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Målfrid Braut-Hegghammer. *Unclear Physics: Why Iraq and Libya Failed to Get the Bomb.*

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Introduction by Vipin Narang, Massachusetts Institute of Technology

Målfrid Braut-Hegghammer's new book *Unclear Physics: Why Iraq and Libya Failed to Get the Bomb* should find itself on the shelf of any serious student of nuclear proliferation, international security, and the internal and external security dynamics of dictatorial regimes. It is by far the best history of Iraq's and Libya's failed attempts at acquiring nuclear weapons, leveraging diverse archival material and primary interviews to illuminate new and interesting features of both programs. It argues that due to a lack of state capacity, Iraqi and Libyan dictators Saddam Hussein and Muammar Gaddafi stunted their own nuclear programs, but to varying degrees. The Libyan program was terminally ill from the beginning, but Saddam and his son-in-law, Hussein Kamil, according to Braut-Hegghammer, were on the cusp of a major breakthrough in their nuclear program on the eve of the 1990 invasion of Kuwait. She argues that while both programs suffered from deep pathologies, Kamil's management of the program pushed Iraq farther along by 1990 than anyone had realized. The implication is that, had Saddam not invaded Kuwait, Iraq might have successfully acquired nuclear weapons. The historical value of the book alone is worth the price of admission. It has no peer in its discussion of these nuclear programs. And the implicit theoretical argument raises a host of fascinating questions about the ability of some types of regimes to effectively pursue nuclear weapons, advancing work done by Jacques Hymans and, more recently, myself.¹

This roundtable includes spirited contributions from Andrew Coe, Hymans, Austin Long, and Rachel Whitlark. All highlight the considerable strength of the book, which is its historical contribution on the Iraqi and Libyan nuclear weapons programs. There is little doubt amongst the reviewers that this book will serve as the reference for both of these nuclear weapons programs. That said, they each raise a number of criticisms and suggest directions for future research, which Braut-Hegghammer addresses in her response.

Theoretically, the major issue raised by all four reviewers is that the book's "state capacity" argument about *why* Saddam and Gaddafi failed to acquire nuclear weapons, but that Saddam fared a little better once Kamil took over, is significantly underdeveloped. To be fair, Braut-Hegghammer explicitly claims in her response here that her aim was to provide a detailed historical account of the Iraqi and Libyan nuclear programs, not to develop a generalizable theory for why some dictatorial regimes fail and do not based on state capacity. Nevertheless, all four reviewers crave a more explicit explanation for why Saddam may have gotten closer to the bomb, or what it is in particular that drives dictatorial regimes to stunt their own nuclear programs. Coe, for example, argues that one critical variable which gets scant mention is the international security environment, which *forces* states like Iraq and Libya into inefficiencies because they fear preventive attacks on their programs. This fear forces dispersion, small signatures, and siloed communication, so that the state can evade international detection of its nuclear weapons program and flows from external security concerns, rather than any particular feature of Saddam's or Gaddafi's brutal rule and coup proofing efforts. Whitlark points out that both programs' failures actually resulted from unrelated mistakes, such as Saddam's invasion of Kuwait, rather than from bureaucratic pathologies. Long's major theoretical criticism is that the same state capacity variables that Braut-Hegghammer claims stunted the Iraqi and Libyan programs did not stymie China, North Korea, or the Soviet Union, all of which suffered from coup concerns and engaged in massive purges themselves but all of which quite efficiently developed nuclear weapons. Using the example of Nazi

¹ See Jacques E.C. Hymans, *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation* (Cambridge: Cambridge University Press, 2012); and Vipin Narang, "Strategies of Nuclear Proliferation: How States Pursue the Bomb," *International Security* 41:3 (Winter 2016/2017): 110-150.

Germany, Long offers an alternative explanation: management strategy, instead of just regime type or pathologies. Most of the reviewers question whether Braut-Hegghammer's proffered explanation is generalizable. Explicitly developing the theory and weighing alternative explanations is a rich area for future research according to the reviewers.

Similarly, the reviewers are all puzzled by the discrepancy between the implicit theoretical argument (and the title), which suggest that both Iraq and Libya failed, and Braut-Hegghammer's empirical argument that Libya's failure was worse and that Iraq was actually close to a bomb in 1990. Either the theory is underspecified, and additional arguments are required to explain why Saddam got closer (a constant cannot explain variation), *or* Braut-Hegghammer's empirical argument about Iraq being closer to a bomb is not quite accurate, which is a point Hymans makes in spirited fashion. Indeed, Hymans argues that Braut-Hegghammer's claim that Saddam's program "was on the brink of success when it was interrupted by the 1991 Gulf War" is unsustainable and makes "miracle world" assumptions about Saddam having a free run at nuclear weapons without being detected. This brings us back to Coe's point, that as Saddam got closer and the signatures clearer, Saddam risked unnatural external termination. Braut-Hegghammer counters that the organizational deficiencies facing the Iraqi program in the mid-1980s had been corrected and the program was on the brink of success; had Saddam not impetuously invaded Kuwait, he might have been able to present the world with a *fait accompli* of nuclear weapons capability. It is for the reader to judge which interpretation they find more compelling.

The debate about just how close Iraq was to a nuclear weapons capability highlights a methodological concern raised by the reviewers as well: how much weight can we give to interviews with Iraqi and Libyan scientists and their statements on how close they were to achieving success? Braut-Hegghammer is well aware of this concern and went to considerable and admirable effort to cross-check her interviewees' claims against, for example, the International Atomic Energy Agency (IAEA) archives. Nevertheless, the reviewers raise the issue of motivated biases that may, for example, have caused, Iraqi scientists to claim that they were closer to a nuclear weapons capability than they actually were in order to provide leverage for their immunity, to claim they were better scientists than they actually were, or for a number of other reasons. Certainly, the extensive archival material allows scholars to check these claims, but the reviewers express caution about how to treat evidence from the interviews and how much historical stock to put in them.

None of these issues should take away from the contribution *Unclear Physics* makes in describing the detailed nature of the Iraqi and Libyan nuclear weapons efforts. Indeed, the book provide great avenues for future research to tease out precisely what caused the observed pattern of management success and failure in these and other "programs of concern." The fact that each of the reviewers is so invested in the theory and history of these programs is a testament to the importance of the work. And one cannot overstate just how important it is to understand why states such as Iraq and Libya pursued nuclear weapons and how they did so, because the lessons of these programs and their pathologies will undoubtedly apply to future proliferators. How likely they are to succeed for internal reasons has real implications for external nonproliferation policy and the levers that can and should be pulled to prevent certain types of regimes from acquiring nuclear weapons. Therefore, any serious student of nuclear proliferation and international security should buy, read, and think critically about *Unclear Physics*.

Participants:

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Målfrid Braut-Hegghammer is Associate Professor of Political Science at the University of Oslo. She has held fellowships at the Belfer Center, Harvard, and CISAC, Stanford. Her current research focuses on authoritarian regimes and negotiations.

Vipin Narang is Associate Professor of Political Science and a member of the Security Studies Program at the Massachusetts Institute of Technology. His research focuses on nuclear strategy and proliferation.

Andrew J. Coe is Assistant Professor of International Relations at the University of Southern California. He has been a Stanton Nuclear Security Fellow at the Council on Foreign Relations and, prior to becoming an academic, he worked on nuclear and other issues at the Institute for Defense Analyses, a federally-funded research and development center. His research interests include nuclear weapons issues in international relations, and the causes and consequences of war. His work has appeared in *International Organization*, *Journal of Conflict Resolution*, *Journal of Politics*, and *The Washington Quarterly*.

Jacques E.C. Hymans is associate professor of international relations at the University of Southern California. Hymans's most recent book, *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation* (Cambridge University Press, 2012) was awarded the \$100,000 Grawemeyer Award for Ideas Improving World Order, the American Political Science Association Don K. Price Award for best book on science, technology and environmental politics, and the National Academy for Public Administration Louis Brownlow Award for best book on public administration. His first book, *The Psychology of Nuclear Proliferation: Identity, Emotions, and Foreign Policy* (Cambridge University Press, 2006) was awarded the International Society of Political Psychology Alexander L. George Book Award for best book on political psychology and the Mershon Center for International Security Studies Edgar S. Furniss Book Award for best first book on national and international security.

Austin Long is an Associate Professor at the School of International and Public Affairs and a Member of the Arnold A. Saltzman Institute of War and Peace Studies and the Harriman Institute for Russian, Eurasian, and East European Studies at Columbia University. He is also a non-resident Senior Fellow at the Foreign Policy Research Institute. Long was previously an Associate Political Scientist at the RAND Corporation. He was an analyst and adviser to the U.S. military in Iraq (2007-2008) and Afghanistan (2011 and 2013). In 2014-2015, he was a Council on Foreign Relations International Affairs Fellow in Nuclear Security, serving in the Joint Staff J5 Strategic Deterrence and Nuclear Policy Division. Dr. Long received his B.S. from the Sam Nunn School of International Affairs at the Georgia Institute of Technology and his Ph.D. in political science from the Massachusetts Institute of Technology.

Rachel Elizabeth Whitlark is an Assistant Professor of International Affairs at the Georgia Institute of Technology. She received her Ph.D. in political science from The George Washington University. Her research and teaching interests lie in international security and U.S. foreign policy. Her work has appeared or is forthcoming in the *Bulletin of the Atomic Sciences*, *International Studies Perspectives*, *International Studies Quarterly*, *Security Studies*, *Survival*, and *The Washington Quarterly*. She is currently completing a book project exploring how leaders decide to use preventive military force as a counter-proliferation strategy against adversarial nuclear programs.

Review by Andrew J. Coe, University of Southern California

This book is an interesting, valuable contribution to the evolving literature on the spread of nuclear weapons. It argues that ‘state capacity’—a state’s ability to manage complex administrative tasks—strongly affects the success or failure of a state’s nuclear weapons program. The bulk of the book is devoted to case histories of Iraq and Libya, drawing on new primary sources to support its argument. The evidence presented convincingly shows that Iraq’s low state capacity led to poor management of its program, and that Libya’s even lower capacity led to worse management of its own. However, it does not demonstrate that this bad management actually explains the slow progress of the two programs.

The principal strength of this book is its use of new sources to narrate the two countries’ programs. Past studies of both programs typically relied heavily on declassified intelligence estimates, documents by or interviews with U.S. officials, and public International Atomic Energy Agency (IAEA) reports. These are obviously valuable sources, and until recently they were the only ones available. However, they are all in some sense *secondary*: they observed the program in question from a distance. They may also be biased to serve high politics, as some were written for public release, and many were written during an international crisis or after a program’s termination.

By contrast, Braut-Hegghammer relies largely on sources that are truly *primary*. For both cases, the author draws on archives of the IAEA, to which she is apparently the first scholar to be granted access. For the Iraq case, these are supplemented by the documents published by the Conflict Records Research Center (CRRC), which were captured from Saddam Hussein’s regime after the 2003 U.S. invasion. For the Libya case, the author has interviewed a number of former officials and scientists who were involved with the nuclear program under Muammar Gaddafi’s regime. These sources come from actual participants in the respective program. Moreover, most are internal documents never intended for public release, and many were written before the programs in question generated any serious international confrontation.

These sources offer a unique combination of new perspectives on Iraq’s and Libya’s programs. IAEA scientists sent to advise and assist the Libyans and Iraqis with their nuclear programs wrote internal reports that are remarkable for their technical detail and apolitical candor. They reveal just how difficult it was for Iraq and especially Libya, with their rudimentary (Iraq) or non-existent (Libya) scientific and industrial infrastructure, to progress in their nuclear efforts. Both programs suffered most from a lack of human capital, and relied heavily on outside assistance that could only partially compensate for this lack. Iraq eventually built the necessary expertise, but it appears that Libya did not.

The CRRC documents were produced by Iraq’s bureaucracy to report guidance, planning, and progress (or problems) in its nuclear program. They demonstrate that Iraq’s program was further impeded by the lack of effective bureaucratic monitoring and control. Higher officials, selected on the basis of fealty to Saddam, lacked the technical expertise to coordinate the scientists’ efforts and were often more concerned with the appearance of progress than its actual occurrence. Competing to win official favor, the scientists sometimes exaggerated their achievements, unnecessarily replicated others’ efforts, or stole credit from others.

These documents also reveal the degree to which Iraq’s program was hobbled by security concerns. Managers were selected on loyalty rather than competence in order to avoid the danger of empowering capable individuals who might turn against the regime. Internal security agents were placed within the program and suppressed candid discussion of its problems. Lines of activity in the program were compartmentalized,

geographically dispersed, and replicated in order to protect them from detection and attack by an outside power. Attempts to seek outside assistance or clear guidance from higher authorities were constrained by the need to maintain ambiguity about the program's intent.

The author's interviews with former Libyan officials are also enlightening, though not as detailed as the CRRC records for Iraq, and potentially biased by hindsight. Still, they reveal that Libya's program suffered from an almost total absence of oversight, qualified or not. As with Iraq, this dearth of effective management seems to have derived partly from the Libyan regime's obsession with internal security, which led to it to eliminate or kneecap the formal bureaucratic organizations involved with the program. And like Iraq, the fear of external detection and attack led to inefficient compartmentalization and dispersion of activities within the program.

Altogether, the evidence that the management of Iraq's program was poor, and that of Libya's even worse, is quite convincing. However, the book does not demonstrate that bad management actually explains why these programs progressed so slowly. To assess the causal effect of state capacity, we must define the appropriate counterfactual: how fast would the program have progressed if state capacity had been higher while all else was held constant? The book appears to assume that if we observe low state capacity, this must at least partly account for a program's slow progress.

Perhaps that is right, but just how much does low state capacity matter? Many factors impeded both states' programs: the initial lack of industrial infrastructure and scientific expertise; limits on foreign assistance; the imposition of economic sanctions; the threat and occurrence of preventive attack; and the lack of state capacity. State capacity differed between Iraq and Libya, but so did several other factors. How do we apportion responsibility for the rate of progress of each program to these various causes? Was Iraq's more successful program due to its higher state capacity, or to the fact that it started with more industrial infrastructure and scientific expertise than Libya? The book devotes a mere two pages in the conclusion to assessing only some of these alternative explanations (228-230).

Moreover, Braut-Hegghammer's evidence suggests that these factors did not operate independently of each other. Sanctions increase internal security threats to a regime and so can lead to coup-proofing, which undermines state capacity and so worsens the management of a nuclear program. The threat of preventive attack also leads to security measures, such as geographical dispersion, that impede effective management. My own recent work with Muhammet Bas suggests that even if a state's higher capacity leads to better management, outside detection that a program will progress more quickly tends to lead to more severe sanctions and a higher threat of preventive attack, slowing the program.¹

Assessing the key counterfactual—how much faster would Iraq's or Libya's program have progressed if either state had higher capacity—is thus very challenging. But it is essential to determining the implications of the evidence presented in this book. Was Libya's state capacity so low that the program would have failed even without the U.S. sanctions and threat of attack, meaning that these coercive measures were unnecessary and, given their costs, tragically wasteful? Or is it that the sanctions and threat of attack themselves *induced* the coup-proofing and other measures that kept Libya's state capacity so low? Are these indirect effects of

¹ Muhammet A. Bas, and Andrew J. Coe, "A Dynamic Theory of Nuclear Proliferation and Preventive War." *International Organization* 70:4 (2016): 655-685.

sanctions and attack more consequential than their direct effects of constraining a regime's resources and blowing up its facilities?

Unclear Physics does not answer these important questions, but its case narratives, and the primary evidence from which they are assembled, form essential inputs to future answers. Together with Jacques Hymans's recent work, this book renders undeniable the case that mismanagement is a serious impediment to many states' nuclear programs.² Sorting out the impact of these internal obstacles, relative to the well-known external ones, will be an important task for future research.

² Jacques E.C. Hymans, *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation* (Cambridge and New York: Cambridge University Press, 2012)

Review by Jacques E.C. Hymans, University of Southern California

Målfrid Braut-Hegghammer's *Unclear Physics: Why Iraq and Libya Failed to Build Nuclear Weapons* greatly enriches the historical record of two nuclear programs that once seemed very scary. Her careful sifting of the evidence reveals that both countries' programs suffered from severe institutional dysfunction that kept them from making rapid progress toward obtaining a nuclear weapons arsenal. Among the problems were inadequate political direction, flawed organization and management, and poor technical decision-making. All of these problems were symptoms of weak state capacity. Iraq's program performed marginally better than Libya's, but as the book's subtitle indicates, "failed" is the word that best describes both countries' efforts.

The scholarly and policymaking communities should pay heed to Braut-Hegghammer's strong empirical findings. Despite the slowing pace of nuclear weapons proliferation since the 1970s, most analysts continue to assume that proliferation is a nearly unstoppable train—a "nuclear express" as Danny B. Stillman and Thomas C. Reed dubbed it.¹ Therefore, when suspect nuclear programs do fail, analysts tend to give the credit to some extraordinary international nonproliferation effort: International Atomic Energy Agency (IAEA) inspections, United Nations (UN) sanctions, American bombs, Mossad assassins, etc. Rejecting this comfortable Western self-congratulatory narrative, Braut-Hegghammer's book contributes to the alternative perspective that has been developed by scholars such as Sonia Ben Ouagrham-Gormley, Robert Kelley, Alexander Montgomery, John Mueller, and myself, who argue that many developing countries and terrorist groups tend to have major internal handicaps that make it very difficult for them to achieve success in something as large and technically demanding as a nuclear-weapons project.² We also argue that proliferant states' internal dysfunction is often so debilitating that they cannot even take much advantage of what is available on the international nuclear black market. The point is not that international nonproliferation efforts are irrelevant, but rather that they can be very productive—and sometimes very counterproductive—precisely because many of the states and terrorist groups they target are already prone to botching the bomb.

The great strength of Braut-Hegghammer's work is the prodigious historical research on which it is based. The book's detailed description of the domestic side of Libya's botched nuclear effort has no equal in the literature. It will serve as a resource for scholars for years to come. The Iraq case study is also full of new discoveries. This is the first work in English that comprehensively provides the long backstory of the Iraqi nuclear program from the 1950s to 1970s. Iraq's nuclear story from the 1970s to the Gulf War has been written about many times before, but *Unclear Physics* helps to clarify our historical fact base even for that period. For instance, I had previously believed that the bold promise by Iraq's top nuclear scientist in 1985

¹ Danny B. Stillman and Thomas C. Reed, *The Nuclear Express: A Political History of the Bomb and its Proliferation* (Minneapolis: Zenith Press, 2009).

² Sonia Ben Ouagrham-Gormley, *Barriers to Bioweapons: The Challenges of Expertise and Organization for Weapons Development* (Ithaca: Cornell University Press, 2014); Robert E. Kelley, "The Iraqi and South African Nuclear Weapon Programs: The Importance of Management," *Security Dialogue* 27:1 (1996): 27-38; Alexander Montgomery, "Stop Helping Me: When Nuclear Assistance Impedes Nuclear Programs," in Adam Stulberg and Matt Fuhrmann (eds.), *Nuclear Renaissance and International Security* (Stanford: Stanford University Press, 2013), 177-202; John Mueller, *Atomic Obsession: Nuclear Alarmism from Hiroshima to Al Qaeda* (Oxford and New York: Oxford University Press, 2012); Jacques E. C. Hymans, *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation* (Cambridge and New York: Cambridge University Press, 2012).

that the nuclear program would achieve “fruitful objectives” by 1990 was his own decision.³ Braut-Hegghammer’s deep dive into the history, however, indicates that the scientist’s promise had been stimulated by pressure from senior regime officials (96). That was a very interesting discovery for me. *Unclear Physics* does not cover the Iraqi story between 1991 and 2003, which is a shame because Braut-Hegghammer’s focus on the damaging consequences of low state capacity might have been most useful to explain the crazy goings-on during that period.⁴ Despite that one lacuna, this book is a gold mine for scholars who wish to learn more details about these two countries’ nuclear histories. It also clearly demonstrates the tremendous general value of getting into the historical nitty gritty of specific country cases, as a prophylactic against falling for the armchair strategists’ simplistic and unfounded claims about the dynamics of global proliferation.

Given the general congruence between Braut-Hegghammer’s perspective and my own, it is surprising that she has decided to frame the theoretical side of her book primarily as a challenge to arguments that I make in my 2012 book *Achieving Nuclear Ambitions*. Here is the key paragraph from the first pages of *Unclear Physics*, where she lays out her basic claim for what her book will contribute to the literature:

“Still, we need more work that examines how other domestic-level constraints, notably in the form of institutional capabilities and resources, affect the implementation of these decisions inside nuclear establishments. In *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation* Jacques Hymans takes important steps in this direction. Observing that many authoritarian states struggle to acquire nuclear weapons, he argues that neopatrimonial rulers undermine the professional culture inside nuclear weapons programs through constant interference. Hymans argues that these leaders do so because their weak state institutions permit, and even encourage, such interventions. For this reason, he posits, Libya and Iraq were doomed to fail. Hymans’s rich and influential account is representative of what has become the conventional wisdom: that Saddam and Gaddafi essentially micromanaged their nuclear scientists, that they were determined to get nuclear weapons, and that they failed largely because their scientists were unwilling or unable to deliver these capabilities. The findings presented in this book challenge all three elements of this conventional wisdom”(4).

It’s flattering that what was a decidedly contrarian view when I adopted it just a few years ago is now being described as the “conventional wisdom” about the dynamics of proliferation. But Braut-Hegghammer does not provide any real proof that the conventional wisdom today is radically different than it was five years ago, and frankly, her assessment of the state of the literature seems wrong to me. Most of the writing on proliferation that I have encountered in recent years continues to assert that many states and terrorist groups find the bomb both attractive and increasingly easy to obtain. It then typically concludes from these questionable assertions that only a strong international front led by the U.S. may be able to avert global disaster.⁵ The great value of *Unclear Physics* lies in the copious evidence that it offers against this standard

³ *Achieving Nuclear Ambitions*, 100-101.

⁴ I discuss the impacts of Iraq’s declining state capacity after 1991 in *Achieving Nuclear Ambitions*, 119-122.

⁵ For an excellent and comprehensive critique of the real conventional wisdom about proliferation, see Benoît Pelopidas, “A Bet Portrayed as a Certainty: Reassessing the Added Deterrent Value of Nuclear Weapons,” in George P. Shultz and James E. Goodby, eds., *The War That Must Never Be Fought: Dilemmas of Nuclear Deterrence* (Stanford: Hoover Institution Press, 2015), pp. 5-55.

narrative. But *Unclear Physics* fails to capitalize on its rich historical research to advance the alternative theoretical framework that I and others in the minority camp have been building. Nor does it present a genuine theory of its own. Instead, Braut-Hegghammer marshals her historical evidence to counter a straw-man version of my arguments. The book sometimes criticizes my work directly, but more often it criticizes the anonymous “conventional wisdom” of which my work is supposedly “representative” (4). This mischaracterization of the state of the literature is the sand on which Braut-Hegghammer’s book tries to build, with disappointing results.

The rest of this review essay will discuss each of the three major points on which Braut-Hegghammer says the “conventional wisdom” (i.e., my work) is wrong when it comes to personalist regimes such as those in Iraq and Libya: (a) the political leaderships’ determination to acquire nuclear weapons; (b) the political leaderships’ tendencies toward disrespectful authoritarian management of their nuclear weapons projects; and (c) the counterproductive consequences of the political leaderships’ interference in technical matters. First, however, I should mention that I have struggled with the question of whether I am just being oversensitive about Braut-Hegghammer’s criticisms of my work. Another reader might hardly notice them, as Braut-Hegghammer certainly does not engage deeply with my specific arguments. But as I have already suggested, it is that very casual approach to the existing proliferation literature that is *Unclear Physics*’s basic problem. Indeed, although Braut-Hegghammer’s book misconstrues my arguments, at least it cites my book, *Achieving Nuclear Ambitions*. A huge amount of highly relevant social science literature on proliferation does not get even a single mention in *Unclear Physics*. For instance, Braut-Hegghammer uses the word “ambivalence” many times to describe both Saddam and Gaddafi’s nuclear attitudes, but she does not cite Itty Abraham’s seminal work “The Ambivalence of Nuclear Histories.”⁶ I was so surprised not to find a discussion of Abraham’s arguments that I ended up going through the book’s footnotes three times searching fruitlessly for a reference (maddeningly, *Unclear Physics* does not contain a bibliography). It is too bad that *Unclear Physics*, a book that is so deep in its historical research, provides so shallow an account of the existing social science literature.

I now turn to the book’s specific criticisms of the so-called “conventional wisdom.” First, on the matter of the Iraqi and Libyan political leaderships’ determination to acquire nuclear weapons, let us begin with the basic factual question of the start dates of their respective dedicated nuclear weapons projects. The question of start dates might seem to be a small detail, but in fact it is crucial for evaluating the empirical validity of various theoretical perspectives. In the case of Iraq, Braut-Hegghammer writes that “the conventional wisdom argues this program was launched in the early 1970s, at Saddam’s behest” (17). She shows instead that 1980 is the earliest date that one could reasonably assert that President Saddam Hussein greenlighted Iraq’s dedicated pursuit of nuclear weapons, and that the real “watershed event” that produced the Iraqi march toward the bomb was the June 1981 Israeli bombing of Iraq’s ‘Osirak’ nuclear reactor (72).⁷ Her empirical finding is an important rebuttal to the many pundits and policymakers who are so enamored of ‘counterproliferation’ airstrikes. What is missing from Braut-Hegghammer’s book, however, is a clear recognition that this empirical finding is not new. Many scholars, including Harvard physicist Richard Wilson and Emory political scientist Dan Reiter, as well as myself more recently, have made the same point that the Israeli attack on Osirak was

⁶ Itty Abraham, “The Ambivalence of Nuclear Histories,” *Osiris* 21:1 (2006): 49-65.

⁷ Saddam’s 1980 “order,” if it really happened at all, was given to two scientists only, and at the time one of them was in jail while the other was under house arrest, so it is hardly surprising that there was no follow-through (69-70).

unjustified by the technical characteristics of the reactor, and in fact that it caused Iraq to engage in exactly the proliferation behavior that the attack was meant to forestall.⁸ The notion that the Israeli attack was the crucial starting gun for the dedicated Iraqi nuclear weapons project is also implicitly embedded in much quantitative proliferation research. For instance, the standard proliferation data set constructed by Sonali Singh and Christopher Way gives a 1982 start date for Iraq's shift from "exploration" to "pursuit" of nuclear weapons.⁹ Again, this is not to deny that many Washington policy wonks still cling to the false narrative of Israel's 'brilliant' strategic strike, but in terms of the political science literature Braut-Hegghammer's conclusion is hardly novel. *Unclear Physics* also overstates the novelty of its findings on Libya. The first page of the Libya case study pronounces, "The few facts and assumptions that have shaped our understanding of the program are misleading. For example, the Libyan nuclear program began as early as 1970, not in 1973 as Libya later declared" (127). But what is the start date for the Libyan "pursuit" of nuclear weapons in Singh and Way's data set? 1970! And I also used 1970 as the start date for the Libyan dedicated nuclear weapons project.¹⁰ The larger point here is that *Unclear Physics* consistently fails to recognize the state of the existing social science literature.

The book's lapse on this matter of start dates also serves as the seedbed for further misguided criticism of the so-called "conventional wisdom." For instance, in two chapters on the history of the Iraqi nuclear program prior to 1981—more than 20% of the book's total pages—Braut-Hegghammer repeatedly emphasizes that the program lacked strong top-down direction and was generally unfocused during those early years. Indeed, her book's very title, "Unclear Physics," comes from a self-deprecating joke that Iraqi nuclear scientists told on themselves at the time (42). The book tries to use the Iraqi experience of "unclear physics" prior to 1981 to falsify "theories arguing that neopatrimonial regimes are structurally determined to want nuclear weapons while at the same time arguing that such states are too incompetent to acquire them" (224). But I made clear in *Achieving Nuclear Ambitions* and in my earlier book, *The Psychology of Nuclear Proliferation*¹¹—another work that is never cited in *Unclear Physics*—that nuclear programs cannot organize themselves properly to

⁸ Richard Wilson, "Nuclear Proliferation and the Case of Iraq," *Journal of Palestine Studies* 20:3 (Spring 1991), 11; Dan Reiter, "Preventive Attacks against Nuclear Programs and the 'Success' at Osirak," *Nonproliferation Review* 12:2 (July 2005): 355-371; *Achieving Nuclear Ambitions*, 96-98. Braut-Hegghammer does cite Reiter's article on a different point, but does not give him or anyone else credit for getting Osirak right. Indeed, she cites a different article by Wilson to suggest that he believes that Iraq may have been able to use the Osirak facility to build the bomb. But Wilson has clearly and repeatedly explained that although he *previously* believed that Osirak could be a bomb factory, after the Israeli bombing of the facility and his visit to it, he realized that he had been wrong. For instance, in his *Journal of Palestine Studies* piece, he states categorically on p. 11, "The reactor was irrelevant to any ambition Iraq might have for making nuclear weapons." I also quoted this sentence in the section on "the Osirak myth" in my book, 96.

⁹ Sonali Singh and Christopher R. Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," *Journal of Conflict Resolution* 48:6 (December 2004): 859-885. For the main proliferation data sets' precise codings of nuclear program dates, see Alexander H. Montgomery and Scott D. Sagan, "The Perils of Predicting Proliferation," *Journal of Conflict Resolution* 53:2 (April 2009), especially 308. Note that for reasons that aren't clear to me, in subsequent research Way changed the start date of the Iraqi "pursuit" of nuclear weapons to 1983.

¹⁰ *Achieving Nuclear Ambitions*, 3.

¹¹ *Achieving Nuclear Ambitions*, 9-10; Jacques E. C. Hymans, *The Psychology of Nuclear Proliferation: Identity, Emotions, and Foreign Policy* (Cambridge and New York: Cambridge University Press, 2006).

build nuclear weapons unless the top political leadership issues a clear top-down order to do so. In the absence of such an order, I argue, drift and confusion are to be expected. In the case of Iraq, both Braut-Hegghammer and I agree that Saddam issued the definitive order to build the bomb in the wake of the Osirak attack in 1981. Therefore, far from disproving my theoretical arguments, Braut-Hegghammer's finding that Iraq made little progress toward the bomb prior to 1981 resoundingly confirms them.¹²

Braut-Hegghammer also usefully poses the question as to whether Saddam really wanted nuclear weapons even after 1981. She argues that although Saddam seemed very definitive when giving the order to start the dedicated nuclear weapons project after the Osirak attack, in subsequent years he was not always clear about his ultimate objective, and he often evinced a surprising lack of interest when scientists were brought to explain their progress to him. This is a very significant observation. How can we explain Saddam's somewhat distanced demeanor toward the scientific and technical workers after 1981? Braut-Hegghammer concludes that the fact that he behaved as he did proves that "personalist leaders in weak states prefer not to micromanage nuclear programs" (221), ergo my theory is wrong. But contrary to her inexact presentation of my theory, I do not limit my discussion of neopatrimonial states' mismanagement of their nuclear programs to the single problem of "micromanagement." What I really say in *Achieving Nuclear Ambitions* is that good management of nuclear programs shows *respect* for the professionalism of scientific and technical workers, whereas bad management shows *disrespect* for the professionalism of scientific and technical workers.¹³ And although disrespectful authoritarian management in practice does very often mean various kinds of top-down political interference and micromanagement, my book's short list of indicators of a disrespectful authoritarian management approach also includes "a top leadership that refuses to discuss its ultimate nuclear objectives with its top scientific workers, and indeed perhaps even fails to inform them of those objectives."¹⁴ Such a refusal to discuss ultimate nuclear objectives is exactly what Braut-Hegghammer finds was the pattern in both Iraq and Libya. In sum, since *Unclear Physics* shows that both Saddam and Gaddafi acted in line with my theory, it has unintentionally provided a strong confirmation of the theory. Having said that, however, I am the first to admit that my list of indicators of disrespectful authoritarian management includes behaviors with somewhat different flavors. Therefore, Braut-Hegghammer could have tried to advance the theory by dividing the overall category of disrespectful management into the sub-categories of "disrespectful disregard" versus "disrespectful interference," and then identifying the institutional conditions under which different kinds of disrespectful management become more likely. She mentions in her conclusion that doing something like this would have been an interesting exercise (229). Indeed.

These points segue into my rebuttal of the second critique that Braut-Hegghammer makes against the so-called "conventional wisdom": her criticism of my view that Iraq and Libya exercised disrespectful authoritarian management after launching their dedicated nuclear weapons projects. Braut-Hegghammer

¹² It should also be noted that, contrary to Braut-Hegghammer's claims on 224, I have never argued that neopatrimonial regimes are "structurally determined to want nuclear weapons." My model of preferences for or against nuclear weapons—most fully elaborated in *The Psychology of Nuclear Proliferation*—focuses on individual-level national identity conceptions, not regime structures. Why the oppositional nationalist Saddam waited until 1981 to give the definitive order is an interesting question that I have not addressed in my work. I might have expected him to make a stronger push for the bomb earlier on, but it is worth noting that he was not fully in control of Iraq until 1979.

¹³ See, for example, *Achieving Nuclear Ambitions*, 25.

¹⁴ *Achieving Nuclear Ambitions*, 76.

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makes the exact opposite argument to mine and describes the Iraqi program prior to 1987 as “captured by scientists i.e., that they effectively redefined the activities of the program according to their own interests and preferences rather than those defined by the regime principals, and operated with unlimited budgets and weak oversight mechanisms” (71). That is an incredible claim. As I pointed out in *Achieving Nuclear Ambitions*, “careful scholarship has found very little support for accusations of ‘bureaucratic dominance’ even in the most highly Weberian legal-rational states.”¹⁵ If bureaucrats have been unable to achieve freedom from politicians even in Western European states or Japan, how could they possibly do so in Saddam’s Iraq? The answer is that they could not.

Braut-Hegghammer’s biggest piece of evidence for her radical claim that scientists “captured” the Iraqi nuclear program is the fact that the political leadership waited until 1985 to set a deadline for the completion of the project.¹⁶ She also makes much of the fact that the leading scientists were somewhat overly enamored of certain specific technical manipulations and therefore wasted time on such things as the PIG ion source for the electromagnetic isotope separation pathway (93).¹⁷ So, yes, as I also made clear in my book, it is true that the Iraqi political leadership was not as consistently tough on the scientific and technical workers as it could have been during the early-mid 1980s—about which more below. Nevertheless, Braut-Hegghammer’s own evidence overwhelmingly shows that the nuclear program was hardly “captured” by the scientific and technical workers, but instead that the workers were always highly vulnerable to the whims of the political leadership. I will highlight five pieces of evidence here; a more detailed review of the case could point out many more.

First, as noted above, Braut-Hegghammer accepts that Saddam’s personal decision to launch the dedicated nuclear weapons project in 1981 caused the massive transformation of the nuclear program that took place thereafter. Without this authoritative decision by Saddam himself, it is impossible to imagine the Iraqi nuclear weapons project ever going much beyond the “unclear physics” of the 1960s and 1970s.

Second, Braut-Hegghammer also accepts that it was Saddam who personally selected the scientist Jafar Dhiya Jafar as leader of the project, and that Jafar (along with Iraq Atomic Energy Commission vice-chairman and Baathist Party stalwart Humam Abdel Khaliq) was henceforth “held...responsible for the progress of the overall program” (87). I should note that to be “held responsible” in Saddam’s Iraq was no great sign of the dictator’s trust, but quite the opposite, as evidenced by the swarm of regime intelligence operatives who were tasked to keep tabs on every aspect of the nuclear program officials’ lives (85, 89). Jafar especially knew how vulnerable he was to Saddam’s power, having been arbitrarily confined in house arrest for many months until the regime swung around and appointed him to take on the nuclear bomb assignment.¹⁸

¹⁵ *Achieving Nuclear Ambitions*, 52.

¹⁶ *Achieving Nuclear Ambitions*, 101. As I previously noted in this essay, in my book I had characterized that 1985 decision to set a deadline as having been done on Jafar’s own initiative, but Braut-Hegghammer shows that in fact this was due to pressure by senior officials (96). This means that the historical justification for my broader depiction of Iraq as a case of disrespectful authoritarian management was even stronger than I knew.

¹⁷ I noted this same fact in *Achieving Nuclear Ambitions*, 100.

¹⁸ Braut-Hegghammer notes that despite his condition of house arrest, Jafar was bold enough to try to set some conditions for his acceptance of the position. This is interesting. But Jafar could hardly have believed that Saddam’s

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Third, Braut-Hegghammer accepts that until 1987, the program consistently abided by Saddam's "clear order" to "avoid sensitive foreign assistance that could alert the outside world to the nuclear weapons program" (80). Saddam's order was a huge burden that prevented the scientific and technical workers from taking many shortcuts, but they meekly obeyed. This situation only changed after 1987 because Hussein Kamil, Saddam's son-in-law and *de facto* regime number two, took over the nuclear program and gave a contrary order to dive into the international nuclear black market, which the scientists also meekly obeyed.¹⁹

Fourth, Braut-Hegghammer accepts that those working inside the program were petrified of admitting failure to their political bosses, especially if they could not blame that failure on somebody else (228), and therefore they wasted their financial, technical and human resources chasing several uranium enrichment technologies simultaneously. Then, instead of fessing up to the fact that they were making slow progress on all fronts, in 1987 they tried to fool Saddam by asking "for his permission to start working on the design and explosive packaging for a nuclear weapon" (72). Braut-Hegghammer inexplicably argues that the scientists' desperate effort to postpone the final judgment day is proof that the nuclear program was "not subject to pressure" (72).

Fifth, Braut-Hegghammer accepts that already by 1985 "senior officials" were inducing both the nuclear and biological weapons programs to make "an apparently premature promise...with a seemingly arbitrary deadline" (96). This fact flatly falsifies her claims that "the nuclear weapons program was not subject to pressure during the first six years" (72). The scientists may have tried to muddy the waters about exactly what they had promised (96, 72). But as Jafar writes in his memoirs, when Saddam was given the promise, Saddam's "eyes swelled with emotional tears," and he told Jafar, "If you are successful with this endeavor, we will make a gold statue of you."²⁰ There can be little doubt about what Saddam believed Jafar was promising him.

In short, Braut-Hegghammer's argument that the Iraqi nuclear weapons project was "captured by scientists" until 1987 is simply mistaken. Again, I am not denying that between 1982 and 1987 the Iraqi nuclear scientific and technical workers enjoyed some relief from direct day-to-day political meddling. I said as much in my own book. But the room to breathe that the regime allowed them during those short years only appears significant in comparison with the insane level of direct interference that came after the 1987 takeover of the program by Saddam's son-in-law Hussein Kamil, who soon made good on his "reputation for applying ruthless pressure" in pursuit of "impossible" results, to quote Braut-Hegghammer (103, 106). All in all, the facts clearly indicate that Iraq's dedicated nuclear weapons project was subject to a lot of disrespectful political interference during its ten-year life span.

word was his bond, and he surely understood the consequences of a determined refusal. His colleague Hussein al-Shahristani did flatly refuse to participate in the bomb project, and therefore he remained locked up in Abu Ghraib prison for over a decade.

¹⁹ Arabic names can be written in different ways in English language texts. I have typically seen this name written as Hussein Kamel rather than Hussein Kamil, but in this essay I am following Braut-Hegghammer's orthography.

²⁰ Cited in *Achieving Nuclear Ambitions*, 101.

As for Libya, Braut-Hegghammer argues that “Libyan scientists could get away with underperforming—to the point of absurdity,” because the Gaddafi state lacked the human and technical resources to monitor their performance (168). This statement seems to imply that the Libyan scientists “captured” their program, too. Braut-Hegghammer is undoubtedly right that the Libyan state lacked sufficient resources to be able to properly oversee nuclear research in the country, and that this lack was a result of Gaddafi’s radical antagonism to state structures that smacked of Weberian legal-rationalism. I had already made these same points in *Achieving Nuclear Ambitions*, but Braut-Hegghammer does a good job of fleshing them out with many telling historical details.²¹

Although I wholeheartedly agree with Braut-Hegghammer’s historical point about the Libyan state’s structural inability to keep the program on the straight and narrow, that point hardly justifies her conclusion that the Libyan regime “did not attempt to micromanage” (195). The only way to sustain such a conclusion is to rely on a preposterously narrow definition of “micromanagement.” Indeed, the facts that Braut-Hegghammer presents show that the Gaddafi regime held its scientific and technical workers in such contempt that it thought Libya could get the bomb without them. The regime was willing to shower the nuclear program with expensive toys, but it distrusted the scientific method, never asked the scientific and technical workers’ advice in advance of its foreign purchasing sprees, and evinced zero expectation that the domestic nuclear program would ever accomplish anything. The politicized nature of the Libyan quest for nuclear weapons becomes especially clear after the 1986 U.S. bombing of Tripoli made Gaddafi even more committed than ever to getting the bomb. Rather than acknowledging the need for greater scientific and technical infrastructure to achieve that goal, the Gaddafi regime “cut back” (202) on its prior expectations of developing in-house expertise. It decided instead that henceforth “the program would be based on a set of super-turnkey contracts from the nuclear black market, reducing the demands on the Libyans in several key areas such as planning, organization, and training” (202). Of course, that is the ultimate tyrant’s dream—to achieve absolute power without any strings of obligation or dependence on those below. But back in the real world, the Libyans’ “combination of weak institutions and outsourcing proved problematic,” as Braut-Hegghammer diplomatically puts it (209). In sum, the Libyan case study in *Unclear Physics* provides another strong if unintentional confirmation of the basic theoretical arguments that I made in *Achieving Nuclear Ambitions*, notably the negative consequences of neopatrimonial states’ disrespect for the scientific method and professional scientists, and the general futility of such states’ attempts to use the international nuclear black market as a shortcut.

Braut-Hegghammer’s third critique of the so-called “conventional wisdom” inveighs against the idea that political meddling in questions that are properly left to technical experts undermines the quality of technical work and therefore greatly impairs the long-term efficiency of nuclear weapons projects (11).²² This critique is weak, too. First, it must be noted again that *Unclear Physics* is taking issue with a distorted version of the argument of my book. The distorted version of my argument claims that nuclear weapons projects will run

²¹ *Achieving Nuclear Ambitions*, 243.

²² To be precise, Braut-Hegghammer criticizes both me and Matthew Evangelista for being wrong on this point. I highly recommend Evangelista’s work to anyone who is interested in the nexus between the technical and the political in this area. See Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca: Cornell University Press, 1988) and Matthew Evangelista, *Unarmed Forces: The Transnational Movement to End the Cold War* (Ithaca: Cornell University Press, 1999).

beautifully if only the politicians don't get involved. But what I actually wrote in *Achieving Nuclear Ambitions* is that nuclear weapons projects typically require great efforts both from the political leadership and from the scientific and technical workers, including (a) the need for a clear top-down political decision to go nuclear as a prerequisite for getting the project in gear,²³ (b) the great utility of the top leadership's continuing active and respectful dialogue with the scientific and technical workers throughout the project's lifetime,²⁴ and (c) the difficulty of building and maintaining an organizational culture of scientific and technical professionalism, even when there is minimal political interference.²⁵

That said, I certainly do argue in my book that a political leadership that meddles in technical decisionmaking is asking for trouble, and Braut-Hegghammer disagrees (11). To empirically disprove my claim about the negative consequences of political meddling, the basic story that *Unclear Physics* needs to tell about Iraq is that the nuclear weapons project made no headway while it was on the long leash of "delegatory management" until 1987, but then Saddam's son-in-law Hussein Kamil took over in 1987 and used micromanagement to whip the scientific and technical workers into a frenzy of progress. Braut-Hegghammer endorses this basic storyline in the conclusion to her case study: "When the senior level of the regime intervened after the leaders of the nuclear program quarreled with the powerful MIC [Military Industrialization Commission, which was overseen by Hussein Kamil], the program made increasingly rapid progress" (123). However, her suggestion that Kamil's intervention turned a dawdling program into a dynamic one is not supported by the bulk of her book's historical narrative of Iraq's nuclear history, which instead basically reaffirms the historical interpretations in my book.

In terms of the pre-Kamil era, Braut-Hegghammer correctly writes that although the program had been drifting for a few years, it underwent a revival "initiated by scientists who persuaded the leaders of the program [i.e., other scientists] that a different organization was necessary. They were proven right, as the EMIS [electromagnetic isotope separation] program made important breakthroughs after the 1987 reorganization" (123). It is very important to stress here that this early 1987 reorganization *from within* is not to be confused with Hussein Kamil's later 1987 imposed reorganization from without. The scientific and technical workers themselves reorganized their program, and as a result it started working better.²⁶ Puzzlingly, Braut-Hegghammer presents this episode as proof of the problematic nature of Saddam's "delegatory management" of the program and "absence of effective monitoring mechanisms" (102). But surely technical and scientific workers showing a capacity for self-correction is the opposite of abusive program capture! Rather, as I argued in *Achieving Nuclear Ambitions*, the real lesson from this episode is that the nuclear program workers' experience of having even a very modest amount of professional autonomy since 1982 was gradually—very gradually—helping them find their sea legs as a professional scientific and technical organization.²⁷ Note that the nuclear program's maturation process between 1982 and 1987 is also a major

²³ *Achieving Nuclear Ambitions*, 9-10.

²⁴ See, for example, *Achieving Nuclear Ambitions*, 25.

²⁵ *Ibid.*

²⁶ For my discussion of these events, see *Achieving Nuclear Ambitions*, 101.

²⁷ *Achieving Nuclear Ambitions*, 102.

theme in Iraqi memoirs.²⁸ It is reasonable to surmise that if the regime had maintained its “delegatory management” approach beyond 1987, the nuclear weapons project might well have borne substantial fruit. Braut-Hegghammer, by contrast, thinks that giving the scientific and technical workers a long leash was a big mistake. But in any case, as I argued in *Achieving Nuclear Ambitions*, it is hard to imagine such a big and important program in Saddam’s Iraq indefinitely remaining free from the political manhandling to which Kamil was soon to subject it.²⁹

Having dealt with the period up to 1987, let’s now turn to the Kamil era of 1987-91. Recall that Braut-Hegghammer’s conclusion is that Kamil’s authoritarian management of the program may have been ugly but ultimately achieved results, and she implies that the nuclear weapons project ultimately failed because despite Kamil’s efforts to keep the scientists’ feet to the fire, Saddam himself remained aloof (123). But the body of her historical narrative reads very differently than the conclusion she draws from it. On page after page, Braut-Hegghammer correctly rains negative assessments on Kamil’s authoritarian management approach and its consequences, just as I did in my book. For instance, she argues that Kamil’s forced-march “campaigns were grueling, intensive efforts that rarely succeeded in finding breakthroughs, despite Kamil’s pressure and scare tactics” (106). She points out that Kamil was responsible for a mushrooming of different technical projects, which “was ultimately deemed detrimental to the organization, as it diverted resources from the key challenges” (107). She notes that Kamil was particularly worried that Jafar’s scientist-led EMIS team was actually moving forward more quickly than Kamil’s, and I would have added that this embarrassing situation led him to try to undermine the competition by cutting off its funding—thus nullifying her aforementioned points about the progress of EMIS after 1987.³⁰ She further accepts that Kamil wantonly violated Saddam’s rule about avoiding dependence on foreign sensitive nuclear assistance, thus achieving a semblance of technical progress, but at the high potential cost of imperiling the entire Iraqi nuclear weapons effort through foreign exposure (108). She also details the major cost overruns and delays at the Atheer site that Kamil intended to serve as his weaponization facility: “Even in May 1990 the site was not ready, as basic utilities were still not in place, including electricity, water, and suitable air systems” (114). And finally she heaps scorn on the crazy “crash program” that Kamil launched after the Iraqi invasion of Kuwait, rightly dismissing it as “mission impossible” (103).

Thus, what initially appeared to be an aim to show that Kamil’s micromanagement was effective ultimately shrinks down to the suggestion that his reign of terror was not entirely disastrous: “New evidence presented in this chapter suggesting that added delays were likely to incur does not undermine the long-standing judgment that the Iraqi program was well on its way toward a nuclear weapons capability” (122). Braut-Hegghammer’s admission that “added delays were likely to incur” is very important as it brings her historical narrative much closer toward mine. But then comes yet more direct criticism. Noting my claim in *Achieving Nuclear Ambitions* that “even if the Gulf War had not intervened the Iraqi nuclear weapons project would probably have been no more successful in the 1990s than it had been in the 1980s. Indeed, it would likely have run

²⁸ Notably: Dhafir Selbi, Zuhair Al-Chalabi, and Imad Khadduri, *Unrevealed Milestones in Iraq’s National Nuclear Program: 1981-1991* (CreateSpace Independent Publishing Platform, 2011); Imad Khadduri, *Iraq’s Nuclear Mirage: Memoirs and Delusions* (Richmond Hill: Springhead Publishers, 2003).

²⁹ *Achieving Nuclear Ambitions*, 102.

³⁰ See Kelley, “The Iraqi and South African Nuclear Weapon Programs,” 34.

definitively into the ditch,”³¹ Braut-Hegghammer writes, “As this and the foregoing chapters in this book have suggested, the weight of the evidence does not support this interpretation” (123). This criticism comes on the culminating page of a highly detailed 100-page historical case study.

What is the relative value of my and Braut-Hegghammer’s dueling counterfactuals about what might have happened after 1991? Braut-Hegghammer invests this debate with great significance, but the first thing to recognize here is that we do not need to know what might have happened after 1991 to decide the theoretical issue of whether disrespectful authoritarian management accelerates or retards genuine progress in nuclear weapons projects. The historical evidence clearly shows that Kamil’s bullying approach was harmful to the Iraqi nuclear program’s long-term health, whatever illusory short-term gains it might have bought him. That is the important point for proliferation theory. Yet I suppose the question remains as to when Iraq might have gotten the bomb if not for Saddam and Kamil’s disastrous decision to invade Kuwait. Braut-Hegghammer writes that she agrees with Kamil that Iraq probably would have had its first bomb by around 1995, but she also notes that Kamil’s estimate was “self-serving” and did not reflect any technical understanding of the case, she does not offer any detailed technical explanation for why she believes that Kamil was right, and she grants that Iraqi scientists in a much better position to know estimated that “a realistic completion date for the regular nuclear weapons program could have been the mid-to-late 1990s” (122). If even the Iraqi scientists—who have just as much reason as Kamil to be “self-serving”—are talking “late 1990s”, then why is my educated guess that Iraq probably would not have succeeded during the 1990s so unreasonable?

More problematic than this issue of potential completion dates, however, is Braut-Hegghammer’s mistake of extrapolating the future by drawing a straight line from where she thinks the nuclear program stood prior to the invasion of Kuwait in 1990. Such straight-line extrapolation is always questionable, but it is especially so in light of Braut-Hegghammer’s own evidence that the Iraqi nuclear program was highly likely to be shaken by yet more disruptive reorganization in the coming years. For one thing, the different expectations of Kamil and the scientists about when the bomb would be built were surely not going to remain inconsequential differences of opinion. When the scientific and technical workers inevitably failed to live up to Kamil’s expectations of producing a working bomb by the early 1990s, heads would have rolled. And then where would the program have ended up? In the ditch, as I suggested in my book.

Finally, it is necessary to point out that this whole game of guessing what would have happened to the nuclear program if the Gulf War had not intervened is extremely tricky and problematic from an epistemological point of view. As I wrote in *Achieving Nuclear Ambitions*, it is what is known as “a ‘miracle world counterfactual,’ which requires us to take a huge leap away from historical reality in order to consider it.”³² It is a miracle-world counterfactual because Iraq’s nuclear weapons project was not a rationally organized endeavor whose future development seemed assured until it was suddenly thrown off course by a single, low-probability external event. Rather, the project was a deeply flawed one that had been woefully underperforming for years with dramatically mounting costs, had made repeated radical changes in direction, and was ultimately killed by decisions taken by its own political masters in 1990-91, including the disastrous launching of the “crash program.” Therefore, as I argue at the end of my Iraq case study in *Achieving Nuclear Ambitions*, “It ultimately does not matter if the trend lines of the nuclear weapons project were positive or

³¹ The original quotation is in *Achieving Nuclear Ambitions*, 115.

³² *Achieving Nuclear Ambitions*, 116.

negative at the time of the invasion of Kuwait. The scientific and technical workers had had their 10-year run, and they had failed; only in a magical realist fantasy world do they get any more time than that.”³³ *Unclear Physics* ignores my arguments on this point.

I want to end this essay by reiterating what I said at the top. There is much to be praised in *Unclear Physics*. It is the product of a great deal of dogged historical spadework on the failed Iraqi and Libyan nuclear programs. It is unparalleled in its detailed description of what occurred within those two programs. Unfortunately, the payoff from that impressive fact-gathering effort is drastically diminished by the book’s failure to properly engage with the existing proliferation literature. *Unclear Physics* is clear when it sticks to history, but it becomes unclear when it ventures into social science.

³³ *Achieving Nuclear Ambitions*, 118

Review by Austin Long, Columbia University SIPA

A brutal dictator in the midst of a long-running war seeks nuclear weapons yet is thwarted by a fractured bureaucracy frittering away resources. In *Unclear Physics*, Malfrid Braut-Hegghammer argues that this describes Iraqi President Saddam Hussein in the 1980s but it could apply to German dictator Adolf Hitler in the 1940s.¹ As Thomas Power describes, the Nazi nuclear effort was an “... unruly mailing list of competing scientists whose only shared hope was to survive the war.”² This is quite similar to “... an opaque organization with a bewildering number of offshoots,” Braut-Hegghammer’s description of the Iraqi Ba’ath nuclear effort in the 1980s (83).

Yet dictators are not obviously doomed to fail in nuclear programs, as tyrants from the USSR’s Josef Stalin to North Korea’s Kim Jong Il have succeeded in getting the bomb. Braut-Hegghammer provides an explanation for the failure of Saddam’s Iraq and Muammar Gaddafi’s Libya to obtain nuclear weapons. This explanation is rooted in the lack of state capacity, efforts to prevent coups, and choices about managing nuclear programs. She then details the nuclear efforts of both Iraq and Libya using an array of new primary and secondary sources.

Braut-Hegghammer’s explanation is persuasive and linked, as she notes, to a growing literature focused on the impact of internal state characteristics and choices on the outcomes of state efforts in the security realm. Her evidence supports her contention that Saddam’s program was much closer to achieving a viable nuclear capability than Gaddafi’s, despite Gaddafi’s much greater access to external technical support from sources such as the A.Q. Khan proliferation supply network. Iraq’s relative success was due to greater state capacity, as whatever the problems of the Ba’ath Party, it had not hollowed out the state to the extent Gaddafi’s revolutionary enthusiasm did.

One of the great strengths of the book is the deep historical account of both Iraq and Libya’s programs. Indeed, it will be an indispensable addition to the library of anyone interested in nuclear proliferation for these revisionist (in the best sense) accounts alone. Yet the historical depth inevitability trades off with confidence in the generalizability of the theory. While the revisionist nature of Braut-Hegghammer’s history undoubtedly required depth in order to make the cases convincing, the lack of comparative cases with more significant variation on the dependent variable (successful development of nuclear weapons) leaves open many theoretical questions.

For example, just how strong must “the institutions that underpin a robust state apparatus” be (7) for a state to have nuclear success? The institutions in the Soviet Union, the People’s Republic of China (PRC), and the Democratic People’s Republic of Korea (DPRK) were all subject to purges and intense political influence in

¹ See for example Mark Walker, *German National Socialism and the Quest for Nuclear Power 1939–1949* (Cambridge: Cambridge University Press, 1993).

² Thomas Power, *Heisenberg’s War: The Secret History of the German Bomb* (New York: Alfred Knopf: New York, 1993) 79.

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the period in which those states developed nuclear weapons.³ The PRC, which successfully tested its first nuclear weapon in 1964, had just undergone the Anti-Rightist Campaign and Great Leap Forward purges and upheaval (1957-1961).⁴ The DPRK was and is characterized by purges and patronage networks. In the mid-1990s it experienced the major collapse of many state institutions, such as the public distribution system for food, during an extensive famine.⁵ Yet in 2006, just over a decade later, it was able to test its first nuclear weapon.

These examples suggest that even fairly weak state institutional capacity may still be sufficient to cross the nuclear threshold. Yet as Braut-Hegghammer notes, there can be variation in the strength of state institutions over time even under the same leader and there is some evidence that this variation may impact nuclear programs even after the first nuclear test. In 1966, just two years after its first test, the PRC entered the profound period of turmoil known as the Cultural Revolution. A deliberate effort to create a revolution within a revolution (and surely an inspiration for Gaddafi's Cultural Revolution, which Braut-Hegghammer describes), this decade-long affair further undermined institutions in the PRC and is widely believed to have contributed significantly to the stagnation of the Chinese nuclear arsenal for nearly two decades.⁶

On the other hand, Nazi Germany, though not without institutional problems of its own, likely had at least as much state capacity as the Soviet Union, PRC or DPRK and yet failed to acquire nuclear weapons.⁷ It also had substantial scientific expertise and resources despite having forced many of the world's best physicists to flee Europe. So while some level of state capacity and technical resources seem to be necessary, they are far from sufficient.

This in turn suggests the other factors Braut-Hegghammer notes, coup-proofing and management strategy, may be of greater overall importance (though again more comparative work is required). Here again coup-proofing seems to be a mixed bag in comparative perspective. Both the Soviets and the Nazis had concerns about coups and took measures, including fragmenting authority, to limit the opportunities for coups. Yet Jasen Castillo has persuasively demonstrated the Soviets appear to have been far more concerned about coups,

³ For an excellent comparative look at the impact of weak institutions on power and leadership succession in the USSR, PRC, and DPRK see Joseph Torigian, "Prestige, Manipulation, and Coercion: Elite Power Struggles and the Fate of Three Revolutions," (Ph.D. thesis, Massachusetts Institute of Technology, 2016).

⁴ See Fredrick Teiwes, *Politics and Purges in China* (Armonk: M.E. Sharpe, 1993).

⁵ See Christoph Bluth, *Crisis on the Korean Peninsula* (Washington, D.C.: Potomac Books, 2011) and Andrew Natsios, *The Great North Korean Famine: Famine, Politics, and Foreign Policy* (Washington, D.C.: U.S. Institute for Peace, 2001).

⁶ See M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation: The Evolution of Chinese Nuclear Strategy and Force Structure," *International Security* 35:2 (Fall 2010): 48-87.

⁷ On the Nazi state's capacity see Jane Caplan, *Government without Administration: State and Civil Service in Weimar and Nazi Germany* (Oxford: Clarendon Press, 1988) and Adam Tooze, *Wages of Destruction: The Making and Breaking of the Nazi Economy* (London: Allen Lane, 2006).

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since they greatly restricted the autonomy of the Red Army and maintained a massive internal security force.⁸ As with state capacity, it is unclear how pervasive the fragmentation of authority must be in order to seriously impede nuclear programs. Gaddafi's all-out assault on the state certainly seems to qualify, but such internal demolitions of the state seem to be rare, with only Mao's Cultural Revolution and perhaps the Khmer Rouge's Year Zero in the same league.⁹

Management strategy, at least in superficial comparison, may be more decisive. Saddam Hussein was a professed admirer of Adolf Hitler, and the two shared certain managerial tendencies. One was an obsession with military technology that was not backed with much understanding of industrial production or technical reality. Both were also susceptible to pitches from entrepreneurs, particularly when it came to 'the biggest bangs.' Hitler approved development of the almost absurdly large 'Maus' tank in 1942 after hearing a proposal from German industrialist Ferdinand Porsche.¹⁰ Saddam was willing to fund the dreams of Canadian engineer Gerald Bull to build a massive "Supergun" capable of firing projectiles into orbit.¹¹

These managerial quirks were surely frustrating to those chosen to bring order to military research and production. Albert Speer, appointed Minister for Armaments and War Production in 1942, groused extensively about living with the Fuhrer's decisionmaking.¹² While we lack the detailed complaining of Speer for Iraq, CIA's Iraq Survey Group uncovered similar frustrations in its post-2003 invasion investigation by Speer's equivalent in Iraq, former Minister of Military Industrialization Abd-al-Tawab 'Abdallah Al Mullah Huwaysh:

Saddam's interest in science meant that some Iraqi weapons-related scientists were able to use back channels to by-pass military industry gatekeepers such as Huwaysh. This enabled them to sometimes secure Saddam's support for odd or marginal programs of little use to defense. For example, retired defense scientist 'Imad 'Abd-al-Latif 'Abd-al-Ridha secured Saddam's backing in January 2000 for the Al Quds UAV program over the objections of Huwaysh. The project never progressed beyond two prototypes and Huwaysh stated that the program was ultimately an expensive failure.¹³

⁸ See Jasen Castillo, *Endurance and War: The National Sources of Military Cohesion* (Stanford: Stanford University Press, 2014). See also the comparative perspective in Torigian.

⁹ On the Khmer Rouge see Ben Kiernan, *The Pol Pot Regime: Race, Power, and Genocide in Cambodia under the Khmer Rouge, 1975-79*, 3rd edition (New Haven: Yale University Press, 2008).

¹⁰ Thomas Jentz and Hilary Doyle, *Schwere-Panzerkampfwagen Maus and E 100 Development and Production from 1942 to 1945* (Boyd: Panzer Tracts, 2008).

¹¹ William Lowther, *Arms and the Man: Dr. Gerald Bull, Iraq, and the Supergun* (San Francisco: Presidio Press, 1992).

¹² Albert Speer, *Inside the Third Reich* (New York: MacMillan, 1970). One need not accept all of Speer's self-serving account to believe Hitler may have been a poor manager.

¹³ Comprehensive Report of the Special Advisor to the Director of Central Intelligence on Iraq's Weapons of Mass Destruction 1:10-11 (2004).

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Conversely, neither seems to have ever embraced the nuclear program in a major way. As Braut-Hegghammer notes, even as the Iraqi program finally began to approach the nuclear threshold in the late 1980s “Saddam was distracted or simply lost interest. He remained distant from the program...” (123). Hitler, despite his fascination with military technology, did not have much connection to the program, perhaps because many German scientists believed it could not be completed in time to affect the outcome of the war.

In contrast to Hitler and Saddam, many of the leaders of successful programs have had more orderly managerial styles. Stalin chose the ruthless but effective head of the secret police Lavrenti Beria to administer the nuclear program and the experienced physicist Igor Kurchatov as the scientific director. He then mostly left them alone to get on with the program.¹⁴

These leaders also placed more personal emphasis on the nuclear programs. Mao, though careful to publicly demean the importance of nuclear weapons when China lacked them, was determined, almost from the foundation of the PRC, to have them. He noted in a 1956 Politburo meeting “Not only are we going to have more airplanes and artillery, but also the atomic bomb. In today’s world, if we don’t want to be bullied, we have to have this thing.”¹⁵

Braut-Hegghammer’s theoretical contribution to the nuclear proliferation literature is thus significant but is only the first step in developing a deeper understanding of how state capacity and a leader’s managerial choices influence the ability of states to develop nuclear weapons. The next step must be a broader comparative exploration with more variation on both independent and dependent variables. Graduate students looking for dissertation topics could do much worse than to pick up where Braut-Hegghammer has left off (though I confess the depth of her empirics would have intimidated me as graduate student).

A closing word on some of those empirics. While Braut-Hegghammer has drawn on an impressive array of sources, from International Atomic Energy Agency records (many not widely available) to captured Iraqi documents, a large portion of her account of the internal workings of the Iraqi nuclear program depend on accounts provided by scientists working in the program. While valuable, these sources must always be viewed with at least a pinch of salt, particularly as those scientists might have had motives to obscure their cooperation with an odious regime. For example, she asserts of the pre-1981 Osirak strike period “... the nuclear scientists did not implement Saddam’s apparent order to develop a nuclear weapons options” (69). Her evidence for this claim appears on 65-67 and is based entirely on writings and statements from those scientists (footnotes 86-99, except 87 and 93).

German scientists after World War II made efforts to distance themselves from the regime. Werner Heisenberg in particular tried to portray himself as having deliberately undermined the German nuclear program. Yet secret recordings made when Heisenberg and other German scientists were interned in the United Kingdom along with other documentary evidence, including an unsent letter from Niels Bohr, portray

¹⁴ David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-56* (New Haven: Yale University, 1993).

¹⁵ “Talk by Mao Zedong at an Enlarged Meeting of the Chinese Communist Party Central Committee Politburo, April 25, 1956;” online at: <http://digitalarchive.wilsoncenter.org/document/114337>.

him differently- mistaken about the physics of a nuclear weapon, but hardly unwilling.¹⁶ One must bear this history, which has been contested for decades, in mind in evaluating the accounts of Iraqi nuclear scientists.

Yet even if one is skeptical of some of the evidence, the totality of Braut-Hegghammer's book is an extraordinary achievement. It should find a prominent place on syllabi of nuclear proliferation alongside such works as Etel Solingen's *Nuclear Logics* and Jacques Hymans' *Achieving Nuclear Ambitions*.¹⁷

¹⁶ See Paul Rose, *Heisenberg and the Nazi Atomic Bomb Project, 1939-1945: A Study in German Culture* (Berkeley: University of California Press, 2002); Jeremy Bernstein, *Hitler's Uranium Club: The Secret Recordings at Farm Hall 2nd ed.* (New York: Springer-Verlag, 2001) and Adrian Cho, "Letters Aver Physicist Supported Nazi Bomb," *Science* (15 February 2002). Power, *Heisenberg's War* is much more sympathetic to Heisenberg.

¹⁷ Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East* (Princeton: Princeton University Press, 2007) and Jacques Hymans, *Achieving Nuclear Ambitions: Scientists, Politicians, and Proliferation*, (Cambridge and New York: Cambridge University Press, 2012).

Review by Rachel Elizabeth Whitlark, Georgia Institute of Technology

Målfrid Braut-Hegghammer's new book, *Unclear Physics: Why Iraq and Libya Failed to Acquire Nuclear Weapons*, offers a carefully researched and in-depth exploration of the causes of two important states' failed attempts at nuclear-weapons acquisition. Presenting a supremely data-rich and deep analysis of Iraqi and Libyan nuclear development, she challenges a variety of conventional wisdoms including that the failures can be explained by the leaders themselves or the role of scientific entrepreneurs inside the nuclear establishment. She also supplants previous works which have struggled with a lack of available information by presenting what is very likely the most comprehensive accounting of the nuclear enterprise within both opaque states to-date. In this commendable undertaking, Braut-Hegghammer makes impressive use of primary-source research, interviews, and newly available materials from both the International Atomic Energy Agency (IAEA) and the 2002 War in Iraq.

This work is a welcome contribution to the literature on nuclear issues, and fits quite comfortably within a variety of existing trends in the scholarship. First, the book follows a well-trodden path of advancement in the nuclear literature which has evolved from a state-centric approach to one which now encompasses a role for both regime-type and individual leaders. Braut-Hegghammer continues this progression and extends the analytical focus beyond a narrow portrayal of regimes, and investigates instead the internal workings of states and their institutional capacity, thus introducing a new variable into the literature. This move has the related advantage of extending the traditional capability vs. willingness debate,¹ which has existed largely at the state level, and deploying it within states for a bureaucratic and organizational approach. Second, *Unclear Physics*, continues a more recent and also significant development in the nuclear literature to explore how authoritarian leaders affect states' nuclear decision-making.² Echoing a discussion within political science writ-large, Braut-Hegghammer demonstrates that in the nuclear space, as elsewhere, personalist dictators are much more constrained than was initially believed.³

Despite these progressive moves and the extremely rich case contribution from which political science, history, and the policy community will benefit handsomely, I found myself wrestling with three tensions that complicate the causal story. I suspect these may stem from the relatively limited attention the theoretical framework receives relative to the depth of the case histories (a choice I am comfortable with as a reader of this book given the size and scope of the empirical effort Braut-Hegghammer puts forward), but tensions which bear mentioning nevertheless.

The first challenge is a terminological one which masks a levels-of-analysis complication. The author's focus on state capacity suggests an interest in drawing a distinction between capability and determination.

¹ Dong-Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapons Proliferation," *Journal of Conflict Resolution* 51:1 (February 2007): 167-194, DOI: <https://doi.org/10.1177/0022002706296158>.

² Matthew Fuhrmann and Michael C. Horowitz, "When Leaders Matter: Rebel Experience and Nuclear Proliferation," *The Journal of Politics* 77:1 (2015): 72-87; Christopher Way and Jessica L. P. Weeks, "Making It Personal: Regime Type and Nuclear Proliferation," *American Journal of Political Science* 58:3 (July 2014): 705-719.

³ Jessica L. Weeks, "Autocratic Audience Costs: Regime Type and Signaling Resolve," *International Organization* 62:1 (2008): 35-64.

Specifically, her argument for failure to acquire nuclear weapons rests on a lack of state capacity, and in particular, how “weak states often lack the institutional resources to set up and operate nuclear weapons programs” (6). To my mind, this claim can be interpreted in three different ways, all of which might describe the reasons for state failure. First, explanations for Iraqi and Libyan failure could rest on a lack of leader dedication to or prioritization of the program, which would undermine a program and manifest as a lack of resources to set up and run the necessary institutional and technological components. Such an explanation would place the causal weight on the role of the leader. Alternatively, failure could be the result of pure technical, industrial, and state capacity deficiencies stemming from low levels of basic national education, limited amounts of indigenous advanced scientific and technical expertise, and a lack of basic administrative skills, all of which seem fundamentally important to organizing a successful national nuclear weapons program. An argument of this nature would therefore find its roots at the state level. Third and finally, failure can be pegged to a lack of appropriate institutional management and organizational capacity which would offer a bureaucratic explanation internal to the state apparatus.

Unfortunately, while Braut-Hegghammer defines state capacity as the professionalism of the bureaucracy (8), suggesting an argument akin to the third articulated above, she also offers a variety of compelling evidence to suggest a strong causal role for the state leaders, Saddam Hussein and Muammar Gaddafi, and the indigenous weaknesses of two relatively poor and underdeveloped states. Early on, for example, the argument is articulated as “showing that authoritarian leaders in weak states have limited capacity—and sometimes limited interest—in managing their nuclear scientists” (6). Later, the conclusion states, “Whether or not leaders want to intervene directly in the management of the nuclear weapons program reflects the intensity of their desire to get the bomb, among other things” (219). Though there are attempts to distinguish capacity from leader interest or commitment (218), this tension is never fully resolved. Indeed, evidence which would support a leader-based argument pervades the narrative in both the Iraqi and Libyan cases: “Nuclear weapons were never Saddam’s or Gaddafi’s primary concern” (220). A variety of other explicit statements like this one, as well as the implicit suggestion of the leader’s determinative role, permeate the author’s attempt to focus on state capacity and undermine the attempt at drawing a clear distinction between this work and prior leader-centric arguments.

A second and related issue concerns the dependent variable under investigation. The introduction suggests that *Unclear Physics* is about Libyan and Iraqi failure to acquire nuclear weapons, but the model and the empirical evidence seem to focus alternatively on delay and inefficiency rather than the actual failure (or success) of the programs. Indeed, in both cases, there are a variety of external (or at least external to the model) factors that seem to determine why both programs ultimately failed. In the Iraq case for example, Hussein’s 1990 invasion of Kuwait and the Gulf War it provoked, were hugely consequential in the eventual destruction of the program – both in the near term as key facilities are attacked and destroyed, and over the long-run as the subsequent weapons inspections dismantled the remaining infrastructure (103, 119, 120). Obviously the events of 1990 and 1991 cannot alone explain the lack of success, but coupled with the Osirak attack in 1981 and a variety of other negatively consequential decisions by Hussein, the reader remains unsure whether the Iraqis might have been eventually successful absent these harmful external interventions. Likewise, in the Libyan case, the sanctions regime and subsequent economic downturn, as well as the external threat environment resulting from the 1988 Lockerbie Bombing and other terrorist-related activities, do a significant amount of work in explaining why Libya did not succeed. Especially given the extreme domestic weaknesses which plagued Libya from its founding, it is not obvious that Hussein and Gaddafi would have succeeded even without these other factors.

Perhaps unsurprisingly, given that my own work focuses on the role of leaders in other nuclear-related decisions,⁴ my resolution to these two tensions focuses on each respective leader's mistakes—invading Kuwait, sponsoring terrorism, Lockerbie, etc.—and how these choices, especially when coupled with the lack of prioritization, doomed the nuclear programs and led to the institutional-capacity issues that Braut-Hegghammer compellingly demonstrates as causing severe inefficiency, malaise, and an overall lack of progress. In this way, my interpretation of the narratives suggests that leader prioritization (or lack thereof) should be a prior variable through which we make sense of the institutional capacity intervening variable that Braut-Hegghammer, I believe correctly, identifies as having causal significance. The narrative of both cases routinely refers to the lack of prioritization that both the Iraqi and Libyan programs received from their respective leaders, suggesting that more attention to this factor is necessary. And, to the extent that leader-related pressures on state capacity lead to inefficiency and can be separated from external factors causing failure, such a clarification would be both warranted and helpful.

Finally, throughout this volume, it remains unclear precisely what would portend success in the nuclear programs of personalist authoritarian regimes. At varying points, it seems as though more skilled and/or more senior oversight might have helped decrease inefficiency and encourage success. The author herself implies that a top-down, centralized program with significant investment by the state leadership, as Josef Stalin created in the Soviet Union, could portend success.⁵ In the Iraq case in particular, the period of 1988-1991 suggests that simply having had more time to continue could have led to a perhaps still inefficient, but ultimately successful, nuclear program. Relatedly, I found myself wondering if there was a developmental level below which states are unable to overcome the educational and scientific limitations of their population? The Pakistani and North Korean programs suggest that this is not the case, but it would be a useful discussion in which to engage.

The above factors are only some of the likely plausible ones which could predict success. These and others would have been useful to explore, however briefly. While I appreciate the methodological choices that Braut-Hegghammer makes in presenting the deep case analyses which on their own do not allow for a full theory-testing exercise in comparable cases of success, it would have been helpful, at least anecdotally, to engage precisely which factors inside these regimes do indicate success. Left to my own devices, my intellectual proclivities cause me to return to state leaders and their choices—the lack of prioritization, the provoking of unnecessary external crises which hamstrung or destroyed key program components, etc.—that seem to go a long way in helping us to understand why the internal structural challenges were not ultimately overcome.

Beyond the above theoretical issues, let me also note three minor concerns. The first is that despite the attention paid to coup-proofing in the introductory chapter, as well as in the introduction and concluding sections of nearly all case chapters, there appears to be little causal role for this factor throughout the cases. While as a state characteristic this factor may make intellectual sense to include given how authoritarian

⁴ Rachel Elizabeth Whitlark, "Nuclear Beliefs: A Leader-Focused Theory of Counter-Proliferation." *Security Studies*. Forthcoming.

⁵ Note, however, that Braut-Hegghammer is explicit in arguing against a simple regime-type explanation for the success or failure of nuclear programs. Her effort on this point is convincing.

leaders seem to behave more generally regarding regime security,⁶ coup-proofing fades into the background of case narratives that focus on the institutional and organizational environment. This leads me to wonder to what extent it is actually necessary for the author's argument.

An additional issue concerns the question of generalizability. While Braut-Hegghammer gets at this to a certain extent with the Syrian extension in the conclusion, it would have been very helpful to have more of this woven throughout. In particular, the reader would benefit significantly from comparative statistics to put Iraqi and Libyan development indicators—level of education, the number of relevant scientists and engineers, etc.—into relative context with other states in the international system, including in particular successful nuclear weapons states. Something similar can be said regarding within country-comparisons, though the author does a limited amount of this when showing how institutional decisions were not necessarily unique to the nuclear industry. While I am sensitive to space concerns, even a few footnotes or parenthetical explanations would have been very useful points of comparison to assist with conceptualizing how unique the Iraqi and Libyan cases actually are.

Last, I found myself clamoring for more of the implications of the findings of *Unclear Physics*. Specifically, how exactly should the United States or other members of the international community deter or coerce states such as these with seemingly ambivalent interests when it comes to nuclear weapons? Relatedly, how can any segment of the intelligence community avoid drawing inappropriate conclusions from ambivalent or contradictory information, given the consequences of underestimating the signs that a state actor might be heading towards nuclear weapons acquisition (158)? More broadly, these concerns speak to the ability or the inherent difficulty of divining intentions from ambiguous, complicated, and opaque information environments, with actors who are often deliberately engaging in a misinformation campaign to deter a variety of both internal and external stimuli. This challenge is far from trivial, given the current implications of the 2002 War in Iraq and the potential magnitude of a similar mistake in the face of a future proliferant.

In sum, Målfrid Braut-Hegghammer's *Unclear Physics*, offers a critical illumination of Iraq and Libya, advancing our understanding of the internal workings of authoritarian and specifically personalist dictatorships and their nuclear behavior. Previously, the scholarly community has had a fuzzy understanding of these complicated environments, and the empirical information Braut-Hegghammer presents is a tremendous improvement for our comprehension. Especially in a time of global challenges to democracy and a potential return towards autocracy in key global actors, this book is very well-timed. In the aftermath of the Arab Spring, which changed the landscape of the Middle East, and the evolution of domestic society taking place in Turkey and Saudi Arabia, it is possible that the next nuclear pursuits to capture the attention of the international community may occur in states with similar internal characteristics to Iraq and Libya. Moreover, this work highlights how, despite notions to the contrary, it is not always about the weapons. Indeed, what starts as a push for domestic energy independence or expansion, or as an ambivalent muddling through all things nuclear, can over time morph even inadvertently into a weapons campaign. This suggests that the

⁶ See for example James T. Quinnivan, "Coup-Proofing: Its Practice and Consequences in the Middle East," *International Security* 24:2 (1999): 131-165; Milan W. Svobik, "Power Sharing and Leadership Dynamics in Authoritarian Regimes," *American Journal of Political Science* 53:2 (April 2009): 477-494, DOI: <https://doi.org/10.1111/j.1540-5907.2009.00382.x>; Cameron S. Brown, Christopher J. Fariss, and R. Blake McMahon, "Recouping after Coup-Proofing: Compromised Military Effectiveness and Strategic Substitution," *International Interactions* 42:1 (January 2016): 1-30, DOI: <https://10.1080/03050629.2015.1046598>.

mechanisms and pathways through which energy concerns, weapons exploration, and even scientific prowess interact, are significant and worth further investigation. Indeed, the literature's recent turn to focus on the energy/security nexus and nuclear latency in particular appears to concur.⁷ For these reasons and many more, Braut-Hegghammer offers a substantial contribution in advancing our understanding of personalist dictatorships and their pursuit of nuclear capability and in helping the scholarly and policy communities continue a most important conversation.

⁷ For example, see Jeff D. Colgan, *Petro-Aggression: When Oil Causes War* (New York: Cambridge University Press, 2013); Matthew Fuhrmann and Benjamin Tkach, "Almost Nuclear: Introducing the Nuclear Latency Dataset," *Conflict Management and Peace Science* 32:4 (2015): 443-461, DOI: <https://doi.org/10.1177/0738894214559672>; Rupal N. Mehta and Rachel Elizabeth Whitlark, "Benefits and Burdens of Nuclear Latency," *International Studies Quarterly*, Forthcoming.

Author's Response by Målfrid Braut-Hegghammer, University of Oslo

It is a privilege to receive such thoughtful, stimulating, and challenging responses to my book. I thank Andrew Coe, Jacques Hymans, Austin Long, and Rachel Whitlark for their insightful comments and criticism. Their reviews highlight the main contributions of my book, raise important challenges, and suggest avenues for future research. Taken together, they help define how *Unclear Physics* fits into the debate on domestic-level factors in shaping the outcomes of nuclear weapons programs in personalist regimes.

We need to enhance our scholarly understanding of these dynamics. We are seeing more personalist regimes around the world, and some of these are likely to want nuclear weapons.¹ *Unclear Physics* delves deep into two cases, Iraq and Libya, but does not offer a comparative analysis of a broader set of cases. Fortunately, as Long notes, there is rich work in the pipeline by Joseph Torigian and others that enables more detailed comparative analyses of authoritarian regimes and nuclear weapons programs across different stages in the nuclear age.² After reading these reviews, I am hopeful that *Unclear Physics* will have a place in these debates in years to come.

In the following sections, I respond to the points raised by the four reviewers. I begin by clarifying the purpose of the book and the scope conditions of the argument. Second, I discuss whether the variables I pinpoint deserve the prominent place they receive in my argument and analysis. Third, I discuss how the argument fares when applied to other cases, and highlight some implications for scholars and decision-makers.

What the argument is (and is not)

In *Unclear Physics* I carry out an exploratory analysis of the role of state capacity in personalist regimes seeking nuclear weapons, proposing that state capacity is an important intervening variable. I argue that state capacity, combined with the management strategies personalist leaders choose to cope with the state's institutional weaknesses, has important consequences for the performance of these nuclear weapons programs. These consequences range from the planning and operationalization of the programs to the mechanisms by which leaders can audit and intervene if the programs underperform. I also suggest that if I am right, the arguments and evidence presented in this book have broader implications for how we think about governance inside personalist regimes. Specifically, I suggest that scholars have perhaps overestimated the amount of control and oversight exercised by these leaders, and underestimated the dysfunctionality of their states. At the same time, my research shows that nuclear weapons programs can become islands of relative efficiency in personalist regimes.

My book does not offer a new theory, nor do I seek to test one. I note that this is a criticism levied by my reviewers, but this is not what I set out to do. An important next step would be to develop and test a theory, and compare its explanatory power with alternative models. My reviewers offer several useful suggestions for how this can be done – for example, Coe highlights the value of a counterfactual analysis, Whitlark and Long

¹ Andrea Kendall-Taylor, Erica Frantz, and Joseph Wright, "The New Dictators," *Foreign Affairs*, 10 March 2017.

² For a recent analysis of leadership struggles among Chinese elites, see Joseph Torigian, "The shadow of Deng Xiaoping on Chinese Elite Politics," *Commentary*, War on The Rocks, 30 January 2017.

point to the importance of testing the argument across a wider set of case studies, while Hymans recommends that such a theory should be explicitly compared and contrasted with other theories, notably his own.

Unclear Physics is primarily a comparative analysis of two crucial cases, whose findings, I suggest, challenge important aspects of the conventional wisdom about the Iraqi and Libyan nuclear weapons programs. As all four reviewers note, the main strength of the book lies in the analysis of the Iraqi and Libyan nuclear weapons programs. Hymans argues that my book overstates its contributions on the case of Libya. I disagree. My four chapters on Libya offer a new history of the emergence, management, and performance of the Libyan nuclear program. These chapters are based on primary sources that I have collected in the course of a decade, during fieldwork in Libya and in several archives, notably the archives at the International Atomic Energy Agency in Vienna.

While my theoretical ambitions are limited, I would argue that there is no dearth of theory-development or testing in this field. What we do not know about nuclear proliferation is not primarily due to a lack of theory, as theory-testing (qualitative and quantitative) has become increasingly central in the field in recent years.³ Shedding new light on two important cases is, in my view, a limited, but constructive, contribution.

My findings speak to ongoing debates on nuclear proliferation, primarily concerning the causal impact of domestic-level factors such as regime type. Hymans argues that I equate his work with the conventional wisdom that I seek to challenge. To be clear: in my introductory chapter, I describe three aspects of his argument as being influential enough to be characterized as the conventional wisdom about the domestic-level causes of dysfunctional nuclear weapons programs in personalist regimes. Throughout my book I refer to a burgeoning body of work on regime type and nuclear proliferation, including specific works dedicated to the cases of Iraq and Libya. I address different sets of “conventional wisdoms” about these regimes and programs in subsequent chapters. Yet Hymans appears to equate any reference to the conventional wisdom in my book to his own work, even sentences where I refer to the work by other scholars (notably including Etel Solingen) in footnotes.⁴ This is the apparent premise for his serious allegations against my book, particularly that it misrepresents the literature.

As I see it, Hymans and I agree more than we disagree about the fundamental problems facing personalist leaders seeking nuclear weapons. We disagree about the options available to leaders seeking to intervene in fledgling nuclear weapons programs and the consequences that are likely to follow. I treat strategies and state capacity as variables, and argue that interventions can have different results. Specifically, I argue that intervention is not necessarily bad—and that the outcomes of such interventions depend in large part on state capacity. Here, I think, lie the seeds for a fruitful debate.

The bulk of Hymans’ review consists of discussing to what extent my evidence fits with his arguments. Seen through this lens, my arguments appear rather different. For example, Hymans suggests that my explanation

³ See Mark S. Bell; Examining Explanations for Nuclear Proliferation. *International Studies Quarterly* 60:3 (2016): 520-529, DOI: <https://doi.org/10.1093/isq/sqv007>; H-Diplo ISSF Forum, No. 2 (2014)- “What We Talk About When We Talk About Nuclear Weapons.” Accessed from <http://issforum.org/ISSF/PDF/ISSF-Forum-2.pdf>.

⁴ Etel Solingen, *Nuclear logics: contrasting paths in East Asia and the Middle East* (Princeton: Princeton University Press, 2009).

for the outcome of the Iraqi program – which he defines as a failure - was the combination of Hussein Kamil's (Saddam's son-in-law and military-industrial czar) brutal management and Saddam Hussein's lack of interest. This is certainly part of my causal story. But my core argument is that the Iraqi program was on the brink of success when it was interrupted by the 1991 Gulf War.

I am puzzled by Hymans' claim that my evidence and analysis confirms his own theory, while he disagrees with how I characterize the outcome of the Iraqi nuclear weapons program (i.e., that it was well on its way to a breakthrough when it was interrupted). While Hymans argues that a counterfactual analysis of what would have happened in the Iraqi nuclear weapons program if Saddam had not invaded Kuwait is irrelevant for assessing his own theory, it is clearly relevant for assessing the arguments made in *Unclear Physics*. Hymans mentions some of the Iraqi assessments I discuss concerning the likely trajectory of the Iraqi program after 1991. While I do not go into detailed technical specifications in projecting the performance of the Iraqi nuclear program, as Hymans notes, I also cite assessments from very capable technical agencies – including different Iraqi assessments, estimates by the International Atomic Energy Agency (IAEA), and several states. Hymans then asks why I find his “educated guess that Iraq probably would not have succeeded during the 1990s so unreasonable”. I have not characterized Hymans' views as unreasonable. What I wrote in my book is that I disagree with his argument that the Iraqi program would “likely have run definitively into the ditch” and could not have succeeded even if Saddam had not invaded Kuwait.⁵

Hymans further claims that it does not really matter that the Iraqi program was performing better in the second half of the 1980s because the program could not carry on for more than a decade – and argues that the program would only have continued beyond 1990-91 in a “magical realist fantasy world.” Back in the real world, the weight of the evidence presented in *Unclear Physics* shows that the Iraqi program would have continued, and in all likelihood eventually succeeded, if Saddam had not invaded Kuwait.

The explanatory power (and limitations) of state capacity

An important question raised by several of the reviewers is how much state capacity can actually explain. The reviewers raise different questions to probe and test the explanatory qualities of the state capacity variable. These include 1) to what extent is this a distinct variable (Whitlark), 2) more specifically, how it relates to management strategies (Coe), and 3) are there thresholds of state capacity that are either too low to permit success or sufficiently high to almost guarantee it (Long, Whitlark and Coe)?

In my book, I describe state capacity as an intervening variable affecting the impact of other variables. I do not discount that these other variables are important for explaining the outcomes of the Iraqi and Libyan nuclear weapons programs – on the contrary, I argue that the failure of both programs was in many ways an overdetermined outcome. In the two case studies, I explore how weak state capacity can affect the performance of nuclear weapons programs in two personalist regimes, and attempt to distinguish these effects from other variables. I do not discount the importance of other variables, such as external shocks (e.g. military strikes or threats of such attacks) and domestic-level variables (e.g. levels of economic and industrial development or changes in leadership demand for nuclear weapons). The question, then, is not whether state capacity alone can obstruct or enable success, but rather how state capacity interacts with these other internal

⁵ Jacques E.C. Hymans, *Achieving nuclear ambitions: scientists, politicians, and proliferation* (Cambridge and New York: Cambridge University Press, 2012), 115.

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and external variables to affect the performance of the program - and how we can distinguish between these effects empirically.

With that caveat, the question of threshold effects raises an important issue. There is likely to be a lower threshold for state capacity where success is an extremely unlikely outcome. In my view, Libya under Colonel Muammar Gaddafi is a rare example of a state whose institutions have been so thoroughly weakened that they are unlikely to succeed with complex technological project such as a nuclear weapons program. I do not believe that Pakistan's or North Korea's state institutions have been as weakened as Libya's state institutions were under Gaddafi. Conversely, is there a threshold of capacity that guarantees success? No—but a well-functioning state apparatus makes success more likely.

Whitlark raises another important issue concerning the distinction between state capacity and leader determination to acquire these weapons. Separating these two variables is challenging, but crucial for my argument. I fully agree with Whitlark that leader determination is an important part of the causal story. Still, I contend that state capacity is an analytically distinct and causally prior intervening variable for explaining the performance of nuclear weapons programs. There are clearly interactive effects between leader determination and state capacity (and as I show in the chapters on Iraq and Libya, there is variation concerning both leader determination and state capacity in both cases). However, the aftermath of the 1981 attack on Osirak is an instructive example of how a sudden intensification of demand for nuclear weapons on the part of the leader does not produce a well-functioning program. In my 2011 *International Security* article I discuss the implications of the 1981 Israeli strike against the Iraqi reactor complex.⁶ In that article, as in *Unclear Physics*, I argue that the Iraqi program after June 1981 became a more focused and determined project, but one that still suffered from several inefficiencies. The Libyan program during the 1980s suffered from similar intensification of demand, following military strikes and altercations with the U.S., without any discernible strengthening of the performance of the nuclear program.

How important are coup proofing and management strategies vis-à-vis state capacity? Here the reviewers disagree. Whitlark suggests that coup proofing does little analytical work in my analysis, whereas Long argues that it might be more important than state capacity. I argue that the scope and depth of coup-proofing—ranging from occasional purges, cultural revolutions to reshuffling of state agencies to prevent the formation of alternative power centers—can have important effects on state capacity. Furthermore, as my cases demonstrate, coup-proofing can be selectively applied by personalist leaders to their state institutions. While nuclear weapons programs can be shielded from most of the direct effects, as they mostly were in Iraq and Libya, the indirect effects can still have significant consequences. In the case of Libya, for example, struggling universities and the weakening of the diplomatic service undermined the nuclear program.

Whitlark and Coe ask whether my argument can actually explain success in the nuclear weapons programs of personalist authoritarian regimes. My book addresses this point implicitly, and primarily by examining variation in the relatively weak state capacity of Iraq and Libya, as Long notes. I agree with Coe that a counter-factual analysis is a useful exercise for testing the full range of implications following from the arguments and evidence presented in *Unclear Physics*. Still, I would argue that the observations presented in my book are useful starting points for a more systematic model of the causal role of state capacity. First,

⁶ Målfrid Braut-Hegghammer, "Revisiting Osirak: preventive attacks and nuclear proliferation risks," *International Security* 36.1 (2011): 101-132.

personalist autocrats that allow for meritocratic principles in the management of their nuclear weapons programs are better placed than those who govern primarily through nepotism. Second, those regimes that invest in a domestic technical and scientific knowledge base are in a better position to train and promote leaders and managers who have the essential skills necessary for launching and implementing complex technical programs.

While the reviewers have kind things to say about my research, they also offer important notes of caution. Long notes that my account of the inner workings of the Iraqi program, in particular, relies heavily on accounts from participants. I agree that this is problematic. All kinds of evidence brings its own set of problems – including archival documents (what is included in the document and/or archive, and why?). But participant accounts are notoriously problematic. For this reason, the IAEA Archives were a crucial breakthrough in my research. These sources enabled me to rely less on interviews and participant accounts, and allowed crosschecking for many of their claims. While my book draws on a broader set of primary sources than previous studies of the Iraqi program, it is admittedly difficult to locate other kinds of evidence for some of the in-house dynamics (and arguments) that plagued the Iraqi program. This is a problem for other nuclear weapons programs too, such as the Pakistani program, where numerous decisions were not written down, apparently to avoid creating a paper trail. But ongoing research in the Iraqi archives can perhaps shed more light on specific episodes in the Iraqi program and add perspectives from other actors in the regime. Hopefully similar research will become possible for the Libyan case too, even though the fate of Libya's archives since 2011 remains unclear. What remains (and what has been seized by foreign organizations and agencies) will undoubtedly become important sources for students and scholars in years to come, once they become available.

Applying the argument to other cases

Because this is not a theory-testing book, I am circumspect about the extent to which I can explain or offer predictions about other cases in my analysis. But even a cursory look at past nuclear programs in Syria, Yemen, Algeria and Egypt suggests that my arguments about state capacity and management strategies could have considerable explanatory power in other cases too. These regimes share several characteristics with the former Iraqi regime, in particular, and should be considered 'easy' tests for my arguments.

Beyond Middle Eastern personalist regimes, does my framework, well, work if applied to a more diverse set of cases such as the nuclear programs in North Korea, Nazi Germany, Pakistan, China, and the former Soviet Union? What we already know about the management strategies of (some of) these other cases suggests that other authoritarian leaders have resorted to similar strategies and choices as those adopted by the former leaders of Iraq and Libya. Specifically, the Soviet and Chinese programs experienced centralized and delegatory management strategies, with varying levels of meritocracy and freedom for scientists and technical workers at different stages of these programs.⁷ Long's discussion of Nazi Germany suggests that there are more parallels between Hitler and Saddam's management of the military-industrial and nuclear realms than I had realized.

⁷ See, for example, David Holloway, *Stalin and the bomb: The Soviet Union and atomic energy, 1939-1956*. (New Haven: Yale University Press, 1994); John Wilson Lewis and Xue Litai, *China builds the bomb* (Stanford: Stanford University Press, 1991).

The intervening variable, state capacity, is likely to vary considerably across these other cases because the scope and depth of these states differ substantially. This underscores the value of applying the argument across a broader set of cases. Consider the following two examples. A distinguishing feature of the Iraqi and Libyan states were their recent colonial and post-colonial experiences, which had a number of consequences for the scope and depth of their states. Furthermore, the frequency of *coups d'état* (or threats of coups) were probably higher in Iraq and Libya than in many other personalist regimes outside this region. Both of these factors have substantial implications for state capacity, in the narrow sense of the term that I adopt in *Unclear Physics*.

Beyond state capacity and management strategies, there are additional variables that should be factored in if my argument is applied to other cases that are far apart in terms of their timing in the nuclear age. For examples, the nuclear weapons programs of Nazi Germany and North Korea are decades apart. This means that the availability of the basic technology and expertise varies considerably. As R. Scott Kemp's analysis of centrifuge technology suggests, the availability of what can be considered relatively "simple" technologies can make a difference to how nuclear weapons programs perform—particularly in countries with weaker state capacity, I would add.⁸ For this reason, comparing states that sought nuclear weapons at very different times in the nuclear age is more complex. That said, institutional capabilities and management strategies are likely to have considerable explanatory power across different personalist regimes, because these are fundamental factors working at the domestic level.

Implications

I now turn to another important point raised by Whitlark – what are the implications in *Unclear Physics* for states weighing their options for how to respond to a potential proliferation threat from a personalist regime? In other words, so what? As the analytical focus of my book is on domestic-level factors as an intervening variable, it is tempting to say that the impact of various interventions targeting a state's nuclear program will largely depend on those domestic-level factors (i.e., it depends). But a more fundamental question is how to weigh the impact of external interventions (military force, sanctions, targeted nonproliferation measures) against these internal dynamics. This is a complex issue, as the impact of different kinds of external interventions are intensely debated. For example, I have argued in the case of Osirak that external interventions can be counter-productive. Hymans has previously argued that nuclear weapons programs can fail on their own if we leave them alone.⁹ Coe and Muhammet Bas demonstrate that external interference can have significant disruptive effects.¹⁰ I will confine myself here to state that there are important interactive effects between external interventions and the domestic level, and suggest that these effects are arguably more dynamic and varied than has been reflected in much of the previous literature.

⁸ R. Scott Kemp, "The nonproliferation emperor has no clothes: the gas centrifuge, supply-side controls, and the future of nuclear proliferation," *International Security* 38.4 (2014): 39-78.

⁹ See Jacques E.C. Hymans, "Botching the Bomb: Why Nuclear Weapons Programs Often Fail on Their Own- and Why Iran's Might, Too," *Foreign Affairs* 91 (2012): 44.

¹⁰ Muhammet A. Bas and Andrew J. Coe, "A Dynamic Theory of Nuclear Proliferation and Preventive War," *International Organization* 70:4 (2016): 655-685.

Unclear Physics offers insights for how states can weigh the proliferation risks posed by suspected nuclear weapons programs in personalist regimes. One of the main implications is, as Whitlark notes, that personalist leaders face numerous obstacles once they seek to implement their decisions to pursue nuclear weapons. These obstacles range from institutional weaknesses to competing regime factions. Nonetheless, states should worry about nuclear weapons programs in personalist regimes. While these regimes are prone to dysfunction, there can be islands of efficiency inside them. As the case of Iraq demonstrates, nuclear weapons programs in personalist regimes can perform sufficiently well to enable long-term success. Another important implication is that capacity can be more important than determination (or demand) in shaping the performance of nuclear weapons programs.¹¹ This suggests that states are well advised to pay close attention to the scientific communities, and the performance of other large-scale technical prestige projects, in the states they worry about. For example, if talented physicists that are established in successful careers in prestigious institutions abroad suddenly begin to return to their home country, this could be an indication that the regime is beginning to invest seriously in a more meritocratic program recruiting (and creating conditions suitable for keeping) their best scientists. Relatedly, if regimes carry out purges, it is important to pay attention to whether their nuclear scientists and engineers are also targeted, or if they appear to escape these tactics. In today's world, even personalist regimes will find it increasingly difficult to shield their coup-proofing tactics from the prying eyes of outsiders.

Whitlark asks how analysts can avoid drawing the wrong conclusions about ambiguous nuclear programs in personalist regimes. One observation from *Unclear Physics* is that personalist leaders face significant information problems, which cautions against taking their statements literally. It can be tempting to attribute intentions to Saddam and Gaddafi's statements. Sometimes these leaders did want to signal intent through their statements. At other times their statements reflected inconsistent priorities, that different regime factions held varying influence over the leader's perspectives, and that Saddam and Gaddafi were sometimes plainly misinformed. Ongoing research on the inner workings of these regimes can help shed more light on how we can identify signals of intent and better distinguish these from other messages, or plain noise.

The question as to whether deterrence and/or coercion can work better against states seeking nuclear weapons is perhaps more relevant for states that are close to acquiring nuclear weapons. For Iraq, the 1991 war and subsequent disarmament under United Nations supervision put a final stop to the nuclear weapons program. Limited military strikes during the 1980s—targeting the nuclear program in the case of Iraq, targeting the leadership in the case of Libya—had mixed effects in both cases. But the emerging nonproliferation regime arguably had significant delaying effects in both cases.¹² Despite many gaps and flaws, this regime—combined with unilateral actions taken by states concerned about nuclear proliferation—placed obstacles along the way, as it became more difficult to purchase sensitive technology from abroad without raising concerns. As the Italian discussions about exporting nuclear technology to Iraq during the late 1970s suggests, even states that had few qualms about proliferation risks were concerned about the likely U.S. response.

¹¹ See Lawrence D. Freedman, "Unclear Physics: Why Iraq and Libya Failed to Build Nuclear Weapons, by Malfrid Braut-Hegghammer" (Capsule Review), *Foreign Affairs* (March/April 2017).

¹² For more systematic research on these effects, see Matthew Fuhrmann and Yonatan Lupu, "Do Arms Control Treaties Work? Assessing the Effectiveness of the Nuclear Nonproliferation Treaty," *International Studies Quarterly* 60.3 (2016): 530-539.

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In closing, let me once again thank my reviewers for engaging with my work, and for asking tough and important questions.