Ahead of Their Time: Technological Invention in Military Bureaucracies

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Introduction

In the nascent political science literature on time horizons and time more generally, the notion of temporal discounting—which describes the extent to which a given actor is present- or future-focused—is customarily conceptualized in one of two ways. It is either represented by an exponential or hyperbolic discounting function or a more holistically described endogenous “bias” integrated in actors’ mindsets, whereby individual decision-makers or states similarly assign disproportionate weight to the present or future but do so in a way that has consequences beyond the degree to which utility decreases

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with temporal distance. The latter, more specifically, effectively posits that the question revolves around more than the mere size of less or more distant payoffs; different temporal orientations should rather be thought of as giving rise to fundamentally different ways of understanding different situations. Even if, in the former model, the discounting rate is taken to be uniform across issue areas, that still fails to capture the fact that temporal orientation is an integral element of the actor’s mindset and that it may also interact with other cognitive processes. This argument is made by Ronald Krebs and Aaron Rapport, who have helped expand the breadth of the debate considerably by introducing to international relations construal-level theory (CLT), a key emerging concept from the psychology literature that describes the way psychological distance affects how concretely or abstractly events and problems are construed. Namely, where psychological distance is small, construal is more concrete, and as that distance increases, so does the abstractness of construal.

This is a very powerful and intuitive concept that also applies to time as one form of psychological distance. In light of its potentially enormous explanatory power, it has been severely underutilized by international relations scholars. One of the most obvious potential applications is to technological invention: Long (short) time horizons prompt

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3. In fact, as temporal distance increases, and with it, the abstractness of construal, the probability of a given outcome becomes a much less important consideration than the payoffs that outcome would yield. Michael D. Sagristano, Yaacov Trope, and Nira Liberman, “Time-Dependent Gambling: Odds Now, Money Later,” *Journal of Experimental Psychology: General* 191, no. 3 (September 2002): 364–376.


6. Construal-level theory was originally articulated as temporal construal theory, with other types of psychological distance being incorporated over the decade following the publication of Nira Liberman and Yaacov Trope, “The Role of Feasibility and Desirability Considerations in Near and Distant Future Decisions: A Test of Temporal Construal Theory,” *Journal of Personality and Social Psychology* 75, no. 1 (July 1998): 5–18.
abstract (concrete) construal, and because, as has been demonstrated by scholars in psychology, abstract construal facilitates creative thinking, it should follow that actors with longer time horizons will have a greater capacity for technological invention (as it manifests itself in patenting trends).

This has wide-ranging implications for the military innovation literature, as it suggests that the capacity for invention and, indirectly, innovation can be shaped by military bureaucracies much more consciously than was previously thought. The military innovation literature generally focuses on doctrinal innovation—and quite rightly so, as a technological advance cannot be of much use unless it is accompanied by organizational integration and management of that technology. However, even studies that focus on specific weapons systems “black-box” the question of how the underlying invention emerged in the first place. A prominent exception to the exclusive focus on doctrine is the work of Stephen Peter Rosen, but even though he devotes considerable attention to technological innovation, the question of invention is similarly treated as subordinate to the larger question of how choices among competing R&D opportunities are made. Given how invention has, together with innovation, historically been understood as largely stochastic, this is not at all surprising, but as advances in CLT now offer themselves as a platform for the exploration of the very foundations of invention upon which the most groundbreaking military innovations stand, the time has come to delve deeper.


The essential premise underlying the overarching theoretical framework of this paper is that organizational patterns of temporal discounting—as an independent variable, that is—should not be treated as something to be determined exogenously on the basis of certain assumptions, which is the dominant approach in the international relations literature on interstate cooperation; rather, time and the perception thereof are understood as an organic, adaptive organizational processes. Time, in short, is understood as being constructed within organizations.\footnote{11} Previous work on bureaucratic time horizons by the present author has imported findings about the determinants of organizational time horizon length from the management and organizational studies (MOS) literature, of course with sensitivity to how far one can extrapolate from studies of private firms, and even though substantial differences do exist between military bureaucracies and private sector firms, they do as hierarchical organizations share certain key characteristics, especially those relevant to the molding of organizational time horizons.\footnote{12} There exists a rich literature on this topic, but it is not discussed in greater detail here because the focus of the paper are the effects rather than the causes of organizational time horizons, with a more detailed explanation of the overarching notion that organizations operate on the basis of a distinct conception of time formulated and embedded in the organization provided in Appendix A.

In short, this paper looks at how well organizational time horizons perform as an explanation for success in technological invention by military bureaucracies—namely, by the US Army and US Air Force.\footnote{13} With this, it also aims to contribute to the psychology lit-


\footnote{13. The Navy is excluded from the analysis because it does not issue basic doctrinal documents comparable to those issued by the Army and Air Force, due to which it was impossible to obtain a reliable measure}
erature by showing that findings about individual-level patterns in temporal orientation as well as construal-level also operate on the group- or, more specifically, organizational-level.

The rest of the paper is organized as follows: First, a detailed definition of technological invention is offered, with the concept being explicitly distinguished from the related but nonetheless distinct process of technological innovation. This discussion of definitional questions and the accompanying brief review of the industrial organization literature on invention is followed by a survey of construal-level theory as it applies to creative thinking. The second half of the paper is devoted to the empirical analysis. A number of issues arise in the operationalization and measurement of both the dependent variable— invention—and the key independent variable—organizational time horizons—which is why a separate section is devoted to each of the two. After a description of the other explanatory variables, the paper presents the results of the regression analysis and offers a discussion of the significance thereof. Finally, the conclusion presents a summary of the findings, describes various limitations inherent in the present approach, and suggests potential directions for future research on this topic.

**Defining Invention**

It is first necessary to clarify the distinction between invention and innovation, as the political science literature invokes the latter concept much more often than it does the former, sometimes even using it to describe both processes. This is not surprising given that innovation cannot occur in the absence of invention, but subsuming the latter un-

nder the former obscures important causal paths. One of the better explanations of the distinctness, even if not discreteness, of the two processes is offered by Jan Fagerberg:

Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. Sometimes, invention and innovation are closely linked, to the extent that it is hard to distinguish one from another (biotechnology for instance). ... While inventions may be carried out anywhere, for example in universities, innovations occur mostly in firms, though they may also occur in other types of organizations, such as public hospitals. To be able to turn an invention into an innovation, a firm normally needs to combine several different types of knowledge, capabilities, skills, and resources.¹⁴

This is further complicated by the customarily non-linear and non-sequential nature of both processes and the interdependencies that link them.¹⁵ However, this does not mean that they cannot at all be disentangled; at least for analytical purposes, they in fact can be. Of particular importance here is the different nature of the two processes: While invention is, just like innovation, an organizational process, it is to a much greater extent dependent on the individuals working within an organizational framework than on the organizational framework itself.

This is not to say that the organizational context is mere background, but rather that it sets soft bounds on the range of possibilities and does not bring about success or failure in invention directly. The organizational framework itself is not a cause of invention, which at its very core appears to be largely stochastic in the way that innovation was once viewed as “manna from heaven.”¹⁶ This view of innovation has long since been phased out, as the voluminous literature on the topic will attest, and it is now incumbent upon researchers to do the same for invention. Beginning with the work of Joseph Schumpeter, innovation came to be viewed as an intrinsically societal and organizational process.¹⁷

¹⁵. Ibid. 5.
¹⁶. Ibid. 9.
¹⁷. Ibid. 9–12.
novation can, as the existence of a vibrant literature on innovation management suggests, be controlled and guided.\(^\text{18}\)

Thus, in the military sphere, doctrinal innovation cannot occur in the absence of the ideational innovation that provides the seed for change, but on its own, the latter would wither away. As Rosen writes, innovation “requires an ‘ideological’ struggle that redefines the values that legitimate the activities of the citizens” belonging to the “political community” of the military service. “Because the service is a military organization, and because it is victory in war that ultimately legitimates any military organization, this ideological struggle will revolve around a new theory of victory, an explanation of what the next war will look like and how officers must fight if it is to be won.”\(^\text{19}\) For an ideational or technological invention to proceed beyond the “raw idea” stage, the structure within which it was conceived must in some way be transformed or, in the view of Barry R. Posen, coerced into compliance by the higher-level principal. In his view, international system-level dynamics prompt the civilian leadership to pressure the military to innovate, picking up individual “mavericks” in military bureaucracies and giving enough backing to their ideas for innovation to occur.\(^\text{20}\) In general, he argues that “[c]ivil intervention should take the form of choosing from the thin innovation menu thrown up by the services. . . . Within services, hierarchy and the chain of command should tend to suppress the emergence of new doctrinal alternatives at levels where the civilians cannot find them.”\(^\text{21}\)

However, both arguments presuppose the existence of a sufficient number of senior military officers with an alternate long-term perspective on warfare, regardless of whether


\(^{19}\) Rosen, Winning the Next War 19–20.


\(^{21}\) Ibid. 57.
they are instrumental in that they form the new organizational leadership or are picked up by the civilian leadership as mavericks. Even if the emergence of the raw idea is a stochastic process, the organization can create conditions that either facilitate or suppress the occurrence of such ideas.

Invention *qua* process is merely embedded in a larger organizational framework and is not, unlike innovation, fundamentally dependent on it for success. Due to this fact and the reality that invention without successful innovation in the form of organizational or societal integration to accompany it is not very meaningful, there exist only a few systematic explorations of invention. This notion—that it is not only innovation but also invention that can be managed, even if only indirectly—is, for example, not present in the industrial organization literature. In their work *The Economics of Industrial Innovation*, Chris Freeman and Luc Soete thus conceptualize what they term “inventive work” as having only a number of measurable inputs—namely, people, payrolls, and outlays—with all of the more central inputs like scientific knowledge, technology, and practical problems understood as intangible. Similarly, Eric von Hippel also treats the occurrence of invention as a black box, instead focusing on its function as an input in the innovation process with the implication that the inventive component cannot be managed. This is not necessarily the case, as the social psychology research discussed in the following section suggests. While different temporal perspectives and the associated psychological distance do not directly cause invention, they can create favorable conditions for it. They are the most proximate *tangible* permissive condition for invention.

This line of thought draws on Jacob Schmookler’s work on invention, which he defines as the raw material for technological progress. In his view, invention is “(a) a new combination of (b) pre-existing knowledge which (c) satisfies some want,” and “chance

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factors aside, the joint determinants of invention are (a) the wants which inventions satisfy, and (b) the intellectual ingredients of which they are made.” While he does note the potential importance of chance, the focus of the work is on larger-scale trends in invention, as one simply cannot investigate chance directly. One can, however, specify scope conditions, as this paper aims to do, and thus reduce the “leverage” of pure stochasticity. In short, as Schmookler writes, “the first element of the definition, by emphasizing the novelty of the product, suggests that unique characteristics of the inventor, his circumstances, or both may have played an important part in bringing the invention into being,” and while the available data are insufficiently fine-grained for an analysis of inventor characteristics, the notion of organizational time horizons allows us to investigate what is perhaps the most idiosyncratic of the idiosyncrasies surrounding innovation: the circumstances. If the mechanism outlined in the following section in fact operates in the hypothesized manner, then we should expect to see systematic variation in how often the “accidents” Schmookler discusses are also “insight-yielding.” In the presence of an organizational pattern of long time horizons and, relatedly, abstract construal, innovators should be more likely to extract insights from what are essentially stochastic events.


25. This is analogous to Eric Gartzke’s conceptualization of the study of interstate conflict; he writes that “[e]xplanations for international conflict are a bit like layers of an onion,” and concludes that it should be acknowledged that at the core of the onion, international conflict is essentially stochastic. Eric Gartzke, “War Is in the Error Term,” *International Organization* 53, no. 3 (Summer 1999): 569. Similarly, we can peel away the outer layers around invention, but at its very core, it too is stochastic.

27. Ibid., 11.
Construal-Level Theory and the Organizational Capacity for Innovation

The central argument of this paper is that long organizational time horizons, by eliciting high-level construal of events and objectives and thereby creating favorable conditions for creative thinking, increase an organization’s capacity for technological invention. This section briefly reviews the literature on psychological distance and construal-level theory, and describes the findings linking it to creativity and innovation. The initial statement of construal-level theory (CLT) by Nira Liberman and Yaacov Trope established an explicit link between the level of construal and temporal distance, where temporally proximal situations are construed more concretely (i.e., at a lower level) than temporally distal situations, construals of which are distinguished by abstractness and a focus on “central” as opposed to “incidental” features. Going beyond the link between temporal distance and construal, further work by Trope and Liberman has expanded CLT to integrate social, spatial, and hypothetical distance as well; it is therefore not only with temporal distance but with psychological distance in general that shifts in the level of construal occur.

Crucially, this paper postulates that even when what is being manipulated is not temporal distance per se but rather the question of how forward-looking an actor is, the effects are the same, as a stronger future orientation brings a greater number of long-term considerations into the analysis and associates even a short-term event with the long-term. In short, even when the actual temporal distance is held constant, it should be the case that the longer the time horizons of an actor, the greater the extent to which a situ-


Since its inception, CLT has been applied to various aspects of individual-level as well as organizational-level phenomena, with the question of creativity being of greatest interest to this paper. There exists a natural link between construal and the processes of invention and innovation: As Batia M. Wiesenfeld et al. explain in their review of CLT in organizational research, “novelty seems to require that people be able to conceptualize a reality that differs from their own in the here and now, suggesting that higher construal may be more likely to lead to innovation.” More concretely, Jens Förster, Ronald S. Friedman and Nira Liberman argue that this is the case because of the “processing shift” attendant upon the move between levels of construal, where “distant future-oriented cognition activates general processes of representational abstraction that facilitate subsequent attempts at insight problem solving and creative generation.” However, shifts can also be “transfer inappropriate”: A focus on the distant future would reduce an actor’s capacity for performing tasks that require a great degree of concrete thinking. Even though the focus here is on the first mechanism due to its direct pertinence to invention, it is worth briefly commenting on the second mechanism as well, as it suggests that while the assumption of homogeneous organizational time horizons can be useful—as it will be for studying different organizations’ capacities for invention—it is very rarely descriptively accurate. Even in organizations with a clearly dominant pattern of long-term (short-term) temporal orientation, there likely exist specialized subunits with a short-term (long-term) orientation; otherwise, complete hyperopia (myopia) would result. Admittedly, in many

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30. Krebs and Rapport also seem to proceed under this assumption, but do not lay out the logic for how findings about temporal distance apply to time horizons as a measure of “how far into the future an individual looks.” Krebs and Rapport, “International Relations and the Psychology of Time Horizons,” 531.
32. Förster, Friedman, and Liberman, “Temporal Construal Effects on Abstract and Concrete Thinking” 179.
33. Ibid.
cases, especially with government bureaucracies, it does seem like complete myopia is the order of the day, but the abovedescribed finding should help us understand it not as a incorrigible and distinctly bureaucratic pathology, but rather as a remediable structural deficiency.

A related reason why longer time horizons and the associated higher level of construal should facilitate innovation is that high-level construal is more facilitative of exploratory learning than is low-level construal. Jean-Nicolas Reyt and Batia M. Wiesenfeld, while focusing primarily on how different degrees of role integration support different types of learning, posit that the key intervening mechanism is the level of construal elicited by particular role alignments. Most relevantly, they focus on the distinction between “exploitation activities” and “exploration activities”: The former is incremental and involves less uncertainty, whereas the latter describes irregular bursts of progress with much less certainty of success. As they summarize, “exploitation is focused on improving mean performance,” and “exploration is associated with generating variance from which adaptive alternatives can be selected.”34 They find that there exists a direct causal link between construal level and the type of learning. As hypothesized, high-level construal is facilitative of exploratory learning, which is crucial for successful innovation.35

Additionally, innovation requires a willingness to challenge the status quo, which is more likely when construal is high-level. As Dominic J. Packer, Kentaro Fujita and Scott Herman find, conscientious individuals, where conscientiousness is defined by “dependability, self-discipline and industriousness,” are more likely to dissent when the level of construal is high; they find evidence for the hypothesis that “low-level construal would enhance group stability goals and thus motivate conformity among conscientious people”

35. Ibid., 756.
while “high-level construal would enhance group change goals and thereby orient conscientious individuals toward dissent.”\footnote{Dominic J. Packer, Kentaro Fujita, and Scott Herman, “Rebels With a Cause: A Goal Conflict Approach to Understanding When Conscientious People Dissent,” \textit{Journal of Experimental Social Psychology} 49, no. 5 (September 2013): 931.}

This does not apply to invention with the same strength it applies to innovation, but to a certain extent, invention also requires a willingness to challenge existing approaches, even if those approaches are purely technical in nature, and come up with a better solution. Research in the academic world serves as a good example: If one is completely content with the status quo in one’s field, it is very difficult to develop novel explanations for a phenomenon or even embark on a search for a new phenomenon to explain, as the most one could do is replicate and increase the depth of extant theories. Of course, research of this type is, just like research that leads to successful patenting, strongly cumulative, but at some point it requires a break with what has come before.

In general, much of the work linking CLT to creativity discusses the mechanism in the context of innovation rather than invention, but as the foregoing discussion of the relationship between the two processes should have made clear, they are by no means discrete occurrences. Rather, invention, be it either purely ideational or purely technological, is at the core of innovation, and even though the link between invention and innovation is not clearly unidirectional, it seems to follow from this that where authors describe high-level construal as being facilitative of innovation, it must at least implicitly also be facilitative of invention—without which there could be no innovation. Hence, the literature on CLT and innovation is understood as being applicable to invention as well.

\textit{H1: The capacity for invention increases with the length of organizational time horizons.}\footnote{Although not discussed here, other investigations of the effects of temporal, social, and spatial distance on creativity of potential interest are Jochim Hansen, Hans Alves, and Yaacov Trope, “Psychological Distance Reduces Literal Imitation: Evidence From an Imitation-Learning Paradigm,” \textit{Journal of Experimental Psychology: Human Perception and Performance} 42, no. 3 (March 2016): 320–330; David A. Kalkstein et al.,}
Measurement and Data

This section describes the response and explanatory variables, and aims to address particularly salient concerns arising in the operationalization and measurement of what may at first glance appear to be unquantifiable or generally intangible inputs and outputs, with particular attention thus being devoted to invention and organizational time horizons. This is followed by the presentation and discussion of the results of the regression analysis.

Operationalizing and Measuring Invention

This section focuses on the different ways in which innovation and invention have been measured in the literature, and attempts to show that this paper’s chosen measure for invention—the number of patents—is well suited to the task despite the potential pitfalls. Patent statistics have been widely used to study innovation, and although the focus of this paper is on invention and not innovation, the literature analyzing the latter is much more extensive, which is not particularly surprising given that the most important inputs for invention are seen as not only unquantifiable but also generally intangible. Because traditional, “coarse” material indicators alone are insufficient to account for differential success in invention at more fine-grained levels such as the firm- and organization-level, studies that have focused explicitly on invention, namely that by Schmookler, have examined it as a broader industry- and national-level phenomenon, with the market as a whole also playing an important role.


However, as already discussed, advances in social psychology suggest that at least in part, the component of the invention process understood as purely stochastic can be managed, insofar as organizational time horizons can be altered through deliberate design. Therefore, innovation can be studied even on a smaller scale, in contexts where some of those “intangible” inputs have to be accounted for if an explanation is to be satisfactory. Since the most concrete operationalization of success in invention is success in patenting, the rest of this section looks at debates about the advantages and potential pitfalls of using patent statistics, even when the surveyed works focus on patent statistics as a measure of innovation rather than just invention. Although care must be taken to not blindly copy approaches designed for answering a different question, the two processes are closely intertwined, which is why studies of innovation should be broadly illustrative of the potential challenges involved.

The innovation and invention literatures both struggle with a number of apparently unquantifiable inputs and outputs. As Keith Smith writes, “innovation involves multidimensional novelty in aspects of learning or knowledge organization that are difficult to measure or intrinsically non-measurable. Key problems in innovation indicators therefore concern the underlying conceptualization of the object being measured, the meaning of the measurement concept, and the general feasibility of different types of measurement.”

Whereas it might indeed be unfortunate for students of innovation that patents “are an indicator of invention rather than innovation,” it is encouraging in that it means the output of the basic process on which innovation then builds can be measured directly. Patent statistics are a relatively clean measure of invention, and although it may be that “[m]any patents refer to inventions that are intrinsically of little technological or eco-

40. Ibid., 160.
nomic significance,"\textsuperscript{41} that seems to apply with much greater force to \textit{national-level} patent statistics, which would undeniably be a very salient concern if one was concerned with explaining overall trends in innovation. The present investigation delimits the scope of inquiry to a narrow slice of the government bureaucracy with broadly comparable goals, so “useless” patents should be less problematic, as it is hardly likely that either of the two bureaucracies under study, the Army or the Air Force, would sustain such pursuits.

Similarly, many of the other key concerns raised by the innovation literature about the use of patent statistics are easily answered by the focused approach of this paper. For example, Sadao Nagaoka, Kazuyuki Motohashi, and Akira Goto write about how patents “are affected by the idiosyncratic features of a particular patent system of a nation at a given point in time,”\textsuperscript{42} and while even a study of patenting trends by organizations operating strictly within the bounds of their national patent system must take into account longitudinal changes within said system, comparability at different points in time is not a problem, as all of the organizations under analysis face the same external constraints, broadly speaking. Perhaps of greater concern is the fact that invention is not always accompanied by engagement in the formal patenting process, as while “[t]he patent system ensures \textit{ex ante} incentive for inventive activities by granting \textit{ex post} monopoly rights to use the fruits of such activities,” a consequences is that “the contents of patent applications are disclosed in return.”\textsuperscript{43} Among the military bureaucracies, one would thus expect differential rates of patenting depending on the specific issue area, even when controlling for the centrality of technology to the operation of the bureaucracy, but the inclusion of organization fixed effects should solve this problem.

Figure I presents historical trends in patenting by the Air Force and Army. As is

\begin{itemize}
\item \textsuperscript{41} Smith, “Measuring Innovation,” 160.
\item \textsuperscript{43} Ibid., 1106.
\end{itemize}
Figure 1: Historical Trends in Patenting and RDT&E Outlays

evident from the figure, there is no clear correspondence between spending on research, development, testing and evaluation (RDT&E) and trends in patenting by the two organizations; indeed, based solely on RDT&E trends, one would expect the Air Force to patent more, but it is rather the Army that has consistently had more of its patent applications approved by the United States Patenting and Trademark Office (USPTO).

Operationalizing and Measuring Organizational Time Horizons

fortunately, a study of corporate time horizons by Mark R. DesJardine details an approach to this seemingly intractable problem, relying on text analysis of pertinent documents to construct an index of different organizations’ temporal foci.\footnote{Mark R. DesJardine, “The Causes and Consequences of Corporate Short-Termism” (PhD diss., The University of Western Ontario, 2016), 75–78, https://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=5400&context=etd.} While this approach technically does investigate the phenomenon of organizational time horizons by studying its consequences, it manages to avoid the tautological trap Joshua D. Kertzer notes studies of resolve, another “latent variable,” often fall into—that is, “some … measures of resolve veer dangerously close to tautology, inferring resolve from the same outcomes they are being used to explain.”\footnote{Joshua D. Kertzer, “Microfoundations in International Relations,” \textit{Conflict Management and Peace Science} 34, no. 1 (2017): 88.} A more frequent use of certain words is not so much an effect as it is a manifestation of organizational time horizons; while this is by no means a perfect operationalization, I argue that it is close enough to the “true” organizational time horizon for it to be treated as a direct measurement, at least for broader theoretical purposes.

Following DesJardine, I describe organizational time horizons as \( \frac{r_{\text{LONG}}}{r_{\text{SHORT}} + r_{\text{LONG}}} \), where \( r_{\text{LONG}} \) stands for the number of long time horizon words in the document under analysis, and \( r_{\text{SHORT}} \) stands for the number of short time horizon words in the document under analysis.\footnote{DesJardine, “The Causes and Consequences of Corporate Short-Termism” 78.} Admittedly, the list of words compiled for this purpose (see Table 1 below) was tailored to a business context, but at its core is comprised of words from various non-context-specific dictionaries, and has the advantage of having been finalized on the basis of verification by an independent rater.\footnote{Ibid. 77.}

Hence, pending further work on this approach to make it optimally suited to bureaucratic contexts, the abovedescribed operationalization is used without modification in this study, in greatest part so as to avoid compromising the validity of the already established measure. Potential concerns should be assuaged by the fact that even if these keywords

\[ \frac{r_{\text{LONG}}}{r_{\text{SHORT}} + r_{\text{LONG}}} \]
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Table 1: Dictionary of Keywords Used to Measure Organizational Time Horizons
are not perfect tools for analysis of documents produced by government bureaucracies, there is no valid theoretical reason that would lead us to expect that either of the two bureaucracies under analysis would systematically use certain types of words more often; any differences should reflect differences in organizational time horizon length. Additionally, if both of the bureaucracies under analysis systematically use certain types of words more often, that should also not be a concern, as it would either artificially inflate or artificially deflate organizational time horizon values across the board; it would be equivalent to multiplying the organizational time horizons index by a constant $C$, which obviously does not affect the results.

Another potential concern might be that the number of long organizational time horizon unigrams and bigrams is greater than the number of short organizational time horizon unigrams and bigrams, but this should similarly not affect the results, as there is no reason to expect that there would be systematic differences across organizations that would bias the results. Again, this will artificially extend the apparent length of organizational time horizons, but as the measure has no independent substantive interpretation, only a relative one, the disparity in the size of the two categories of words should not be seen as a problem.

Variables

In addition to organizational time horizons, a number of other factors could potentially influence a military bureaucracy’s capacity for invention: the number of personnel, military as well as civilian, that are part of the service; the number of deployed DoD personnel; the RDT&E outlays (spending) by the service; the centrality of technology to organizational culture; the number of USPTO employees; the number of USPTO examiners; and overall patent approval rates. These are examined in greater detail below.

**Number of Personnel.** As outlined in Table 5 of Appendix A, the size of an orga-
nization may affect organizational time horizon length, possibly because a larger organization is likely to be “taller” in terms of the number of hierarchical levels in its structure. Apart from that, the number of personnel also provides a measure of the pool of potential innovators, albeit a rather crude one; ideally, this would be measured directly using a count of the number of advanced STEM degree holders in the organization, but no comprehensive longitudinal data are available for either the Air Force or the Army.

**Number of deployed DoD personnel.** Necessity, as they say, is the mother of invention—that is why studies of military innovation, for example, treat wartime innovation separately from peacetime innovation.\(^49\) Accounting for the number of DoD personnel deployed abroad is intended to capture the effects of organizational learning through use of inventions that have been adopted as innovations, where direct exposure to hostile forces or even participation in military exercises with partner nations may help identify potential weaknesses of the materiel in use. Unfortunately, a multitude of different intervening mechanisms that cannot be observed operates, meaning that the effect of “exposure” will likely capture a considerable amount of noise as well.

**RTD&E outlays.** Ubiquitous in studies of innovation is the inclusion of research and development (R&D) budgets or expenditures as explanatory variables; among the variety of innovation covariates, R&D is, as Smith observes, “[b]y far the longest-standing area of data collection.”\(^50\) In Freeman and Soete’s conceptualization of the links between invention and innovation processes, R&D outlays are listed as one of the few measurable invention inputs.\(^51\) In general, there exists a staggering amount of literature on R&D in general as well as on the link between R&D as input and patents as output\(^52\), but it is not

\(^{50}\) Smith, “Measuring Innovation,” 153.
\(^{51}\) Freeman and Soete, *The Economics of Industrial Innovation*, 7–8.
at all clear whether and how influential R&D is as an input, with one recent challenge to the “R&D produces patents” orthodoxy even questioning the direction of the causal relationship. Especially prominently, Zvi Griliches has found that R&D is a far cry from a perfect predictor of patenting activity, noting that in light of how inconsistent patenting trends were with trends in R&D, “patent numbers should not be taken as a good, constant-yardstick, indicator of the output of R&D unless one admits the possibility of sharply diminishing returns to such investments.”

The Department of Defense reports budget data in three different ways: As “Budget Authority” (BA), “Total Obligational Authority” (TOA), and finally “Outlays,” the definition of which is as follows: “Also known as expenditures or disbursements; are the liquidation of the federal government’s obligations. Outlays generally represent cash payments, and may also represent the liquidation of obligations incurred over a number of years.” Since BA and TOA both express variations on the amount of authorized spending or appropriated funds, and outlays capture the actual amount of funds spent in a given year, it is the latter that is used to measure R&D; R&D BA and TOA may express the premium an organization puts on the activity itself, but cannot be treated as a direct input, since part of the amount reported is either being carried over from previous fiscal years or will be carried over to future fiscal years.

55. BA, on the other hand, captures the amount of appropriated funds, with additional fine-grained aspects thereof being detailed by TOA. More specifically, BA is defined as “[t]he authority to incur legally binding obligations of the federal government which will result in immediate or future outlays,” and TOA as “expressing the value of the direct Defense program for a fiscal year.” Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2016* (Washington, DC, 2015), 267–269, [http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2016/FY16_Green_Book.pdf](http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2016/FY16_Green_Book.pdf)
A potential issue with DoD R&D data is that the amounts reported in more recent years are technically funds for RDT&E—research and development as well as testing and evaluation—with separate R&D data being unavailable for a large part of the period under analysis. The RDT&E budget is obviously larger than the R&D budget, as the former includes two additional functions, meaning that it is important to keep in mind that the magnitude of the R&D marginal effect is likely being overestimated.

CENTRALITY OF TECHNOLOGY. This variable measures the centrality of technology to the service’s organizational culture; given the nature of air operations and modern air combat, it should not be surprising if the Air Force perceives technology as more central to the management of its key environmental problem than does the Army. While ground combat is such that the technologically more advanced side does under certain conditions have a potentially enormous advantage thanks to its superior weaponry, it has been shown that it is the efficiency and effectiveness of force employment that is the key determinant of combat outcomes. After all, regardless of how much ordnance is dropped by close air support (CAS) assets and how much artillery preparatory fire is directed at the opposing side, enemy positions in the end still have to be secured by ground troops; in air combat, however, technology can often offer a decisive edge, as it would in beyond-visual-range (BVR) engagements.

56. As Stephen Biddle argues: “Against exposed targets, superior weapons can have much more decisive effects—especially when wielded by a modern-system force that can protect itself from preemptive fires. Is is when neither side uses the modern system, however, that dyadic technology comes into its own. A modern-system military will often defeat a non–modern-system opponent even without superior weapons—technical superiority makes victory more one-sided but is neither necessary nor sufficient in itself. When both sides are exposed, however, marginal differences in the quality … or quantity … of their weapons becomes decisive [emphases in original].” Stephen Biddle, Military Power: Explaining Victory and Defeat in Modern Battle (Princeton, NJ: Princeton University Press, 2004), 67.

57. In the First Gulf War, it most certainly did: “Of the twenty-three AIM-7M kills credited to USAF F-15s during the period 17 January–28 February 1991 (including two helicopters), sixteen involved missiles that ‘were fired’ from beyond visual range. As a result, Desert Storm was the first conflict in history in which a significant percentage of the air-to-air engagements that produced confirmed kills—sixteen of the thirty-eight victories credited to Coalition fighters during Desert Storm (more than forty percent)—involved beyond-visual-range shots. The degree of control over highly dynamic engagements implied by this statistic has no historical precedent.” Eliot Cohen and Thomas A. Keaney, Gulf War Air Power Survey: Operations
In short, I expect the organizational focus on technology to have an effect that goes beyond what organization fixed effects can control for. Although the index developed for measuring the centrality of technology is less comprehensively specified than the organizational time horizon index, it should be sufficiently narrow and well-targeted to capture the differences discussed above. The centrality of technology as reflected in organizational culture is measured as \( \frac{r_{TECHNOLOGY}}{n_{PAGES}} \), where \( r_{TECHNOLOGY} \) denotes the number of key technology, innovation, and invention-related words appearing in a given document, and \( n_{PAGES} \) rather self-explanatorily refers to the number of pages of that document. The centrality of technology index therefore measures the frequency of technology-related words in key doctrinal documents.

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Table 2: Dictionary of Keywords Used to Measure Centrality of Technology

CENTRALITY OF TECHNOLOGY (BUDGET). An alternative measure of the centrality of technology is also used: RDT&E BA as a proportion of overall service BA. Although TOA data would also be acceptable, BA is used because it is more easily compared to budget statistics commonly provided by other government agencies—TOA is a DoD-specific way of presenting budget data.

of these variables are intended to capture the overall bureaucratic/organizational capacity of the USPTO to process patent applications. This follows the work of Zvi Griliches, who in a study of patent activity trends finds that “[t]he chief determinant of the number of patents granted is the number of patent examiners employed by the Patent Office.”

The number of USPTO employees is included as an alternative measure of USPTO bureaucratic capacity.

**Overall Patent Approval Rate.** Finally, this provides yet another way of measuring USPTO bureaucratic capacity, even if indirectly. The patent approval rate is calculated by dividing the number of approved patents at time \( t \) by the number of applications filed at \( t - 2 \), which should help account for at least part of the processing gap.

### Results and Discussion

Since the outcome variable, the number of patents granted by the USPTO by year of application filing, consists of count data, the two families of models considered are Poisson regression models and negative binomial regression models, with the latter being used if real overdispersion is present in the data. If real overdispersion is present in the data, the number of zeros; if the “modeling mechanism … structurally excludes zero counts,” this must be accounted for.

There is good reason to believe that a zero-truncated Poisson or zero-truncated neg-

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59. Because this is an auxiliary measure and not central to the analysis, a simple formulation is used. A more sophisticated formalization is reported by Griliches, where predicted grants are a function of differentially weighted patent applications at times \( t - 1 \), \( t - 2 \), \( t - 3 \), and \( t - 4 \): 0.65(0.1applications\(_{-1}\) + 0.61applications\(_{-2}\) + 0.24applications\(_{-3}\) + 0.04applications\(_{-4}\)).
60. Joseph M. Hilbe, *Negative Binomial Regression*, 2nd ed. (Cambridge: Cambridge University Press, 2011) provides what is an excellent and perhaps the most comprehensive discussion of negative binomial regression models available. This and the discussions of negative binomial regression modeling choices that follow in this paper rely primarily on Hilbe’s work.
61. Ibid. 36.
ative binomial model would be the most appropriate for patent data, as the number of patents issued to the Air Force and Army is positive for all of the years in the period under analysis; more generally speaking, patent data are going to suffer from an absence of zeros, even for individual organizations, as the USPTO obviously does not include in its datasets organizations that do not file patent applications, which is realistically the only case in which zeros would be present in the data. It is theoretically possible for an organization to have all its patent applications rejected, but this would not be reported; even the most fine-grained data on patent statistics for individual organizations provided by the USPTO includes only entities with 40 or more patent grants per year.\textsuperscript{62}

However, due to the fact that this paper focuses on military bureaucracies, a very narrow category of organizations, and the fact that 1970–1983 data are excluded due to missing values for Air Force organizational time horizons,\textsuperscript{63} the sample size is correspondingly small, which makes zero-truncated models seem inappropriate despite potential inconsistencies that may arise if non-zero-truncated versions of the Poisson and negative binomial regression are used. Despite there being no clear consensus on what defines a “small” sample, it is generally considered inadvisable to use zero-truncated Poisson or zero-truncated negative binomial models in such situations.\textsuperscript{64} Hence, regular Poisson and negative binomial models were considered, but due to the persistence of overdispersion, even with the inclusion of all available explanatory variables—which suggested real and not just apparent overdispersion—a negative binomial model was used, first without the inclusion of year or organization fixed effects. The results are reported in Table 3.

Most importantly, the ORGANIZATIONAL TIME HORIZON LENGTH coefficient is posi-

\textsuperscript{62} For pre–1998 reports, the cutoff is 30 patent grants per year. See https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports_topo.htm.

\textsuperscript{63} AFM 1-1 (1971) and AFM 1-1 (1975) were unfortunately not obtained.

tive and statistically significant across all alternate model specifications \((p < 0.01)\). Since \(n\) is small, both AIC and AIC\(_c\) are reported, but the differences between the two are small and do not affect the conclusions about model fit. Regardless of whether AIC or AIC\(_c\) is considered, Model 8, Model 9, and Model 10 appear to provide the best fit. \(n = 54\) for all three models, meaning that the difference between the AIC of model A and the AIC of model B should be larger than 10 for model A to be considered clearly preferable\(^{65}\). Hence, it cannot be claimed that one of these three models is clearly preferable to the other two in terms of model fit.

Although the results reported in Table 3 do offer support for H1 and although statistical significance does obtain for many of the explanatory variables included as additional controls, coefficient signs for RDT&E OUTLAYS, CENTRALITY OF TECHNOLOGY (BUDGET), NUMBER OF USPTO PATENT EXAMINERS, and NUMBER OF USPTO EMPLOYEES are all negative, which goes against the expectations outlined in this paper as well as in a large literature on patents and innovation. There is simply no good explanation for why or how investing more in RDT&E would lead to a decrease in the number of patents issued to the organization. Similarly striking are the negative signs of coefficients for USPTO bureaucratic capacity variables; this would seem to suggest that as the number of patent examiners processing applications decreases, the acceptance rate for Air Force and Army patents increases. It was assumed that these results were being driven by omitted variable bias. To account for this, unconditional fixed effects for year and organization were added to the model. An unconditional fixed effects quasi-Poisson model was used, with the results reported in Table 4.

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65. For AIC “significance levels” for different \(n\), see Hilbe, *Negative Binomial Regression*, 70.
Table 3: Negative Binomial Regression Results

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Note: *p<0.1; **p<0.05; ***p<0.01
The effect of ORGANIZATIONAL TIME HORIZON LENGTH is robust to the inclusion of organization and year fixed effects, with the size of the marginal effect actually increasing across most of the alternate model specifications. For model fit, both QAIC and QAIC<sub>c</sub> are reported<sup>66</sup> and due to the increase in the number of estimated parameters brought about by the inclusion of fixed effects, QAIC and QAIC<sub>c</sub> do differ substantially for all ten model specifications. Although the guide to interpreting model fit developed by Joseph M. Hilbe is intended to be used for comparison of AIC values, it is assumed to provide at least a rough guide to QAIC and QAIC<sub>c</sub> interpretation. Judging by QAIC<sub>c</sub>, Model 1 provides the best fit. Admittedly, the difference between the Model 1 QAIC<sub>c</sub> and the Model 7 QAIC<sub>c</sub>, which is the second smallest, is smaller than 10, but a partial <i>F</i>-test confirms that the inclusion of NUMBER OF DEPLOYED DOD PERSONNEL and CENTRALITY OF TECHNOLOGY (BUDGET) is unnecessary (<i>p</i> = 0.8656, <i>F</i> = 0.0293). Model 1 is thus clearly preferred over all other model specifications, even though the only explanatory variable in it is ORGANIZATIONAL TIME HORIZON LENGTH. Apart from providing strong support for H1, this also suggests that R&D, which has been dissected quite thoroughly in the literature, is not influential. Figure 2 provides an illustration of the size of the ORGANIZATIONAL TIME HORIZON LENGTH marginal effect.

<sup>66</sup> QAIC<sub>c</sub> was calculated manually following Ben Bolker, “Dealing with Quasi-Models in R,” 2017, [https://cran.r-project.org/web/packages/bbmle/vignettes/quasi.pdf](https://cran.r-project.org/web/packages/bbmle/vignettes/quasi.pdf)
Figure 2: Model 1 Quasi-Poisson Predicted Counts
Table 4: Unconditional Fixed Effects Quasi-Poisson Regression Results

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<td>CONSTANT</td>
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<td>0.010 (1.161)</td>
<td>1.785* (0.951)</td>
<td>−1.029 (2.128)</td>
<td>−0.931 (1.852)</td>
<td>−0.757 (2.289)</td>
<td>0.793 (7.951)</td>
<td>2.769 (15.078)</td>
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<td>378.768</td>
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<td>378.768</td>
<td>378.768</td>
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Note: Year and organization fixed effects included but not reported.

*p<0.1; **p<0.05; ***p<0.01
Conclusion

In conclusion, the findings of this paper provide strong support for the hypothesis that longer organizational time horizons are associated with a greater organizational capacity for technological invention. While organizational time horizons are not the only statistically significant predictor, it appears that the optimal model specification is that which includes organizational time horizons as the sole explanatory variable. This is especially surprising given the traditional prominence of R&D expenditures as a significant input in the technological invention process. Of course, this should not be taken to mean that bureaucracies or organizations more generally could cease investing in R&D and still expect results, but it does suggest that R&D spending does not have much of an effect beyond satisfying a baseline precondition—that of bureaucracies having a supply of funds that they can devote to basic research. Beyond that, throwing more money at whatever problem needs to be solved does not appear to have the desired effect.  

A concrete illustration of this are the differences in RDT&E spending and patenting between the Army and Air Force, as outlined in Figure 1. Throughout the period under analysis, the Air Force has consistently outspent the Army in the RDT&E sphere, generally by a factor of two, and yet it has almost as consistently also produced fewer patents than the latter. It could very well be the case that this is an artifact of the type of research of Air Force conducts, with the Army solving “simpler” problems, so this trend must be interpreted with caution, but it does at the very least indicate that the effect of R&D on patenting is very complex, as is the process of invention as a whole, and that the point of marginal returns is reached fairly rapidly. The notion that one can outinnovate one’s potential adversaries by outspending them, therefore, serves little purpose other than to lead to maldistribution of resources with the military apparatus.

67. This is very much in line with the finding about “sharply dimishing returns” in Griliches, “Patents: Recent Trends and Puzzles” 299.
However, a number of caveats must be kept in mind when interpreting these findings. First, the number of observations is fairly small, and they describe the activity of a mere two US government agencies. It is possible that because an otherwise unquantifiable and perhaps even intangible quality is being captured through the use of an index that relies on what organizations say rather than do, the organizational time horizons variable is actually measuring some other organizational characteristic associated with but nonetheless distinct from temporal perception. Second, as mentioned, the study relies on a sample that is fairly narrow in spatial and temporal terms; one danger in generalizing from these findings is that the effect of “organizational time horizons” might for some reason be idiosyncratic to the US context. It is less likely that it is idiosyncratic to the time period under analysis, as the period contains considerable variation in engagement abroad, as well as in the level of tension and scale of interstate conflict.

Future research should hence focus on expanding the scope of inquiry to other national contexts as well. In the process, special attention should be devoted to deconstructing and better understanding the organizational time horizons index used here, and, if possible, comparing it to other quantifiable manifestations of organizational time horizons. Unfortunately, those are few and far between, and to the best of the present author’s knowledge, invariably reflect not organizational time horizons themselves but rather the effects thereof. What makes the issue of measuring organizational time horizons seem so intractable is the fact that even if one accepts the premise that an organization as a whole can have an unified organizational time horizon, the number of determinants involved in the shaping of this time horizon is rather overwhelming.0

Nevertheless, even in light of the above limitations, the conclusions this paper reaches about organizational time horizons are, as mentioned, surprisingly robust to the inclusion of other predictors. Assuming that the organizational time horizons variable is in fact an

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68. See Table 5 in Appendix A.
accurate reflection of the “true” organizational time horizons, it is difficult to offer a coher-
ent theoretical explanation for what else could be driving the sign and size of the relevant
marginal effect. While invention does require a focus on the future insofar as it implies
the setting aside of funds for activities that will not yield immediate payoffs, it seems that
if that were the only effect of time on invention, model specifications that explicitly in-
clude the RDT&E predictor would perform better than a model with organizational time
horizons as the sole explanatory variable. The mechanisms developed in studies and ex-
tensions of CLT offer the best explanation for the results obtained in this paper, which
is further encouraging in that it suggests individual-level cognitive mechanisms operate
on a group-level and can potentially be assessed using aggregated, organizational-level
observational data.  

69. This is in line with the findings of Norbert L. Kerr and Scott R. Tindale, “Group Performance and
Relations and the Psychology of Time Horizons," 541 for a brief note on this question.
Appendices

A  Organizational Conceptions of Time in the Management and Organizational Studies Literature

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Variable Level</th>
<th>Effect Size</th>
<th>Susceptibility to Exogenous Shocks</th>
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<tbody>
<tr>
<td>Management of Environmental Problem</td>
<td>Leadership-formulated Dominant Logic</td>
<td>Organizational Leadership</td>
<td>Large</td>
<td>Low</td>
</tr>
<tr>
<td>Management of Environmental Problem</td>
<td>Adherence to and Integration of Dominant Logic</td>
<td>Individual Hierarchical Level</td>
<td>Large</td>
<td>Low</td>
</tr>
<tr>
<td>Organizational Structure</td>
<td>Height of Organizational Structure</td>
<td>Organizational Level</td>
<td>Medium</td>
<td>Low</td>
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<td>Organizational Structure</td>
<td>Presence of Embedded Collectives</td>
<td>Organizational Level</td>
<td>Large</td>
<td>Medium-Low</td>
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<td>Personnel Management</td>
<td>Position of Embedded Collectives in Organizational Structure</td>
<td>Organizational Level</td>
<td>Large</td>
<td>Medium</td>
</tr>
<tr>
<td>Personnel Management</td>
<td>Employee Turnover Rates</td>
<td>Individual Hierarchical Level</td>
<td>Small</td>
<td>Medium</td>
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<td>Personnel Management</td>
<td>Leadership Tenure Stability</td>
<td>Organizational Leadership</td>
<td>Small</td>
<td>High</td>
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Table 5: Determinants of Organizational Time Horizons

Table 5, drawing primarily on the author’s previous work on the topic, summarizes findings of the MOS literature about which variables are relevant as determinants of organizational time horizons and groups them into three categories, depending on which broader organizational function or characteristic they are most closely linked to: (1) management of the organization’s “environmental problem”; (2) organizational structure; and (3) personnel management. These categories have been constructed specifically to provide a link to the broader organizational culture literature, as the purpose of this paper is not to show that organizational culture is not important—far from it—but rather that organizational time horizons can also be understood as part of a broader organizational mindset, even if they exert an effect distinct from that exerted by culture more broadly. Furthermore, it is important to be able to provide a rough estimate of which

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70. Kuhelj Bugaric, “Time in Bureaucracies.”
72. Dima Adamsky makes a similar argument about temporal orientation being an element of strategic culture and about its importance in shaping the capacity for innovation; however, he does so for a state-level analysis, and distinguishes not between short and long time horizons, but between “polychronicity” and “monochronicity”, with the former being more facilitative of innovation. Dima Adamsky, The Culture
of these many determinants are most influential in shaping organizational time horizons, and that is precisely what these categories aim to do. Managing the environmental problem is thus most closely linked to organizational culture, in part even defining it, with organizational structure reflecting general beliefs about how to most effectively manage said problem and execute the organizational mission. Finally, personnel management is the most “superficial” of these three categories, and not centrally linked to organizational culture. Moving down from “Management of the Environmental Problem” through “Organizational Structure” to “Personnel Management”, the magnitude of the effect decreases; that is, variables under “Management of the Environmental Problem” will be most decisive in shaping organizational time horizons, and variables under “Personnel Management” will be least influential, with those in “Organizational Structure” falling somewhere in between.

Although susceptibility of the values of these variables to exogenous change is also influenced by their centrality to organizational culture, “Effect Size” and “Susceptibility to Exogenous Shocks” are not perfectly collinear, as should be evident from the table. This might seem surprising given the fact that both effect size and susceptibility to shocks are derived from how central a given variable is to organizational culture, but especially factors related to “embedded collectives”—“relatively small professional organization[s] in which there is a lack of codified information and experts need to work together very closely through mutual adjustment”—exert a disproportionately large effect on time horizon length (given that these structures are not especially closely linked to organizational culture). A large effect is hypothesized here because the conception of time that is constructed within embedded collectives is more malleable than “bureaucratic time”

and is to a much greater extent molded around the nature of the environment[74] This means that embedded collectives are much more likely to foster time horizons that correspond to the environmental problem with which they are dealing. Where these collectives are embedded also exerts a disproportionately large effect due to way in which successive management levels engage in what Kevin Laverty calls “agenda control,” where the quantity of information that is filtered out increases with the number of hierarchical levels it has to pass through to get to the top of the organizational pyramid[75] The closer they are to the top, the greater is the extent to which embedded collectives can influence organizational time horizons by conveying unfiltered arguments to the organizational leadership; other management levels are thus deprived of the opportunity to intervene.

However, it is crucial to note that exogenous shocks are not the “penultimate” independent variable; after all, they strongly affect only the organizational time horizon determinant that produces the smallest effect (leadership tenure stability). This is not to say that shocks do not matter, but rather than being the ultimate cause, they should be understood as a confounder to be controlled for. The label of ultimate cause rather belongs to organizational culture, or, more specifically, the temporal aspect of the organizational mindset.

74. For a complete typology of organizational time, see Butler, “Time in Organizations” 938.
B  Frequency of Long and Short Time Horizon Words

Air Force Doctrinal Documents

AFM 1–1 (1984)

AFM 1–1 (1992)

AFDD 1 (1997)

AFDD 1 (2003)
Army Doctrinal Documents

FM 100–5 (1982)

FM 100–5 (1986)

FM 100–5 (1993)

FM 3–0 (2001)
References


