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Toward an International Relations Theory of National Innovation Rates

MARK Z. TAYLOR

The ability of nations to innovate technologically plays an important causal role in both security studies and international political economy. Explanations for national differences in technological capabilities, however, have had little place in international relations theory. This gap is partly the result of assumptions made by scholars that the rate and direction of technological change are determined by a state's domestic institutions and policies. This article will bring together recent findings about the political economy of technological innovation in order to show that much of this conventional wisdom is incorrect. Instead, it will be shown that, due to the distributive nature of technological change, different combinations of domestic tensions and external security concerns motivate elites to pursue or eschew a technologically competitive economy. Institutions are not causal, they are merely instrumental. Recent findings in the economic development literature therefore have important implications for security studies.

Why are some countries more technologically innovative than others? This article will combine a review essay with theory development to offer a novel, security-based explanation for national differences in innovation rates. The primary independent variable is the balance of domestic tensions vs. external

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threats, where the latter includes threats to economic competitiveness (that is, the ability to pay for strategic imports or produce them domestically). This article argues that countries for which external threats are relatively greater than domestic tensions should have higher national innovation rates than countries for which domestic tensions outweigh external threats. This contradicts the prevailing consensus that holds the differences in domestic institutions and policies cause nations to become more or less innovative. Certainly, domestic institutions and policies matter. They are necessary tools for acquiring national technological capabilities. Institutions do not, however, cause nations to innovate, nor is there some "best" institutional design which policymakers need converge upon in order to improve national innovation rates. But since most economists and science and technology (S&T) scholars focus on domestic variables, security variables constitute a source of omitted variable bias in many explanations of national innovation rates. This article takes the side of those scholars who argue that security studies can make significant contribution to the national innovation rate debate.

Explaining national innovation rates is of central importance to security studies because it affects almost every aspect of the subfield. For example, a nation's skill in developing and producing new technology has a significant effect on its economic growth, industrial might, and military prowess; therefore, national innovation rates necessarily influence the balance of power between states and hence have a role in calculations of war and alliance formation.[1] Research published within the pages of this journal has further highlighted the effects of technological change on organizational praxis, great power behavior and systemic change, and terror network effectiveness.[2] Technological competitiveness also determines a nation's trade profile, affecting which products it will import and export, as well as where multinational corporations will base their production facilities, including defense manufacturing.[3] Along these lines, security scholars have debated the degree to which the production of advanced military hardware is now dependent on technologically competitive economies around the globe and the implications of this for interstate violence.[4] Thus, in broad theoretical terms,

[1] Robert Gilpin, *War and Change in World Politics* (New York: Cambridge University Press, 1981); Robert Jervis, "Cooperation Under Security Dilemma," *World Politics* 30, no. 2 (1978): 167–214; Stephen M. Walt, *The Origins of Alliances* (Cornell: Cornell University Press, 1987).

[2] On technological change on organizational praxis, see Gautam Mukunda, "We Cannot Go On: Disruptive Innovation and the First World War Royal Navy," *Security Studies* 19, no. 1 (2010): 124–59. On great power behavior and systemic change, see Emily O. Goldman and Richard B. Andres, "Systemic Effects of Military Innovation and Diffusion," *Security Studies* 8, no. 4 (1999): 79–125. On terror network effectiveness, see Justin V. Hastings, "Geography, Globalization, and Terrorism: The Plots of Jemaah Islamiyah," *Security Studies* 17, no. 3 (2008): 505–30.

[3] Suzanne Berger, *How We Compete: What Companies Around the World are Doing to Make it in Today's Global Economy* (New York: Currency Doubleday, 2006).

[4] Eugene Gholz, "Globalization, Systems Integration, and the Future of Great Power War," *Security Studies* 16, no.4 (2007): 615–36; Jonathan D. Caverley, "United States Hegemony and the New Economics

technological innovation is important to security studies because of its overall implications for both the relative and absolute power of states, as well as for the behavior of defense organizations, industry, and other non-state actors. This is not to suggest that technological innovation alone determines international politics but rather that shifts in both relative and absolute national innovation rates have a major impact on international security and therefore need to be better understood.

To date, most major international relations (IR) and security theorists note the importance of technology as an independent variable affecting international political behavior or defense organizations, but only a few attempt to explain the underlying variance of national innovation rates. In fact, despite the clear influence of politics on technology, this phenomenon is only sparsely studied by political scientists.[5] Rather, the national innovation rate debate has largely become the purview of a small number of economists, business scholars, and sociologists who often ignore or misconjecture important political variables in their analysis. Moreover, as if in retaliation, most political scientists who discuss technological variables often neglect the enormous body of innovation research that has developed over the past fifteen years in the other social sciences. Meanwhile, amongst themselves, political scientists seem to share little consensus on the origins of technological change at all.

Recent research in the economic development literature provides a basis for crossing the divide between the different social science approaches to innovation, as well as the empirical evidence and theoretical motivation for investigating international security variables as causal factors. This essay will synthesize findings about the political economy of technological innovation and posit a security threat theory of national innovation rates. The review parts of this essay will synthesize several books, while referencing important complementary research as necessary, to substantiate the argument. The primary selection criteria are: (1) each book investigates national technological competitiveness as its dependent variable; (2) collectively, the books consider different countries and industries, use different theoretical lenses, and focus on overlapping but different sets of independent variables. Empirically,

of Defense," *Security Studies* 16, no.4 (2007): 598–614; Stephen G. Brooks, "Reflections on Producing Security," *Security Studies* 16, no.4 (2007): 637–78. See also Stephen G. Brooks, *Producing Security: Multinational Corporations, Globalization, and the Changing Nature of Conflict* (Princeton: Princeton University Press, 2005).

[5] Rare and valuable exceptions include Eugene B. Skolnikoff, *The Elusive Transformation: Science, Technology, and the Evolution of International Politics* (Princeton: Princeton University Press, 1993); David M. Hart, *Forged Consensus: Science, Technology, and Economic Policy in the United States, 1921–1953* (Princeton: Princeton University Press, 1998); Peter Dombrowski and Eugene Gholz, *Buying Military Transformation: Technological Innovation and the Defense Industry* (New York: Columbia University Press, 2006); Geoffrey L. Herrera, *Technology and International Transformation: The Railroad, the Atom Bomb, and the Politics of Technological Change* (Albany: SUNY Press, 2006).

these selection criteria result in a set of books that constitutes a meta case-study analysis that, when combined with complementary research, provides a solid foundation for generation of new theory.

The remainder of the article proceeds as follows. The first section outlines the basic argument. The next section provides working definitions of key terms. The third section summarizes the conventional wisdom regarding the role of the state in promoting technological innovation. It then points out major problems and paradoxes within this wisdom. The fourth section examines recent scholarship by Dan Breznitz that captures the current state of research using three country-case studies of successful innovation in Israel, Taiwan, and Ireland. The section that follows reviews Kevin Gallagher and Lyuba Zarksy's recent book that corroborates and supplements Breznitz with a country-case study of technological failure in Mexico. In the sixth section, I begin construction of an alternate explanation for national innovation rates with a discussion of how domestic tensions are exacerbated by technological change. In the seventh section, I discuss the role of international security variables in national innovation rates. Here I build upon the insights of scholars such as Eugene Gholz, Barry Posen, Harvey Sapolsky, Etel Solingen, and Jeffrey Taliaferro to synthesize domestic and external variables into a novel, security-based theory of national innovation rates. In the next section, I refer back to the case studies of Breznitz and Gallagher and Zarsky, as well as additional complementary research, for evidence confirming the plausibility of this alternate theory. The ninth section reviews a recent book by Richard Doner that, along with complementary research, provides further theoretical and evidentiary pieces of the puzzle from the cases of Thailand, Indonesia, the Philippines, and South Korea. The tenth section summarizes and offers novel prima facie statistical tests of the new hypothesis, using citations-weighted patent data to capture national innovation rates. An online appendix clarifies and justifies the quantitative data and methods used in the large-N tests.[6] Finally, it is important to emphasize that this article uses theory and data in an inductive-iterative approach to develop new theory; it does not claim to produce definitive proof of a final, perfected theory.

THE ARGUMENT

The conventional wisdom holds that a nation's domestic institutions and policies determine its rate of technological innovation; this article disagrees. It instead posits that the balance of two opposing forces, domestic tensions and external threats, drive national innovation rates in the long run. The definition of external threats is expanded here to include strategic threats

[6] http://mzak.net/research.

to a nation's economy. Put simply, the theory generated in this article is that all else equal, countries for which external threats are relatively greater than domestic tensions should have higher national innovation rates than countries for which domestic tensions outweigh external threats.

Since this is a somewhat novel approach to both security and technological innovation, it is important to note what this article is not arguing. The hypothesis is not that external security concerns alone drive technological innovation or that defense spending is the key policy variable. Rather, my primary independent variable is the balance of domestic tensions vs. external threats, where the latter includes threats to a country's ability to pay for strategic imports or produce them domestically. The dependent variable is the rate of indigenous technological change over the long run.

There are two opposing causal mechanisms at work. In the first, a nation's domestic tensions act as a force to slow and obstruct political support for technological change. Why? As will be described below, technological change is not neutral; rather, it has distributive effects that create winners and losers within society. When threatening innovations loom, the technological losers often rise to defend the status quo or to protect their resources from being reallocated to programs supporting new technologies. These resisters to innovation use their economic and political clout to influence government to slow technological change. Government can slow technological change via a range of institutions and policies: tariffs, taxes, licensing, subsidies, standards setting and regulations, anti-trust regimes, changes in guidelines for research, etc. This political resistance to new technology can be especially strong and antagonistic when the distributive effects of innovation overlap long-standing conflicts within society (between rival geographic regions, ethnic groups, cultural groups, or economic classes). Therefore, elites who seek to quiet domestic tensions, or who represent resistor interests, or who merely support the status quo, should tend to show limited policy support for technological change and perhaps even oppose it.

The second, opposing causal mechanism involves external threats, broadly defined to include threats to a nation's economy. External threats act to increase political support for technological change. Militaries can use technological change to build their indigenous defense capacity; civilians can use innovation to forge a more competitive export sector. New technology thereby allows states to better protect their borders and earn foreign exchange for strategic imports via higher value and more competitive exports. Thus, increases in external threats should put pressure on elites—and the interest groups they represent—to support technological change as a solution.

It is the sum of these two forces then, domestic tensions vs. external threats, that drives national innovation rates. Rapid and widespread technological change tends to exacerbate existing domestic tensions; yet technological change also offers solutions to external threats. Both elites and the

groups they represent must therefore face the key question of whether their interests are better served by restraining or supporting technological change. As the potential costs of external threats increase relative to those of domestic tensions, the overall political support for technological change should increase. Elites should calculate that their interests are better served by accepting the costs of coercing or compensating technological losers in order to gain their acquiescence to technological change and to the institutions and policies that promote it. Indeed, as the threat balance shifts more and more toward the external, even many technological losers may recognize that their interests are better served by accepting the costs of technological change and government actions that support it. In the opposite scenario, elites facing relatively higher domestic tensions may find that technological change threatens the stability of society and their positions of power. They should therefore find it in their interest to restrain technological change using state institutions and policy.

Where do domestic institutions fit in? First, the evidence in the books reviewed below shows that, as long as institutions solve the basic market failure and network problems that impede innovation, the particular institutions the government selects are not so important. Therefore, the search for a "best" S&T institution or policy may be unproductive, or at least secondary, because different institutional designs can achieve the same basic goals. Second, institutions are influential, but they are not causal. Institutions are the tools modern societies use to achieve their technological goals; but the intent of their users matters. The same institutions that can be used to foster technological innovation can also be directed toward entirely tangential goals or be neglected altogether. Hence institutions can aid a society that seeks to innovate, but it is the balance of security concerns that drives how (and whether) these institutions are used.

DEFINITIONS

For the purposes of this essay, "technology" is defined as a physical product or a process for physically altering materials that is used as an aid in problem solving. More precisely, technology is a product or process that allows social actors to perform entirely new activities or to perform established activities with increased efficiency.

"Innovation" is defined as the discovery, introduction, or development of new technology, or the adaptation of established technology to a new use or to a new physical or social environment. Innovation occurs throughout the technical evolution of an invention. It includes the technological changes introduced from first prototype to the establishment of a globally

competitive industry.[7] It therefore takes place both inside and outside the research laboratory. Note that since technology is defined as a product or process, innovation can refer to advances in either. Security scholars should also observe that, for the purposes of this essay, innovation is limited to improvements in technology; it does not include changes or improvements in doctrines, organizations, policies, or institutions. Nor do I include creativity in food, fashion, entertainment, or cultural products. These are not the types of innovation I wish to capture here; rather, I am specifically interested in technological innovation because it brings with it the increasing returns upon which endogenous growth, military and industrial competitiveness, and considerable national wealth are based.

The term "national innovation rate" refers to a country's indigenously produced technological change over a given period of time. It is a measure of output or performance. Therefore, in the context of an international system of rival states, one might interpret relative national innovation rates as an indicator of technological competitiveness—the relative quantity and quality of states' outputs of new technology. National innovate rates are a function of a country's technological capability: the aggregate ability of a nation's science, technology, engineering, and mathematics (STEM) labor, often working together with businessmen and entrepreneurs, to innovate. This distinction is necessary because, although innovation requires technological capability, merely possessing the capability to innovate does not compel a nation to do so. In the tenth section, following the standard practice of innovation scholars, national innovations rates will be measured using technology patents per capita, weighted by forward citations, granted during a specified time period. Note that no distinction is made here between invention and development or between military and civilian innovation. These often overlapping phenomena can be "black-boxed" without affecting the argument below. Future research might consider distinguishing between these dependent variables; however, the purpose of this essay is to develop rudimentary theory fundamental to overall innovation. The overlapping realms of science and technology are also left alloyed. However, attention here is paid mainly to technology. Nations with highly competitive science programs, but less remarkable high technology industries (Australia, Denmark), are not as relevant to this discussion as those states with the opposite characteristics (South Korea, Taiwan).

Institutions, as discussed here, are limited to those which adhere closest to Douglass North's description of them as "the rules of the game in a society." They are sets of established practices, rules, or laws that regulate

[7] James M. Utterback, *Mastering the Dynamics of Innovation* (Boston: Harvard Business School Press, 1996).

the relations between individuals, groups, and organizations.[8] Also, the terms "institutions" and "policies" are used more or less interchangeably. They are defined here as different degrees of the same concept (or at least overlapping concepts), with institutions being greater in scope, depth, longevity, or inertia than policies.

The independent variable is the balance of domestic tensions vs. external security concerns. Both forces are assumed to be continuous variables rather than dichotomous. Domestic tensions imply the degree to which a polity is divided along social lines (political, economic, cultural, ethnic) and the severity of domestic conflicts that these differences threaten. That is, to what degree will social divides be resolved via peaceful participation in the political process versus illegal, perhaps violent, political-economic behavior (black markets, corruption, strikes, crime, domestic terror). External security concerns have two components. The more traditional component consists of foreign threats to a nation's borders, assets, or strategic imports (food, energy). But I also add serious threats to a nation's economy. Economic threats are here defined as "external" when they jeopardize a country's ability to earn foreign exchange through exports.

BACKGROUND: PARADOXES AND OMITTED VARIABLE BIAS IN THE INNOVATION DEBATE

Currently the debate over the causes of innovative activity is dominated by economists and business experts. According to these scholars, the answer to the innovation puzzle is clear: domestic political-economic institutions determine national innovation rates. The right institutions cause political-economic actors to develop competitive high-technology industries; technological backwardness is caused by flawed institutions. One encounters this assertion throughout the innovation, economic development, and endogenous growth literatures.[9]

Domestic institutions monopolize the innovation debate for several reasons. First, institutions are the proximate tools governments use to promote innovation. Also, institutions differ across the industrialized democracies as do innovation rates. A causal linkage between domestic institutions and technological change therefore makes good sense, at least prima facie.

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[8] Douglass C. North, *Institutions, Institutional Change, and Economic Performance* (New York: Cambridge University Press, 1990), 3–10.

[9] For recent surveys of this literature, see Christine Greenhalgh and Mark Rogers, *Innovation, Intellectual Property, and Economic Growth* (Princeton: Princeton University Press, 2010); Daron Acemoglu, *Introduction to Modern Economic Growth* (Princeton: Princeton University Press, 2009); Peter Gourevitch, "The Role of Politics in Economic Development," *Annual Review of Political Science* 11 (2008): 137–59; Jan Fagerberg, David C. Mowery, and Richard R. Nelson, eds., *The Oxford Handbook of Innovation* (New York: Oxford University Press, 2004).

Second, economists have long believed that certain domestic institutions are necessary to address the chronic market failures that prevent or slow investment in innovative activity. Research and development (R&D) tends to generate positive externalities such that for-profit firms do not undertake research at the socially desirable level.[10] Externalities make it difficult to establish property rights on the outputs of scientific and technological research, rendering the performance of R&D a typical market failure problem.[11] Other scholars emphasize the high levels of uncertainty, risk, high transaction costs, and incomplete information that characterize progress in science and technology.[12] In either case, these types of market failure routinely prevent private actors from allocating efficient investments in innovation.[13]

In theory, domestic institutions help to solve each of these problems. Institutions solve the free-rider problem by providing selective incentives to innovators. Institutions also lower information and transaction costs; they lower and spread risk and uncertainty. Hence as social scientists, when we observe the market failures associated with the production of risky scientific and technological public goods, we are naturally drawn to institutional explanations. Thus domestic institutions have come to play a determining causal role in theories of national innovation rates.

Exactly which institutions matter? This is where the theoretical consensus breaks down. Domestic institutions theories of innovation have proliferated inconsistently, taking myriad forms and employing different levels of analysis. Theoretical arguments separately extol the benefits of competitive democracy,[14] decentralized government,[15] property rights,[16] free markets,[17]

[10] The classic references here are Kenneth Arrow, "Economics of Welfare and the Allocation of Resources for Invention," in *The Rate and Direction of Inventive Activity*, ed. Richard R. Nelson (Princeton: Princeton University Press, 1962), 609–26; Zvi Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *The Journal of Political Economy* 66, no. 5 (1958): 419–31; Richard R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy* 67, no. 3 (1959): 297–306.

[11] Partha Dasgupta and Paul A. David, "Towards a New Economics of Science," *Research Policy* 23 (1994):487–521.

[12] North, *Institutions*.

[13] Arrow, "Economics of Welfare"; Paul M. Romer, "Endogenous Technological Change," *Journal of Political Economy* 98, no. 5 (1990): S71–S102; Robert E. Hall and Charles I. Jones, "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" *Quarterly Journal of Economics* 114, no. 1 (1999): 83–116; Philippe Aghion and Peter Howitt, *Endogenous Growth Theory* (Cambridge, MA: MIT Press, 1998).

[14] Daron Acemoglu, Simon Johnson, and James Robinson, "Institutions as the Fundamental Cause of Long-Run Growth," in *Handbook of Economic Growth*, ed. Philippe Aghion and Steve Durlauf (Amsterdam: Elsevier, 2005).

[15] Daniel Drezner, "State Structure, Technological Leadership and the Maintenance of Hegemony," *Review of International Studies* 27, no. 1 (2001): 3–25; Witold J. Henisz, "The Institutional Environment for Economic Growth," *Economics & Politics* 12, no. 1 (2000): 1–31.

[16] North, *Institutions*.

[17] Ibid.

different styles of capitalism,[18] different "national innovation systems,"[19] and so forth. Hence, despite the fact that domestic institutions have come to dominate the innovation debate, there exists little agreement on exactly which institutions determine innovation rates or precisely how they do so.

To complicate matters further, the empirical evidence provides little support for domestic institutions causing innovation in the aggregate, regardless of the type of institution tested or the measure of innovation used. To be more precise: although institution or policy X might appear to explain a certain country's innovation rate during a specific period of time, it does not do so in other time periods nor in other countries. For example, repeated tests of "varieties of capitalism" theory show that the theory does not accurately predict national innovative behavior over time and space.[20] Likewise, both statistical analysis and case studies show that decentralized democracies are no better (or worse) at science and technology than states with more centralized political structures.[21] In fact, measures of democracy and political rights have no correlation with national innovation rates, whereas free market measures reveal only minor correlations.[22] Even the effects of intellectual property rights on innovation are rigorously contested.[23] Finally, there are many countries that are conventionally understood to have good political-economic institutions, but have not developed particularly innovative economies (Norway, Austria, New Zealand). Meanwhile, many countries with relatively bad institutions have nonetheless produced globally competitive high-technology sectors (Taiwan, South Korea, Japan, Israel).[24] In many

[18] Peter A. Hall and David Soskice, "Introduction," in *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*, ed. Peter A. Hall and David Soskice (New York: Oxford Press, 2001), 1–68.

[19] Richard R. Nelson, ed., *National Innovation Systems: A Comparative Analysis* (New York: Oxford Press, 1993).

[20] Mark Z. Taylor, "Empirical Evidence Against Varieties of Capitalism's Theory of Technological Innovation," *International Organization* 58, no. 3 (2004): 601–31; Dirk Akkermans, Carolina Castaldi, and Bart Los, "Do 'liberal market economies' really innovate more radically than 'coordinated market economies'? Hall and Soskice reconsidered," *Research Policy* 38, no. 1 (2009): 181–91.

[21] Mark Z. Taylor, "Federalism and Technological Change in Blood Products," *Journal of Health Politics, Policy and Law* 34, no. 6 (2009b): 863–98; Mark Z. Taylor, "Political Decentralization and Technological Innovation: Testing The Innovative Advantages of Decentralized States," *Review of Policy Research* 24, no. 3 (2007a): 231–57.

[22] Mark Z. Taylor, "International Linkages and National Innovation Rates: An Exploratory Probe," *Review of Policy Research* 26, nos. 1–2 (2009a): 127–49.

[23] Michele Boldrin and David K. Levine. *Against Intellectual Monopoly* (New York: Cambridge University Press, 2008); Adam B. Jaffe and Josh Lerner, *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It* (Princeton: Princeton University Press, 2004); Mark Z. Taylor and James M. Watkins, "Intellectual Property Protection and U.S. Foreign Direct Investment in Emerging Economies," *Journal of Intellectual Property Rights* 15, no. 6 (2010): 415–28.

[24] These countries each achieved dramatic increases in technological output under either repressive non-democratic regimes (South Korea, Taiwan); non-market economies with highly interventionist states (South Korea, Taiwan, Israel, Japan); or non-competitive one-party democracies (Japan).

of these latter countries, institutions did improve over time, but only after an upward trend in innovation rates was well underway.

Thus the current state of the innovation debate is that of a persistent puzzle. The preponderance of theory argues that domestic institutions and policies matter. However, neither theory nor evidence has generated rigorous support for the causal importance of any particular institution or policy; and all the while, security concerns are generally omitted as causal factors.[25]

INNOVATION AND THE STATE IN ISRAEL, TAIWAN, AND IRELAND

The next two sections of case studies mostly present the authors' arguments on their own terms. Their purpose is to frame the puzzle about the proper role of the state in countries seeking to gain and maintain competitiveness in the production of new technology. A logical place to find answers is in the rapidly innovating nations (Japan, South Korea, Taiwan, Finland, Israel, Ireland, India, China, etc.) that, during the last half-century, graduated from basic agriculture and manufacturing to global technological competitiveness. A better understanding of the fundamental causal forces and mechanisms driving these success stories would be a useful improvement over the generalization that "institutions matter."

A comparative study to identify the specific institutions and policies necessary to create globally competitive high-tech industries is precisely the approach taken by Dan Breznitz in *Innovation and the State*.[26] To investigate the institutional sources of high-tech competitiveness, he compares relative success in the hardware and software industries in three rapidly innovating countries—Taiwan, Israel, and Ireland—with special attention paid to cross-national variations in political institutions, policies, and economic conditions.

Breznitz points out that, from a political-economic standpoint, Taiwan, Israel, and Ireland share many similarities. Each entered the late-1960s with similar profiles in terms of size, population, education levels, and labor skills (that is, few STEM workers). Also, all three economies depended heavily on agriculture and were equipped with poor communication and physical infrastructures. Then, during the late-1960s, each government put forward state-led initiatives to develop indigenous high-tech industries. To that end, each country recognized the critical need for the state to step in and foster

[25] Important exceptions include Vernon W. Ruttan, Is War Necessary for Economic Growth? Military Procurement and Technology Development (New York: Oxford University Press, 2006); Merritt Roe Smith, ed., Military Enterprise and Technological Change: Perspectives on the American Experience (Cambridge: MIT Press 1985).

[26] Dan Breznitz, *Innovation and the State: Political Choice and Strategies for Growth in Israel, Taiwan, and Ireland* (New Haven: Yale University Press, 2007). In this section, subsequent references to this book will be cited in the text.

the development of domestic S&T skills and capabilities. In its policy strategies, each state improved its physical infrastructure, telecommunications, and education systems. The countries also based their separate growth strategies on small- and medium-sized enterprises.

Brenzitz goes on to describe how each of the three states chose a very different development strategy that should have resulted in vastly different outcomes. Ireland pursued a relatively free-market strategy focused on inward foreign direct investment (FDI) from high-tech multinational corporations (MNCs). Here the focus was on creating jobs in information technology (IT) services, not an indigenous manufacturing or research capability. Israel left leadership to private domestic firms but heavily subsidized R&D. The focus here was on the domestic development of new high-tech products, to be financed and marketed via international networks. In Taiwan, the government led the R&D effort in the form of public research institutes whose products were then diffused to private industry to manufacture and distribute. Moreover, Taiwan sought innovation in intermediate product design and manufacturing rather than new high-technology consumer or business end products.

Despite their different policy strategies (and bureaucratic structures), all three countries generally succeeded in overcoming similar obstacles and becoming globally competitive high-tech producers in a fairly short time span. However, according to Breznitz, only Israel managed to create strong, sustainable domestic hardware and software industries. Taiwan succeeded only in hardware. Ireland succeeded only in software and perhaps only temporarily.

Breznitz argues that the common factor explaining the countries' mutual successes was a dedication not to particular institutions or policy designs but to solving market failures and creating networks. Specifically, the private markets of each country failed to supply sufficient investment in the skilled labor, research institutions, and infrastructure necessary in order to achieve sustained progress in science and technology. States that stepped in to solve these market failures succeeded, regardless of the particular institution or policy used to do so. Additionally, successful states helped to create domestic networks that knit together STEM labor with local entrepreneurs and investors, as well as international networks that linked domestic innovators with foreign markets for exports, investment capital, and sources of technical skills and knowledge. Breznitz's argument is supported by his case study evidence.

Israel

Breznitz describes how Israel transformed itself from an agrarian economy into a globally competitive high-tech producer in a few short decades. Israel's strategy was to create institutions that solved market failures and established

networks, both domestic and international. The Office of the Chief Scientist (OCS), a pre-existing agency within the Ministry of Trade and Industry, became Israel's primary development institution (51–57, 64–71). For years, OCS was the main, and often only, source of financial capital for Israeli high-tech ventures. Unlike Japan or South Korea before it, the Israeli state did not "pick winners." Instead, Israel put private firms at the center of its strategy, subsidizing them with public R&D money and skilled STEM labor generously leaked out of military research programs (42–43). Meanwhile, the government sharply reduced funding for public research institutions, except for its joint projects with private firms. The idea here was for state institutions to reduce, but not eliminate, the costs and risks of private-sector innovation.

The state also pressed Israeli companies to form networks with foreign, especially American, firms for finance, marketing, and technology transfer. For example, one important institution, the Bi-National Industrial Research Foundation (BIRD), was established during the mid-1970s specifically to foster joint ventures between Israeli and US firms. BIRD became instrumental in attracting US high-technology firms to set up joint research facilities in Israel, including IBM, Lucent, Digital, Motorola, National Semiconductor, and Intel (57–71, 86). Other government policies aggressively persuaded MNCs from other high-tech countries to create R&D centers, but not manufacturing bases, in Israel (37, 50, 65, 80). The state also helped to link Israeli firms and domestic finance together with foreign financial markets that soon became major sources of capital for Israeli high-tech firms (37). In addition, a variety of policies and institutions were created to develop the United States and Europe as major export markets and as foreign partners in marketing and business development, two notorious weaknesses of Israeli high-tech. Finally, another major international linkage was formed by Jewish immigrants from advanced S&T countries. This includes the surge of highly educated ex-Soviets who entered Israel with extensive STEM backgrounds, were settled with financial assistance from the United States, and came to serve as an important input to the Israeli high tech sector (77–78).

Taiwan

Breznitz argues that, like Israel, Taiwan's successful strategy was to create state institutions that solved market failures and created networks, both domestic and international. Unlike Israel, Taiwan followed a strategy of heavy government intervention. In particular, the Taiwanese response to insufficient private investment was government-run research institutions that decided which technologies to pursue and then undertook the initial R&D activities. If successful, the results and proto-types from government labs were then disseminated to private industry to develop into final products for

mass production. The most prominent of Taiwan's public research institutions are the Industrial Technology Research Institution (ITRI) for research in computer hardware, Hsinchu Science-Based Industrial Park, and the Institute for Information Industry (III) for research in computer software.

Domestically, the ITRI, III, and Hsinchu brought together networks of scientists and then connected them with industry. For example, Hsinchu Park was formed to knit together networks of researchers from Taiwan's three top engineering institutions situated nearby and then feed the research into a nascent domestic semiconductor industry (106–7). International networks were also instrumental to Taiwan's success. Chinese-American STEM workers and entrepreneurs played central and recurring roles in the development of Taiwan's computer industries. The genesis and evolution of Taiwan's semiconductor industry flowed from expats working in the US semiconductor industry, and Taiwan's hardware revolution was staffed by thousands of graduate-level scientists and engineers trained at US universities. The inflows however were not limited to human capital; rather, Taiwan's system was also "primed to give private companies constant access to new technologies from abroad," with ITRI taking the lead in directing inward technology transfer (110, 139, 142).

Ireland

Ireland made its graduation from agrarian economy to high-tech competitor most recently, during the late 1990s. It entered into this period with a deeply entrenched portfolio of private sector, free-market development policies. Therefore, its high-tech approach was based on FDI, rather than on state-run laboratories or heavy government intervention. The Irish strategy was to attract foreign high-tech MNCs to set up large scale manufacturing facilities but not necessarily R&D centers. Hence Ireland took a very different technological development path than that followed by Israel or Taiwan.

Breznitz, yet again, finds the state acting successfully to create institutions that solved market failures and formed networks, both domestic and international. From the late-1950s through the mid-1990s, the Industrial Development Authority (IDA) was Ireland's primary development agency. On the market failure side, the state provided public goods by expanding its education system, with an emphasis on STEM training (148–53). Ireland also upgraded its physical and communications infrastructures in order to increase its attractiveness to MNCs (151–56). The IDA was also instrumental in fostering international networks that were central to Ireland's approach. Restrictions on foreign ownership were eliminated in order to lure foreign MNCs to set up production. Meanwhile, the IDA created special economic zones around major transportation points and successfully lobbied to cut export taxes. The

IDA also set up offices in foreign countries to attract high-tech MNCs, such as Digital Equipment, Ericsson, and Lotus, to Ireland (164–68).

Breznitz argues, however, that Ireland, unlike Israel or Taiwan, paid little attention to developing indigenous production capabilities (186–89).The Irish state did not actively support domestic high-tech start-ups via grants, subsidies, or military procurement programs, nor did it enact policies to embed deeply foreign high-tech within the Irish political economy. Only in computer software, and only after some domestic success stories, has the Irish state recently begun to change its development strategy toward greater government intervention. Hence Ireland is arguably the least successful high-tech "miracle" of the three. Breznitz contends that this is because Ireland has thus far done the least to embed foreign high-tech actors into the domestic political economy. MNCs therefore view Ireland and its generous supply of STEM labor as an export base and perhaps increasingly a source of high-tech services (185–87).

DOMESTIC INSTITUTIONS AND TECHNOLOGICAL FAILURE IN MEXICO

To contrast these three cases of technological success, a recent study of failure can be found in *The Enclave Economy:* FDI *and Sustainable Development in Mexico's Silicon Valley* by Kevin Gallagher and Lyuba Zarsky.[27] This book is primarily intended as an empirical critique of the Washington Consensus. I find, however, that its case study data corroborate many of the elements Breznitz finds in his studies of Israel, Taiwan, and Ireland.

Gallagher and Zarsky describe how, during the 1970s, a successful domestic computer industry grew up around Mexico's high-tech self-sufficiency programs. Under the direction of Mexico's National Council on Science and Technology (CONACYT), many of these programs addressed market failures and established international networks in ways similar to state interventions in Taiwan and Israel. Under these programs, foreign firms were invited to invest in Mexican computer production but only through joint ventures with local partners granted majority ownership (43–49, 122–23). Foreign computer manufacturers were also required to invest in Mexican R&D and STEM training centers. Other policies, such as domestic content requirements, government procurement programs, and tax and financial incentives rounded out the successful strategy (121–25, 148). Hence Mexico's domestic institutions

[27] Kevin Gallagher and Lyuba Zarsky, *The Enclave Economy:* FDI *and Sustainable Development in Mexico's Silicon Valley* (Cambridge: MIT Press, 2007). In this section, subsequent references to this book will be cited in the text.

established networks that embedded foreign high-tech producers within the domestic economy.

While they lasted, CONACYT's programs were fairly successful in their attempts to attract FDI with a large manufacturing component. Over sixty firms entered into joint production ventures, including major computing MNCs such as Hewlett-Packard, IBM, Digital, NCR, Tandem, and Wang. Mexican computer production eventually reached $400 million, split between micro-computers, mini-computers, and peripheral equipment, with half exported to the United States and Canada. The Mexican company, Printaform, became the top domestic producer of personal computers. Printaform soon manufactured computers of quality high enough that Mexico's top university (UNAM) began to purchase them instead of those made by foreign competitors (122–24, 141). Starting in the mid-1980s, however, Mexico changed the nature of both its domestic institutions and the international networks it promoted. Mexico switched from protectionist, interventionist approaches to extreme free-market policies by dropping tariffs, lowering licensing requirements, and ultimately joining NAFTA. The new development strategy was to attract FDI via almost complete market liberalization and allow Mexico's advantage in low-wage labor to lure foreign flagship S&T firms (124–33).

However, as the economy liberalized, Mexico's foreign computer manufacturers began to insist on exemptions from self-sufficiency requirements. The first exemption came in 1985. In exchange for a STEM training center, Mexico allowed IBM to set up a wholly owned production facility, without local partners, in Guadalajara. Other foreign firms soon followed suit, often with no stipulations for local development projects extracted in exchange (124–25). Gallagher and Zarksy contend that this had disastrous results during the 1990s, when the protections of Mexico's industrial policy gave way to NAFTA and the new free-market development strategies. Without anything tying their fate to the local high-tech sector, foreign computer manufacturers located in Mexico simply wiped out their Mexican competition.

The problem was that, unlike the previous national success stories, the Mexican government did not intervene to address the market failures associated with high-tech production. There was little state-led effort to improve STEM education, subsidize R&D centers, or provide finance to domestic high-tech start-ups. Instead, in order to attract FDI, the state eliminated the protections for such programs that existed during the 1970s. Also, the Mexican state did not knit together domestic networks of investors, entrepreneurs, industry, and STEM workers, nor did the state act to embed foreign S&T manufacturers within domestic networks. Mexican universities were instead tasked by foreign firms to help with quality control and to perfect assembly operations, rather than to develop indigenous R&D capabilities (121–25, 144, 148). Instead of drawing upon local manufacturers of components, foreign firms brought in foreign suppliers, like Flextronics and Solectron (129–30, 141). Thus, the

only major input Mexico provided was low-skill labor, and neither the government nor the market provided incentives for foreign S&T manufacturers to transfer knowledge or skills to the local economy.

Gallagher and Zarsky locate the final blow in 2001, when foreign computer manufacturers began to depart Mexico, leaving little domestic computer industry or indigenous STEM labor behind. The accession of China to the WTO provided an unbeatable source of competition as a destination for high-tech FDI. Mexico might compete well with China on transportation costs but not in terms of wages, skilled labor, or potential domestic market size. Meanwhile, the collapse of the IT bubble forced computer firms throughout the industry to reduce their foreign operations, especially in relatively small IT markets like Mexico (110–17, 134–38, 150).

Summing up the research reviewed thus far, both case study and quantitative data reveal that domestic institutions and policies matter. They are necessary tools for acquiring national technological capabilities. Institutions, however, do not cause nations to innovate, nor is there a "best" institutional design that policymakers need converge upon in order to improve national innovation rates. Furthermore, networks are just as important as domestic institutions as tools for acquiring science and technology capabilities. Domestic networks must knit together STEM labor with local entrepreneurs and investors; international networks must link domestic innovators with foreign markets for exports, investment capital, and sources of technical skills and knowledge. Indeed, the two tools—institutions and networks—must build upon one another; successful domestic institutions and policies are those that, regardless of design, create and maintain these types domestic and international networks.

TOWARD A NEW THEORY I: DOMESTIC RESISTANCE TO TECHNOLOGICAL CHANGE

To reiterate, the case studies above suggest that domestic institutions and policies should not be modeled as causal forces; rather, they are better described as tools. These tools can help societies or individuals to innovate better, but they do not cause them to innovate. This is an important distinction because, like any other set of tools, institutions and policies can be neglected, misapplied, or abused. In this manner, institutions and policies are analogous to surgical equipment. A skilled surgeon, intent on healing her patient, can practice better medicine when equipped with the tools of her trade. If her tools are broken, missing, or incomplete, then she will be severely handicapped. All else equal, she will practice medicine inferior to a well-equipped surgeon. Surgical tools do not, however, cause a person to become a good surgeon, nor do they cause a skilled surgeon to practice her craft well. Intent matters. In the remainder of this essay, I hypothesize that a

nation's intent, how it uses its institutions, is strongly affected by the balance of security concerns (domestic vs. external) it faces.

I posit that the first step is to understand domestic political resistance to technological change. Joseph Schumpeter described innovation as "creative destruction," the killing off of the old by the new.[28] The destructive element of technological innovation is essential because it clears the path for new economic activity. Without it, vital markets and inputs (capital, labor, infrastructure, raw materials) remain dominated by status-quo industries, crowding out untested challengers. In order for new technologies and industries based upon them to flourish, the old must fail. But the losers created by technological change do not go quietly; technological innovation may benefit society, but it has its victims, and these victims fight back politically.[29]

These dynamics are familiar to security scholars since there is a vast body of research that examines the conditions for successful military doctrinal innovation. These studies almost uniformly draw attention to the effects of internal resistance to change. For example, scholars such as Owen Cote, Barry Posen, Stephen Rosen, Harvey Sapolsky, and Adam Stulberg describe the painful adjustments born by defense organizations faced with changes in military doctrine. According to these theories, the obstacles created by internal resistance are such that doctrinal innovation must either be imposed from outside,[30] occur only slowly through the protection and promotion of less invested junior personnel,[31] or require fierce competition between otherwise resistant actors for limited resources and prestige.[32] Regardless, political resistance to the changes imposed by new technology plays a role in determining the rate and direction of doctrinal innovation.

IPE and CPE scholars also depict political resistance to institutional and policy innovations in their own subfields. For example, research on western Europe has found that, be it technology policy, economic growth programs, or changes in labor and education institutions, losing elites and interest groups consistently organize political resistance to slow distributive change.[33]

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[28] Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (1942; repr., New York: Harper, 1975), 82–85.

[29] Harvey M. Sapolsky and Mark Z. Taylor. "Politics and the Science of Science Policy," in *The Handbook of the Science of Science Policy* (Stanford University Press, 2011).

[30] Barry Posen, *The Sources of Military Doctrine: France, Britain and Germany Between the World Wars* (Ithaca: Cornell University Press, 1984).

[31] Stephen P. Rosen, *Winning The Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991).

[32] Owen Cote, Jr., *The Politics of Innovative Military Doctrine* (PhD diss., Massachusetts Institute of Technology, 1996); Harvey M. Sapolsky, "On the Theory of Military Innovation," *Breakthroughs* 9, no. 1 (Spring 2000); Harvey M. Sapolsky, "The Interservice Competition Solution," *Joint Forces Quarterly* (Spring 1996); Adam N. Stulberg, "Managing Military Transformation: Agency, Culture, and the U.S. Carrier Revolution," *Security Studies* 14, no. 3 (2005): 489–528.

[33] On technology policy, see Gunnar Trumbull, *Silicon and the State: French Innovation Policy in the Internet Age* (Washington, DC: Brookings, 2004); Nicholas J. Ziegler, *Governing Ideas: Strategies for Innovation in France and Germany* (Ithaca: Cornell University Press, 1997). On economic growth, see

IPE theorists such as Charles Boix, Michael Hiscox, Jeffry Frieden, Helen Milner, and Ronald Rogowski also highlight the role of distributive politics in obstructing the liberalization of international trade and finance policies and even regime change itself.[34]

I point out that similar resistance can be found within societies faced with technological change.[35] Investment and advances in science and technology can, by a variety of mechanisms, alter the power relations within a society and thereby trigger political resistance from technological losers. For example, science and technology can alter the scope and nature of human activity (in combat, production, transportation, etc.) and thereby change the social, economic, or political standing of the people performing these activities.[36] New technologies can also be purposely constructed so as to privilege one social group over others.[37]

The most powerful causal mechanism by which technological innovation triggers political resistance is economic redistribution. On the input side, money spent on research must come from somewhere. In order to fund S&T education, R&D, and procurement programs, governments generally have to raise taxes or reduce spending on competing programs. Similarly, state institutions and policies designed to promote S&T also redistribute resources and power within society. For example, patents, infant-industry protection, technical standards, anti-trust regulations, and so forth, all favor some innovators at the expense of other actors, often their competition in status-quo industries.[38]

Jonah D. Levy, *Tocqueville's Revenge: State, Society, and Economy in Contemporary France* (Cambridge, MA: Harvard University Press, 1999). On changes in labor and education, see Wade Jacoby, *Imitation and Politics: Redesigning Modern Germany* (Ithaca: Cornell University Press, 2000).

[34] Ronald Rogowski, "Political Cleavages and Changing Exposure to Trade," *American Political Science Review* 81, no. 4 (1987): 1121–37; Jeffry A. Frieden, "Invested Interests: The Politics of National Economic Policies in a World of Global Finance," *International Organization*, 45 no. 4 (1991): 425–51; Helen V. Milner, *Interests, Institutions, and Information: Domestic Politics and International Relations* (Princeton: Princeton University Press, 1997); Michael J. Hiscox, "Commerce, Coalitions, and Factor Mobility: Evidence from Congressional Votes on Trade Legislation," *American Political Science Review* 96 no. 3 (2002): 593–608; Charles Boix, *Democracy and Redistribution* (New York: Cambridge University Press, 2003).

[35] Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York: Oxford University Press, 1990).

[36] See, for example, Ruth Schwartz Cowan, *More Work For Mother* (New York: Basic Books, 1983).

[37] For example, Robert Moses, the designer of New York's expressways and state parks deliberately used bridge, road, and even pool design to restrict their usage by poor and lower-middle class families, especially African-Americans. Robert A. Caro, *The Power Broker: Robert Moses and the Fall of New York* (New York: Vintage Press 1974), 318, 546–7, 951–4. For a critique of Caro, see Bernward Joerges, "Do Politics Have Artefacts?" *Social Studies of Science* 29, no. 3 (1999): 411–31. Political battles over birth control technologies or genetically modified foods might also be appropriate here.

[38] Peter F. Cowhey and Jonathan D. Aronson, Transforming Global Information and Communication Markets: The Political Economy of Innovation (Cambridge, MA: MIT Press, 2009); Jaffe and Lerner, Innovation and Its Discontents.

On the output side, new technology is economically distributive in that it allows its possessors to perform entirely new activities or to perform established activities with increased efficiency. This equates to the acquisition of competitive advantage within an economy. Innovation provides this competitive advantage either via productivity increases or through the accumulation of factor inputs. More subtly, but equally important, technological innovation can trigger distributive politics by changing the resource requirements for various economic activities. Where this occurs, new technology changes the supply and demand conditions for particular inputs, increasing the value of some relative to others. For example, the advent of steam-powered railroads changed the relative values of land, coal, lumber, and various metals and drastically increased the demand for engineering skills. The subsequent appearance of the internal combustion engine increased the value of oil relative to coal, and the rise of modern fuel-cell technologies may, in the future, decrease the value of both commodities and put a premium on hydrogen production and storage.[39]

The summary point is that technological innovation creates winners and losers, especially in the long run. Identifying technological losers often depends on the particular innovation in question, but generally they are holders of assets (skills, capital, land, resources, etc.) whose relative value is punished by the effects of technological change on supply and demand conditions. Losers might be skilled labor defending their jobs; owners of natural resources who seek to prevent their destruction or degradation; producers of competing technologies who seek to retain market share and profitability; consumers with large sunk-costs in existing technologies; even investors in stocks, bonds, or physical capital who seek to maximize returns on their investment.[40]

More important for our discussion is that these losers may seek to resist threatening scientific research or technological change. Like other victims of economic distribution, technological losers can resist by influencing or capturing government policy in order to slow or obstruct threatening change. Specifically, resisters can use their economic or political power to influence government to slow technological change via a range of mechanisms: tariffs, subsidies, taxes, procurement programs, licensing, standards setting and regulations, anti-trust regimes, changes in guidelines for research, etc. Note that these are the very same institutions (tools) governments use to promote S&T.

[39] David R. Beasley, The Suppression of the Automobile: Skulduggery at the Crossroads (New York: Greenwood Press, 1988).

[40] Joel Mokyr theorizes that political resistance to technological change is linked to asset specificity. Joel Mokyr, "Cardwell's Law and the Political Economy of Technological Progress," *Research Policy* 23 (1994): 561–74.

In those cases where the distributive effects of innovation overlap long-standing conflicts within society (between rival geographic regions, ethnic groups, cultural groups, or economic classes), we should expect the political resistance to new technology to be especially strong and antagonistic. For example, in the United States, innovation in container technologies set two age-old adversaries, dock labor and shippers, against one another, resulting in decades of successful strikes, violence, and political activism.[41] In England, the advent of automobile technologies, backed by urban and banking interests, resulted in political pressure and violence from traditional opponents in agriculture, thus delaying innovation and diffusion for generations.[42] For much of the last sixty years in Kenya and Ghana, disputes over S&T and the institutions and policies promoting them fell along tribal or ethnic lines, intensifying historic conflicts between such groups.[43]

The point is that technological change, along with the institutions and policies supporting it, can sometimes cause new domestic conflicts or excite traditional ones. In these cases, political elites should seek to slow such change. Specifically, elites who seek to quiet domestic tensions, or who represent resistor interests, or who merely support the status quo, should tend to show limited policy support for technological change and perhaps even oppose it. The net effect is that a nation's domestic tensions should act as a force to slow and obstruct political support for technological change.

TOWARD A NEW THEORY II: EXTERNAL THREATS AND INNOVATION

I argue that the domestic politics of distribution described above do not alone determine national innovation rates. Rather, both history and military innovation scholarship tell us that international security variables should also play a prominent explanatory role in the debate over national innovation rates. Certainly Gholz, Posen, Sapolsky, Solingen, and a handful other security scholars have linked threat level to investment in the defense industries.[44] Also, countless new technologies have either emerged directly from

[41] Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger* (Princeton: Princeton University Press, 2006).

[42] Beasley, *The Suppression of the Automobile*.

[43] Warigia Bowman, "Governance, Technology and the Search for Modernity in Kenya," *William and Mary Policy Review* 1 (2010): 87–116; Sanjaya Lall and Carlo Pietrobelli, *Failing to Compete: Technology Development and Technology Systems in Africa* (Northampton: Edward Elgar, 2002).

[44] Eugene Gholz, "The Curtiss-Wright Corporation and Cold War–Era Defense Procurement: A Challenge to Military-Industrial Complex Theory," *Journal of Cold War Studies* 2, no. 1 (2000): 35–75; Eugene Gholz and Harvey M. Sapolsky, "Restructuring the U.S. Defense Industry," *International Security* 24, no. 3 (1999/2000): 5–51; Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca: Cornell University Press, 1984); Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East* (Princeton: Princeton University Press, 2007).

defense-oriented research funding or have been the unintended by-products of military demand or of actions taken to improve national security. Most obviously, these include advances in dual-use technologies such as navigation, aircraft, aerospace, telecommunications, nuclear power, computers, software, and the internet.[45] But defense concerns also played a significant role in advances in predominantly civilian industries such as standardized parts, machine tools, railroads, food processing, electric lighting, trucking, container shipping, and robotics.[46] This observation is not intended to posit a spin-off argument but rather to recognize the fact that resources and technical knowledge are often fungible and can therefore spill over between military and civilian spheres.[47]

In this journal, one attempt at incorporating security into the innovation debate is that made by Jeffrey Taliaferro.[48] Taliaferro, a security studies scholar, argues that a state's decision whether or not to innovate depends largely on that state's capacity to mobilize society and extract resources from it. Put simply, strong states should pursue technological progress, whereas weak states will tend to maintain the status quo. This is because the governments of strong states have the cohesion and autonomy necessary to maintain the high levels of long-run, risky investment necessary for successful innovation. Weak states, by contrast, have governments plagued by fragmentation and powerful interest groups. As a result, they can neither raise the necessary capital nor mobilize private actors to invest in significant change. Given a strong state, and thus the capacity to innovate, the level of external threat then determines whether that state will emulate the advanced technologies of frontier innovators countries (for example, Meiji Japan) or whether that state will attempt to create its own (for example, Cold War United States). Thus, Taliaferro combines an institutionalist argument, whereby institutions determine state capacity and hence national technological output, with a security argument, whereby the level of external threat dictates national technology strategy.

Although Taliaferro's model has never been specifically tested, some of its mechanisms have not been supported by recent empirical research.

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[45] Ruttan, *Is War Necessary for Economic Growth?*; Richard R. Nelson, *Government and Technical Progress: A Cross-Industry Analysis* (Oxford: Pergamon Press, 1982); Janet Abbate, *Inventing the Internet* (Cambridge, MA: MIT Press, 1999); Kent C. Redmond and Thomas M. Smith, *From Whirlwind to MITRE: The R&D Story of the SAGE Air Defense Computer* (Cambridge, MA: MIT Press, 2000).

[46] John A. Alic, et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston: Harvard Business School Press, 1992); David C. Mowery and Nathan Rosenberg, *Paths of Innovation: Technological Change in 20th Century America* (New York: Cambridge University Press, 1998); Levinson, *The Box*; Robert G. Angevine, *The Railroad and the State: War, Politics, and Technology in Nineteenth-Century America* (Stanford: Stanford University Press, 2004).

[47] For the state of the debate over spin-off, spin-on, and the distinction between military and commercial markets for technology, see Dombrowski and Gholz, *Buying Military Transformation*.

[48] Jeffrey W. Taliaferro, "State Building for Future Wars: Neoclassical Realism and the Resource-Extractive State," *Security Studies* 15, no. 3 (2006): 464–95.

For example, Taliaferro points out that "centralized and insulated states can extract societal wealth better than decentralized and constrained states can" and will therefore pursue technological change more aggressively.[49] Empirical tests of this hypothesis, however, fail to support it. Both quantitative and qualitative research find no significant causal linkage between political centralization and innovation rates; by contrast, politically decentralized states diffuse new technology faster than centralized states.[50] Hence, to the extent that "diffusion" and "emulation" are synonymous, the Taliaferro hypothesis is confirmed but with a reversed sign: decentralized states perform better. Granted, these tests do not control for state-sponsored nationalism or statist ideology, which Taliaferro sees as conditional variables affecting state power. But prominent cases of successful technological innovation provide little support. For example, post-war Japan remained a technologically progressive state, reaching new heights of technological performance, despite that fact that it has experienced a significant decrease in state-sponsored nationalism and statist ideology since its early Showa period (1926–45). A similar description could be applied to Finland, where statism and nationalism decreased but whose technological performance nonetheless leapt after the mid-1980s. Meanwhile, states with increasing or persistently high levels of state capacity, statist ideology, and nationalism, such as post-war France and Austria, saw little change in their technological performance.

Standing on the shoulders of this prior research, I carry forward the argument started by these scholars. I posit that, instead of playing a conditional role or affecting only defense innovation, security concerns may play a primary causal role in determining national innovation rates overall. In its simplest form, my argument is that as concerns over external threats rise to outweigh those over domestic tensions, the greater political support should be for new technologies to respond to these threats.

In order to best explain the data on national innovation rates, however, external security concerns should be more broadly defined to include serious threats to a nation's economy. Economic threats here are defined as "external" when they affect a country's ability to earn foreign exchange through exports. Such crises jeopardize a nation's security when they strike an economy characterized by a heavy reliance on imports for strategic goods (food, energy, materials, capital goods), especially the weaponry and other technologies necessary for military defense. In the long run, a stagnant economy may pose another type of security threat. It can lead to increasingly obsolete domestic production and therefore a military that is supplied with increasingly inferior domestic goods, services, and technologies at relatively higher

[49] Taliaferro, "State Building for Future Wars," 487–88.

[50] Taylor, "Political Decentralization and Technological Innovation"; Taylor, "Federalism and Technological Change."

prices than competing militaries. Hence a strong competitive economy can be important for the provision of security.

External security concerns can counteract domestic political resistance to innovation because they increase both the benefits of technological change and the costs of technological stagnation. First, technological innovation can create a more competitive economy on international markets, thereby boosting exports and earning the foreign exchange necessary to purchase strategic imports. Second, a globally competitive high-technology sector can also provide the foundation for a domestic defense industry, thus easing reliance on foreign weaponry. Finally, in civilian sectors, the development of indigenous high-tech capabilities can enable domestic industry to produce those strategic goods that are expensive to purchase abroad, have unreliable foreign suppliers, or are vulnerable to hostile interdiction. Higher levels of external threats therefore should cause political-economic elites to alter their calculus regarding the relative costs and risks of technological change. Indeed, as the threat balance shifts more and more toward the external, even many technological losers may recognize that their interests are better served by accepting the costs of technological change and the government actions supporting innovation.

THE INNOVATION CASES REVISITED

Although not explicitly theorized by Breznitz, Gallagher, or Zarsky, I argue that the empirical case studies each contain within them data that support the above relationship between domestic tensions, external security concerns, and national innovation rates. Combined with complementary research, these case studies show that addressing external security threats often requires that elites increase national innovation rates. Moreover, it is partly due to their ability to solve the market failures that obstruct innovation and to reduce the costs of technological development that elites turn to the institutions and networks extolled by the authors above.

Israel Revisited

Israel, for roughly two decades after statehood, was typified by a highly fragmented and divided political system.[51] Per capita immigration rates remained high for years as Israel was infused with waves of immigrants from around Europe, the Middle East, and Africa, who spoke diverse languages and came from different cultures and economic systems. Another domestic divide over resources and state policies pitted more educated, skilled, secular, white

[51] This section benefited from the advice of Jeremy Pressman and Lawrence Rubin.

Ashkenazi Jews from Europe against the more religious, less educated or skilled Sephardic Jews from the Middle East and North Africa. Both groups competed with an ultra-orthodox Jewish minority who questioned the legitimacy of a pre-messianic Israeli state and obligations to it.[52] Hence, social cohesion amongst Israelis was not strong, even within military units.[53] Golda Meir described Israel during this time as a "rather claustrophobic community, coping—not always well—with all sorts of economic, political, and social discontents."[54] Meanwhile, external threats were relatively less existential. Although menaced on all sides, Israel had only one major conflict after independence occurred in 1956; the conflict lasted for just two weeks, during which Israel acted as part of an overwhelming coalition with France and the United Kingdom against Egypt's nationalization of the Suez Canal.[55]

In this environment, the key to Israel's security was to forge a more durable, united polity. There emerged a highly interventionist state whose primary mission was to absorb Israel's disparate groups and knit them together into a strong, cohesive society that could defend itself against Arab incursions.[56] To accomplish this, the state promoted economic institutions and policies that favored agriculture and basic industries, as well as benefited the large labor and religious groups and the lower classes; but these institutions were not directed toward promoting S&T. Even within defense, there was scant focus on high technology. R&D was based in public research institutions with little or no private activity and low overall R&D spending (lower than any OECD country except Italy) or STEM labor (less than half the proportion of STEM labor as in frontier innovators like United States or Sweden).[57] Indeed, until the early 1970s, only a single Israeli university offered engineering degrees.[58]

The triggers for change in Israel's approach toward indigenous high technology were the twin crises of the state's first economic recession (1965–67) and the Six-Day War (June 1967). Prior to the first two crises, Israel depended on foreign imports for much of its energy, manufactured goods, and military hardware. In particular, France was its primary supplier

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[52] Howard M. Sachar, *A History of Israel: From the Rise of Zionism to Our Time* (New York: Alfred A. Knopf, 1976).

[53] For example, for months after the formation of Israeli state, both left and right parties tried to maintain private armies, each under their own command. Michael I. Handel, "Israel's Political-Military Doctrine," Occasional Papers in International Affairs, no. 30 (Cambridge, MA: Harvard University Center for International Affairs,1973).

[54] Golda Meir, quoted in Michael C. Desch, *Power and Military Effectiveness: The Fallacy of Democratic Triumphalism* (Baltimore: Johns Hopkins University Press, 2008), 129.

[55] Desch, Power and Military Effectiveness.

[56] Dan Horowitz and Moshe Lissak, *Trouble in Utopia: The Overburdened Polity of Israel* (Albany: SUNY Press, 1989).

[57] Breznitz, *Innovation and the State*, 44–46.

[58] Carl Alpert, *Technion: The Story of Israel's Institute of Technology* (New York: American Technion Society, 1982).

of weapons. However, on the eve of the 1967 war, France suddenly cut off Israel from its weapons exports, leaving the Jewish state strategically vulnerable to predatory neighbors. Meanwhile, the USSR emerged as ally of the Arabs, pitting Israel against a superpower. These external threats soon increased as repeated skirmishes erupted with Egypt (1969–70), Arab terror attacks rose, and Israel suffered the surprise attacks of the Yom Kippur War (1973). US support was then growing, but it was still new, of questionable reliability, and never entirely trusted by Israelis.[59] Moreover, after 1973, Israel fell into a twelve-year economic crisis. Economic growth slowed from 9–10 percent to 3 percent, foreign debts and inflation skyrocketed, and the banking system collapsed.[60]

On the domestic front, internal divisions were ratcheted down. The political, economic, and cultural differences between different Jewish groups became less severe, and immigration as a percentage of the total population had eased by the late 1960s, such that major sections of Israeli society were no longer being transformed on a regular basis. The major left-wing political parties, which had dominated Israeli politics since statehood, began to share power, however reluctantly, with the right.[61]

Thus, one could argue that, after 1967, Israel's balance of security concerns consistently shifted away from domestic tensions and toward external threats. Having forged a strong national identity and with major interest groups willing to compromise with one another on economic policy, Israel's main priority became to reduce dependence on foreign technology. The major actors and interest groups recognized that the creation of indigenous high-technology industries would not only decrease the Israeli military's reliance on foreign imports but would also create jobs and reduce pressures on the foreign exchange necessary to pay for strategic imports. By the early 1970s, labor and business groups had united to support a broad reform of Israeli political-economic institutions and networks favoring greater investment in science and technology, such as those documented by Breznitz in his case study.

Taiwan Revisited

I find within Breznitz's data, as well as in other recent studies, evidence that Taiwan's turnaround was also triggered by twin crises in economics and

[59] Asher Arian, *Security Threatened: Surveying Israeli Opinion on Peace and War* (Cambridge: Cambridge University Press, 1995).See also Desch, *Power and Military Effectiveness*; Jeremy Pressman, *Warring Friends: Alliance Restraint in International Politics* (Ithaca: Cornell University Press, 2008).

[60] Michael Bruno, "From Sharp Stabilization to Growth: On the Political Economy of Israel's Transition," Working Paper no. 3881(Cambridge, MA: National Bureau of Economic Research, October, 1991).

[61] Asher Arian, *Politics in Israel: The Second Generation* (New York: Chatham House, 1989)

security.[62] Taiwan largely ignored S&T for decades after its 1949 split from mainland China. During the 1960s, sharp declines in foreign aid to Taiwan initiated a brief, unsuccessful flirtation with industry-oriented technology policy. From a policy perspective, this early effort failed because the state was unwilling to knit together a cohesive domestic network between its education sector, R&D sector, and private industry. From a political perspective, it failed because political elites did not perceive advancement in technology as necessary for Taiwan's economic development, nor did they see either technological or economic development as vital for Taiwan's security. Taiwan's leadership therefore refused to give this first attempt at industrial science policy its full support.[63]

The triggers for long-run change in Taiwan were the 1971 de-recognition of Taiwan by the United Nations, the 1973 oil shocks, and the simultaneous reemergence of mainland China on the international political scene. Severed politically from key allies and threatened by a resurgent China, Taiwan now sought to embed itself economically in the global system by becoming a major supplier of essential electronics and computing components.[64] Competitiveness in these industries would also earn Taiwan the foreign exchange necessary to import vital supplies of energy, natural resources, and advanced weaponry. Taiwan's leaders now unequivocally linked economic development to Taiwan's political survival and hence their own.[65]

Ireland Revisited

Ireland is the least successful of Breznitz's cases and experienced the least severe external security concerns relative to domestic tensions. Ireland's history, until the mid-1990s, was one of both economic and technological underperformance, despite alternating between free market and state-interventionist policy trajectories. Gaining independence in 1921 as an agriculture-based free market economy, Ireland first changed its policy course during the Great Depression to pursue economic autarky behind high tariff walls. After 1958, Ireland steered itself back toward a neoliberal development path. The state began to provide economic and tax incentives to foster industrial development and investment, both to domestic firms and through FDI. To facilitate these efforts, Ireland proceeded toward free trade,

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[62] For other studies, see Megan J. Greene, *The Origins of the Developmental State in Taiwan: Science Policy and the Quest for Modernization* (Cambridge, MA: Harvard University Press, 2008).

[63] Greene, The Origins of the Developmental State in Taiwan, 71–92; Breznitz, Innovation and the State, 100–3.

[64] Breznitz, *Innovation and the State*, 9, 108, 111; Greene, *The Origins of the Developmental State in Taiwan*, 117–20.

[65] Greene, The Origins of the Developmental State in Taiwan, 117–20, 138–40.

joining GATT (1967) and the European Common Market (1973); but throughout both time periods, no special attention was paid to increasing domestic S&T output.

The catalysts for change in Ireland's approach toward indigenous high technology were extreme and prolonged levels of unemployment and emigration during the 1980s. This was not a short-run recession but a prolonged economic crisis that threatened the country's cohesiveness. From 1980 to 1997, Irish unemployment ranged between 10–18 percent, resulting in widespread private income and government problems and considerable emigration as approximately 1 percent of the island's population (especially its young, highly educated workers) left in search of employment elsewhere.[66] Ireland was fast losing the human capital base for its economy and hence its ability to earn foreign exchange. As a result, Ireland came to have one "overarching goal": employment.[67] Ireland's supply of low-wage, low-skill labor was not attracting employers, therefore Irish policymakers believed that the solution was to attract foreign high-tech MNCs. If successful, this strategy would not only create skilled (and therefore high-wage) high-tech, manufacturing, service, and supplier jobs but also become a source of foreign exchange earnings. There was, however, no external military threat to complement Ireland's economic crisis. Irish political-economic elites therefore were not motivated to invest deeply in indigenous S&T capabilities or the domestic institutions and international networks to build them. Thus, Irish development strategy switched from straightforward trade liberalization to supplying indigenous STEM labor and other incentives for high-tech FDI and exportation.

Mexico Revisited

The data also suggest that, like Ireland's, Mexico's crises were primarily economic, and their nature seems to have determined the state's approach to building institutions and networks. Because Mexico was virtually cut off from the global economy by a combination of the Great Depression, World War II, and its own import substitution industrialization policies, Mexican firms began producing radios, televisions, and other consumer electronics in the 1940s and 1950s, eventually moving into computer manufacturing during the 1970s.[68] An almost complete reversal occurred during the 1980s and 1990s, when threats to Mexico's economy took the form of recurring balance of payments and currency crises. Mexico suddenly became heavily indebted to foreign banks and governments. This was not only widely seen as

[66] Breznitz, *Innovation and the State*, 151. See also World Bank Development Indicators.
[67] Breznitz, *Innovation and the State*, 148.
[68] Gallagher and Zarsky, *The Enclave Economy*, 122.

humiliating to Mexico, but also as a threat to her policy independence and therefore an affront to her sovereignty.[69] In response, the Mexican state's primary goal became to increase foreign exchange earnings and thereby restore macroeconomic stability. Only then could Mexico escape the dictates of her foreign creditors.

At first, Mexico's response to this escalation in external threat was increased support for S&T-based innovation via domestic institutions. Trade, investment, and procurement policies were developed or changed to foster innovation in the automotive, pharmaceutical, microcomputers, and capital goods sectors. Taxes on business were reduced, and innovators and businessmen were given more freedom to increase their income earned through their industries.[70] But the economic shocks hit Mexico faster than these policies could counter: real wages plummeted, urban unemployment skyrocketed, and inflation rose sharply throughout much of the 1980s. Mexico's wealthy shielded themselves by shifting their assets abroad, leaving the middle and lower classes, especially the peasant farmers, to bear the burden of the economic crises. Hence, as inequality grew, domestic tensions began to rise. Robberies in the capital went up by 250 percent; major strikes and protests reached new highs; millions of desperate workers risked physical harm and incarceration to cross illegally into the United States; and meanwhile, corruption plagued federal and local government.[71] The incompetence of the government's response to the 1985 earthquake, which killed up to 40,000 people and left over one hundred thousand homeless, served to further catalyze domestic unrest. By the 1990s, domestic tensions had turned violent: an armed uprising of Zapatista rebels appeared in Chiapas; the ruling party's handpicked candidate for president was assassinated; police massacred agricultural protesters in poor farming regions; and a Maoist guerrilla movement (the Popular Revolutionary Army) rose up in Guerreo and initiated attacks on army, police, and government targets.

As these domestic tensions escalated, the Mexican government was forced to repeatedly shift its resources back to the provision of basic welfare, health, and education for the poor. As a percentage of GDP, federal spending on S&T activities was cut by over 50 percent during the mid-1980s, never to recover its 1981 peak of 0.45 percent of GDP. Other social spending was also cut but not by nearly so much.[72] In comparison, spending on education (mostly primary and secondary) was only cut by 30 percent, and health spending fell by only 23 percent. Furthermore, these two categories

[69] Ibid., 44–53, 125–32.

[70] Mario Cimoli, ed., *Developing Innovation Systems: Mexico in a Global Context* (New York: Continuum, 2000).

[71] Nora Lustig, *Mexico: The Remaking of an Economy* (Washington, DC: Brookings Institute, 1998).

[72] Organization for Economic Cooperation and Development (OECD), *Reviews of Innovation Policy: Mexico* (Paris: OECD, 2009).

remained the lion's share of social spending and, taken together, they never broke below 5 percent of GDP during the mid-1980s.[73]

Also, unlike Israel or Taiwan, Mexico had no military component to its external security concerns. Hence there was less motivation for the state to spend precious funds on research institutions, STEM training, or to finance risky S&T ventures. As many of Mexico's college-educated researchers were employed in the social sciences and humanities (27 percent of total) as were employed in the natural sciences (27 percent) and almost twice those employed in engineering and technology (15 percent).[74] Instead, Mexico merely sought to avoid frightening off potential foreign investors by lightening requirements for local ownership, joint-ventures, or technology transfer. In comparison, Israel and Taiwan had aggressively pursued domestic technological capabilities in the face of foreign threats. Absent similar external threats and facing swiftly escalating domestic tensions, Mexico's political leadership was content to wait and hope for knowledge spillovers and technology transfer to happen naturally, as foreign firms trained local workers and firms as suppliers in their technology production chains.[75]

SYSTEMIC VULNERABILITY, VETO PLAYERS, AND TECHNOLOGICAL DIFFUSION IN SOUTHEAST ASIA

The Politics of Uneven Development by Richard Doner provides further theoretical and evidentiary pieces of the puzzle.[76] The book also offers a rare collection of empirical evidence. Thailand serves as a middle case, having successfully achieved some degree of technological development but not having reached the heights of countries such as Taiwan, Israel, or Ireland. Moreover, within Thailand, different industries have innovated at different levels, therefore allowing for study of within-case variation. Although the primary focus of this book is on Thailand, it also contains shadow comparative case-studies of Indonesia, the Philippines, and South Korea. Altogether these constitute a good mix of cases of relative success, failure, and middle achievement.

Doner's dependent variable is the spread of new technologies throughout industries in developing economies. According to Doner, successful economic development is a two-stage process, composed of structural change and upgrading. Structural change is simply sector diversification: a broadening of domestic production out of agriculture and natural resources and into

[73] Lustig, *Mexico*, 79–81.

[74] Ludovico Alcorta and Wilson Peres, "Innovation Systems and Technological Specialization in Latin America and the Caribbean," *Research Policy* 26, nos. 7–8 (1998): 857 –81.

[75] Gallagher and Zarsky, *The Enclave Economy*, 8, 139–57.

[76] Richard Doner, *The Politics of Uneven Development* (New York: Cambridge University Press, 2009). Comments and advice from Richard Doner were invaluable for writing this section.

a wider portfolio of manufacturing and service industries. "Upgrading" is defined as moving up the value chain, producing at high levels of efficiency and doing so with local inputs.[77] Finally, "uneven development" refers to those countries, like Thailand, that have achieved middle-income status through successful structural change but then failed at upgrading. Structural change can be based on imports of foreign technology, but upgrading requires that LDCs develop domestic S&T capabilities.

Similar to that of other political economists, one of Doner's main emphases is on the importance of domestic institutions to solve the market failures associated with upgrading. Like Breznitz, Gallagher and Zarsky above, Doner argues that there is no "best" institutional design policymakers need converge upon; rather, different development tasks require different types and degrees of institutional capacity. Hence successful development is explained by the goodness of fit between a country's institutions and its stage of development. Networks are also important to Doner. The state must establish domestic networks so as to raise the overall level of STEM labor and prompt innovators to cooperate more thoroughly and efficiently with each other and with agents of financial and physical capital. Doner implies that states must also develop international networks for channeling foreign skills, knowledge, and technology into domestic industry.

Doner's institutions and networks, however, are not sui generis. They rely on key political players to support, not veto, them. For Doner, it is the number of veto players that determines the ability of the state to decide and commit to upgrading. There exists a sweet spot where too few veto players will allow the state to suddenly abandon upgrading, and too many veto players may prevent elites from forming a consensus to pursue upgrading in the first place. Doner further argues that a polity's number of effective veto players is determined by three variables: formal government structure (the vertical and horizontal separation of powers), the diversity of preferences amongst office holders, and the distance between these diverse preferences.[78]

In the background sits security, which Doner invokes under the rubric of systemic vulnerability. "Systemic vulnerability" is defined as the sum of three separate pressures on political elites: external security threats, domestic popular discontent, and economic resource constraints. Doner argues that increases in systemic vulnerability can cause an increase in elite interest in economic growth.[79] Increased systemic vulnerability also causes a decrease

[77] Ibid., 7–9.

[78] Ibid., 91–94.

[79] Etel Solingen makes a similar argument for why states pursue nuclear weapons technology and even conflict itself. Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia & The Middle East* (Princeton: Princeton University Press, 2007); Etel Solingen, "Pax Asiatica versus Bella Levantina: The Foundations of War and Peace in East Asia and the Middle East," *American Political Science Review* 101, no. 4 (2007): 757–80.

in the effective number of veto players by affecting players' preferences.[80] Although this model is similar to my domestic tensions vs. external security approach, Doner puts less emphasis on security and more on the institutional determinants of veto players. Also, his dependent variable is not national innovation rates but economic development in general and the diffusion of technology in particular.

The case-study evidence Doner presents, combined with complimentary research, is supportive nevertheless. Doner argues that, from the 1950s onward, Thailand faced fluctuating and generally moderate levels of systemic vulnerability that got high enough to motivate Thai elites to pursue structural change but not upgrading. Thailand's level of systemic vulnerability was primarily determined by economic pressures, with intermittent external security threats. Thailand's best progress in national S&T performance came on the heels of the 1980s debt crisis and the 1997 financial crisis.[81] As these crises intensified, the number of effective veto players shrank, and policies for innovation-based economic growth moved forward in a decisive manner; yet when these systemic vulnerabilities subsided, so too did the political will to innovate.[82] Diverse interest groups reasserted their individualist preferences, and support for the institutions and networks necessary for innovation faded. Moreover, comparing across three separate industries (sugar, textiles, and automobiles), Thailand has been relatively more successful at upgrading in those industries where the barriers to technological change are lower. In sugar, the industry with the least barriers to S&T upgrading, Thailand performed best with significant, widespread mill expansion and modernization.[83] As we move up the value chain into textiles and automobiles, Thailand does successively worse, demonstrating less innovation and development of indigenous S&T capability.

Furthermore, Thailand's success at upgrading relative to Indonesia, the Philippines, and South Korea generally correlates with the different degrees and duration of systemic vulnerability felt across these countries. For my purposes, it is also noteworthy that Indonesia and the Philippines failed to innovate well because both these countries suffered relatively higher domestic tensions than external threats. Since independence, Indonesia has regularly faced violent sectarian infighting, including threats from armed Marxist cells, rebel factions in East Timor and West Papua, an ethnic Javanese movement

[80] Doner, *The Politics of Uneven Development*, 19; See also Richard F. Doner, Bryan Ritchie, and Dan Slater, "Systemic Vulnerability and the Origins of Developmental States: Northeast and Southeast Asia in Comparative Perspective," *International Organization* 59, no. 2 (2005): 327–62.

[81] Doner, *The Politics of Uneven Development*, 118–19, 125–26, 129–30.

[82] See also Richard F. Doner, Allen Hicken, Bryan K. Ritchie, "Political Challenges of Innovation in the Developing World," *Review of Policy Research* 26, nos. 1–2 (2009): 151–71.

[83] Ibid., 141–81.

in central Aceh, and terrorist Islamic groups.[84] Hence, Indonesia's military, which plays a decisive role in the country's politics, is almost entirely focused on keeping these domestic tensions in check.[85] Meanwhile, for their economic security, Indonesians can rely on petroleum exports; thanks to oil, even the 1998 financial crisis only resulted in a single year of negative growth for Indonesia.

In the Philippines, external military threats have been shouldered by the United States for generations, and regular infusions of foreign aid can be counted on to cushion the worst economic crises. Instead, the main threats have sprung from extreme economic inequality. Since independence, Philippine political economy has been typified by a well-entrenched wealthy elite that must constantly defend itself against militant labor and socialist movements. A form of "mafia capitalism" has since evolved, with occasional infighting occurring amongst the elites, and the masses of poor paying for it.[86] Meanwhile, the Philippines' few forays into high technology have been termed "asymmetric" by scholars, dominated by foreign multinationals providing temporary employment to powerless, low-skilled workers. National institutions and policies have not been used to solve market failures and promote networks in way that advances long-run, indigenous technological innovation.[87]

Meanwhile, South Korea has outperformed because its level of systemic vulnerability was consistently elevated over long periods of time.[88] South Korea has sparse natural resources and sits in the immediate neighborhood of bellicose and jingoistic North Korea, a resurgent China, and the Japanese techno-nationalist economic juggernaut. Although heavily dependent on US economic and military aid, South Korea's threats are more proximate and existential than the Philippines'. Koreans know from Cold War history that failure to bear their own defense or economic burden can have dire consequences. South Koreans' domestic relations, although far from quiescent, have been tempered by relatively low inequality originating in drastic postwar land reforms.[89] Thus, with considerable support from the Korean military and reluctant submission from farmers and labor groups, big business has cooperated with the state to implement industrial, trade, and investment policies, along with subsidies for R&D, with the goal of vaulting Korea to the

[84] Jun Honna, *Military Politics and Democratization in Indonesia* (New York: RoutledgeCurzon, 2003).

[85] Damien Kingsbury, *Power Politics and the Indonesian Military* (New York: Routledge, 2003).

[86] Marissa de Guzman, Mary Lou Malig, and Herbert Docena, *The Anti-Development State: The Political Economy of Permanent Crisis in the Philippines* (New York: Palgrave, 2005).

[87] Steven C. McKay, Satanic Mills or Silicon Islands? The Politics of High-Tech Production in the Philippines (Ithaca: Cornell University Press, 2006).

[88] Doner, *The Politics of Uneven Development*, 266–72.

[89] For a direct comparison of South Korea and the Philippines, see David C. Kang, *Crony Capitalism: Corruption and Development in South Korea and the Philippines* (New York: Cambridge University Press, 2002).

technological frontier.[90] Periodic labor strikes and political violence occurred, but these were responded to with a combination of short-run repression and long-run increases in real wages, social programs, and democratization.[91] Meanwhile, Koreans across society have enjoyed ever increasing standards of living and levels of consumption, much of which is attributed to indigenous technological change. Thus Korea's internal tensions have not evolved into a systematic challenge to her technological development.

TOWARD AN INTERNATIONAL RELATIONS THEORY OF NATIONAL INNOVATION RATES

We now have the components for a more complete theory of technological change, with each of the IR subfields contributing major pieces to the solution of the puzzle. This article argues that a proper synthesis of security, IPE, and CPE theories of innovation should model security concerns as a balance between domestic tensions and external threats, where the latter includes strategic threats to a nation's economy.[92] It then links this balance of security threats to technological change, through the tools of institutions and policies. On the one hand, domestic tensions therefore act as a force to slow and obstruct support for technological change and the institutions that promote it. On the other hand, technological change offers a solution to external threats due to its ability to build an indigenous defense capacity, and civilian innovation can forge a more competitive economy. Summing these two causal mechanisms, the hypothesis from which my model flows is: countries for which external threats are relatively greater than domestic tensions should have higher national innovation rates than countries for which domestic tensions outweigh external threats.

If the relative balance of security concerns helps to determine support for (or opposition to) technological change, then this relationship should show up in the empirical data. Countries whose domestic tensions outweigh external threats should innovate less than countries whose external threats dominate over domestic tensions. Security threats may have subjective components (based on perception, psychology, and social construction), but if this theory is to have useful explanatory power, then it should nonetheless find support in cross-national correlations in some relatively non-controversial observables.

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[90] Alice Amsden, *Asia's Next Giant: South Korea and Late Industrialization* (New York: Oxford University Press, 1989).

[91] Eun Mee Kim, *Big Business, Strong State: Collusion and Conflict in South Korean Development* (Albany: SUNY Press, 1997).

[92] For an introduction to the nontraditional security threat literature, see Michael E. Brown, Owen R. Cote, Sean M. Lynn-Jones, and Steven E. Miller, eds., *New Global Dangers: Changing Dimensions of International Security* (Cambridge, MA: MIT Press, 2004).

TABLE 1 Indicators of a Country's Relative Balance of Security Concerns

External Threats > Domestic Tensions	Domestic Tensions > External Threats
• Fewer labor strikes	• More labor strikes
• Lower economic inequality	• Greater economic inequality
• Higher imports of food and energy as% of total consumed	• Lower imports of food and energy as% of total consumed
• Longer recent history of external conflicts	• Shorter recent history of external conflicts
• No recent civil war	• Recent civil war
	• Anti-S&T, pro status-quo military dictatorship

For the purposes of theory development, I offer two prima facie empirical tests of this security balance-innovation theory. These empirical investigations are not intended to provide exhaustive hypothesis testing; rather, they are meant to demonstrate the plausibility of the theory and to lay a credible empirical foundation upon which more rigorous research can be built.

In the first plausibility test, I rank forty-two countries according to their relative balance of security concerns and national innovation rates. Following the standard practice of innovation scholars, national innovations rates are measured using technology patents per capita, weighted by forward citations, granted during a specified time period. The relative balance of security concerns is estimated using data summarized in Table 1. Countries are ranked relative to one another in each category (strikes, inequality, etc.), then split into above average and below average groups, and assigned a +/- 1 accordingly. These scores are then summed across categories to provide a rough approximation of the overall relative balance of security concerns for each country. Further explanation of country selection, data, and methods can be found in an online appendix.[93]

Table 2 shows the results of this test for the 1970–2005 period. Countries with the highest overall innovation rate during this time period are indicated in boldface; asterisks indicate those nations with greatest and most rapid positive changes in their annual innovation rates during this time period. The relative balance of security concerns is indicated along the left-right dimension. Countries with relatively greater external threats than domestic tensions are placed to the left within the table.

The results generally support the security balance-innovation thesis. In Table 2, included amongst these "relatively more external threat" states are all of the nations with the largest and most rapid improvements in annual innovation rates during the past several decades (Finland, Ireland, Israel, Japan, South Korea, Taiwan). Although each of these countries was troubled by domestic tensions, these tensions were outweighed by external threats.

[93] http://mzak.net/research. See also Taylor, "Empirical Evidence."

TABLE 2 Relative Balance of Security Concerns vs. National Innovation Rates (1970-2005)

Relative Balance of Security Concerns				
More External Strongly External	← Moderately External	Balanced	→ Moderately Domestic	More Domestic Strongly Domestic
Hong Kong	Austria	**France**	Australia	Argentina
Israel*	**Belgium**	**Netherlds**	**Canada**	Brazil
Japan*	**Denmark**	Norway	Costa Rica	Chile
S. Korea*	**Finland***	Singapore	Italy	El Salvador
Sweden	**Germany**	Turkey	Jamaica	Greece
Taiwan*	Hungary		Libya	Mexico
USA	Ireland*		Spain	Panama
	New Zealand		Venezuela	Peru
	Portugal			Saudi Arabia
	Switzerland			S. Africa
	UK			Uruguay

Source: NBER Patent Database; OECD PATSTAT database; University of Texas Inequality Project; World Bank Development Indicators.
*Nations with largest and most rapid improvements in annual innovation rates between 1970 and 1995. Boldface = overall top innovating nations 1970-2005.

In some of these countries, innovation could not proceed until domestic tensions had been reduced, either by compensating, coercing, or convincing the losers to allow it (for example, Japan, South Korea, Taiwan). In others, changes in external military or economic threat triggered drives for technological competitiveness (for example, Israel, Ireland, Finland). Some of these cases were reviewed above. Note also that included amongst the "relatively more external threat" countries are ten of the fourteen most innovative countries overall. In fact, only one country, Hong Kong, has the highest level of relative external threat but is not ranked as a top innovator. Meanwhile, none of the eleven countries with the highest relative levels of domestic tension are ranked as top innovators. In fact, of the nineteen "domestic tension" countries listed in the right half of the table, only one, Canada, is a top innovator.

A second set of supporting evidence is presented below in Figure 1. If external threat partly determines national innovation rates, then higher levels of external threat should correlate with higher national innovation rates ceteris paribus. The Correlates of War dataset allows us to check this prediction by providing variation in external threat. In Figure 1, correlation coefficients are presented between threat levels and overall national innovation rates for the 1975–1995 period. Figure 1 reveals that instances of full war correlate more highly with overall national innovation rates than with instances of the use or display of force for this twenty-year period. Instances of the threat of force correlate slightly more highly with innovation than instances of the "display" or "use" of force, but all of these are positively correlated with

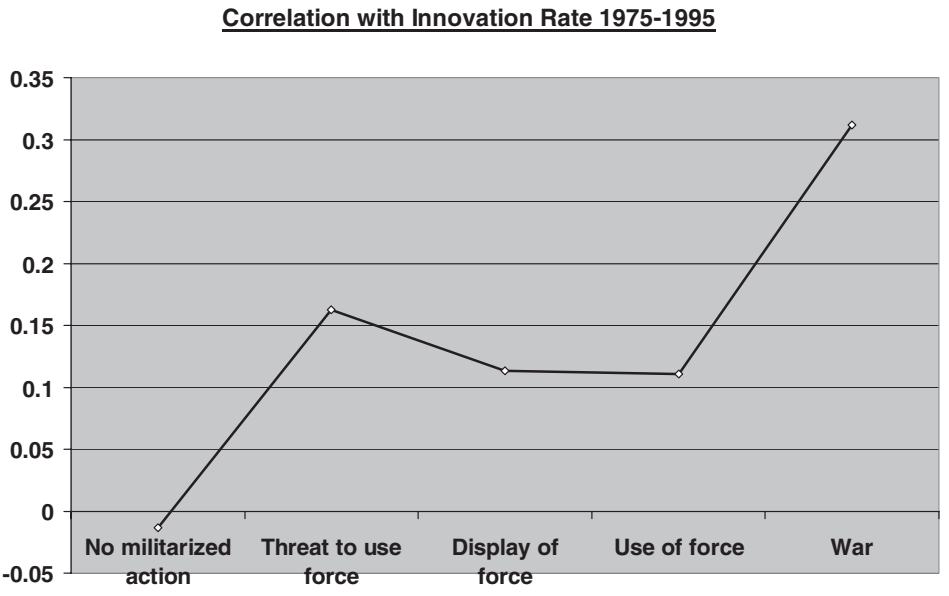

FIGURE 1 Innovation and Level External Threat. *Source*: Correlates of War Dataset; NBER Patent Data Set. *Note*: "Innovation Rate" is patents per capita weighted by forward citations for patents granted during the 1975–1995 period.

innovation. Meanwhile, "no militarized action" has a negative correlation with overall national innovation rates. Thus higher levels of external threat correlate better with national innovation rates than lower levels of external threat.

These tests are simple and subject to debate; however, they are useful in that they provide a Van Everan "hoop test" that should flunk the theory if failed. Having passed these simple face-validity tests, the task for scholars is to design stricter analyses with which to go beyond correlation and better get at causal mechanisms. Such analysis might consider outlier cases that both contradict the conventional wisdom and present significant variation on the independent variables (for example, Finland, Spain, historical Great Britian). Given the sometimes subjective, often shrouded measures and causal mechanisms, scholars should use both statistical and qualitative methods in a complementary fashion where possible to achieve maximum rigor.

CONCLUSIONS AND IMPLICATIONS

What has this essay found then? I would argue that we can derive three sets of conclusions. First, it has substantiated several novel empirical findings:

- Innovation is inherently political in that it involves highly contested decisions over the allocation of resources, institution and policy design, and the formation and maintenance of domestic and international political-economic networks. The study of technological innovation therefore should not be left to economists, business scholars, and sociologists who tend to ignore or dismiss politics in their research. Political scientists have competitive advantage here and should assert it.
- Domestic institutions and policies influence the rate and direction of inventive activity; but they are tools, not causal forces. Scholars studying the sources of national technological performance therefore should look beyond domestic institutions and policies to the fundamental political bargains upon which they are based and the international political forces that act to change them.
- International networks of trade, finance, production, knowledge, and human capital flows also play important roles in determining national success in high technology; but like institutions, they are not causal. They are means to a national technological ends.
- The balance of domestic vs. external security concerns (broadly defined to include threats against access to foreign exchange) appears to play a major causal role in influencing national technological trajectories. Thus security and IPE are intimately bound together though technological innovation in a causal relationship that is understudied in IR. Into the basic security-innovation model described above, future research might incorporate: (1) the endogeneity of institutions, (2) the role of natural resource endowments (the "resource curse"), and (3) explanations for cross-national variation in investment in military vs. civilian technological innovation.

Second, this article has revealed that a diverse set of political scientists can improve our understanding of national innovation rates. Throughout the discussion above, theory and research by security studies and political economy scholars play complement to one another, with insight and advances in one field acting to fill in the others' gaps. Unfortunately, these complementarities often go unrealized. In many ways, the scholars cited in this essay resemble the proverbial men in a dark room who examine different limbs of an elephant and then disagree upon what animal is before them. In fact, despite similar findings on questions of common interest, few of these scholars cite one another, and many seem unaware of the contributions each may have for the other. Collectively, their work therefore demonstrates the value of bringing together diverse theories, methods, and data for explaining national innovation rates and pointing toward the policy implications of these findings. Hence this review can be interpreted as a call for greater integration of science and technology politics within the major subfields and especially as a basis for synthesis between IPE and security studies. We need to combine dispersed problem-specific and country-specific approaches into

a more generalizable theoretical and policy-relevant cross-field debate about the politics of innovation. Thus, this review is also a call for greater cooperation and common focus amongst fragmented S&T scholars within political science and across the social sciences.

What should such a debate look like? Naturally, every subfield and scholar will offer a different opinion. But this diversity is a virtue, not an obstacle. It dovetails well with the broad opportunities for research in the politics of S&T. For example, there is substantial intellectual territory for each of the major theoretical perspectives. Realists might investigate the security and competitive pressures on countries to develop or obstruct S&T and the ability of technology to affect systemic change. Liberal institutionalists should relish the collective actions problems, public goods issues, transactions costs, risk, and imperfect information associated with S&T development. They might also probe the ability of technology to affect systemic governance or the endogeneity of institutions. Constructivists might examine the formation and evolution of technonationalism and how the identification and defining of security threats become linked to the identification and definition of S&T as either a solution or a threat in itself. Neo-Marxists should be drawn to the issues of power and control inherent in S&T: the decisions over who gets to govern it, use it, and decide its trajectory. Is technological change leading us to a world of greater cooperation, human rights, and stronger democracy, or down a path toward the domination by a new S&T elite? Adherents to the new Open Economy Politics paradigm should appreciate the opportunity to model how the combination of international and domestic macro-economic forces (balance of payments, flows of economic inputs, domestic internal balance) triggers political change.

I would end this essay by repeating the assertion with which it began: the paucity of research on the politics of science, technology, and innovation is holding back progress in several major debates within international relations. Science and technology play important causal roles in questions of cooperation and conflict, systemic governance, systemic change, the evolution of institutions, and the developmental state, to name but a few. Technology changes the interests of states and the role of government by reconcentrating power and by allowing new activities and producing new market failures. We possess, however, only a basic understanding of the political causality surrounding S&T, either as an independent or dependent variable. Science, technology, and innovation therefore appear to constitute a "reverse salient" in the study of international politics.[94] Furthermore, studies of economic growth, comparative advantage, production theory and even some aspects of finance theory all hinge on technological change as an independent variable. This implies that, until we can explain technological change

[94] Mark Z. Taylor, "International Political Economy: The Reverse Salient of Innovation," *Review of Policy Research* 26, nos.1–2 (Jan/Mar 2009): 219–23.

as a dependent variable, these lines of research will likewise suffer. The conception of a political theory of technological change therefore has greater stakes than simply satisfying the intellectual curiosity of a handful of S&T scholars. It will have a major impact on scholarship across political science, economics, and business. It should therefore be made a greater priority for political research. A better understanding of science, technology, and innovation will help political scientists in all subfields better solve their problems, answer their major questions. It is therefore time for this debate to enter the political science mainstream.