplomatic isolation, regional power status, and their major power status variables as covariates. In the following sections I expand on each of the variables from Mehta and Whitlark (2017) that I employ as covariates in my study.

A. Security

A state's reactive acquisition of nuclear latency may be the result of it having a neighbor with nuclear weapons rather than a neighbor with latent nuclear capabilities. To control for this possibility, I created two *nuclear neighbor* covariates and included them in all of my models. The first is a dummy variable that is coded 1 if a state had any neighbors with nuclear weapons in a given year and 0 if it did not. The second is a count variable that tallies the number of *nuclear neighbors* that a state had in a given year, the most of which being three nuclear neighbors in a given year. A state's decision to acquire latent nuclear capabilities may be driven by its conventional military power— a sort of militaristic determinism. Accordingly, I included the same measure of conventional military power that Mehta and Whitlark (2017) used, the COW Project's *Composite Index of National Capability (CINC)*. CINC values range from 0- 0.13271, meaning that the CINC coefficient in each model will seem quite large compared with the coefficient outputs for other variables.

A state's regional security environment may impact its decision to pursue or acquire latent nuclear capabilities. In order to control for this, I followed Mehta and Whitlark's (2017) lead and used a count variable noting the number of *borders* that a state has as a proxy for its security environment (Stinnett et al. 2002; Alesina & Spolaore, 1997; Mehta & Whitlark, 2017). Mehta and Whitlark (2017) decided to use borders as a proxy for a state's security environment because scholarship indicates that neighboring states engage in more frequent militarized interstate disputes than states that are far away from one another (Boulding, 1962; Bremer, 1992). Finally, like Mehta and Whitlark (2017), I also included a *rivalry* variable that uses data from the COW project to code the number of enduring rivals that a state had in a given year.

B. Economic

In order to control for the possibility that states pursue and acquire nuclear latency as a result of their economic capacity, I include Mehta and Whitlark's (2017) logged measure of *gross domestic product (GDP) per capita* (Mehta & Whitlark, 2017; Singer, 1988). Additionally, Etel Solingen has produced some compelling work exploring the impact of a state's orientation to the global economy on its decisions pertaining to its pursuit of nuclear weapons capability (Solingen 2007). In order to control for the impact that a state's orientation toward the global economy may have on its proclivity to become latent, I include the same measure of *economic openness* employed by Mehta and Whitlark (2017).

C. Institutional

The global nonproliferation regime interacts with every step of a state's legal journey toward becoming latent. In order to begin controlling for the impact of the global non-proliferation regime, I included a dummy variable that both Gartzke-Jo (2007) and Mehta-Whitlark (2017) utilize that codes 1 if a state is an *NPT signatory* in a given year and 0 if it is not. The data that Gartzke-Jo (2007) and Mehta-Whitlark (2017) use to construct this variable is from the United States Arms Control and Disarmament Agency (ACDA 1996). Supplementing the NPT signatory variable, I also include Mehta and Whitlark's (2017) *NPT era* dummy variable to further control for the impact of the global nonproliferation regime. Mehta and Whitlark (2017) include the NPT era variable because "an operative nonproliferation norm may have reduced both the incidence of latency and its impact on [a state's diplomatic and military interactions]" (Mehta & Whitlark 2017, 523).

D. Domestic

In order to control for the domestic political factors that may impact a state's proclivity for nuclear latency, Mehta and Whitlark (2017) include a *regime type* variable that I also employ in my analysis. Mehta and Whitlark (2017) acquired the data necessary to construct this variable from the Polity IV Project (Marshall, Gurs, & Jaggers 2010). The Polity IV Project rates regimes on a scale of -10 to 10, which Mehta and Whitlark (2017) directly mimic with the regime type variable that they include. In the context of the Polity IV Project classification, the more negative the number, the more authoritarian the regime and the more positive the number, the more democratic the regime. Finally, I included three time variables in my analysis (*time*, $time^2$, and $time^3$) because of the impact that the simple passage of time may have on a state's proclivity for latency. I included $time^2$ and $time^3$ in the event that the relationship between time and latency resembles a quadratic or cubic function. Each of the time variables counts the years from a state's "date of birth" within the dataset and either leaves them alone, squares them, or cubes them respectively. I drew the data for each state's "date of birth" from the COW State System Membership (v2016) dataset.

5. Method

By conducting a large-N statistical analysis, I was able to leverage the comprehensive history of states' latent capabilities provided by Fuhrmann and Tkach's

2015 NL dataset to further tease out the causes of states' motivations to become latent. Two state-year datasets (Datasets I and II) that include all states in the international system between 1945 and 2000 that have not possessed laboratory or pilot-scale nuclear latency for more than a year, respectively, undergird my analysis. I run three phases of regression models that each include four logistic regressions. These models are outlined in Table III, which is included below. In Phase 1, I analyze the impact of a laboratory-scale latent neighbor or neighbors on whether or not a state reaches laboratory or pilot-scale latency itself. In Phase 2, I analyze the impact of a pilot-scale latent neighbor or neighbors on whether or not a state reaches laboratory or pilot-scale latency itself. Finally, in Phase 3, I analyze the impact of a commercial-scale latent neighbor or neighbors on whether or not a state reaches laboratory or pilot-scale latency itself. I employ Dataset I when the response variable is laboratory-scale latency, and I employ Dataset II when the response variable is pilot-scale latency. Recall that Dataset I censors out all state-years after the first year that a state has achieved laboratory-scale latency and that Dataset II censors out all state-years after the first year that a state has achieved pilot-scale latency. Utilizing Dataset I when the response variable is pilot-scale latency would result in the censoring of too many state-years while utilizing Dataset II when the response variable is laboratory-scale latency would result in the censoring of too few state-years. In the results section that follows Tables I-III, positive coefficients suggest increased likelihood of an outcome of interest and negative coefficients suggest decreased likelihood of an outcome of interest.

6. Limitations

The results of this thesis cannot be taken at face value because of a number of limitations. First, the findings of this thesis project are limited by the exclusion of the covariates utilized by Gartzke and Jo (2007) that are likely relevant to a state’s acquisition of latent capabilities. Recall that I chose not to include these variables in my study because their state-year data ends in 1992 rather than in 2000. Additionally, future analyses would do well to include a covariate that effectively encapsulates the energy environment in which each state exists. Finally, quantitative methods beyond the scope of my expertise may be capable of teasing out more information about the relationship between a state’s neighbor’s latent nuclear capabilities and a state’s own proclivity for latency. The results of the quantitative element of this thesis aim to provide inspiration for future scholarship rather than to present a definitive response to the question of what causes a state’s acquisition of nuclear latency.

Table I: States with Latent Nuclear Capabilities (Fuhrmann 2015)

State	**Laboratory-scale latency**	**Pilot-scale latency**
Algeria	1992-2012	—
Argentina	1968-73, 1987-94	1987-94
Australia	1972-83, 1992-2007	—
Belgium	1966-74	1966-74
Brazil	1979-2012	1979-94, 1998-2012
Canada	1944-56, 1990-93	1944-56
China	1958-64	1963-64
Czech Republic	1977-98	—
Egypt	1982-2012	—
France	1949-1960	1954-60
Germany	1964-2012	1967-2012
India	1964-73, 1977-88	1964-73
Iran	1974- 2012	2002-2012
Iraq	1982-91	1990-91
Israel	1963-67	1963-67
Italy	1966-90	1966-90
Japan	1968-70, 1975-2012	1975-2012
Libya	1982-2003	—
The Netherlands	1973-2012	1973-2012
North Korea	1975-2006	1983-93, 2003-06
Norway	1954-68	1961-68
Pakistan	1973-87	1973-1987
Romania	1985-89	—
Russia	1941-49	1948-49
South Africa	1967-79, 1991-2012	1975-79, 1991-2012
South Korea	1979-82, 1990-2012	—
Spain	1967-71	1967-71
Sweden	1954-72	—
Taiwan	1976-77	—
UK	1952	1952
USA	1941-45	1943-45
Yugoslavia	1954-78	—

Table II: States with Nuclear Weapons (Gartzke & Jo 2007)

State	**Nuclear Weapons Possession**
United States	1945-
Soviet Union/ Russia	1949-
United Kingdom	1952-
France	1960-
China	1964-
Israel	1966-
South Africa	1979-1991
India	1988-
Pakistan	1987-

Table III: Outline of Statistical Models

Model (Phase.Number)	**Explanatory Variable**	**Response Variable**
1.1	Laboratory-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency
1.2	Laboratory-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency
1.3	Laboratory-scale latent neighbor (count variable)	Laboratory-scale nuclear latency
1.4	Laboratory-scale latent neighbor (count variable)	Pilot-scale nuclear latency
2.1	Pilot-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency
2.2	Pilot-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency
2.3	Pilot-scale latent neighbor (count variable)	Laboratory-scale nuclear latency
2.4	Pilot-scale latent neighbor (count variable)	Pilot-scale nuclear latency
3.1	Commercial-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency
3.2	Commercial-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency
3.3	Commercial-scale latent neighbor (count variable)	Laboratory-scale nuclear latency
3.4	Commercial-scale latent neighbor (count variable)	Pilot-scale nuclear latency

IV. Results

1. Results Tables: Models Phases 1-3

Table IV: Effect of laboratory-scale latent neighbor(s) on a state's latency (LOGIT)

	Model 1.1 (Lab-scale nuclear latency)	*Model 1.2 (Pilot-scale nuclear latency)*		*Model 1.3 (Lab-scale nuclear latency)*	*Model 1.4 (Pilot-scale nuclear latency)*
Lab-scale latent neighbor (dummy variable)	0.189 (0.388)	0.390 (0.521)	**Lab-scale latent neighbor(s) (count variable)**	-0.342 (.304)	-0.24 (0.399)
Neighbor with nuclear weapons	0.980** (0.401)	0.539 (0.561)	**Neighbor(s) with nuclear weapons**	0.670*** (0.227)	0.522~ (0.323)
CINC	42.77*** (7.548)	47.81*** (9.85)	**CINC**	42.23*** (7.619)	44.27*** (9.991)
Borders	-0.029 (0.064)	0.019 (0.087)	**Borders**	-0.003 (0.068)	0.0427 (0.095)
Rivalry	-0.802* (0.0463)	0.347 (0.632)	**Rivalry**	0.744* (0.448)	0.036 (0.062)
GDP per capita	0.00006** (0.00003)	0.0000009 (0.00006)	**GDP per capita**	0.00008** (0.00003)	-0.000003 (0.00006)
Economic openness	-0.007 (0.006)	-0.009 (0.010)	**Economic openness**	-0.007 (0.006)	-0.009 (0.011)
NPT signatory	-0.956* (0.498)	-2.964*** (0.903)	**NPT signatory**	-1.008** (0.492)	-2.905*** (0.894)
NPT era	-0.273 (0.603)	-0.412 (0.872)	**NPT era**	-0.373 (0.598)	-0.553 (0.869)
Regime type	0.052** (0.024)	0.132*** (0.038)	**Regime type**	0.038~ (0.025)	0.129*** (0.039)
Time	-0.085 (0.130)	0.132 (0.038)	**Time**	-0.109 (0.129)	0.077 (0.169)
Time^2	0.010~ (0.007)	0.002 (0.008)	**Time^2**	-0.016* (0.007)	0.004 (0.008)
Time^3	-0.0002** (0.00009)	-0.00005 (0.00009)	**Time^3**	-0.0002** (0.00009)	-0.00008 (0.00009)

Observations	5840	6077	**Observations**	5840	6077

NOTES: (1) Standard errors included in parentheses below coefficients, (2) Statistical significance: ***p<0.01, **p<0.05, *p<0.1, ~p<0.15, (3) Significant results are highlighted

Table V: Effect of pilot-scale latent neighbor(s) on a state's latency (LOGIT)

	Model 2.1 (Lab-scale nuclear latency)	*Model 2.2 (Pilot-scale nuclear latency)*		*Model 2.3 (Lab-scale nuclear latency)*	*Model 2.4 (Pilot-scale nuclear latency)*
Pilot-scale latent neighbor	0.102 (0.429)	-0.360 (0.624)	**Pilot-scale latent neighbor(s)**	0.017 (0.356)	-0.247 (0.489)
Neighbor with nuclear weapons	0.965** (0.432)	0.716 (0.605)	**Neighbor(s) with nuclear weapons**	0.612** (0.247)	0.545~ (0.344)
CINC	42.26*** (7.483)	45.44*** (9.171)	**CINC**	44.24*** (7.461)	47.00*** (9.141)
Borders	-0.149 (0.062)	0.031 (0.085)	**Borders**	-0.037 (0.063)	0.011 (0.085)
Rivalry	0.765* (0.461)	0.359 (0.639)	**Rivalry**	0.752* (0.448)	0.386 (0.631)
GDP per capita	0.00007** (0.00003)	0.000008 (0.00005)	**GDP per capita**	0.00006** (0.00003)	-0.000004 (0.00006)
Economic openness	-0.007 (0.006)	-0.009 (0.010)	**Economic openness**	-0.007 (0.0057)	-0.008 (0.011)
NPT signatory	-0.092* (0.050)	-2.997*** (0.915)	**NPT signatory**	-1.049** (0.495)	-3.018*** (0.909)
NPT era	-0.032 (0.059)	-0.486 (0.868)	**NPT era**	-0.299 (0.595)	-0.585 (0.874)
Regime type	0.049** (0.025)	0.134*** (0.004)	**Regime type**	0.040~ (0.025)	0.126*** (0.039)
Time	-0.089 (0.013)	0.092 (0.169)	**Time**	-0.0823 (0.129)	0.086 (0.169)
Time^2	0.001~ 0.0066	0.003 (0.008)	**Time^2**	0.010~ (0.007)	0.0039 (0.008)
Time^3	-0.0002** (0.00009)	-0.00007 (0.0001)	**Time^3**	-0.0002** (0.00009)	-0.00008 (0.0001)
Observations	5840	6077	Observations	5840	6077

NOTES: (1) Standard errors included in parentheses below coefficients, (2) Statistical significance: ***p<0.01, **p<0.05, *p<0.1, ~p<0.15, (3) Significant results are highlighted

Table VI: Effect of commercial-scale latent neighbor(s) on a state's latency (LOGIT)

	Model 3.1 (Lab-scale nuclear latency)	*Model 3.2 (Pilot-scale nuclear latency)*		*Model 3.3 (Lab-scale nuclear latency)*	*Model 3.4 (Pilot-scale nuclear latency)*
Commercial-scale latent neighbor	0.978~ (0.619)	0.490 (0.935)	**Commercial-scale latent neighbor(s)**	0.411 (0.459)	0.628 (0.659)
Neighbor with nuclear weapons	0.2700 (0.633)	0.201 (0.923)	**Neighbor(s) with nuclear weapons**	0.257 (0.469)	-0.0398 (0.652)
CINC	43.42*** (7.556)	44.85*** (9.158)	**CINC**	44.87*** (7.55)	44.69*** (9.113)
Borders	-0.039 (0.063)	0.0318 (0.0845)	**Borders**	-0.046 (0.063)	0.005 (0.085)
Rivalry	0.809* (0.453)	0.3169 (0.6235)	**Rivalry**	0.738* (0.444)	0.331 (0.616)
GDP per capita	0.00007** (0.453)	0.000004 (0.00006)	**GDP per capita**	0.00006** (0.00003)	-0.00001 (0.00006)
Economic openness	-0.0075 (0.0057)	-0.009 (0.011)	**Economic openness**	-0.007 (0.006)	-0.009 (0.011)
NPT signatory	-0.919* (0.501)	-2.922*** (0.903)	**NPT signatory**	-1.095** (0.493)	-3.018*** (0.899)
NPT era	-0.331 (0.596)	-0.487 (0.873)	**NPT era**	-0.301 (0.595)	-0.567 (0.874)
Regime type	0.044* (0.025)	0.128*** (0.039)	**Regime type**	0.037~ (0.025)	0.122*** (0.039)
Time	-0.108 (0.128)	0.090 (0.171)	**Time**	-0.088 (0.128)	0.075 (0.168)
Time^2	0.011* (0.006)	0.003 (0.008)	**Time^2**	0.011* (0.006)	0.004 (0.008)
Time^3	-0.0002 (0.00009)	-0.00007 (0.00009)	**Time^3**	-0.0002** (0.00009)	-0.00008 (0.0001)
Observations	5840	6077	**Observations**	5840	6077

NOTES: (1) Standard errors included in parentheses below coefficients, (2) Statistical significance: ***p<0.01, **p<0.05, *p<0.1, ~p<0.15, (3) Significant results are highlighted

V. Discussion

1. Impact of Latent Neighbors

Table VII, which is included below, includes a summary of the main coefficient estimates from each of my models. For clarity of analysis, covariates are included but are not presented in Table VII.

Table VII: Summary of Main Coefficient Estimates

Model (Phase. Number)	**Explanatory Variable**	**Response Variable**	**Direction**	**Significance**
1.1	Laboratory-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency	Positive	Not Significant
1.2	Laboratory-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency	Positive	Not Significant
1.3	Laboratory-scale latent neighbor (count variable)	Laboratory-scale nuclear latency	Negative	Not Significant
1.4	Laboratory-scale latent neighbor (count variable)	Pilot-scale nuclear latency	Negative	Not Significant
2.1	Pilot-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency	Positive	Not Significant
2.2	Pilot-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency	Negative	Not Significant
2.3	Pilot-scale latent neighbor (count variable)	Laboratory-scale nuclear latency	Positive	Not Significant
2.4	Pilot-scale latent neighbor (count variable)	Pilot-scale nuclear latency	Negative	Not Significant
3.1	Commercial-scale latent neighbor (dummy variable)	Laboratory-scale nuclear latency	Positive	**Significant (~)**
3.2	Commercial-scale latent neighbor (dummy variable)	Pilot-scale nuclear latency	Positive	Not Significant
3.3	Commercial-scale latent neighbor (count variable)	Laboratory-scale nuclear latency	Positive	Not Significant
3.4	Commercial-scale latent neighbor (count variable)	Pilot-scale nuclear latency	Positive	Not Significant

NOTE: Statistical significance: ***p<0.01, **p<0.05, *p<0.1, ~p<0.15

My Phase 1 Models evaluate the association between having a neighbor or neighbors with laboratory-scale nuclear latency and whether a state becomes latent. The results of Models 1.1 and 1.2 show a positive but not statistically significant relationship between having a laboratory-scale latent neighbor and achieving laboratory and pilot-scale latency, respectively. In Models 1.3 and 1.4, a laboratory-scale latent neighbor count variable, rather than the laboratory-scale latent neighbor dummy variable of Models 1.1 and 1.2, is included. Interestingly, the results of both Models 1.3 and 1.4 show a negative but not statistically significant relationship between having laboratory-scale latent neighbor(s) and achieving laboratory-scale nuclear latency and pilot-scale nuclear latency, respectively. The results of my Phase 1 Models are inconclusive, which is expected. The idea that a state would reactively pursue and then achieve nuclear latency in response to a laboratory-scale neighbor is incongruent with the thinking regarding the relationship between nuclear latency and a state's security. Laboratory-scale latency indicates exploration rather than significant investment, and it seems unlikely that a state would hedge against a neighbor's exploration.

My Phase 2 Models evaluate the association between having a neighbor or neighbors with pilot-scale nuclear latency and whether a state becomes latent. The results of my Phase 2 Models are just as inconclusive as those of my Phase 1 Models. The results of Model 2.1 show a positive but not statistically significant relationship between having a pilot-scale latent neighbor and achieving laboratory-scale latency. The results of Model 2.2 show a negative but not statistically significant relationship between having a pilot-scale latent neighbor and achieving pilot-scale nuclear latency. In Models 2.3 and 2.4, a pilot-scale latent neighbor count variable, rather than the pilot-scale latent neighbor dummy variable of Models 2.1 and 2.2, is included. The results of Model 2.3 show a positive but not statistically significant relationship between having pilot-scale latent neighbor(s) and achieving laboratory-scale nuclear latency. The results of Model 2.4 show a negative but not statistically significant relationship between having pilot-scale latent neighbor(s) and achieving pilot-scale nuclear latency. The ambiguous nature of these findings is somewhat surprising, unlike that of the Phase 1 Models. It would stand to reason that if states were to pursue latent capabilities in response to a neighbor's latency, that a neighbor's acquisition of pilot-scale capabilities would at least tip the scales toward exploration. Interestingly, the idea that acquisition of pilot-scale latency sets off international alarm bells was not reinforced by the results of my Phase 2 Models.

My Phase 3 Models evaluate the association between having a neighbor or neighbors with commercial-scale nuclear latency and whether a state becomes latent. Model 3.1, which more specifically evaluates the association between having a commercial-scale latent neighbor and achieving laboratory-scale latency, produces the most interesting finding of any of the models pertaining to the impact of neighboring latency on a state's own latency. All else being equal, Model 3.1 indicates that the presence of a commercial-scale latent neighbor increases the likelihood that a state achieves laboratory-scale latency by a factor of 2.66. The 95% confidence interval for this factor is [0.79, 8.95]. The results of Model 3.2 show a positive but not statistically significant relationship between having a commercial-scale latent neighbor and achieving pilot-scale latency. Finally, the results of Models 3.3 and 3.4 both indicate a positive but not statistically significant relationship between having commercial-scale latent neighbor(s) and achieving laboratory and pilot-scale latency, respectively.

My findings from Model 3.1 indicate that states may explore nuclear options in response to more modest proliferation stimuli than proposed by Phillip Bleek (2010). Recall that in *Does Proliferation Beget Proliferation? Why Nuclear Dominoes Rarely Fall*, Bleek finds that states are more likely to explore nuclear options if they have security rivals that have proliferated. Such “modest increases in proliferation motivation” are “sufficient to push many over the low thresholds to exploring nuclear weapons options” but are not “sufficient to push most over the far higher thresholds to launching nuclear weapons programs or seeing such programs through to acquisition” (Bleek 2010, iii). Model 3.1 indicates that states that have a neighbor that has achieved commercial-scale latency may be more likely to achieve laboratory-scale latency. This finding reinforces and supplements Bleek and could undergird future research exploring the factors that contribute to reactive latency.

2. Significant Covariates

Through reflecting on the three phases of modeling that I present in this thesis, interesting relationships between the covariates that I included and a state becoming latent are elucidated. In many of the models that I ran, I found a positive and statistically significant relationship between most of the security-specific covariates that I included and a state becoming latent. These findings further affirm the existing scholarship on latency— Mehta and Whitlark (2016) find that security specific factors seem to be significant drivers of a state’s pursuit of latency at both its laboratory and pilot-scale phases of acquisition (Mehta and Whitlark 2016, 50). Additionally, I found a greater relationship between some of my covariates— GDP per capita, NPT signatory status, and regime type— and acquisition of laboratory-scale latency than between these covariates and acquisition of pilot-scale latency. For ease of analysis, I discuss covariates with statistically significant relationships with a state becoming latent in the same order as the covariate categories outlined in my research design: (A) security, (B) economic, (C) institutional, and (D) domestic. In this section, I discuss general relationships between my covariates and whether a state becomes latent— specific results are included in Tables IV-VI. I also discuss the relationship between my findings here and the growing body of scholarship that explores the causes and consequences of nuclear latency.

First looking to the covariates within the security category, across my three phases of modeling the nuclear neighbor, nuclear neighbor(s), conventional military power, and rivalry covariates each at some point had a statistically significant relationship with a state's proclivity to become latent. Interestingly, the covariate that I included in order to proxy for a state's security environment, *borders*, never had a statistically significant relationship with a state becoming latent in any of my models. This finding comes as a surprise because of how borders are commonly operationalized as a proxy variable for opportunity to engage in conflict in the quantitative IR literature. Reactive latency is not a form of conflict, of course, but it is interesting to consider how the classic literature that defines what constitutes an "opportunity" for conflict may not effectively encapsulate such an opportunity in the context of incremental steps toward nuclear proliferation. Such discussion, though, should serve as fodder for future research within the nuclear latency space. In the section that follows, I will discuss each of the security-specific covariates with a statistically significant relationship with a state's proclivity to become latent in turn.

Recall that the nuclear neighbor covariate is a dummy variable coded 1 if a state has any nuclear neighbors and coded 0 if it does not. The nuclear neighbor covariate was included in Models 1.1, 1.2, 2.1, 2.2, 3.1, and 3.2. In my Phase I Models, the nuclear neighbor variable had a positive statistically significant relationship with a state becoming latent in Model 1.1 (explanatory variable: lab-scale latent neighbor, response variable: lab-scale latency) but not in Model 1.2 where the explanatory variable was still lab-scale latent neighbor, but the response variable was pilot-scale latency. In my Phase II Models, the nuclear neighbor variable had a positive statistically significant relationship with a state becoming latent in Model 2.1 (explanatory variable: pilot-scale latent neighbor, response variable: lab-scale latency), but not in Model 2.2 where the explanatory variable was still pilot-scale latent neighbor, but the response variable was pilot-scale latency. In my Phase III Models, the relationship between the nuclear neighbor variable and a state becoming latent was not statistically significant in either model in which it was included.

The nuclear neighbor(s) covariate is a count variable that coded how many, if any, nuclear neighbors a state had in any given year. This covariate was included in Models 1.3, 1.4, 2.3, 2.4, 3.3, and 3.4. In my Phase I Models, the nuclear neighbor(s) covariate was positive and statistically significant in both Model 1.3 (explanatory variable: lab-scale latent neighbor(s), response variable: lab-scale latency) and in Model 1.4 (explanatory variable: lab-scale latent neighbor(s), response variable: pilot-scale latency). In my Phase II Models, the nuclear neighbor(s) covariate was positive and statistically significant in both Model 2.3 (explanatory variable: pilot-scale latent neighbor(s), response variable: lab-scale latency) and in Model 2.4 (explanatory variable: pilot-scale latent neighbor(s), response variable: pilot-scale latency). In the same vein as the nuclear neighbor covariate, in my Phase III Models, the relationship between the nuclear neighbor(s) variable and a state becoming latent was not statistically significant in either model in which it was included.

These findings reinforce Bleek's (2010) conclusion that having a nuclear-armed rival leads to modest steps toward proliferation and my conclusion in the previous section that the proliferation stimuli that may beget such exploratory nuclear action may be less substantial than we had previously believed. After all, I find a positive and statistically significant relationship between having a nuclear neighbor or neighbors and becoming latent in many cases rather than between having a nuclear-armed rival and becoming latent, as Bleek (2010) found. As I discussed earlier, it is however more likely that neighboring states have a rivalrous relationship and see their interactions in zero-sum terms. In future work, scholars should consider whether a hypothetical nuclear neighbors vs. nuclear-armed rivals Venn diagram indeed looks more like a circle. For now, though, it is interesting to contemplate the idea that the external proliferation stimuli that beget exploration of latency may be at a lower threshold than we had previously thought.

Shifting toward consideration of the relationship between a state's conventional capabilities and its proclivity for latency, I found that the conventional military power (CINC) covariate had a positive and statistically significant relationship with a state becoming latent in all of the models that I ran in Phases I-III. This finding is supportive of my earlier proposal that latency could arise out of a sort of militaristic determinism. In regard to the impact that the relationship between states may have on pursuit of latency, the rivalry covariate had a statistically significant relationship with a state becoming latent in all models where the response variable was laboratory-scale latency but in no models where the response variable was pilot-scale latency. Interestingly, the rivalry covariate had a negative statistically significant relationship with a state becoming latent in Model 1.1 (explanatory variable: lab-scale latent neighbor, response variable: lab-scale latency). However, in all other models in which the rivalry covariate was statistically significant (1.3, 2.1, 2.3, 3.1, 3.3) the relationship between the rivalry covariate and a state becoming latent was positive. The findings from Models 1.3, 2.1, 2.3, 3.1, and 3.3 are supportive of the idea that acquisition of nuclear latency could be a sort of hedging strategy, yet the peculiar results of Model 1.1 may be warrant further analysis beyond the scope of this thesis.

In terms of the economic covariates that I included, the logged measure of GDP per capita covariate had a statistically significant relationship with a state's proclivity to become latent in some cases, yet the measure of economic openness did not. The logged GDP per capita covariate had a positive statistically significant relationship with a state becoming latent in all models where the response variable was laboratory-scale latency but in no models where the response variable was pilot-scale latency. This pattern could indicate that GDP is a prominent driver of interest in latent capabilities, but that more substantial investment in latent capabilities requires additional external motivation. In regard to the institutional covariates that I included in my models, the NPT signatory covariate, which coded 1 if a state was an NPT signatory in a given year and 0 if it was not, had a negative statistically significant relationship with a state's proclivity to become latent in all of the models that I ran. Interestingly though, the NPT signatory covariate had a more negative impact on the likelihood that states achieved pilot-scale latency than laboratory-scale latency. However, the NPT era covariate did not have a statistically significant relationship with a state's proclivity to become latent in any of the models that I ran. The finding that being an NPT signatory had a greater negative relationship with acquisition of pilot-scale latency than with acquisition of laboratory-scale latency may be a feather in the NPT's cap: its signatories are less likely to take more significant steps toward proliferation, even those which it allows for.

Also, I included one variable that was meant to help control for the domestic political factors that may impact a state's proclivity for nuclear latency. This variable, regime type, rates regimes on a scale of -10 to 10 and had a positive and statistically significant relationship with a state's proclivity to become latent in all of the models that

I ran in Phases I-III. Across all phases of modeling, there was a greater positive relationship between regime type and acquisition of pilot-scale latent capabilities than there was between regime type and acquisition of laboratory-scale latent capabilities. Since states with more democratic regimes received higher scores within the context of this index, these findings indicate that a greater democracy measure indicates a greater likelihood of achieving laboratory-scale latency, and an even greater likelihood of achieving pilot-scale latency. This finding is interesting because we often consider latency in the context of states whose adoption of democratic norms leaves much to be desired, such as Iran and Saudi Arabia, and we forget about latent states such as Japan in this process. If democratic states truly are significantly more likely to explore and invest in latent nuclear capabilities, what does this say about the perceived utility of latent status? Why are regimes that are comparatively more beholden to public opinion also more likely to become latent? These questions are deserving of future analysis beyond the scope of this thesis project.

Finally, I included three time variables in my analysis— *time*, $time^2$, and $time^3$. The pure time covariate did not have a statistically significant relationship with a state's proclivity to become latent in any of the models that I ran. However, the $time^2$covariate had a statistically significant relationship with a state's proclivity to become latent in all models where laboratory-scale latency was the response variable and no models where pilot-scale latency was the response variable. The $time^3$ covariate had a negative statistically significant relationship with a state's proclivity to become latent in all models where laboratory-scale latency was the response variable except for Model 3.1 (explanatory variable: commercial-scale latent neighbor, response variable: lab-scale latency) and no models where pilot-scale latency was the response variable.

VI. Conclusion and Avenues for Future Research

Why do states become latent? By analyzing the relationship between whether a state has a latent neighbor or neighbors and whether or not that state itself becomes latent, this thesis project contributes to a growing body of scholarship that aims to answer this question. Through three phases of statistical modeling, I find a positive and nearly statistically significant relationship between a state having a neighbor that has reached commercial-scale nuclear latency and whether that state has achieved latency itself. I also find a positive and statistically significant relationship between a state having a neighbor or neighbors that have proliferated and whether that state has achieved latency in many of my models.

Future scholarship that I envision growing from this thesis project would first analyze the impact of having regional neighbors with latent nuclear capabilities rather than just considering the impact of contiguous neighbors with latent nuclear capabilities. Region, of course, is an arbitrary classification that often falls short of encompassing the similarities between some states in separate “regions” as well as the dissimilarities between states within a “region”. Therefore, future scholarship could potentially classify relationships between states based upon distances between them rather than upon if two states exist within one of the arbitrary regional classifiers that we employ to organize our world. Additional future scholarship should analyze whether states that have neighbors that have concluded lax civilian nuclear cooperation agreements are more likely to become latent than states that have neighbors that have concluded more stringent civilian nuclear cooperation agreements. Such an analysis is particularly timely because of the potential proliferation of lax civilian nuclear cooperation agreements as a result of China’s BRI.

Finally, future scholarship should aggregate and analyze information pertaining to international responses to states reaching different latency milestones in order to get a clearer picture of the true nature of beliefs about latency. Mehta and Whitlark (2017) argue that reactions from the international community to a state's acquisition of commercial nuclear technology are muted in comparison to those regarding pilot-scale technology. They present two cases to illustrate this point. First, they note the subdued response from the international community to China's plans to acquire commercial-scale plutonium reprocessing facilities (Reif 2015). They contrast this situation with the tensions and intensive diplomacy and sanctioning that occurred in the wake of the disclosure that Iran was constructing its first enrichment facility at Natanz in 2002.

Because a state's acquisition of commercial-scale facilities in addition to pilot-scale facilities is seen as an increase in size rather than an increase in skills, it seems logical to focus analysis on the laboratory versus pilot-scale dichotomy. I am not, however, entirely convinced that comparing the international response to these cases is particularly useful because of how the two situations were and are fundamentally different. First, China is an NWS and Iran is not. If acquisition of commercial-scale facilities offers marginal gains to states that already have pilot-scale facilities, then it would seem that such acquisition would offer minuscule gains to NWS such as China.

Iran is also a more malign actor than China, in the immediate and overt sense, at least. Strong arguments exist pertaining to the long-term security threats presented by China's revisionist behavior, and there is an interesting conversation to be had regarding the centrality of Iranian malign behavior to the US national interest. However, in 2002 Iran presented an immediate proliferation threat, a threat that persists today. Because of the gulf between Iranian and Chinese nuclear development as well as the difference between the threats that the two states present, I worry that the comparison of international reactions to cases such as these is not truly descriptive of sentiments towards development of pilot versus commercial-scale nuclear technology.

Many important and policy-relevant opportunities for future scholarship exist within the nuclear latency space, some of which are outlined above. It is my hope that the findings and discussion that I presented throughout this thesis project will serve as a foundation and potential inspiration for future academic exploration of the causes and consequences of nuclear latency. Such academic exploration should aim to provide direction for the efforts of the policymakers who work to construct and uphold the institutional environment in which states pursue and achieve latency. I think that such coordination between the academic and policymaking communities is crucial in preventing additional proliferation of nuclear weapons.

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