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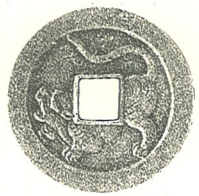

"RICH NATION, STRONG ARMY"

NATIONAL SECURITY AND THE TECHNOLOGICAL TRANSFORMATION OF JAPAN

RICHARD J. SAMUELS

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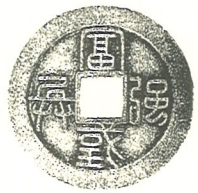

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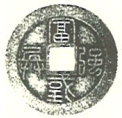
To Brad and Alex

CHAPTER ONE



The Strategic Relationship of the Military and Civilian Economies

Guns will make us powerful; butter will only make us fat.
—Hermann Goering
Reichsmarshal, 1936

The English language is rich in borrowed metaphors for the relationship between civilian and military activities. The King James Bible (Isaiah 2:4) speaks of beating swords into ploughshares. The trade-off between guns and butter that so dominated the Vietnam and Korean war debates originated with Nazi planners.[1] Often the metaphors have been physiological: to Mutianus and Bacon, money was the "sinew of war"; for Jean-Baptiste Colbert trade was "the source of finance and finance [was] the vital nerve of war." Mary Kaldor asks if defense spending is a spur to the development of technology or if it is a siphon, a boost, or merely a baroque ornament.[2]

The sinews and nerves of war in the late twentieth century, however, have become as much technological as financial. The United States responded to the mid-century Soviet threat with "force multipliers," deploying one of every three scientists and engineers in defense-related work.[3] The Persian Gulf War of 1991 seemed to reinforce the view that wars are won, troops fielded, aggression deterred, and nations defended by inventions from laboratories as much as by silver from national treasuries. The industrialization of war in the Cold War United States also involved the militarization of technology.[4] But militarization did more than enhance defense capabilities, it introduced new products and processes that profoundly affected the distribution of wealth and the economic vitality of entire nations. In sum, it transformed balances of power in times of war and peace alike.

A paradox frames this book, a paradox whose implications have an extraordinary importance. Japan came to global preeminence in many dual-use technologies, *without* making significant investments in the military economy. Despite its extremely low spending on defense, Japan is becoming a global leader in innovative products with military applications. The United States, by contrast,

pursued guns and butter simultaneously: its defense establishment became the largest single source of R&D funding in the world. Nonetheless, as an ironic counterpoint if not a causal consequence, the relative strength of the U.S. technical base has declined.

The production of arms has shaped technology and, indeed, the behavior of the entire economic system. How can we best understand the technological interdependence of military and civilian production? How do different nations at different times understand the interdependence of economic and political power? How do nations choose between guns and butter? How do the choices they make constrain the choices that confront their children? How do these choices change as technology and industry change? We have a considerable intellectual heritage concerning the relationship of technology to the general economy and to grand strategy, but little in the Western intellectual inheritance offers a reliable guide to the centrality of ideas and values. This absence conceals a consensus so powerful we hardly notice it, a particular ideology with so powerful a grip that we take it to be a fact of nature rather than the result of choices, disagreements, contests. This book describes a rather different national system from that of the United States. And one result, I hope, will be a more nuanced understanding not only of America's most powerful industrial competitor but also of the organization of U.S. thinking about technology and national security.

Liberalism—the belief in the sovereignty of rational individuals rather than of nations—has dominated much of that thinking. It seems as if Americans want so much to believe in their personal sovereignty that they have embraced ideas that posit that all the world's people will become individually sovereign "just like us." We have wanted to believe that "internationalization" will solve problems of national security (ironically, by restricting individual freedom through mutual dependence) and erase the retrograde nationalism inhibiting social progress toward that convergent end—liberal democracy. But Japan is important because it shows how much more is possible than we currently acknowledge, especially as regards providing for national security.

Japan shows that America's focus on individual welfare, and on concepts of security in an international world where individual rights are paramount, ignores the crucial role that collective action—what we call, in normal parlance, "national interests"—plays in fostering individual rights. Unless societies organize to defend the wealth of the individuals they comprise—including their skills, productive relationships, and the firms and R&D centers that create their wealth—much of what their citizens value will erode. This is not to say that Japanese national strategies are themselves a solution to the country's domestic security objectives or, as is more problematic, its relationships with other societies in the modern world. In many respects, Japan's challenge is the obverse of America's: Japan needs to complement its predominantly national focus with a more universal objective. Yet, Japanese practice makes clear that collective

benefit and national security can derive from the institutions of the economy and innovation as well as from the deployment of forces.

Specifically, Japan shows how nations can foster the geographic collection of skills and resources that enable a people to define and then defend their (often nonliberal) ideas about a just society. Japan shows that it is the nation that must construct security and defend its citizens from the losses of skills and wealth, losses that can be as devastating as the losses of territory. Japan teaches that the proper way of thinking about national security may not be self-evident. It suggests that those who embrace ideas they believe to be self-evident may overlook ways to make themselves strong and secure. Japan's experience with military enterprise thus becomes important for what it teaches us both about history and about future possibilities for industrial technology, regardless of its application.

The Japanese experience with military enterprise is long and rich. Since the turn of the seventeenth century, Japanese leaders have inspired their subjects and more recently their citizens to sacrifice for national security in a hostile world. Central to the Japanese quest for security has been what Tetsuo Najita sees as a pervasive perception that Japan "assures its autonomy only through economic power—*fukoku*. . . . [The government's] 'mission' [is] to enhance the well-being of the nation through the systematic creation of industrial wealth."[5] This underlying ideological consensus has been central to Japanese national development. It has informed significant organizational innovation, and these innovations have led Japan to the threshold of global power.

In this book I review the Western experience in general terms and the Japanese historical record in detail. I conclude that the institutional development of whole economies (and thereby the trajectories of innovation and growth) depends on the way technology is understood strategically and the role it plays ideologically. I show how choices made by Japanese planners have served consistently to enhance the Japanese technology system in two ways: by stimulating the interdiffusion of technology between civilian and military applications, and by embedding military production in the commercial economy. Each tactic has helped to enhance Japanese national security under the postwar U.S. umbrella, but each was enabled by a technology and security ideology that originated in Imperial Japan.

This book is about the influence of ideas of security, technology, and the economy on what nations defend as their key interests. Cold War America defended territory but acted as if its economic interests were a subordinate component of national security. Indeed, at the extremes, it created isolated "Manhattan Project" technology or production development efforts, rather than explicitly linking commercial activities with military needs, to meet defense requirements. It also routinely traded technology and economic advantage for political and military objectives. The Japanese were never taught to make such a distinction between national defense objectives and economic interests and

indeed reject such arguments as naive whenever they are presented. Instead, technology and production, as well as territory, are each seen as national interests that can and must be defended. Two different ways of approaching civilian and military technology development thus grew from the divergent ideas that the United States and Japan had about national interests. For years, the Cold War obscured the consequences of that divergence and made it possible for Americans to believe that they had found the single right way of defining and organizing to meet their defense needs.

In the United States during the Cold War, private research and development grew considerably smaller relative to public R&D. In Japan, the opposite was true. Military R&D became the single largest source of R&D spending in the United States, whereas in Japan it virtually disappeared. Since both military and trade relationships depend increasingly on technology, and since the end of the Cold War is stimulating considerable readjustment, the relationship between civilian and military activities *within each of our economies* has become central to the U.S.-Japan relationship. Americans have lessons to learn for the future from the way the Japanese have subordinated defense production yet emerged as one of the most technologically sophisticated nations in the world. The Japanese may have demonstrated, like the Venetians and the Dutch before them, that butter is as likely as guns to make a nation strong and, further, that nations cannot be strong without advanced technology. In essence, the Japanese story is one in which ideology and institutions are linked, shaping strategic choices based on different conceptions of national interests than are widely accepted in the United States. To see how these ideas shaped the industrial and security choices each nation made, we must therefore consider what our major theorists have to say about the link between military and industrial interests. As we see in the next section, the thinkers who fashioned the dominant liberal ideology actually offered what in retrospect seems a particularly limited view of the economic and technological aspects of national security. At the same time, many of their contemporaries were much more aggressive in arguing that economic welfare is central to national security, ideas that resonated in Japan but did not take root in the United States. But for the resolution of industrial security debates in favor of the classical liberal scholars, America could well have integrated its military and commercial economies more effectively.[6] We begin, therefore, with the ideas and doctrines that dominate our intellectual repertoire for thinking about associations between wealth and national security.

The Political Economists: Linking Markets, Technology, and National Security

We start with a surprise: the economic foundations of military power and the military foundations of economic power have not preoccupied great theorists of economy and society.[7] Classical theorists such as Adam Smith and Karl Marx paid little attention to the interdependence of military and civilian economies. Alexander Hamilton and Friedrich List did not focus closely on the importance of technology. And those theorists who looked carefully at technology, such as Joseph Schumpeter, largely ignored its diffusion between civilian and military applications. There have been a plethora of ideas about the organization of production, each weakly linked to ideas about security or technology. As a result, practitioners have been "free to choose" (in the classical liberal formulation) among often inconsistent or ambiguous ideas about national wealth and strength.[8] As we see here, their choices mingled with their institutions to create new opportunities and to foreclose others.

Let us begin with the liberal tradition. Adam Smith's purpose was to limit the sovereign and to free markets for trade, for economic progress, and (very specifically) for entrepreneurs. He accepted state intervention in the economy only when it might provide the nondivisible "public goods" investors would not produce on their own. Smith accepted defense as a public good, but he limited that acceptance in two important ways. First, because the military was expensive to maintain, only an otherwise rich and productive nation could defend itself in modern times: "The first duty of the sovereign . . . that of defending the society from violence and injustice of other independent societies, grows gradually more and more expensive, as the society advances in civilization. . . . A musquet is a more expensive machine than a javelin or a bow and arrows; a cannon or a mortar than a ballista or a catapulta. . . . As the superiority of the modern artillery too, over the ancients is very great, it has become much more difficult, and consequently much more expensive, to fortify a town." Second, the military is parasitic; it drains resources away from productive purposes. Smith compared lawyers, opera singers, and scholars with generals and declared that "the labor of some of the most respectable orders in the society is, like that of menial servants, unproductive of any value. . . . The sovereign, for example, with all the officers both of justice and war who serve under him, the whole army and navy, are unproductive laborers. Their service, how honorable, how useful, or how necessary so-ever, produces nothing for which an equal quantity of service can afterwards be procured. The protection, security, and defence of the commonwealth, the effect of their labor this year, will not purchase its protection, security, and defence for the year to come."[9] In short, military forces were necessary but parasitic appendages to modern economies. The prophet of liberalism said little, however, about the factories that produce weapons or the scientists and engineers who design them.

The senior statesman of nineteenth-century mercantilism, Friedrich List, for whom productive power of manufactures was central to national security, had rather more to say on this matter.[10] He followed Smith on the economic foundations of military power. Strong armies and national survival depend on national wealth: "War or the very possibility of war makes the establishment of

a manufacturing power an indispensable requirement for a nation of the first rank." "Power is of more importance than wealth . . . because the reverse of power—namely feebleness—leads to the relinquishment of all that we possess, not of acquired wealth alone, but of our powers of production, of our civilization, of our freedom, nay, even of our national independence, into the hands of those who surpass us in might."[11] But List disagreed fundamentally with Smith over the role of public officials in ensuring the generation of national wealth. He ridiculed Smith's notion of productive labor by pointing to the role of scientists: The man who rears pigs is thus a productive, the man who teaches men is an unproductive member of society. The physician who saves the lives of his patients does not belong to the class of producers, but the chemist's boy does, although the exchange-values (the pills) which he produces may only exist for a few minutes before they become valueless. A Newton, a Watt, or a Kepler is less productive than an ass, a horse or a plough-ox." List argued, against Smith, that comparative advantage is not only bequeathed; it can be *created.* Its creation requires a nation to "sacrifice some present advantages in order to insure to itself future ones." In the short term, protection is undoubtedly less efficient than free competition, because the protected goods are more costly. In the long term, however, the price paid to protect infant industry might well prove a good investment.[12]

A nation must promote military as well as civilian manufacturing if it is to maintain its independence. Indeed, List inverted Smithian ideas about the relationship of free trade and peace. It is not that the former inexorably generates the latter. Rather, List suggested, the constant danger of war requires each nation to maintain its productive capacity (even by means of tariff protections). Presaging contemporary disputes, List stated his views of war and trade clearly: "War is nothing but a duel between nations, and restrictions of free trade are nothing but a war between the powers of industry of different nations."[13] He asked sardonically whether nations should refrain from arming themselves, because they would certainly be happier not using weapons. The obvious answer, he argued, has an economic analogue: simply because free trade would bring greater prosperity does not mean that nations should fail to protect their citizens' welfare through tariffs and other means.

This is, after all, a real world of competing nations, not an ideal world of interest-maximizing individuals. Speaking of Smith on this point, List argued that "his error consists in not adding to those general principles the modifications caused by the fraction of the human race into national bodies."[14] List, like traditional mercantilists, appreciated that the economic interest of individuals and the economic interest of the nation might diverge. There is a national purpose larger than individual utility, and, although citizens may from time to time have to sacrifice wealth for power or power for wealth, these are fundamentally compatible goals, each valuable for its own sake.[15] Wealth and power, in sum, are both legitimate aims of public policy.

The military is just one of many means to protect national welfare:

> Government, sir, has not only the right, but it is its duty, to promote everything which may increase the wealth and power of the nation. . . . So it is its duty to guard commerce by a navy, because the merchants cannot protect themselves; so it is its duty to protect the carrying trade by navigation laws, because carrying trade supports naval power, as naval power protects carrying trade; so the shipping interest and commerce must be supported by breakwaters; agriculture and every other industry by turnpikes, bridges, canals, and railroads; new inventions by patent laws; so manufactures must be raised by protecting duties, if foreign capital and skill prevent individuals from undertaking them.

List did, on occasion, go further; he drew a direct *causal* link between warfare and economic prosperity. "Did not the last war create a navy and lay the corner-stone of a manufacturing industry? . . . The contests between nation and nation, often pernicious and destructive to civilization, were as often causes of its promotion."[16]

Although technology for military production was not central to List's work, he was not silent on the matter: "The present state of nations is the result of the accumulation of all discoveries, inventions, improvements, perfections, and exertions of all generations which have lived before us. . . . Every separate nation is productive only in the proportion in which it has known how to appropriate these attainments of former generations and to increase them by its own acquirements."[17]

Japanese ideas about the relationship between wealth and might, it turns out, are more consonant with Listian neomercantilism than with Smithian liberalism.

Karl Marx largely ignored List and the mercantilists, focusing instead on Smith and other "modern bagmen of free trade."[18] He ridiculed Smith's association of generals with opera singers, distinguishing between productive and unproductive labor but arguing that the difference is not based on material product. An opera singer, he suggested, can be productive because labor has a *social* aspect; entertainers can create surplus value as surely as factory hands can. Of Smith's equation of generals and opera singers, Marx wrote:

> [This is] the language of the still revolutionary bourgeoisie, which has still not yet subjected to itself the whole of society. . . . When on the other hand the bourgeoisie has won the battle, and has partly itself taken over the state, partly made a compromise with its former possessors . . . then things take a new turn, and the bourgeoisie tries to justify economically, from its own standpoint, what at an earlier stage it had criticized and fought against. . . . These economists, who themselves are priests, professors, etc., are eager to prove their "productive" usefulness to justify their wages economically.[19]

Like Smith and List, Marx had little to say directly about the production of arms and about the productive (or unproductive) role of the scientists and engineers who build them.

His associate, however, had more on the subject. Friedrich Engels outlined the material superstructure of force in 1878:

> The triumph of force is based on the production of arms, and this in turn on production in general—therefore on the *material* means which force has at its disposal. . . . Force is conditioned by the economic order which furnishes the resources. . . . Nothing is more dependent on economic preconditions than precisely the army and navy. . . . It is not the "free creations of the mind" of generals and genius which have revolutionized war, but the invention of better weapons. . . . The modern warship is not only a product, but at the same time a specimen of modern large-scale industry, a floating factory—producing mainly, to be sure, a lavish waste of money.

For Engels, new weapons technologies above all else represented *economic* advance. Invention was undifferentiated with regard to application: "Industry remains industry, whether it is applied to the production or the destruction of things." More important was the social class controlling its use: gunpowder was the tool of the burghers, mercenaries the tool of princes. Engels argued, without discernible irony, that militarism "carries in itself the seeds of its own destruction."[20] Military competition among states would bankrupt national economies at the same time conscription empowered the masses to turn against the state.

By the turn of the twentieth century, Marxists were beginning to focus directly on the role of military production in the progress of capitalism. Marxist theories of imperialism made concrete references to the benefit capitalists gained from the production of war materiel. Rosa Luxemburg suggested that military spending (and indeed militarism) helps capitalists respond to the chronic shortages of purchasing power in the civilian economy. Apart from its function in conquering and subjugating people, militarism "is a preeminent means for the realization of surplus value." Asserting that capitalism needs to expand to the noncapitalist regions of the world economy, and referring specifically to military production, Luxemburg sketched how capitalists, by forcing the peasantry into wage labor, directly, and through taxation indirectly, extract resources that otherwise would not have circulated in the economy. Peasants would have hoarded what otherwise becomes currency. The state provides a stable and massive demand for capitalists' products, demand that otherwise would be subject to the "vagaries and subjective fluctuations of personal consumption." Since weapons are manufactured with tax revenue derived from wages, they are a sort of forced savings imposed on labor. Once invested in arms, however, these funds are lost to consumption. A regular, stable economic growth can develop around military production—sustained by capitalists' control of the media and legislatures—in ways that "at first seem capable of infinite expansion."[21]

Thus did the Marxist tradition begin to pay attention to the relationship of military production to capitalist development. Military production, though, was an artifice, not a central feature of economic growth, and certainly not valued as a user or creator of new technologies.

This relationship was understood differently in the work of two contemporaries of Luxemburg, both students of Wilhelm Dilthey. Werner Sombart was a disaffected socialist who found in German romanticism, and ultimately in fascism, a military-centered explanation for economic progress. The other, Max Weber, provided the first extensive analysis of how military organizations affect civilian society. Neither Sombart nor Weber is commonly associated with the study of technology per se, yet each contributed considerably to our understanding. Each preferred to understand society and the economy as a whole rather than as the mechanical aggregation of rational individuals portrayed as in liberal theory. Each appreciated the importance of institutions, values, and ideas as central to economic and technological development.[22] Each strove to replace Smith's "rational man" with "institutional man," one whose choices and values derive from a prevailing social context, and to supplement Marx's materialism with an appreciation of the independent influence of values and norms. As Lewis Mumford remarks, "Sombart well observed that Adam Smith would have done better to have taken arms rather than pin-making, as an example of the modern productive process."[23]

Sombart agreed with Luxemburg that military production and war are positive forces in the development of capitalism.[24] In his *Krieg und Kapitalismus*, he praised the "union of warlord and capitalist," which in his view led to the evolution of scale economies to meet military demand. War, and especially the preparation for war, stimulate innovation, new forms of management and industrial organization, and that development in turn has positive effects on the general welfare.[25] Sombart argued that, once industrially produced weapons became decisive, the cost of producing them and of supporting soldiers would make it necessary to assemble capital in unprecedentedly large amounts, integrating and centralizing capitalism and facilitating its further development.

Weber believed that Sombart's views were overstated and largely unsubstantiated. He pointed out that some nations, such as Spain, spent up to 70 percent of public funds for the military, and that in China there were great and well-equipped armies without any obvious "impulse towards a capitalistic development."[26] Weber argued that military needs could be met by the parallel development of military and civilian production. Thus, military demand was neither an unproductive impediment to the development of capitalism, as Smith suggested, nor a necessary condition for the emergence of the capitalist system, as both Luxemburg and Sombart argued. Weber suggested that armories and private factories are independent: "In the west the army needs were met to an

increasing extent, developing in parallel with capitalism itself, by the military administration on its own account, in its own workshops and arms and munitions factories; that is, it proceeded along non-capitalistic lines. Hence, it is a false conclusion to ascribe to war as such through the army demands, the role of prime mover in the creation of modern capitalism." Weber did acknowledge, however, that "two great sources of demand . . . war and luxury, the military administration and court requirements," were critical in the development of the factory system.[27] Military consumption increased in tandem with the rise of the "great mercenary armies," and "the more so as army discipline and the rationalization of arms and all military techniques progressed." Crucial in the end, however, was rationalization. For Weber, military uniforms were of greater importance for the creation of a regimented society than for the stimulation of the textile industry. As one might anticipate from the theorist most closely associated with the development of the modern bureaucracy, Weber's central analytical contribution to this discussion concerns the military's part in the development of the standard operating procedures on which modern states and modern bureaucracies depend.[28]

Although John Maynard Keynes addressed military issues even less directly than did Weber, he had an even greater influence on twentieth-century prescriptions for the military economy. His ideas about the management of the economy, particularly about the use of fiscal policy to stimulate growth and employment, became a central justification for military spending and, post hoc at least, for investment in defense technology in the mid-to-late twentieth century.[29]

Keynes would have none of the Smithian assumption that public investment was inherently unproductive. His great contribution to economic theory and economic policy rested in his demonstration that the state could and at certain times must stimulate the economy. His views on the utility of fiscal policy are well known: as long as aggregate demand remains under capacity, deficit spending increases economic growth. (He accepted the risk that public spending would crowd out domestic investment and generate inflation once full employment was achieved.)

Keynes directly addressed the salutary effects of military spending for the civilian economy only once. In July 1940 he pleaded publicly for U.S. industrial mobilization to assist the European war effort, justifying such a mobilization entirely in economic terms. Keynes argued that only massive military production could ensure the full employment that had eluded the New Deal. He implored the United States to begin full-scale war production, arguing that it would unlock "the unprecedented output [that] has to be reached before a state of full employment can be approached. . . . It is, it seems, politically impossible for a capitalistic democracy to organize expenditure on the scale necessary to make the grand experiment which would [achieve full employment]—except in war conditions. It is thus that, not for the first time in the fluctuating fortunes of mankind, good may come out of evil." Keynes noted that at some point a

further expansion of military production must come at the expense of private consumption, but—perhaps self-servingly, given the exigencies of the times—he argued that "this is surely a long way off. It will not come quickly or suddenly. I should not expect it unless the United States was also supporting a large army in the field, which is a contingency we need not now contemplate. . . . [So] your war preparation, so far from requiring a sacrifice, will be the stimulus . . . to greater individual consumption and a higher standard of life."[30]

This passage is as close as Keynes ever came to providing an intellectual justification for investment in defense. Although there were many historical precedents for the use of military spending to stimulate civilian production, until Keynes's treatises there had been little theoretical development of the idea.[31] What later came to be known as military Keynesianism was at most a metaphorical inference from Keynes's work. Nonetheless, these inferences were powerful:

> [By the late 1950s] as a corollary of the triumph of Keynesian economics, the notion of an absolute ceiling on peacetime military spending was discarded. No longer was it believed that high military expenditures would bankrupt the economy.[32]

> Once a state of permanent preparedness was established in the 1950s, an apparent state of prosperity was established with it. A sort of unintentional Keynesianism had rescued the economy, a variant of Keynes in which the large demand-creating government intervention into the economy was almost wholly military in origin.[33]

Military Keynesianism holds that war preparation, rather than war itself, is a net stimulant for the civilian economy. Defense preparation produces more than weapons; it provides fuller civilian employment, stimulates private consumption, nurtures innovators (often small entrepreneurs) by assuring demand for products, and in general enhances competitive forces in the economy. The intrinsic effect of military spending is to stimulate demand for capital goods, promote regional development, and enhance the skills of the labor force.

The view that Keynes's ideas were embraced as a "highly ideologized argument . . . a 'belief system,' a kind of hardened elite conviction" of its benefits for the economy, is widespread but not well substantiated.[34] There is precious little evidence that American policymakers wore Keynesian uniforms, except as garments of convenience, and there is no evidence at all that this uniform ever resembled a lab coat. U.S. Defense Department programs during the Cold War rarely espoused broad industrial policy objectives. Despite post hoc comparisons of the DOD to the Japanese Ministry of International Trade and Industry (MITI), neither the DOD nor its supporters understood even an indirect responsibility to foster industrial policy. They were using technology and industry to enhance military capabilities in order to meet a Soviet threat.

Nonetheless, the claim is often made that ideology, not honesty, was driving defense spending. The origin of these claims seems to be the decision by President Harry Truman to pursue full mobilization in peacetime. Responding to fears and pressures of Soviet power, Truman ordered a reassessment of American foreign policy and national strategy in 1949. That reassessment, which came to be known as NSC-68, called for huge increases in the defense budget and for a more assertive American role in the geopolitical and ideological struggle with the Soviet Union. The framers of NSC-68 surmounted Truman's concern about the inflationary effects of so massive a commitment of resources by invoking Keynesian fiscal ideas. Under the leadership of Leon Keyserling, the President's Council of Economic Advisors advocated increased government spending to stimulate the U.S. economy, thereby enabling it to reach its productive capacity. Not only could the economy survive increases in defense expenditures, Keyserling believed it would actually prosper from such increases. Moreover, he was convinced of the need for an active role for the federal government, through such means as tax policy, federal expenditures, and credit aid for private urban development. Keyserling had not singled out defense spending as an economic stimulus, but when increased defense expenditures gained support among conservatives Keyserling and his associates agreed.[35] So, through a curious alliance of hawkish foreign policy makers and liberal economic advisers, military Keynesianism first worked its way into debates over the size of the defense budget.

Military Keynesianism was, however, neither a decisive factor in the adoption of NSC-68 nor an important influence on defense expenditures for the remainder of the 1950s. There is simply no evidence to suggest that Truman himself intended to accept the defense budget called for in NSC-68. In fact, the defense budget did grow along such lines, but that growth was a function of the war in Korea, not of Truman's embrace of military Keynesianism.

Keyserling endorsed full mobilization in peacetime, but like Keynes he had nothing to say about technological innovation and its relation to the domestic economy. Those concerned with economic matters focused on unemployment, inflation, and federal regulation of industry. Keyserling received considerable support from private industry, which saw sectoral benefits in a Keynesian policy.[36] Geopolitical necessity undergirded the politics of defense budget making throughout the 1950s. Military technology finally came out of the closet when the Soviets launched Sputnik, but it was championed for military reasons. The mission of the U.S. Department of Defense was not to advance industrial technology but to stay ahead of the Russians. If better technology would ensure success, DOD would support it. David Casagrande suggests that this had a profound and intended salutary effect: "Investment in war production had recapitalized American industry, and led to a profusion of new technologies. . . . The government did have a policy, albeit a truncated one, to lubricate the transition from military to commercial production."[37]

Keynes himself was little concerned with what specifically the government should spend money on in order to moderate the fluctuations of the private economy. Managing aggregate demand through fiscal policy, even with unbalanced budgets, was a general idea, one that could apply as readily to the transfer of piles of dirt as to the transfer of technology. As Peter Hall notes, "the very ambiguity of Keynesian ideas was one source of their influence. They became a cloak with which to cover or dress up a wide variety of economic practices."[38] Keynes, like other economic theorists, failed to sustain his analysis on the role of technology.

The omission was not lost on Joseph Schumpeter, whose ideas about technology and innovation have for decades influenced our understanding of economic change. Whereas Keynes looked from the top down, on consumption, money, and other macroeconomic forces, Schumpeter focused from the bottom up, on the ways entrepreneurs, firms, and sectors affect capitalist development. Schumpeter wrote that, by assuming that methods of production did not change, Keynes excluded "the salient features of capitalist reality" and "refused to bend the full force of his mind to the individual problems of coal, textiles, steel, shipbuilding, and instead supported resolution of England's difficulties through monetary management."[39]

Schumpeter's understanding of innovation encompasses two broad claims: an argument as to the centrality of innovation in capitalist competition, and a theory of how innovation comes about. He viewed innovation and its "creative destruction" as "the essential fact about capitalism." He chided neoclassical economics for assuming "perfect competition"—an abstract state that never exists in real markets—and for paying insufficient attention to the role of innovation in the capitalist economy, an omission he likened to "Hamlet without the Danish prince." Innovation is both the driving force and the necessary consequence of capitalism: "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer goods, the new methods of production, the new markets, the new forms of industrial organization that capitalist enterprise itself creates."[40]

Schumpeter depicted innovation—defined broadly as the "new combination" of factors that may already exist, rather than as simple invention—as central to competition; price, the feature emphasized by neoclassical economics, is of marginal significance: "Economists are at long last emerging from the stage in which price competition was all they saw. . . . In capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization . . . competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives."[41] His explanation of how innovation comes about emphasized neither processes nor government policies but social actors, in particular entrepreneurs

and monopolists—individuals who carry out revolutionary economic transformation.

Schumpeter's claim that technology is the central component of economic competitiveness resonates throughout Japanese economic culture and practice. So does List's claim that the independence and security of a nation depends on the independence and vitality of its manufactures. It should be no surprise that each in his own era was widely studied and enormously influential in Japan.[42] Japanese leaders have long understood that firms and economies compete on more than price alone; they have long understood that comparative advantage can be created and that national systems often intervene to distort the practical applications of the ideals of free trade. These ideas resonate well with the historical experience of late-developing nations. Backward nations seeking to industrialize confront several handicaps: noncompetitive industries, a shortage of skilled labor, a dearth of advanced technology, and underdeveloped capital markets with large and "lumpy" capital requirements. Under these circumstances, economic development does not come naturally. A set of institutions must be established to overcome the handicaps of backwardness: investment banks willing to make long-term loans to fledgling industrial clients (typically on condition that they be allowed substantial say in the running of the company); labor market institutions to promote the training and retention of labor by firms (typically featuring lifetime employment guarantees, seniority-based promotion, and extensive corporate welfare benefits); and, most important, a strong state to protect infant industries, channel resources from consumption to investment, and order markets to assure profitability. Classical economic theory dictated that Japan, with its cheap and abundant labor, would specialize in low-tech, labor-intensive industries such as textiles. However, believing that comparative advantage is something created rather than given by nature, the Japanese state promoted industries on which to build a great industrial and technological power. Japan's late development has been a kind of "national Schumpetarianism."[43] Military Keynesianism was drafted into the service of the microeconomic management of innovation, and Smith's "invisible hand" now wears the brass knuckles of Listian mercantilism.

Competing Paradigms

Contemporary theorists have begun to develop a vocabulary of economic and technological change which encompasses claims broader than Schumpeter's microeconomic models and incorporates institutions ignored in the macroeconomic worlds of Smith, Keynes, and even List. They have begun to argue that technological outlooks and habits, indeed whole *cultures* of innovation, define relevant questions for economic actors.[44] These cultures, or "technoeconomic paradigms" naturally include some and exclude other solutions to problems; they

define the ways engineers, designers, managers, and entrepreneurs approach innovation. To Giovanni Dosi, the technoeconomic paradigm "embodies strong prescriptions on the direction of technological change to pursue and those to neglect. . . . [It is] an 'outlook,' a set of procedures, a definition of the 'relevant' problems and of the specific knowledge related to their solution." Christopher Freeman suggests that technoeconomic paradigms constitute the current "best practice," the set of rules and norms by which technological decisions are made. He compares shifts in these rules and norms to cultural revolutions that occur perhaps once or twice a century. Like Schumpeter's "gales of creative destruction," paradigmatic shifts stimulate profound changes in the organizational structure of firms, capital stock, skill mixes, educational systems, and management styles.[45] In this view, competition takes place not simply between an old technology and a new one but between alternative systems of (or ideas about) innovation—clusters of technologies and approaches that determine the trajectory of economic advance. These systems build on shifts in, but are larger than, key technologies. They are the novel ways of organizing production introduced by Britain in the late eighteenth century, in which the new key technological factors of cotton and pig iron were adopted by individual entrepreneurs; by Germany in the late nineteenth century, where steel trusts and cartels with state support introduced steel for the manufacture of heavy equipment; and by the United States in the mid-twentieth century, where multinational corporations with Fordist organizational principles shaped the national technological trajectory.[46] Nations endowed with institutions and ideas about technology and production which are compatible with the new paradigm can assume global leadership.

The technoeconomic paradigm of the late twentieth century is associated with the technologies nurtured by the information industries: computers, telecommunications, and microelectronics. Freeman shows how practices within this new paradigm effect economic change by reducing design and manufacturing costs, permitting more production flexibility; integrating networks of suppliers and assemblers, encouraging the growth of new producer services such as design and software; and reducing the weight and number of mechanical parts. Like its predecessors, this "fifth-wave" paradigm is identified with novel ways of organizing production and establishing new centers of global power. British hegemony, associated with early mechanization and private entrepreneurs, gave way to German and U.S. hegemony based on different production factors, different corporate models, and different institutions of national economies. Japan may be the latest paradigmatic innovator. And note that the generic technologies of information and communication, such as data processing and remote sensing, are also the technologies that enhance the battlefield capabilities of modern weapons.

The technoeconomic paradigm provides a theoretically rich empirical and historical anchor for explanations of technological development. It assumes

neither that consumer demand determines technological choice, as in the neoclassical tradition, nor that forces of production possess their own development logic isolated from markets and institutions, as in the Marxist approach. It focuses on the role of "transformational technologies," such as steel, steam, and oil, but it does not assume that technologies exist apart from their institutional context. It substitutes contingency for linear, evolutionary models of the economy without abandoning the importance of innovation. Perhaps most important, it accommodates analysis of political forces. Effective use of the paradigm to model innovation and growth requires careful analysis of the interaction of public institutions and political leaders with entrepreneurs and scientists to select technologies. This sort of analysis requires an intimacy with historical and institutional settings.[47]

Each technoeconomic paradigm involves a cluster of institutions and ideas about how the economy and politics interrelate and about how to innovate. These are basic understandings about how the world works—or at least about how this current version of the world works. As we consider these paradigms, we are in effect considering definitions of national security. Most modern commentators on national security have noted the crucial importance of technological advance to the security, even to the survival, of the nation, and a large literature has grown to explore the relationship between technology and strategy.[48] But, the literature on the relationship of strategy and technology pays little attention to ideology or to culture. Either strategy is determined by perceptions of the technological capabilities of enemies, or technological choices are determined by bureaucratic politics or by grand strategic concerns. Questions about how those larger concerns are formed, and about what makes nations feel more or less secure, are rarely examined. In particular, ideology is virtually always a residual explanation, much in the way "culture," in its most vulgar formulation, was once used as little more than some invariant and determinant "tradition" sustaining explanations such as "The Soviets did what they did because they were Russian."[49]

Discussing the strengths and limits of ideology as an explanation, Peter Gourevitch argues that "the economic ideology interpretation of economic policy choices explains outcomes in terms of national traditions and values concerning the economy. Its strength lies in the reality of ambiguity. . . . The difficulties of its approach lie with the rapidity of change. . . . Rapid changes within countries . . . undermine arguments that . . . like those of the economic ideology approach, stress constants over time."[50] Although Gourevitch is on balance correct, there are several problems with rejecting ideology and culture entirely. It is not at all clear that we have any theories that adequately anticipate or explain change—least of all structural or production based models. And it is often continuity, rather than change, that requires explanation. Finally, culture and ideology need not be static or vulgar explananda. They are each, after all, products of "the history of the collectivity"[51] and subject to its inconstancy. Historical events,

including great catastrophes and great accidents, can produce dramatic changes in the orientation of individuals and affect grand strategies by determining how missions are defined, how weapons systems are selected, how scarce resources are allocated, and how citizens are exhorted. Gourevitch acknowledges this in the conclusion of his comparative historical study of responses to international economic crises: "As the importance of organizations has grown with the growth of the state, so the importance of ideology has grown in accounting for the purposes to which organizational power is put. . . . Politicians may pick political strategies as a function of economic ideology . . . or they be more adaptive and look for economic ideologies that enable them to adopt different political strategies. . . . In either case, economic ideology provides important cues for analyzing both political and policy options."[52]

Culture and ideology thus are far more than history passively constituted. They are hardly the simple consequences of historical accidents. Each uses history politically; each is an actively constructed resource available to leaders who mobilize loyal citizens, part of an active agreement among people to forget and reconstitute the past. This is what Charles Sabel refers to as "genesis amnesia" and what Eric Hobsbawm and Terrence Ranger call "invented traditions."[53] In Japan, an ideology of corporate paternalism was invoked by industrialists who sought to reduce labor mobility (and raise profits) by tailoring reconstructed images of group loyalty, extended families, and benevolence. In France after 1945, elites from both the left and the right found it convenient to elevate the role of the state to a central place in French history; the state was glorified in the retelling of French history from Colbert to de Gaulle, even though much of the French elite had always been ferociously antistatist. In short, culture and ideology can be tools rather than constraints, agents for change as well as excuses for stagnation. They are constructs as well as inheritances; each can be the object of determined conflict and can change considerably.[54] "Modernity" may be no more than the triumph of "tradition," and "old" ideas may be very new indeed.

Ideas about security are a good case in point, for strategies may not be consciously chosen and ideologies may not be consciously held. Mary Kaldor invented the term "imaginary war" to describe the postwar East-West conflict in Europe and to explore the consequences this military confrontation held for ideology and action in whole social systems. Kaldor argues that the imaginary war—the assumptions strategists make about their enemy's capabilities and intentions—generates distinctive "military-technological styles" that are capable of determining the "specific mix of military products, both weapons and infrastructure—transportation, communication, food, uniforms, even health care." Her notion of a military-technological style can be seen as one species of the genus "technoeconomic paradigm." It is thus a techno*military* paradigm, an ideological construct that incorporates technological, social, and organizational innovations, all derived from how strategists and other stakeholders imagine wars will be fought and from

how they imagine national security can best be provided. Technology may not be merely a servant of grand strategy for Kaldor, but it does owe its shape and direction to strategic calculations that go beyond simple estimates of the capabilities and intentions of adversaries. Strategy provides a rationale for the development of capabilities, a rationale embedded in *ideas* about power, security, and national purpose which transform social institutions.[55] Ideas about power do not supersede battlefield or market capabilities, but, as I show in this book, they can shape them. There have been two such technomilitary paradigms: *spin-off* and *spin-on* (or *dual-use*). *Spin-away* is a pathology inherent in the spin-off paradigm which also deserves special attention. Each maps neatly onto the political economic debates outlined in the preceding section.

Spin-off

The technomilitary paradigm that most deeply penetrated conventional understandings of the purported technological benefits of military spending in the United States during the Cold War was spin-off. The general idea of spin-off rests on a view that military spending can have a pervasive positive impact on the civilian economy.[56] Historians have observed that "*knowledge* acquired in making weapons contributed to the rise of industrial civilization."[57] The performance requirements of technologically sophisticated military systems directly boost the innovative capabilities of the supplier firms, who thereupon develop and license technologies of broad commercial benefit. Military production enhances the embedded skills of management, marketing, and systems integration that can be embodied in products and that infuse the technological infrastructure of the entire economy. Although most casual accounts of technology spin-off focus on products, such as jet engines and space-age plastics, the transfer of production methods, process control technologies, and the other infrastructural institutions that foster innovation, such as subcontracting and industrial finance, may be even more significant for the economic potential of nations.[58] In short, the spin-off paradigm focuses on the ways the military develops (or at least nurtures through procurement) products, processes, and organizational innovations, including national technological infrastructures, manpower training, equipment, and indeed whole sectors and firms that transform and enhance the civilian economy. It has aptly been referred to by James Kurth as "military Schumpetarianism," the microeconomic counterpart to the macroeconomic effects of "military Keynesianism:" "With 'military Keynesianism' depressions were domesticated into recessions . . . [and] with 'military Schumpetarianism,' military innovations spun-off to become commercial industries."[59]

The most commonly cited contemporary examples of the "civilian fertility of military R&D"[60] are *products*, such as kevlar, insecticides, satellites for telecommunication, navigation, or weather forecasting, robotics, medical diagnostic equipment, lasers, digital displays, fire resistent clothing, integrated circuits,

and nuclear power.[61] The transfer of innovative products from military to civilian applications is seen as natural and desirable—indeed, in some contexts it is seen as purposeful and essential. This transfer may take place within single firms, intrasectorally between competitors, intersectorally between user and supplier firms, between universities or national laboratories and the private sector, or (in innumerable ways) across national boundaries.[62]

Spin-off commonly involves whole military-industrial processes and institutions that benefit the general economy. In the United States, institutions created by the military, such as the U.S. Army Corps of Engineers, the Argonne National Laboratory, and the Office of Naval Research, are viewed as incubators of technological innovation for the entire economy in much the same way that Alfred Chandler credited railway development as sowing the seeds of modern management and American economic growth.[63] Jacques Gansler argues that cost-benefit analysis, operations research, critical path analysis, systems analysis, and most of the other commercially useful post—World War II management techniques were developed by and for the defense sector.[64] Maryellen Kelley and Todd Watkins find that defense contracting had a widespread salutary effect on human resource development, technology modernization, and the diffusion of process know-how in the metalworking industries in the United States.[65] But this is hardly limited to the postwar world, or even to the United States. Historians of science and technology point to such industrial processes as standardized production, Taylorist "scientific management," and the quality testing that originated in U.S. armories for military products.[66] Merritt Roe Smith concludes that "military enterprise has exerted a powerful influence in determining the institutional and technological dimensions of the modern industrial era."[67]

The influence Smith refers to takes many forms—not all immediately obvious. One, is the simple fact of economies of scale and scope. We are frequently reminded that early missile guidance systems consumed virtually all the early production of integrated circuits in the United States, that computers were developed for military markets and that DOD commitments to purchase machine tools likewise assured the development of the entire industry, and that government military demand has always been central to technological development.[68] Smith reminds us that three of the four most innovative sectors of the American economy in the nineteenth century—railroads, machine tools, and the manufacture of standardized parts—were closely related to military enterprise, and that the very origins of mechanized production are found in the American arsenal system.

The European experience was earlier, but not different. William McNeill observes that,

> if French entrepreneurs were to catch up with British advances in ferrous metallurgy, the navy offered the only readily apparent consumer. . . . To transplant the

> new technology . . . required an assured outlet for the product. . . . In Britain, by contrast, a nationwide civilian market had already appeared by the 1780's, offering the ironmasters of Wales, and soon also of Scotland, a variety of outlets for their goods. . . . the men who built the new coke-fired blast furnaces in previously desolate regions of Wales and Scotland would probably not have undertaken such risky and expensive investments without an assured market for cannon. . . . both the absolute volume of production and the mix of products that came from British factories and forges, 1793–1815, was profoundly affected by government expenditures for war purposes. . . . *government demand created a precocious iron industry* . . . [and] it also created the conditions for future growth by giving British ironmasters extraordinary incentives for finding new uses for the cheaper product their new, large-scale furnaces were able to turn out . . . Military demands on the British economy thus went far to shape the subsequent phases of the industrial revolution.[69]

As Lewis Mumford notes, military demand is unlike any other, especially during wartime: "The army is the ideal consumer, in that it tends to reduce the gap in time between profitable original production and profitable replacement. The most wanton and luxurious household cannot compete with a battlefield in rapid consumption. A thousand men mowed down by bullets are a demand more or less for a thousand more guns, a thousand more bayonets; and a thousand more shells fired from cannons cannot be retrieved and used over again. . . . nothing ensures replacement like organized destruction."[70]

Louis XIV placed the first large-scale order for standardized, mass-produced textiles to clothe his troops, and the French war department placed the first orders for the sewing machine after its invention in 1829. In short, writes historian Guatam Sen, "endemic wars and the evolution of mass armies prepared the basis for the subsequent transformation in Europe. The demand for mass produced and standardized goods for the purpose of war stimulated innovation in the technologies of production and the adoption of new methods of organization, lowering unit costs for the sizeable civilian demand which had previously only remained potential. The wars also accelerated the process of capital formation."[71]

It seems clear that government procurement of private sector products for military applications thus almost certainly altered the trajectory of industrial technology by determining what and how the civilian economy would produce.[72] It also determined who would produce it. In antiquity this included the trumpets, bugles, and mirrors that provided military communications, and today this same relationship explains how entirely new firms, such as Texas Instruments, Motorola, Fairchild, and TRW, held a two-third market share for integrated circuits as early as 1957.[73]

Officials responsible for the procurement of weapons (and thus indirectly responsible for the development of national systems of innovation) often resist

technological change, it is true. The most famous example is the oft-cited memorandum from the English Admiralty that states "their Lordships feel it is their bounden duty to discourage to the utmost of their ability the employment of steam vessels."[74] Slow judgments or misjudgments notwithstanding, there is no arguing the considerable direct impact that defense procurement has had on the development of modern economies.[75]

Ted Berlincourt, a U.S. Defense Department official, has made the most unambiguous claim for spin-off as a linear process: "History has shown time and time again that the capabilities which are exclusive to the military in one generation are in subsequent generations demanded by the public and provided by commerce. . . . It is safe to predict that within a decade or two the civil and commercial sectors will reap rich harvests from seeds planted today and subsequently nurtured by defense R&D."[76] This view (at least tacitly) justified the way the United States focused its technological resources on military production in civilian firms in the mid-twentieth century. During the Cold War, private firms became the centerpiece of research and defense procurement for the first time in the United States.[77] Berlincourt argues that this allows "commercialization [to take] place in the most natural manner."[78] Richard E. Donnelly, former assistant deputy undersecretary for manufacturing and industrial programs, testified before Congress in 1989 that "the U.S. has only one industrial base. We do not have a defense industrial base that is separate and distinct from the commercial industrial base."[79] Despite these claims, it is not clear to all analysts that spin-off has worked, or even that it was an intentional element of public policy.[80] Despite the extremely high portion of advanced research done in private firms in the United States for defense purposes, U.S. firms have failed to stay at the state of the commercial art in a range of technology-intensive sectors. Kelley and Watkins find that defense contractors are more advanced technologically than are similar firms that produce entirely for civilian markets.[81] Something happened to impede the "natural" interdiffusion of military and civilian economies. I call it "spin-away," the iatrogenic consequence of an excessively close embrace of technology for military end use.

Spin-away

Robert Solo, in the first important critique of the assumptions about spin-off, summarized the conventional view in 1962 to be that an increase in R&D spending generally accelerates economic growth.[82] He noted, however, that phenomenal increases in R&D spending were not accompanied by productivity increases. He concluded that no statistical correlation between growth and research spending existed, not because technology was unrelated to productivity, but because something was getting in the way. This impediment, he claimed, was military and space research: "Not only is space and military research growing

farther apart from industrial research in a technical way, but communication between the two sectors is becoming more unmanageable."[83]

It is far from clear that the military acts primarily as an agent of technological innovation, that a linear relationship exists between defense and civilian products, or that military spending has had a pervasive positive impact on the civilian economy.[84]

Since Solo, an entire generation of critics has outlined and generalized from the shortcomings of the spin-off paradigm, arguing that "massive defense spending did great *harm* to the economy—particularly to its key technology sectors."[85] Much of the criticism can be captured in an alternative metaphor for the relationship of the military and the civilian economies: spin-away—the progressive alienation of defense production from the commercial economy. As John Alic and his colleagues point out, "the defense industry has become isolated from commercial industry . . . [and] the barriers between DOD (and its contractors) and the commercial sector are deeply rooted in the American political system."[86]

There are many explanations for spin-away. Some depend on fundamental differences between military and civilian economic activity. It is often claimed that the structure and cultures of the innovation process in military and commercial systems are very different.[87] Until the 1960s, Solo argued, "military technology was substantially a branch of industrial technology or (as in the case of aircraft) vice versa." He described the two different developmental paths as "entirely natural. . . . For those who produce and sell to the civilian market, and those who produce weaponry, control systems, instruments, and components for the military market operate in quite different environments, and are shaped by quite different forces (including the nature of risk, the emphasis on cost versus performance, the size of production runs, and the relationships between buyer and sellers."[88]

The most obvious source of this difference is the need for secrecy that is so central to the military economy. Where dependence on technology transfer is central to the commercial market, governments have struggled to prevent the diffusion of military technologies for reasons of national security. This enforced isolation has taken a great many forms, including separate accounting and audit systems, different bidding and marketing procedures, export controls (extending to dual-use technologies), separate divisional structures, classification schemes, and nationality requirements, all of which aim to prevent (or at least to impede) technology diffusion.[89] Communication among researchers, even within the same firm, is often proscribed for national security reasons. U.S. firms have been given few incentives to transfer state-of-the-art technology; to the contrary, they have been given any number of reasons not to do so. Restrictions often have indirect effects as well. Nathan Rosenberg reports that Bell Labs, for example, refused to disclose the invention of the transistor to the military until just one week before the public announcement out of a concern that an earlier disclosure "might lead to a restriction of its use or to its classification."[90]

A second explanation invokes opportunity costs. Military and civilian laboratories compete for the same research personnel and the same research funding. Because the supply of each is inelastic, one is apt to crowd out the other and may not in any event substitute for efforts to enhance the productivity of the commercial economy. The "crowding out" problem is certainly not unique to defense. It occurs whenever an economy's resources are fully and efficiently deployed.[91] But defense uniquely conveys the symbolic content of these tradeoffs. Consider the eloquent observation of President Eisenhower in April 1953:

> Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and are not clothed. . . . The cost of one modern heavy bomber is this: a modern brick school in more than thirty cities. It is two electric power plants, each serving a town of 60,000 population. It is two fine, fully equipped hospitals. It is some fifty miles of concrete highway. We pay for a single fighter plane with a half million bushels of wheat. We pay for a single destroyer with new homes that could have housed more than 8,000 people.[92]

A third explanation for the declining innovative capacity of the military sector concerns the criteria by which success is measured. In the military market, unlike the civilian market, rewards are based almost entirely on product performance: mission comes first and cost comes second. The products that go "bang" are more important than the processes by which they are manufactured, which naturally affects the purposes, methods, and results of defense research. Berlincourt explains these differences: "In general, defense R&D addresses the most stressing and most avant garde technological requirements. By necessity attention is focused on extremes in performance."[93] Rosenberg, discussing the specific case of integrated circuits, outlines the consequences: "The highly specialized nature of military components has led to the development of manufacturing processes for custom-designed (or semi-custom-designed) products of limited relevance to civilian semi-conductor markets, which require manufacturing technologies emphasizing low cost and high volume production."[94] One result is that military electronic components can cost ten to one hundred times more than civilian electronic components.[95] Whereas defense contractors in the United States have been reimbursed on a "cost plus" basis, recouping the expense of design as well as manufacturing changes, purely commercial projects have to respond to cost and ease of manufacture.[96] As a result, some suggest, military contractors lose the capability to design, manufacture, and sell in a competitive marketplace.[97]

By responding more to performance than to cost criteria, and by funding

product and system development more than basic research, defense contracting may have resulted in the strategic subordination of new technologies. J. Arthur Burns, former chairman of the Federal Reserve Board, has made precisely this point: "If the defense sector has stimulated economic development in some directions, it has retarded growth in others."[98] In spinning away from the commercial economy, defense research became a custom-design business, a boutique industry, with greater incentives to build the unit at high cost than to design it for ease of manufacture. The Department of Defense has been well aware of this problem. According to a DOD Technology Assessment Team in 1988,

> in the 1960's, as the shift to more sophisticated weapons accelerated, equally sophisticated manufacturing technologies were required; technologies which often exceeded the capabilities of current commercial production, particularly as US industry began to drop out of various commercial sectors. The focus on qualitative superiority also led to the production of progressively smaller lots of more highly differentiated weapons. This has further accentuated the separation from commercial practice which has traditionally been oriented toward much higher volume and less product diversity."[99]

In her 1981 study, *The Baroque Arsenal,* Kaldor questions whether this was, in fact, a matter of sophistication at all. She argues that "modern military technology is not only misguided, it is decadent,"[100] and suggests that a process of "baroque technological change"—the incremental improvements, the incessant elaboration of existing weapons systems, and the ubiquitous "follow-ons" that preclude significant change—merely makes armaments more expensive, more complex, more cumbersome to support, and more distant from innovation. The result is a military-industrial system characterized more by "diminishing returns"[101] than by innovation: "Baroque military technology artificially expands industries that would otherwise have contracted. It absorbs resources that might otherwise have been used for investment and innovation in newer, more dynamic industries. And it distorts concepts of what constitutes technical advance, emphasizing elaborate custom-built product improvements that are typical of industries on the decline. . . . It has thus contributed to the slowdown of capital investment and productivity growth and the gradual degeneration of the American economy."[102]

The chroniclers of spin-away paint a bleak picture of opportunities lost and innovations foregone. The best examples are the machine tool industry and nuclear power reactors. U.S. Air Force procurement significantly assisted the development of numerically controlled machine tool technology, but its very complexity may have deterred potential users, especially the smaller firms.[103] Machine tool makers were from the beginning excessively dependent on one excessively specialized military customer. As a result, the early numerically

controlled machine tools may have served the Air Force and no one else. The story of nuclear reactor design is similar. The high power density and high pressure requirements that pose little problem for submarine application are hardly suited to stationary, land-based reactors. Admiral Rickover's success with submarine reactors resulted in a commitment by the U.S. electric power industry to the virtually exclusive use of light water reactor technology.[104] As a result, conventional light water reactors for electric power generation have required extensive safety modifications, which have inflated their cost to end users. It is plausible, suggest John Holdren and F. Bailey Green, that "the commercial nuclear industry would be considerably better off today if it had done without the spin-off of military reactor technology."[105]

Solo (himself more a prophet than a chronicler) bemoaned the drain of "creative resources" and predicted that "those who were, or who might have been, restless, probing industrialists, innovating entrepreneurs, or inventors tinkering in their shops became, instead, engineers on project teams, heads of research divisions, scientists in laboratories, or subcontractors with the task of developing a component for a complex weapon system. Something is given to one side, but lost from the other. . . . Who bears the responsibility for mining the rare metal out of the mounting slag heaps and fabricating it into the stuff of economic growth?"[106]

But for all the attention it has received, and for all that is at stake, the debate remains inconclusive. Some see slag heaps where others see rich veins of precious metal. Function and dysfunction, creation and destruction are in the eye of the beholder. And different viewers wear different lenses. Some note that by the late twentieth century "American firms have experienced some of their most dramatic *loss* of world market share in precisely those industries which have traditionally been most closely tied to the Department of Defense."[107] Others, pointing to the indisputably high levels of DOD investment in graduate education and to the considerable commercial benefits of basic research, suggest that the military has played a unique role in forcing research and development from pure science into applications.[108] Was it true as late as 1974 that military technology was "probably many decades ahead of the civilian sector and potential peaceful applications"?[109] Or, as Solo warned in 1962, had the balance already begun to shift? The aggregate evidence is mixed: it depends on both time frame and substantive referent.

Given these problems, and the various ideological and political lenses through which they have been examined, it is not surprising that most of the evidence demonstrating spin-off is anecdotal. Philip Gummett and Judith Reppy conclude that "most discussions of spin-off are based on little more than ad hoc lists of important technical developments that have originated in military programmes. . . . They are not, however, a basis for generalization."[110] Kelley and Watkins offer some of the only systematic plant-level data and find evidence that defense contractors in the metalworking industries are more likely than nondefense

contractors to use advanced process technologies. They also tend to be more efficient. Contrary to the spin-away thesis, moreover, they find that most of these defense contractors operate dual-use facilities.

Their data on process innovations notwithstanding, however, there is also evidence that the technological lead once enjoyed by defense products virtually evaporated by the late twentieth century. Military jet engines and microcircuitry that had been a decade more advanced than those for civilian use were dependent on civilian product and process technologies by the late twentieth century.[111] Gansler shows that defense contractors invested in capital equipment and new technology at only half the rate of comparable commercial firms.[112] There was clearly something else going on, something not anticipated either by advocates of defense-led research investment or by those who argued that "black programs" were actually a "black hole." This "something"—sometimes referred to as "dual-use"—was the emergence (or reemergence) of a technomilitary paradigm that depends on and reinforces technological advances in the civilian economy. The Japanese did not invent the alternative paradigm, but they did coin the phrase that describes it. They call it "spin-on."

Spin-on

If those who saw spin-off were too complacent about the benefits of military research, those who saw spin-away failed to anticipate the explosion of civilian innovation and entrepreneurship that characterized technological advance in the late twentieth century. They also may have failed to appreciate the potential for dual-use production, particularly among supplier firms. David Casagrande notes: "Though the Cold War did lead to a substantial militarization of American technical and scientific capital, it had positive effects as well. As it turns out, the 'sapping' effect of defense spending on the civilian economy is not quite as enfeebling as . . . [some] would frame it. . . . The(y) have overstated the association between the military-industrial complex and economic decline."[113] Even if the spin-off model was not correct, technological advance was hardly snuffed out by defense spending. To the contrary, innovation in the civilian economy flowered in the late twentieth century. The prophets of spin-away had not anticipated that advanced technologies would develop independently of the military and diffuse to both the commercial and military economies as dual-use technologies. Critics of defense spending underestimated the vitality with which innovations would spring from the commercial economy, opportunity costs and spin-away notwithstanding. Commercial technologies today lead military ones throughout the world.

The term "spin-on" is of Japanese origin, although civilian technological advances have for centuries informed military production. Spin-on refers metaphorically to the transfer of products and process technologies "off the shelf" from civilian to military applications. Its leading role in technological change

was hardly anticipated. Consider Bernard Udis's glancing reference in 1978 to the prospects for the central technomilitary paradigmatic shift of our times: "It is certainly possible that something of value could be learned by studying the process [by which civilian technology is transferred to the military]."[114] The underappreciation of the potential for spin-on is odd, since history is filled with examples of dual-use products and processes. Perhaps the most significant spin-on product was incendiaries. Gunpowder was developed without reference to warfare. Its use was nonmilitary in the late twelfth and early thirteenth centuries, and the first reference to its use in cannon was not until the early fourteenth century. John Nef goes to great lengths to explain that "saltpeter and gunpowder appear in western history as by-products of remarkable general progress in knowledge for peaceful purposes."[115] The telescope, invented in 1608 by Lippershey, was first applied to astronomy by Galileo the next year; it was not until the late eighteenth century that it was adapted for use as a military semaphore.[116] Martin Van Creveld claims that "all the most important nineteenth century military devices originated in the minds of civilians," a list in which he includes the first practical breech-loading rifle developed by locksmith John Dreyse.[117] We are told by J.F.C. Fuller that, in the twentieth century, the invention of engine-powered flight "raised war into the third dimension," while wireless telegraphy "raised it into the fourth . . . annihilat[ing] time as well as space."[118] And products will continue to spin on from the commercial economy: two of the most critical twenty-first-century weapons systems now under development, stealth and multispectral technologies, depend critically on innovative manufacturing and design technologies that reside in the commercial sector.[119] Three-quarters of the computing power in the state-of-the-art Aegis cruiser depends on commercial equipment.[120] Fourteen of twenty-two "critical" items on the U.S. Department of Defense/Department of Energy "critical technologies" list issued in April 1989 were dual-use. This is hardly surprising, since nearly three-quarters of the cost of a missile, and nearly half of all DOD spending on aircraft, is for electronics.[121] On the basis of her study of microelectronics in the U.S. defense industry, Anna Slomovic concludes that, "although it was a leader early in the history of the semiconductor industry, few areas of DOD leadership remain. . . . it does not make sense for the military to spend money on advancing the general state of the art in the semiconductor industry. . . . It makes sense to institutionalize the process of 'spin-on' from commercial to military applications—a process that is already taking place informally."[122]

The first formal recognition that indeed the contemporary military had become a net consumer rather than a producer of commercial technology was by the Presidential Blue Ribbon Commission on Defense Management in 1986. This Packard Commission, as it was known, argued vigorously that the Pentagon ought to pursue the cost savings and quality improvements realizable through the application of civilian technology and the relaxation of some military perfor-

mance specifications.[123] Gansler notes that the commercial equivalents of computer, communications, display, and sensor systems were often "between two and ten times cheaper, up to five times faster to acquire, generally more reliable, one to three years more advanced in technology, and capable of withstanding equally harsh environments."[124]

But expense and quality are not the only concerns in the 1990s; it has long been equally clear that foreign dependence, often on Japanese producers, is increasing. The congressional Office of Technology Assessment reported in 1990 that a defense trade balance eight to one in the U.S. favor in 1977 had narrowed to barely two to one by 1988. It further reported that the United States depends on foreign defense contractors for a large, growing, and unknown portion of its own defense production. These products, including telecommunications, chemicals, and electronics, are usually based on advanced civilian technologies. Import penetration in the U.S. defense industrial base grew during the 1980s at roughly the same rate as in the U.S. manufacturing base overall, but at a significantly higher rate in the lower tiers of the defense industrial system, for example, in components and materials.[125] U.S. military systems such as the Patriot missile deployed in the Gulf War of 1991 used technologically advanced components produced by Japanese subcontractors and developed initially for commercial markets.

Why has this happened? First, the performance requirements for commercial markets have caught up with (and in some cases surpassed) military specifications. In the commercial world, advanced technology is used both to lower costs and to enhance performance; as a result, and through their interaction, cost and performance each improved faster in the commercial than in the military sector, where only performance seemed to matter. Second, the large and increasing development costs for new technologies can now be supported as easily by the volume sales of consumer products as by the guaranteed markets of military procurement. Third, product life cycles in competitive markets are considerably shorter than are those for military systems. And the life cycle gap is getting larger. Commercial producers have had to become significantly more responsive and flexible than military producers, whose product runs of smaller volume are of longer duration. The civilian economy has proved itself an even more voracious consumer of technology-intensive products than the military.

Spin-on products, such as polymer, composite, and optoelectronic materials, or photonic devices, are easier to identify than spin-on processes; indeed, each of the most significant innovations in microelectronics—Bell Labs' transistor, Texas Instruments' integrated circuit, Fairchild's planar process, and Intel's microprocessor—all emerged from purely civilian research.[126] Today's command, communication, control, and intelligence systems (so-called C^3I)—the core application of defense technologies including the most advanced telecommunications and microelectronics systems, and components such as optical

The Mitsubishi Electric Corporation, one of Japan's top five defense contractors, is an active developer of dual-use technology. This advertisement of the late 1980s proclaims that "Electronics plays the leading role in defense." Less than five percent of MELCO sales are to the Japan Defense Agency. Courtesy Mitsubishi Electric Corporation.

fibers, microelectronic circuits, and sensors—have spun-on from civilian products.[127]

Jan Herring has identified specific product innovations that have flowed from military laboratories to civilian products and vice versa.[128] He sees two postwar periods: the first in which the military led the civilian innovation (1946 to mid-1960s), and the second in which civilian innovation began to lead the military. Representative transfers include the following:

PERIOD I

Military technology	*Civilian application*
Bombing radar systems	All-weather civil air transports
Tactical field radios	Police, safety, rescue communications
Fire control computers	Industrial process control systems
Infrared sensors	Geological mapping
Radar magnetrons	Microwave ovens
Satellite systems	Communications satellites

PERIOD II

Civilian technology	*Military application*
Integrated circuits	Command control systems
Space-based sensors	Military intelligence
LSI, VLSI	Cruise missile guidance
Fiber optics	Missile guidance
Electro-optical devices	Intelligence sensors
Lasers	Target designation, range measurement
Artificial intelligence	Smart weapons

Clearly, the Japanese notion of spin-on abbreviates an even more dynamic historical fact: every economy—industrial and preindustrial—has been shaped and transformed by the development and interdiffusion of dual-use technology. The wheel was not invented for the Roman chariot, but the spoked wheel was. Dye casting was not developed for the gun barrel, but boring machines were. Gunpowder was not developed for war, but controlled nuclear reactions were. Historically, there has always been a dual use of products and processes: technology has always interdiffused, and its interdiffusion has long been abetted by military procurement, regardless of the changing institutional locus of knowledge.

These technomilitary paradigms each have their own logic and their own consequences for economic development. Each suggests different ways nations can develop technology and provide for national security. The United States, operating under liberal assumptions, came to believe that it could use technology to provide security and that commerce would take care of itself. Despite evidence of "military Schumpetarianism," the institutions of the Cold War U.S. economy may have spun away as much as they spun off. The Japanese had different ideas. Operating under mercantilist assumptions, Japan experienced a historical transition from a military-led to a commercial-led national system of innovation.

It is incorrect, however, to apprehend this as the straightforward shift from spin-off to spin-on often depicted. Undergirding each nation's policy was a coherent, consistent, and contested view of technology as the source of national security. I call this view "technonationalism" and differentiate it from what often is excoriated as "technoprotectionism."[129] As we see in the course of this book, the embrace of technology for national security in Japanese practice was a very positive force. Japanese technonationalism never isolated defense production from the general commercial economy. To the contrary, industrial, technological, and national security concerns have long been fused in the institutions of the Japanese economy. Much as Kaldor would have it, Japanese technonationalism is derived directly from ideas about adversaries; the "imaginary wars" of Japanese leaders are interpreted in technological and economic, as well as military, terms. In the Japanese case, adherence to technonationalism's tenets both precluded the pathology of spin-away and stimulated the positive benefits of spin-on as part of the more comprehensive interdiffusion of technology.

In short, technonationalism is an ideology, and like all ideologies it is a force that precedes and informs the institutions of an entire national economy as well as strategies for national security. Institutions are more than formal organizations in this context, of course, and in particular they include the network of protocols—the rules and practices that guide and constrain social, political, and economic choice. These protocols thus express the values bound up in ideology and provide behavioral and institutional expressions of national ideology.

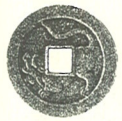
In Japan these protocols are profoundly technonational: they recognize that technological innovation and the national welfare are indissolubly linked. They have evolved from more than a century's efforts to counteract the effects of late development, and the beliefs that animated that long race to catch up have become fixed as part of Japan's national practice. That, in brief, is the story of this book.

One final point: although this story is about Japan, the moral of the story is a practical lesson for the United States. We are confronted with the fact that Cold War America operated with inadequate ideas about the interdependence of military and commercial economies which a post—Cold War America is seeking to change. "Defense conversion," a mantra incanted in the early 1990s, seems desirable only because commercial and military programs were allowed to diverge. Successful "conversion" will require consolidation of a single industrial technology base, not simply the removal of barriers between two separate ones. The conversion debate is long overdue and well under way;[130] Japanese ideas can help.

Japan presents not only an immediate, palpable challenge to the United States but also a profound example of how ideology and national purpose can combine to open or to preclude options for the welfare of whole societies. We learn

that national interests can matter beyond the deployment of troops and the mobilization for war and that a proactive technonational agenda—protocols that nurture producers and diffuse and indigenize global knowledge—is an essential element of national security. This element is not merely a matter of strategy; it is a matter of beliefs and values that must be inculcated and adjusted vigilantly. Technonationalism has been excoriated as retrograde thinking in an emerging, interdependent world economy and as a mercantilist regression. Yet, the moral of the Japan story is that technonationalism can be a part of any intelligent nation's security strategy. This requires no apology. It is not that naked mercantilism makes transcendent sense but that, even in global economies, national interests lie in enhancing the skills and welfare of citizens within their geographic boundaries. Having a national technology ideology is not an evil but a desideratum to ensure that as the world "globalizes," deprived regions are not left behind (or worse). Technonational protocols can ensure, moreover, that once-hegemonic economies need not experience the relative decline that invites dangerous political and social unrest. Clearly there is a lot more at stake here than determining the optimum reorganization of laboratories and factories.

CHAPTER TWO



The Ideological Basis of Japanese Technonationalism

The Japanese have the poorest spirit for cooperation.
—Nippon Oil President Naitō referring to failed oil cartels in the 1920s

Joint action for the common good apparently had little appeal to the Japanese mind.
—U.S. Strategic Bombing Survey referring to the failure of Japanese aircraft manufacturers to collaborate during World War II

Collaboration is Everything.
—Organizing slogan for the Japanese research program in very large scale integrated circuits in the 1970s

In this chapter I explore the intellectual underpinnings of Japan's technology and security ideology. Before the Tokugawa period began at the turn of the seventeenth century and until Japan's defeat in 1945, military production stimulated and transformed civilian manufacturing. Scarce resources—particularly capital and technology—were focused on defense production. Military product and process technologies were then spun off to benefit the commercial economy. Although it was unevenly applied, Japan's national technology policy comprised three elements: (1) import-substituting indigenization—the identification and acquisition of foreign products and manufacturing/design processes in order to stimulate local development; (2) diffusion—the distribution of this know-how throughout the economy; and (3) the nurturance of a capacity to innovate and manufacture.

Technology, then, was a matter of national security, and the bundle of beliefs and practices that constitute this view can be called "technonationalism." The national leaders of Imperial Japan, after considerable debate and despite occasionally glaring inconsistencies, arrived at a formula—"military technonationalism"—that would enhance economic and military security simultaneously. Despite failure in the Pacific War, postwar Japanese planners inherited the institutions of this military technonationalism and the workforce skills it engendered. Some sought to reconstruct the prewar paradigm. Others struggled to pacify the economy and its managers. But none contested the singular importance of acquiring, diffusing, and nurturing technology; none contested the

technonational paradigm. The period 1945–1955 was critical in determining whether the Japanese national system of innovation would be military- or commercial-led.

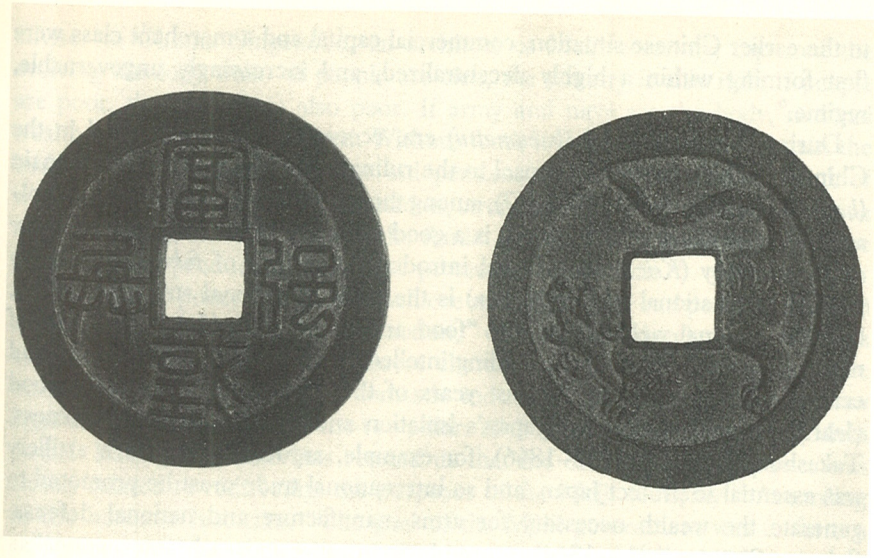
In 1922, a Japanese bureaucrat observed that "the degree of development of a nation's military industry not only tells the strength of its military preparations, but also serves as an indicator of the progress of its general industry and its economic status, as well as the grade of its civilization."[1] This view, shared by many Western strategists, persists in nonmilitary form; today technological capabilities are stressed more than military ones in the calculation of wealth and power, whether the observer is civilian or military. Dokō Toshio, one of postwar Japan's most respected industrialists, was characteristically straightforward when, as president of Ishikawajima-Harima Heavy Industries in 1952, he declared, "If Japan does not build jet engines, it will be a third-tier country."[2] A retired lieutenant general from the Japan self-defense forces argues, "In thinking long-term about Japan's national security, we must focus on technology-based productive capabilities . . . as a strategic element of Japan's national defense structure, in additional to technological power per se." He adds, "It is meaningless to think we can separate clearly civilian from military technologies. . . . They are all dual-use."[3]

That wealth and power are seen as interdependent is not unique to Japan. It is striking, however, how consistently they are wedded in national practice. Japan now pursues technology as a central element of national security in much the same way it did in its Imperial past. According to Nakayama Shigeru, a historian of Japanese science, "The rationale of technonationalists tends to run like this: 'Japan is a country scarce in natural resources. To counter this state of affairs, Japan has to be strong in other areas; it must be science and technology.' This logic was used repeatedly during the war to rationalize the military budget. . . . Such hypotheses were revised in the postwar period. . . . It has developed into a national psychosis . . . and is often used as a means of national mobilization."[4]

The subject of this chapter is a Japanese technonational ideology that makes little distinction between military and commercial sources of national strength and security. I explore this ideology as a set of coherent, even laudable, ideas rather than as an irrational psychosis; I examine its evolution, show its impact on the institutions of the Japanese technology system, and compare it to European and North American experience.

Fukoku Kyōhei and the Origins of Modern Japanese Technonationalism

National histories are littered with exhortations designed to mobilize and transform society. The French Revolution offered the lofty ideals of "liberty, equality,



A copper *fukoku kyōhei* coin, minted by the Mito *han* in 1866. The face of the coin has four characters: *fu koku kyō hei* (rich nation, strong army). It is also called the "tiger coin" *(tora sen)*. Photo courtesy of the Currency Museum of the Bank of Japan.

and fraternity"; the Russian peasantry was inspired by promises of "bread, peace, land"; Americans responded to calls for freedom from "taxation without representation." In Japan, the phrase *fukoku kyōhei*—four Chinese characters: "rich (*fu*) nation (*koku*), strong (*kyō*) army (*hei*)"—became the formal ideological foundation of industrial and technological development during the Meiji period. Its contested legacy has continued to inform Japanese security policy ever since.

Fukoku kyōhei was not originally a Japanese concept. The phrase first appears in the writings of Shang Yang (d. 338 B.C.), a Qin dynasty political leader and philosopher. Lord Shang argued that the monarchy should be strengthened and its power consolidated by embracing the principles of *fukoku kyōhei.* Good government would encourage commerce and strong state institutions. Lord Shang taught that the state ought to wage foreign wars and encourage domestic agricultural production while centralizing its authority. He wrote, "Governing a country lies in consolidating power; doing so [the ruler should] enrich the nation and strengthen the army."[5]

It remains unclear who first cited the phrase in Japan, but "rich nation, strong army" (in the original Japanese rendering: *Kuni o tomase, heiryoku o tsuyomeru koto;* in the shortened Chinese reading: *fukoku kyōhei*) was widely debated even before it became the slogan of the Meiji government. The mercantile and military components of *fukoku kyōhei* became the focus of political struggle during the final years of the Tokugawa shogunate when, in a striking parallel

to the earlier Chinese situation, commercial capital and a merchant class were first forming within a highly decentralized, and increasingly ungovernable, regime.[6]

During this late feudal (*bakumatsu*) era, economic advisers steeped in the Chinese classics provided counsel to the ruling lords (*daimyō*) in each domain (*han*). Dazai Shundai (1680–1747), among the most important Confucian scholars and economists of the period, is a good example. In his influential *Treatise on the Economy* (*Keizairoku*), Dazai introduced the idea of *fukoku kyōhei.* He posited that national wealth (*fukoku*) is the basis of national strength (*kyōhei*), but that national welfare (literally "food and money," *shokka*) is the basis of national wealth.[7] Many of the leading intellectuals advocated *fukoku kyōhei* and centralized power during the last years of the shogunate. They understood clearly the consequences of Japan's isolation and its technological weakness. Takashima Shuhan (1798–1866), for example, argued that modern artillery was essential to protect Japan, and so international trade must be promoted to generate the wealth necessary for arms manufacture and national defense. Sakuma Shōzan (1811–1864), a prominent royalist and early internationalist, first introduced the idea of combining foreign technology with Japanese values (*tōyō dōtoku seiyō gijutsu*) to strengthen the nation. This notion later was embraced in the Meiji slogan *wakon yōsai* (Japanese spirit and Western technology). Sakuma favored Japanese isolation but later concluded from studies of the Netherlands that only international trade could provide Japan access to the technology and resources to become a military power.[8] Ōkubo Takusui (dates unknown) is the most frequently cited pre-Meiji advocate of *fukoku kyōhei.* In 1855, just one year after the second arrival of Commodore Perry's "black ships," Ōkubo was arguing that "*fukoku kyōhei* is the grand foundation, maintaining the world" (*tenka wo iji suru daihon*). He emphasized that the country would be in danger unless its wealth was assured and argued that financial control should be above military command to ensure frugality among the populace.[9]

Thus, by the time of the Meiji Restoration, Japanese intellectuals had already identified the nation's vulnerabilities caused by 250 years of isolation. Their solution, *fukoku kyōhei,* was embraced by the young Meiji oligarchs and by the emerging commercial elite. Yet there was some opposition. During the Freedom and Popular Rights Movement (1874–1890), newspapers supporting a democratic constitution and Western-style liberalism argued that national wealth and military power might be incongruous. But Fukuzawa Yukichi, the most influential liberal of the period, embraced the need to advance learning to protect the nation, and the leading business intellectual of the period, Shibusawa Eiichi, used *fukoku kyōhei* to oppose the Confucian values that had dominated the Tokugawan hegemony. After returning from Europe in 1889, Shibusawa delivered a commencement address to the Tokyo University of Commerce (today's Hitotsubashi University) in which he rejected the traditional Confucian idea of social hierarchy and expressed his belief in *fukoku kyōhei.* Yano Fumio, a political adviser to Ōkuma Shigenobu, an architect of Meiji economy, captured the evolving ideology well: "If people are rich, the country is also rich; if people are poor, the country is also poor. If army and navy are the body, national wealth is the food we consume. Without food, it is impossible to maintain the body. In this situation, however independent a country may be, the lack of wealth will extinguish it."[10] "Rich nation, strong army" served the determination of modernizing elites to dissolve the feudal system and to bring military force and industrial production under the protection of the state.[11]

The specific policy designed to achieve national wealth and power was called *shokusan kōgyō*—"production promotion," or industrial development. But its essence, as derived from its Chinese characters, is better understood as the nurturance and protection of domestic industry.[12] Taken together, *shokusan kōgyō* and *fukoku kyōhei* were the two pillars of the evolving ideology of the Meiji period. Intellectual historians remind us that the centralization of power was closely related to redirecting the purposes of the Meiji economy.[13] According to one business historian, "The goal of the Meiji government was to form a unified country by negotiating with the old ruling class and to achieve economic autonomy in the face of hostile powers. The reform of the mode of production into capitalism and the launching of arms production that were to be realized in the name of *fukoku kyōhei* and *banpō taiji* [standing against all countries] were implemented by the *shokusan kōgyō* policy."[14]

The *shokusan kōgyō* program involved at least four general instruments to nurture Japanese industry: protection of industries, provision of subsidies, leasing and transferring of new machinery, and establishing and ultimately transferring ownership of state-owned "exemplary" factories. *Shokusan kōgyō* was formally inaugurated with the establishment of the Ministry of Engineering in 1870. In his proposal to establish the ministry, Ōkuma Shigenobu (then in the Foreign Office) pointed to the need to "encourage all industrialists to work for the benefit of the nation and the people." Ōkuma, a keen advocate of Western technology and a future finance minister, was joined by Itō Hirobumi and other modernizers and confronted by a group that preferred a more gradual approach to national development, including Kido Kōin and Iwakura Tomomi.[15] Ōkuma clearly married the *shokusan kōgyō* program to *fukoku kyōhei;* he stipulated that the purpose of the new ministry was to achieve *kokka fukyō* (richness of the country) and *gunkaku hitsuyō* (the need for military buildup).[16] The ministry's first tasks included mining and railway development for the military, and government shipyards at Yokosuka and Nagasaki were prominent in making mining and transportation equipment.

The *shokusan kōgyō* program had other important advocates, even among Ōkuma's erstwhile rivals. Ōkubo Toshimichi, another leading figure in the Restoration movement, established the Ministry of Home Affairs (Naimushō) after an extended study tour of European industry. Singularly impressed by Germany, he proclaimed that England should be the model for the Japanese

program of *fukoku kyōhei* through *shokusan kōgyō*. He returned "on fire with enthusiasms" for economic reform and industrialization.[17] In 1873, Ōkubo commissioned himself minister of home affairs, wresting responsibility for industrial promotion, civil law, railway administration, and civil engineering from other ministries. Naimushō's central purpose was industrial nurturance. In 1874, he argued in his famous *Shokusan Kōgyō ni kansuru Kengisho* (Proposal for Industrial Promotion) that the government should "induce and monitor the weak entrepreneurs to produce industries."[18] In the event, weakness was highly relative. Ōkubo's new ministry worked most closely with Iwasaki Yatarō, architect of the burgeoning Mitsubishi empire, transforming it into one of the world's greatest military-industrial combines.

One of Ōkubo's junior associates, Inoue Shōzō (1846–1886), was sent to Germany to learn military science in 1870. Inoue, a young staff member of the Industrial Development Bureau of the Naimushō, became disenchanted with military science after coming to the conclusion that "it was not military science but manufacturing that lay behind the German military might of the time."[19] He returned to establish the government-owned Senjū Woolen Mill, a demonstration plant built because Ōkubo, petitioned by foreigners to build textile factories, was dissatisfied with the response of Japanese entrepreneurs. In Ōkubo and Inoue's plan (which included the promotion of sheep ranching), the plant would be built initially to supply the military with uniform cloth, but it would thrive on private demand as well. Byron Marshall recounts Inoue's own observation: "I want to make our country the equal of Europe and America. Today even the small children of Japan talk of enriching the country and strengthening the military. But there are few men who really have attempted to discover the tree than has brought forth the fruit of civilization and enlightenment. . . . In my search for the source of wealth, the military power, the civilization, and the enlightenment of present day western nations, I realized that the source must lie in technology, industry, commerce, and foreign trade."[20]

The promotion of small-scale manufacturing and raw silk exports was consistent with the larger program, although the small manufacturing sector as a whole developed for different markets and at a greater distance from the state than did the "strategic industries." As we see in Chapter Three, the first looms and mechanical devices for the nascent industry were developed (or back-engineered) and produced in the military arsenals. Moreover, as G. C. Allen points out, "Japan's first problem was to take over as quickly as possible the technical apparatus of the West. . . . she feared for her security and her leaders could not neglect the strategic aspect of economic development."[21]

In fact, promotion of small, regional producers was strongly advocated by influential Meiji elites who had a deep commitment to *shokusan kōgyō*. Maeda Masana, first secretary in the Ministry of Agriculture and Commerce, proposed in 1885 that an industrial bank be established expressly to focus resources on small, regional producers. He argued that a capital-poor Japan should first

nurture an export sector to generate capital for later heavy industrial development. His proposal for a bank to provide priority financing for regional export industries was defeated by Finance Minister Matsukata Masayoshi, who had developed his own idea for an industrial bank that could relieve the government of part of its civil works obligations, thereby freeing central finances for his first priority—building up military and heavy industries. After leaving the government in 1890, Maeda led a movement to organize local industries in order to improve and standardize production and thereby increase exports. When finally established in 1900, the Industrial Bank of Japan was used to steer foreign capital away from direct investment and toward portfolio holdings as a way of limiting foreign control of Japanese industry.[22] Although Maeda's version of industrial promotion was not officially embraced, in practice small industry and foreign trade were important instruments of Japanese industrial development. The absence of protective tariffs, prohibited by the "unequal treaties" of the *bakumatsu* period, stimulated the development of export industries—particularly textiles—to generate foreign currency to pay for imported technology and the training of Japanese engineers.

Textile-led foreign trade grew rapidly, and as it grew it became technologically sophisticated and increasingly independent of state control. The textile industry's escape from bureaucratic controls reminds us that *shokusan kōgyō* was not a linear or uniform part of Japanese economic development: "Although government initiative had been an important factor in their development in the early years of Meiji, and although improvements, in the silk industry especially, owed much to official regulation, yet on the whole the expansion of these trades depended little either on direct assistance from the government or on the national economic policy then being worked out."[23] In 1894, on the eve of the Sino-Japanese War, agricultural and mineral products accounted for more than 60 percent of Japanese exports. Between 1900 and 1913, the composition of exports had shifted to finished products, primarily silk piece goods and cloth. Between 1913 and 1929, according to Allen, the textile industries greatly expanded and maintained their leading role in the Japanese economy. Clearly, *shokusan kōgyō* is not a complete explanation for Japanese industrial development, and some argue that the success of the Japanese cotton industry was owed in part to avoiding the mistake of the *shokusan kōgyō* program.[24]

But neither was the development of export-led textile manufacturing entirely a story of independent entrepreneurs maximizing profit. Private enterprise owed much to the nurturing vision of economic bureaucrats. After Ōkubo's assassination in May 1878, his ally Matsukata Masayoshi supervised the largest noncoerced privatization of industrial facilities in history. Facing massive budget deficits and runaway inflation, Matsukata scaled back state ownership and transformed *shokusan kōgyō* by transferring state-owned factories to private entrepreneurs at nominal prices (*kanei no haraisage*). Jackson Bailey suggests that, "like virtually all the Meiji leaders, [Matsukata] was guided first and last by a

commitment to the twin objectives of *fukoku kyōhei*. . . . Meiji leaders made most of their political and economic decisions to contribute to its fulfillment from a sense of urgency. Otherwise Japan, which was patently far behind the nations of the West, would be swallowed up in the intense competition for markets and colonies that marked the world in the late nineteenth century."[25] Thus under Matsukata industrial nurturing for national strength remained central to Japan's developmental ideology, but the instruments became largely private. After 1880, the state's major industrial facilities were transferred to "political merchants" (*seishō*), comprising the leading *zaibatsu* of the time—Mitsubishi, Mitsui, Furukawa, Kawasaki, and Ogura. *Zaibatsu* growth was abetted significantly by military production and the nurturance of the state.

Again, there were important political struggles for control of the economy and the distribution of the benefits of state nurturance. Business and military interests did not always coincide. When Matsukata sought to nationalize the private railways in 1892, he had the general support of the business community, including the chambers of commerce of Nagoya, Osaka, and Tokyo. But others, including Shibusawa, strongly opposed the nationalization, because new routes would be designed to be less vulnerable to attack rather than to facilitate commerce. The Mitsubishi *zaibatsu* and Ōkuma Shigenobu, then minister of agriculture and commerce, joined the opposition. After considerable debate, the railways were nationalized in 1908. This incident shows that there was no monolithic commitment to *fukoku kyōhei* in late Meiji, but as Marshall reminds us it was "the only instance in which government ownership gave rise to any serious debate among the business community."[26]

The greatest setback for advocates of *shokusan kōgyō* came several years later, after the World War I, when the Seiyūkai program of industrial nurturance was challenged by the Minseitō's deflationary plan to return to the gold standard (*kin kaikin seisaku*). *Shokusan kōgyō* was falling out of favor, and in its place was positive financing (*sekkyoku zaisei*) for an industrial-based nation (*sangyō rikkoku*). Finance Minister Inoue Junnosuke, seeking to harmonize Japanese with Western economic practice, moved to abolish the *dirigiste* programs of his predecessors. He cut defense budgets drastically, lowered tariffs, and disposed of overseas gold holdings—all in keeping with neoclassical, monetarist orthodoxy and in opposition to developmental state philosophy. This proved a boon for the established *zaibatsu*, which profited from the deflation by acquiring small firms ruined by high interest rates and shrinking export markets. In a global depression, however, Inoue's program proved calamitous. In the words of G. C. Allen, it "intensified the industrial depression and the social malaise."[27]

The government anticipated some of the undesirable consequences of liberal macroeconomic policy. Return to the gold standard was part of the "way of civilized nations," but the negative effects of liberalization had to be ameliorated.[28] Yoshiro Shinji of the Ministry Commerce and Industry and Gō Seinosuke of the Tokyo Chamber of Commerce and Industry designed a microeconomic palliative, "industrial rationalization," to correct for the excesses of the coming macroeconomic dislocations. In June 1930 the Temporary Bureau for Industrial Rationalization—forerunner of the Industrial Rationalization Bureau of the Ministry of Commerce and Industry (Rinji Sangyō Gōri Kyoku) responsible for the cornerstone of Japanese industrial policy, the "Important Industries Control Law" of 1931--established the Indigenization Promotion Council (Kokusan Shinkō Iinkai). This council was the first formal government effort to direct popular preferences toward domestic products. The following year, the Diet passed a law, drafted by the council, which designated sixty-five categories of domestically produced items for priority purchase by Japanese firms "even if they may be inferior to some extent [*tashō no sonshoku aru mono de atte mo*]."[29] The first among the sixty-five designated items were for shipbuilding: steel plate, specialty steel, pipes, tubes. Others included automobiles, aircraft engines, propellers, airframes, cables, mechanical controllers, batteries—in short, virtually all equipment necessary for the operation of a mechanized, industrial economy.

The government kicked off a national *kokusanka* campaign that included songs exhorting the nation to "Buy Japanese," postage stamps linking modernization to indigenization ("Imports in Meiji, Domestic Production in Shōwa" [*Meiji Hakurai, Shōwa Kokusan*]), and exhibitions in which hundreds of firms displayed their wares side by side with imported products. Prime Minister Hamaguchi, whose finance minister Inoue was committing the government to liberal trade, exhorted the nation to an "urgent duty not to use foreign products."[30] The entire campaign to "(Buy) Domestic by All Means" (*Zehi Kokusan*) was justified on the grounds that Japan's trading partners were all pursuing beggar-thy-neighbor trade and fiscal policies to which Japan had to respond by creating jobs and preventing waste.

Thus the Hamaguchi cabinet would have it both ways. While Hamaguchi and his minister of commerce and industry, Tawara Magoichi, promoted beggar-thy-neighbor microeconomic policies, Finance Minister Inoue and the *zaibatsu* pursued liberal macroeconomic policies. After Inoue and several industrialists were assassinated in 1932 by right-wing extremists, the *zaibatsu* made their peace with the militarists and retreated to benefit from a reworked *shokusan kōgyō* built on easy credit, especially for arms production. But the peace was often uneasy. Takahashi Korekiyo, Inoue's successor, refused to sign a blank check for the military, even though his reflation and their rearmament were closely related. He feared renewed inflation and, as Allen notes, "had cheerfully acquiesced for four years in a financial policy which made it possible for the militarists to pursue their ambitions." Takahashi, an unreconstructed advocate of *shokusan kōgyō* and protectionism, was fiscally aggressive. He used the defense budget to stimulate economic recovery: the military portion of the general account budget rose from 31 percent in 1931–32 to 47 percent in 1936–37. But, after he insisted on limiting military spending, he was assassinated by

junior army officers in the famous February 26 incident in 1936—ironically, the same year Keynes published his *General Theory.*[31]

Shokusan kōgyō was about far more than fiscal policy. Technology was central to the Japanese developmental ideology from the very beginning. According to one historian of science, "the modernization of technology was undertaken to achieve *shokusan kōgyō* and *fukoku kyōhei.*" Each was connected deeply to an emerging Japanese technonationalism, often referred to in Japanese as "nation-building through technological development" (*gijutsu rikkoku*).[32] The Japanese economy recovered from the depression by mid-1932, in part (but by no means entirely) through military demand. Thus, Allen seems to overstate the case when he argues: "In the 1930's [Japan] directed all her newly found technical skill to the creation of what she herself called a *Jun-senji Keizai* [quasi-wartime economy] . . . [and] she rescued herself from the depression. . . . Economic affairs passed under the control of the militarists, and were molded by the needs of war preparation."[33] But clearly, military production, national security, and technological development were already very closely linked by this time. Japan's technology and security ideology and especially the ideas of *fukoku kyōhei* and *shokusan kōgyō* evolved with the institutions of the Japanese political economy—across industrial development, military mobilization, and war; later we see how it evolved over occupation, and a commercial "economic miracle," as well. A Japanese economic historian expresses the connection succinctly: "In Japan, external forces have been central to national policymaking. The Meiji government nurtured the initial stage of technological development through a technology transfer policy. The *fukoku kyōhei* policy of the prewar period guaranteed the priority of the military sector. Teaching and learning of Western technologies were the basics of this policy. In the postwar period, then, it was the industrial policy administered by MITI that sustained technological development in Japan."[34]

The Three-Note Chord

Japan's technology and security ideology has evolved to serve the nation across a diverse set of structural conditions. It has informed and provided justification for militarist and commercial strategies alike. Historically, it has comprised three separate modalities: indigenization, diffusion, and nurturance.

Indigenization

In his elegant intellectual history of Japan, Tetsuo Najita outlines two pervasive themes—"bureaucratism" and "self-less human spirit"—that define "an elemental axis that is basic to understanding modern Japan." Bureaucratism is an "underlying ideological consensus" that growth and development should be

generated internally, and the bureaucratic ideology of modern Japan is a matter of "national integrity." Japanese ideology has congealed around the perception that national development is a matter of autonomy. National integrity can be achieved only through economic power—*fukoku.*[35] This *fukoku,* of course, is familiar as the first half of the Meiji exhortation *fukoku kyōhei.* It is not limited to matters of military strategy.

For more than a century, the struggle to be equal with and independent from the West has animated Japanese technology and security thinking, thinking that posits Japan in a hostile, Hobbesian world in which interdependence inevitably leads to dependence, and dependence eventually results in domination. In Reinhard Drifte's apt phrase, Japanese security thinking is dominated by "a genuine cult of vulnerability."[36]

The leading Meiji educator and liberal "enlightenment" thinker, Fukuzawa Yukichi, renounced his samurai status but was an outspoken advocate of the government's program of *fukoku kyōhei*—although he stressed the mercantile over the militarist elements of national security:

> The fact that England has one thousand warships does not mean that she has one thousand warships only. If there are one thousand warships, there have to be at least ten thousand merchant ships, which in turn require at least one hundred thousand navigators; and to create navigators there must be naval science. Only when there are many professors and many merchants, when laws are in order and trade prospers, when social conditions are ripe,—when, that is, you have all the prerequisites for a thousand warships—only then can there be a thousand warships. . . . In countries where there is an imbalance in military strength there is apt to be no sense of proportion—indiscriminate military expenditures drain the national treasury and undermine the country.[37]

At the core of Fukuzawa's support for *fukoku kyōhei* was his belief in independence and self-respect. In his classic *Outline of a Theory of Civilization (Bunmeiron no Gairyaku),* Fukuzawa argued that both civilization and wisdom were necessary to protect the nation. Wisdom, he argued, could be learned from abroad but was best nurtured at home. From the start, Fukuzawa and other influential Japanese taught, the advancement of independent knowledge and scientific competence was as necessary as military power to achieve security. The emphasis, from the beginning, was the ultimate goal of independence and autonomy—even if in the short run the cost was dependence.[38]

These beliefs had immediate practical application. Meiji Japan strove to learn Western industrial practices, particularly military technologies, and to indigenize with dispatch. Japan's first national research institutes were established by MITI's forerunner, the Ministry of Agriculture and Commerce, to strengthen Japan by achieving independence from foreign industrial products. To fortify Japan against a rapacious West, the indigenous development of strategic indus-

tries was accorded top priority, and responsibility was given to the Hyōbushō, the Ministry of Military Affairs. In the words of the 1868 Charter Oath of the Emperor Meiji: "Intellect and learning would be sought throughout the world in order to establish the foundations of Empire."[39]

This process of indigenization is called *kokusanka* (literally, "national productionization") in Japanese. Its progress was certain but unevenly applied. Despite efforts to nurture a domestic machine tool industry, for example, the Imperial Navy favored foreign suppliers throughout the Meiji period, but in 1907 the Navy grew concerned about foreign dependence and, abruptly switching policies, it gave Japanese firms the blueprints for imported machine tools then being used in government arsenals. In other areas, such as shipbuilding, every effort was made to stimulate indigenization, even if the immediate result was inferior products. Japanese shipyards were forbidden from using imported ship parts without permission after 1896. That same year, shipbuilders of 700–1,200-ton ships were given subsidies to offset import duties on steel and iron materials; in 1899 the government trimmed in half the subsidies of merchant fleets that used imported ships. The Encouragement of Navigation Law had its intended effect: sales of domestic ships soon swelled.[40]

Indigenization was most lethargic in the textile industry. Yoshi Tsurumi reports that, although the government sponsored engineers to back-engineer imported looms and develop indigenous models, over 96 percent of all spinning machines were brought from abroad in 1892. Whereas in textiles technicians learned to operate and maintain imported equipment until well into the interwar period, technical training was more extensive in the chemical, mining, and heavy industrial sectors:

> Although the importance of the government as a direct technological source faded about the time of the outbreak of World War I in 1914, government-owned plants and laboratories had long served as the training places of engineers, scientists, and skilled workers who either joined private manufacturing firms or established their own workshops and plants. In particular, the procurement policies of the government-owned plants were often designed to aid the private manufacturing firms to absorb new technologies or upgrade the technologies they already possessed.

In short, the "unequal treaties" that so stimulated the development of export industries were also responsible for renewed emphasis on technological development and indigenization: "Since it took the Japanese government from 1858 to 1911 to regain its rights to determine import duties, the government's major weapons for developing Japanese manufacturing industries were limited to direct subsidies, *legal sanctions to discourage the use of imported parts and machines,* and more important, the building up of the general technological level of the nation."[41]

Today the preference for domestic products or for licenses to produce foreign products at home is codified in the "three unwritten principles of *kokusanka.*"[42] In order of priority they are (1) domestic supply; (2) if domestic supply is not possible, licenses using domestic manufacture and equipment; and (3) equipment with application beyond the project for which purchased. In accordance with these principles, in both military and civilian cases, it is not uncommon for each subsequent generation of Japanese product to depend less than its predecessor on foreign technology. According to one historian of Japanese technology who has focused on indigenization,

> Self-reliance in technology does not mean autarky. . . . [it] refers to the ability to absorb all needed technologies, and the attainment of this self-reliance is attained not at a stroke but in stages. . . . One reason Japan could successfully absorb foreign technology in the nineteenth century was because most of the technology and machinery in those days could be dismantled into separate components, and these components could be replaced by parts produced locally. . . . Although replacements were often less efficient and poorer in quality, they satisfied national needs in being less expensive and easier to maintain. The repetition of this process made it possible to eventually turn old technologies into new ones.[43]

Some of the most important debates over Japanese industrial policy have centered on how to achieve local control of knowledge. The *kokusan* ideal has been invoked to motivate researchers and to justify R&D spending in sectors as diverse as petrochemicals, nuclear power, telecommunications, computers, aircraft, and steelmaking. The contemporary catch phrase is *ichigō yunyū, nigō kokusan* ("import the first one, indigenize the second").[44] Appeals to "catch up and surpass the West" dating from the Meiji era echoed throughout Japan's subsequent industrial history and are still invoked routinely to justify the indigenization of licensed technology. Tanaka Masami, a senior MITI official, refers to indigenization as the "unraveling of knowledge"; he argues that the real learning comes not from instruction manuals or foreign teachers but from local machinery operators who are encouraged to improve the equipment: "Knowledge alone has no meaning until it has been embodied in machines." The objective of such learning is to wean the industry from dependence on licenses and to design equipment autonomously so that "the recipients can become competitors of the suppliers of technology in world markets."[45] Between 1950 and 1962, nearly 2,000 separate contracts were signed by Japanese firms for access to foreign technology—including licenses, tutoring, and overseas training. By 1960 there was not a single substantial enterprise in any advanced manufacturing sector not a party to such an agreement; in 1970 nearly 2,000 technology purchases were approved by the Japanese government, and in 1990 Japan remained a net importer of technology and more than 8,000 such purchases were approved.[46] Acquisitions such as the transistor were crucial to Japanese industries that now dominate world markets. Throughout the rest of

the twentieth century, Japanese firms have licensed for tens of billions of dollars foreign technology developed at a cost of hundreds of billions in a rapidly succeeding effort to achieve autonomy through dependence. As Terutomo Ozawa notes, this purpose was enshrined in Japan's postwar Foreign Exchange and Foreign Trade Control Law; the preamble states: "The purpose of this Law is to create a sound basis for foreign investment . . . by limiting the introduction of foreign investment to that which will contribute to self-support."[47]

Appeals for indigenization have been loudest in the defense sector. The Association to Promote the Patronage of Japanese Products (Kokusan Aiyō Suishin Kyōgikai)—a direct descendent of the movement started in the early 1930s—directed its energies toward home appliances, stationery supplies, and automobiles in the 1950s and 1960s and shifted toward the indigenization of defense equipment in the mid-1960s.[48] The Defense Production Committee of Japan's Federation of Economic Organizations, or Keidanren, has justified military *kokusanka* in at least five ways: Japan's unique policy of "defensive defense" requires equipment different from that manufactured in Europe and North America; Japanese military personnel have a "special spirit and body size," just as Japan has special "land, water, and seas"; licensing breeds dependence of the licensor on the licensee, making upgrading difficult; licensors are less willing to transfer technology to Japan now that Japan's technological level has improved; and codevelopment with other nations can succeed only if Japan has something of its own to offer.[49] Note the absence of military rationales for autonomous development of weapons. Rather, *kokusanka* avoids foreign dependence generally and specifically improves Japan's bargaining position to obtain technologies from abroad.[50]

Like much else in Japanese politics, and throughout Japanese history, limited resources and diverse constituencies have generated fractious contests for control of security policy. The defense and industrial faction that has lobbied for "pure" or "complete" autonomy (*jun kokusanka*) has enjoyed only limited success. More often than not, advocates of indigenous design and manufacture of military equipment, especially aircraft, have lost to advocates of licensed production. In the 1970s and 1980s, the United States transferred more weapons to Japan than to any other ally except Germany. But these transfers were not sales of finished products. To the contrary, Japanese defense contractors licensed and coproduced twenty-nine major U.S. weapons systems, more than any nation in the world. In 1990, 89 percent of military aircraft procured by the Japan Defense Agency (JDA) was manufactured in Japan.[51] Complete autonomy is just one (higher-cost and higher-risk) route toward enhancing the domestic industrial and technology base. Licensing has been a middle road toward the ideological high ground of technological autonomy.

Takayama Katsuichi, a senior JDA official, puts this choice in its proper, pragmatic context: "We are not at war right now, so both domestic development and licensed development are possible, and this is an advantageous situation. It gives us the chance to work hard on good projects, to discard the failures, and while importing when necessary, to operate economically in such a way as to support our own research and development." Like the Meiji policy elite who preceded them by four generations, Takayama and other proponents of indigenization argue that R&D capabilities are a central component of national power.[52] Profits and costs should be subordinated to learning and the enhancement of domestic technological capabilities.

The struggle for technological autonomy did not slacken once Japan emerged as a technological superpower in the 1980s. To the contrary, industry and the bureaucracy frequently use parity with the United States to justify increased funds for scientific and technological development and for *accelerated kokusanka*.[53] A group of defense industrialists convened by Keidanren responded to U.S. demands for technology codevelopment by arguing for accelerated indigenization to ensure against a U.S. technology blockade. A former Air Self-Defense Force general supports U.S.-Japan cooperation in defense technology, but he argues that cooperation alone will not suffice: "Japan must think on its own about an independent national security strategy in a forward-looking way."[54]

Efforts to achieve autonomy are central to international cooperation. Consider the opening lines of the 1991 report "Promoting International Cooperative Aircraft Development" from the Japanese Machinery Industry Alliance and the International Aircraft Development Fund; its author, a senior corporate adviser to Hitachi, echoes Meiji insecurities:

> It goes without saying that, in order to secure a stable rank in international society, it is essential to more fully utilize our nation's meager resources and, moreover, to develop high-level industrial technologies, leading the world. In order to do this, we must stir up the will for a technological renovation . . . as well as reinforce and nurture the capability to develop technology autonomously. . . . In order to overcome the fragility of our resource poverty, it is necessary for us to shift our policies of promoting a technology-based nation [*gijutsu rikkoku*] and establish our economic security; this is a major objective that we must aim at, especially now.[55]

A survey of Japanese dual-use and related defense production capabilities by the Mitsubishi Research Institute in 1987 was blunt about the tactical use of international cooperation and the strategic goal of autonomy: "With the exception of some very advanced high technologies, the commercial base of Japanese electronics materials and vehicles technology is equal to or better than in the United States and Western Europe. We anticipate progress in commercial-led R&D for military application. However, in those areas of high technology where domestic technology is behind, it will be necessary to supplement [domestic efforts] with international cooperation."[56]

In Japanese parlance, the purpose of "international cooperation" is to enhance Japanese technology, which in turn strengthens the Japanese position in international projects. The notion of Japan as a technology-based nation is more comfortable than that of technonationalism, although *gijutsu rikkoku* has been translated both ways. According to one aerospace engineer (who used the term *tekunonashyonarizumu*), "The word 'technonationalism' cannot be used to describe Japan. Technonationalism connotes closing down access. This describes the United States. Japan promotes national security through technological improvement. This is not 'technonationalism' but 'technoglobalism.' How else can we be reliable partners if we do not have first-class technological capabilities to contribute?"[57]

But others acknowledge the deep strains of technonationalism in Japanese thinking about national security. Nakayama points out that the government invoked the term *gijutsu rikkoku* in the 1980s in response to U.S. *tekunonashyonarizumu.* He argues that *gijutsu rikkoku,* which translates as "technonationalism," carries a nationalistic implication, that of building up Japan's own creative technology as a bargaining tool against the hypothetical enemy of U.S. technology.[58] Inoguchi Takashi, an international relations theorist at Tokyo University, has identified this aptly as Japan's "two-track policy": "One branch of this [two-track policy] is to depart from the system of dependence on U.S. research for technological information and to expand its niches on the technological frontiers autonomously, as far as it can; the other is to strengthen the Japan-U.S. collaborative research system."[59] The benefits of autonomously controlling technology remain as clear as ever in Japanese strategic thinking, in large part because Japan's cult of vulnerability has never dissipated. As Arthur Alexander notes, "Japanese [defense industrial] behavior has been conditioned by many objectives: a desire for national independence and autarchy, a search for commercial technological spin-offs and other commercial advantages, the sales and profit goals of individual companies, and a belief that mastering military high technology is the key to modern industrial competence."[60]

Diffusion

Autonomy is widely accepted as a legitimate goal of every nation's security policy, of course. Equally important is the Japanese commitment to diffuse technologies as broadly as possible throughout the economy. As a MITI official acknowledges, "It is widely recognized that since the Second World War a formula for Japanese success has been the adoption and often improvement of foreign technologies. . . . Most of the R&D effort has been geared to the adaption, assimilation, and diffusion of foreign technologies."[61] Like much else in current Japanese thought about technology, this is consistent with Meiji practice. Institutions develop in ideology's image. Whereas technologies were imported by the military and the Ministry of Engineering during the early Meiji

period, Ōkubo's Ministry of Home Affairs emphasized technology nurtured, developed, and diffused at home. It held full-scale expositions for the promotion of domestic industry to encourage people to increase productivity in the interest of the nation. The first such exposition was held in Tokyo in 1877. To encourage technical development and technology transfer to the private sector, the sponsors invited contributions and awarded the winners for outstanding work.[62]

Formal associations of firms have long been key elements in the diffusion of technology. The first legislation authorizing trade associations (*dōgyō kumiai*) was promulgated in 1884. The purpose was to stimulate cooperation among small-scale manufacturers who might generate foreign exchange. By 1925 the formula was expanded to industry associations (*kōgyō kumiai*), and the government actively encouraged shared facilities as well as joint purchase and sale organs. Today, technology is often a quasi-public good distributed through elaborate networks of producers and public bureaucracies.[63] Participants believe that proprietary technology can be distinguished from generic information and that each contributes significantly to Japanese national security. As a consequence, Japan has built an extensive network of "technology highways"—an infrastructure with at least as many lanes but perhaps fewer roadblocks than its U.S. counterpart. The lanes are familiar from elsewhere: movement of personnel within large, highly diversified firms; organizations within firms dedicated to internal transfer of knowledge; interfirm relations, both vertically between firms at different points on the value-added chain and horizontally among competitors who agree to identify and share generic, nonproprietary information.

The interdiffusion of civilian and military technology has long characterized the Japanese technology process. Japan's first machine tools, although they proved inferior to foreign products for years, were manufactured in a government arsenal in 1869, and modern communications were first used by the army to suppress the Satsuma rebellion. Similarly, as Tsurumi notes, the naval shipyards were a crucial source of technology: "The shipyards, whether government owned or privately owed, provided markets as well as necessary manufacturing technologies for the young Japanese electric and machinery industries. In particular, the technologies needed to make steam engines and ship boilers were applied to produce steam engines and boilers for textile plants and mines." As Kobayashi Ushisaburō explained in 1922, the basic technologies initially absorbed for military purposes were crucial in building Japan's commercial industries: "While the manufactured articles made as war materials are seldom fit for general use, the tools and machines that manufacture them may for the most part be used for making other kinds of articles wanted by the people at large. . . . One industrial work is apt to cause another of a similar kind, and so on, and the result was the evolution of all sorts of new industries. But that is not all. Workmen who had been employed and trained in the military industry went to work elsewhere in private factories or started little works of their own."[64]

This is not ancient history. Low barriers to the interdiffusion of civilian and

military technologies profoundly shaped Japan's postwar development, even if not always by design. The country's earliest export successes, such as cameras, watches, small machinery, and later even automobiles, were developed under the supervision of former military engineers scattered by order of the Occupation authorities.[65] Senior executives of many of Japan's most successful firms—including Morita Akio and Ibuka Masaru, the founders of Sony—learned their first lessons about manufacturing and technology management in the laboratories and factories of the Imperial Naval Air Arsenal (Kugishō).

As Chapters Six and Seven show, the direction of technology diffusion from the military to the commercial economy was not simply reversed in postwar Japan. Although Japanese technonationalism shifted to a commercial base, military technologies and military production continued to matter. Japanese firms used U.S. military procurement during the Korean War to benefit the entire economy. This "special procurement" (*tokuju*) resuscitated moribund industries by transferring American engine and machinery technologies and introducing production, quality control, and manufacturing process know-how. Military demand, and especially technologies first introduced for military production, actively contributed to Japan's commercial economy for at least two decades after the resumption of military production in 1952. Industry repeatedly demanded increased military production in part because "the diffusion of modern weapons production raises the technological level of general industry."[66] Engineers noted in surveys that participation in defense R&D "helps raise technological capabilities in other areas" such as systems integration and design.[67] As long ago as 1963, 98 percent of the production equipment employed in the manufacture of military products was being used for nondefense products as well.[68]

Diffusion of knowledge in Japan occurs at several levels, inside and among firms and between sectors. Within firms it is accomplished through parallel, undifferentiated efforts affecting both commercial and military technologies. The major defense contractors are diversified manufacturing conglomerates that take special pains to establish mechanisms for functional area specialists, such as materials, design, and control engineers, to share know-how and experience. Although they rarely transfer engineering personnel across applications, they actively seek to transfer knowledge accumulated in one area to others within the firm.[69]

The result is a cadre of multifunctional design and manufacturing specialists who understand their application area comprehensively and are expected to systematically diffuse their accomplishments company-wide. Though engineering and technical staff typically do not leave their specific application areas, they each participate in every program phase from design to production and in a range of intrafirm mechanisms that transfer their knowledge. Thus quality control methods derived from production have diffused throughout the machinery industry divisions of Japanese primes; commercial automated manufacturing processes have rationalized the production of fighter aircraft parts; aerospace materials have improved automobile and bus body production. In Japan, defense production is like any other resource within a firm: something to be mined for technological wisdom.

Technology also diffuses horizontally, among competitors. Japan's technological capacities were fostered by institutions such as research consortia that allow competitors to achieve a common technical base before they compete in the market. Firms cooperate in consortia at every level of the development cycle, including basic research, systems development, and (especially in aircraft) device manufacturing. The form and function of these consortia vary, and competition among participating firms never disappears (and is often extremely vigorous). Still, collaboration is highly valued in Japan but (at least until the 1980s) denigrated as collusion in U.S. thinking. Since the 1970s, every government program designed to support technology development has provided incentives for even more collaborative research.[70]

In other "external" and information networks, too, technology is exchanged, traded, or otherwise diffused among competitors. These networks include joint ventures, technology exchange agreements, cross-licensing, second sourcing, production sharing, and a wide range of informal technology trading and information sharing. In the late twentieth century, as in the mid-nineteenth, state-sanctioned industry associations and regional and prefectural manufacturer associations (*kumiai*) provide opportunities for vendors and subcontractors to exchange technological information. Christopher Freeman explains this as the historical and institutional development of a "national system of innovation" that seems to offer advantages over firm-based innovation vis-à-vis technology diffusion.[71] Because resources are pooled and risks shared, participants in research consortia may undertake technology strategies more ambitious than if they were working alone. Rapid diffusion of technologies and the avoidance of unnecessary duplication mean that resources may be employed more efficiently. Also, collaboration permits Japanese industry to enjoy the advantages of size and scale without vitiating competitive pressures. Indeed, by creating a "level technological playing field," research consortia may actually increase competition.[72]

An additional highway connects suppliers and their customers. It extends to (and indeed defines) the vertical relationships among prime and subcontractors and facilitates learning both upstream and downstream. Japanese prime contractors have been the principal conduit to diffuse knowledge gleaned from licensed production to supplier and vendors. Typically, with each new project subcontractors dispatch teams of engineers to the primes for several weeks or months of training to master imported design or manufacturing techniques. The primes also provide technical guidance on equipment purchases such as autoclaves, new numerically controlled machinery, or specialty composite materials technology.[73]

There is also substantial diffusion from the bottom up; indeed, a dominant trend in Japanese manufacturing is the increased role subcontractors play in

applying technology to foster new products. As the subcontractors diversify or undertake independent research and development, they often learn techniques or skills that they spin on to their old lines of work. This knowledge is often transferred downstream in generic form as the subcontractors design or manufacture new products.[74]

As in the United States, prime defense contractors are directly responsible for only a fraction of their nominal production. The 1,373 firms the JDA lists as suppliers are merely the tip of an elaborate network of indigenous producers.[75] A 1987 survey by the Mitsubishi Research Institute found that reliance by primes on their subcontractors for defense production was high and growing.[76] The volume of upstream and downstream technology diffusion differs among companies and industries; downstream transfer may be comparatively rare in Japanese defense manufacturing, given the heavy influence of licensed production. Nevertheless, it is yet another institutional mechanism by which technologies flow between companies that is consistent with Japan's technology and security ideology.

Finally, and perhaps of the greatest consequence, the Japanese technology ideology and the structure of Japanese industry combine to encourage the diffusion of technology across industrial sectors. A MITI official connects intersectoral and vertical diffusion to indigenization: "Local technology capacity is an important factor at several stages of technology transfer. At the first stage . . . local skills are required. . . . At the second stage the [local] machinery industry . . . should supply the necessary equipment. A more important matter is that the technology thus adapted contributes to [the] elevation of the technological level of the [economy] as a whole through the diffusion of equipment to a wide range of [local] industries."[77] Japanese practice has capitalized on an industrial structure and beliefs about technology that treat knowledge as generic rather than specific to existing industrial sectors. As a result (as we see in the manufacture of aircraft and arms in Chapters Three and Four), both product and process technology diffuse within diversified firms and between firms in different sectors in ways that enhance the productivity of the national economy, a matter that is, after all, still central to Japanese conceptions of national security. And so, firms and their competence must be nurtured.

Nurturance

Consistent with the Meiji program, today indigenization and diffusion are still incomplete without a parallel effort to support the producers that benefit from these processes. According to one leading aerospace designer, "technology is about more than know-how. It also includes 'know-why' and 'know-who.' One must nurture people and relationships as well." Likewise, a director of Japan's Aircraft Technology Association explains that industrial policy is about

"targeting technology, not an industry. We are nurturing capabilities, not a sector."[78]

This strategic belief has important tactical manifestations. Japanese thinking recognizes not only the standard threats to long-term manufacturing capabilities—including market shifts and technological revolutions—but fratricidal competition among firms that results in bankruptcies and unemployment. In neoclassical Western economics, "excessive competition" is an oxymoron. But in the Japanese view the social dislocations of excessive competition are great. This need to manage competition and nurture technological development simultaneously is ubiquitous across decades of Japanese industrial policy. It is also widely embraced by firms. As the Society of Japanese Aerospace Companies explains, "In a free economy, each firm undertakes its own research and development, giving birth to duplicated investments and unstarted projects. In order to avoid the evils associated with R&D by individual firms . . . government action is of utmost importance."[79]

The Japanese have constructed an elaborate system of protocols—sometimes tacit, at other times explicit—to induce domestic firms, even as they compete, to negotiate constantly with their competitors and with bureaucrats to share market jurisdiction and control. These protocols can be as simple as legitimacy afforded to government advisory commissions and as complex as reciprocity accumulated over decades of interaction. They force interests as varied as the largest industrial producers, small subcontractors, regional industrial associations, local and national bureaucrats, and financial institutions to take account of each other's needs in shaping the economy. No single interest can ignore the others in making industrial strategy; no one bureaucracy, multinational firm, or domestic union can significantly disadvantage the others through unilateral decisions.[80] These protocols integrate the institutions and ideology of the Japanese economy.

This contrast with American views is stark. U.S. economic bureaucrats have historically been preoccupied with excessive market concentration. Meanwhile, their Japanese counterparts have feared that excessive competition may drive producers out of business. Bargaining and negotiation protocols help mediate business cycles, differential access to capital, cutthroat regional development competition, and large-firm market power—which typically generate enormous dislocations in other countries—so that even sick players can stay in the game, and none can move too far ahead. Small and large producers in Japan share the pain of economic downturns, at least to a greater extent than in the United States; capital is allocated across the board, to talented niche producers as well as to brand-name corporations. Exit from the economy is made less attractive than collaboration that progressively builds the skills of individual firms, regions, and the economy as a whole.[81] And when exit is unavoidable, as in Japan's coal mining districts in the 1960s, the state and consumers are expected to bear their fair share. In February 1992, for instance, the government announced its

ninth coal rationalization program. Through three decades, Japan's coal industry has enjoyed a relatively soft landing and was transformed along the way from an extractive to a higher value-added processing industry.[82] Domestic firms thus enjoy considerable long-term stability from which, individually and collectively, they can find ways to exploit what they have learned. Understood in this fashion, Japanese nurturing strategies—while not perfect by any means—encompass the public, private, tacit, and explicit bargains that undergird the economy.

This three-note chord—the pursuit of technological autonomy, diffusion, and the nurturance of Japanese industry—has long been central to an evolving, dominant conception of security in Japan. By the 1970s, with the defense debate still the most divisive issue in domestic Japanese politics, Japanese strategists undertook to reassure the electorate that Japan could provide for its national security without resorting to militarism. Their framework, "comprehensive security," has proved a durable tool for both domestic and international constituencies.

In April 1979, Prime Minister Ohira Masayoshi requested separate task forces to study external economic relations, the concept of the Pacific Basin community, and comprehensive national security. In July 1980, the third task force, chaired by Inoki Masamichi, submitted its report. Nations, it asserted, can make three kinds of efforts to achieve security: change the external environment so that threats recede, achieve self-reliance to cope with threats, and achieve solidarity with allies to confront or eliminate threats. The military assessment report was straightforward: the "absolute and relative" decline of the United States vis-à-vis its Japanese and European allies dictates greater self-reliance, but Japan's own self-defense forces do not possess the minimum necessary denial strength.

The report was noteworthy because it stipulated formally that military affairs was only one part of national security and codified the concept of comprehensive security.[83] The concept was designed as an omnibus threat assessment to mobilize a broad consensus on security issues. It addresses Japan's foreign relations, its military power, and its vulnerabilities (including energy, food, and natural disaster). It includes overt military threats as well as economic threats to the livelihood of Japanese citizens. Comprehensive security recognizes no single threat as greater than the others (see Table 2.1).

Until the mid-1980s, technology was rarely a central theme in studies of comprehensive security, although, as Richard Barnett reports, "an underlying assumption in Japanese thinking about national interest and effectiveness is that the possession of voluminous, accurate, and usable information is a paramount strategic asset. . . . Japan's intense attention to potentials of technology . . . confirm[s] commitment to the idea that knowledge is power."[84] The July 1980 report referred only in passing to the benefits of military R&D and of spinning-

Table 2.1. Structural outline of national security

	Threat	Means of protection: Direct	Means of protection: Indirect	Goal: to protect
Military	attack	military force	arms reduction	territory
	broken peace	collective security	appeasement	lives
	indirect attack	diplomacy	information	regional peace
Economic	control	development	trade	lives
	blockade	stabilize public welfare	economic exchange	economic activities
	sanctions	science/technology	technology exchange	economic freedom
Sociopolitical	ideological propaganda	national consciousness	diplomacy	national prestige/dignity
	psychological war	level of knowledge	cultural exchange	political stability
	spiritual coercion	nationalism	international friendship	political freedom

Source: Keizai . . . Iinkai, 1976, p. 41.
Note: This report predates the formal commission and does not use the term "comprehensive security" per se.

on capabilities from Japan's advanced electronics and computer technology, but it did recommend a substantial increase in defense research spending and in domestic procurement. The Inoki report brought the issue of indigenous technology nearly back to where it had been before 1976. According to Michael Green, in the preceding decade "the *kokusanka* debate had come—if not full circle—then a good 300 degrees around."[85] But many reports since then have made the argument in greater detail, and indeed the prospect of a technology blockade has replaced interdiction of energy and food as the central nightmare of resource planners.[86] A former Air Self-Defense Force general makes the link clearly: "In order for Japan to think seriously about its own national security as a technological nation, we must above all else establish an invisible technology strategy within our general security strategy."[87] Michael Chinworth likewise concludes that "the Japanese notion of security makes no distinction between economic and military considerations, resulting in a situation in which the importation of military technologies, domestic development of advanced, multipurpose technology, domestic development of advanced, multipurpose technologies, and indigenous production of new weapon systems are just as important for their economic impact as for their impact on the government's ability to ensure territorial integrity against an external threat."[88]

Japanese strategic beliefs have converged on a national commitment to indigenize technology, to diffuse it throughout the economy, and to nurture firms that could benefit. These beliefs have been embraced throughout Japan's modern history and have informed the development of the institutions of the Japanese economy, although with varying intensity. Pursued separately and measured in

conventional economic terms, each note has effects that can be costly and inefficient. Pursued jointly and understood in ideological context, the three-note chord has led to industrial strength and national security. Japanese ideology and practice raise two important questions: (1) Is the Japanese conception of its technology and security significantly different from that of the United States or Western Europe? (2) Is this technology and security ideology limited to defense production, from which it was derived, or is it a set of general beliefs? I take up these questions in the following two sections.

Is Japan Different?

Ideas about Technology and Autonomy Are Familiar

The components of Japan's technology and security ideology, and the strategies they inform, are not alien to Western thought and practice. As noted in Chapter One, many non-Japanese thinkers have put forth ideas that coincide closely with the Japanese ideology, particularly its emphasis on industrial development, self-reliance, and nurturance. Joseph Schumpeter's claims that technology is the central component of economic competitiveness and that capitalism is a relentless process of innovation resonate throughout Japanese economic practice. So does his claim that the "preservation of capitalism require[s] powerful political adjustments and careful management by elite bureaucrats."[89] Thomas McCraw notes that Schumpeter's "attitude toward big business is echoed in the Japanese way of thinking. . . . Japanese culture has seldom looked with much fear on big companies . . . [which] have usually been regarded not as evil monopolies but as national treasures." Friederich List likewise anticipated the mercantilist thread in Japanese technology ideology. List's argument that a nation's independence and security depend on the independence and vitality of its manufacturers is isomorphic to Japan's relentless acceleration toward autonomy and its unflagging commitment to nurturance and technology diffusion. Indeed, Ōkubo was exposed to List's neomercantilism during his visit to Germany in the early 1870s, and List's ideas suffuse Ōkubo's 1874 economic program, Japan's first formal rejection of laissez-faire principles. List's works became widely available in Japan in the 1880s.[90]

In short, Japanese industrialists, security planners, and policymakers have been more informed by Schumpeter's belief in the centrality of technology and List's belief in the importance of domestic industrial and technological capabilities than have their counterparts in America.

To be precise, the embrace of different principles—in particular Smithian ideas of free trade and comparative advantage—are characteristic more of the late twentieth-century United States than of the United States in earlier periods or of many U.S. allies in the postwar period. U.S. protectionism and industrial nurturance, à la Alexander Hamilton in the early nineteenth century and (in a different context) Herbert Hoover a hundred years later, were widely accepted until the United States assumed its hegemonic role after World War II. And even then, military production in the United States was treated exceptionally. Japan is hardly the only late-developing state to nurture strategic industries, or to rely on foreign technologies to do so.[91]

Likewise, elements of the Japanese technology ideology are consistent with postwar European beliefs. Consider this account of Britain by William Walker: "It was taken for granted that industrial autarchy would be maintained in the defense area. . . . The norm was national procurement, maintenance of a near comprehensive defense technology base, support for national champions, and national ownership of the means of production if need be."[92] In postwar France, Charles de Gaulle eschewed collaboration with allies to nurture French national laboratories and manufacturers. Like Japan, France pursued an apprenticeship strategy of licensing for learning, designed to wean the French aircraft industry from its dependence on U.S. technology. The French motto was *reculer pour mieux sauter*: take a step back in order to leap forward.

Or consider the 1958 words of Franz Joseph Strauss, soon to become Christian Democratic defense minister of the Federal Republic of Germany: "The technical economic position of a country today is largely determined by the performance of its aeronautics industry and related areas." Strauss laid out a plan parallel to but even more ambitious than Japan's strategy. He recalls that "we proceeded systematically. Beginning with the maintenance, assembly, and licensed production of American aircraft, we were able to create the necessary engineering capacities and scientific-technical potential, and ultimately our own aerospace industry."[93] In short, pursuit of autonomy in defense and aircraft manufacturing is not peculiarly Japanese.

In the postwar United States, however, autonomy and nurturance often took a backseat to alliance geopolitics. Listian principles of mercantilism were rejected in favor of Ricardian ideas about comparative advantage and free trade. The orthodoxy of neoclassical economics served American power. During the Cold War, moreover, U.S. policy nurtured the industrial and technological infrastructure of allies as well as of domestic producers. "Offsets"—production in allied nations in return for deployment of U.S. troops and military systems—provided extensive foreign access to U.S. design and production for military and aerospace uses.[94] One unintended consequence was increased dependence by U.S. prime contractors on components manufactured abroad. Defense Department "Buy American" support often ends at the prime contractor, the final assembler of (often foreign) components. Several government studies show that foreign dependence increases farther down the supply chain. American manufactured alternatives could substitute for some of these components and

subassemblies, but in many cases U.S. program managers report that it would take five years to develop replacements.[95] Sometimes these dependencies are driven by price, Japanese dual-use technologies, for example, can be significantly less expensive than U.S. technologies developed entirely for military markets.

The Japanese, by contrast, employ different criteria. According to a Mitsubishi aerospace plant manager,

> It is easier to control a Japanese firm than a U.S. one. They are more flexible about design changes, deliveries, cost, and so forth. We have a natural preference for Japanese suppliers. . . . [Our "make or buy" decision] includes a concern for what our customer wants, and the Defense Agency usually wants to nurture the capabilities of other Japanese firms. If we try to do too much on our own, the Defense Agency will ask us, "What are you doing to your younger brother?" We have been in this business a long time, and we know it is our responsibility to spread the work around.[96]

As we see in more detail in later chapters, Japanese belief in the (often uneconomical and inefficient) primacy of national producers is indeed different from U.S. practice, and its evolution certainly was abetted by Japan's propitious alliance with the U.S. hegemon. In Japan, national wealth now precedes military power, whereas in the United States military power was pursued as if it could be sustained independent of national wealth. It was as if Cold War American strategists, with no larger power to protect them, had reversed Japan's developmental ideas and promoted "strong army, rich nation" just when the Japanese were abandoning military technonationalism in favor of commercial development.

Technology Diffusion Is Familiar Too

The relationship between civilian and military economic activity is rarely linear, and the interdiffusion of civilian and military technologies is hardly peculiar to Japan.[97] Most accounts stress the ease and rapidity with which product, process, and organizational technologies spread. William McNeill, speaking of sixteenth-century Europe, reports that "whenever anything new really worked, it spread court to court, shop to shop, and camp to camp with extraordinary rapidity." Such relationships obtained even earlier; consider gun design and manufacture. The earliest drawings date from 1326 in Europe and 1332 in China, suggesting a common origin. The origin could have as easily been civilian as military, since explosives were first used for ceremonial and commercial purposes, and the first recorded gunsmiths were bellmakers. Military explosives, in turn, were the vanguard of the modern chemical industry.[98] But in the Middle Ages the interdiffusion cycle could be measured in centuries,

at the eve of the Industrial Revolution in human generations, and today scarcely in years.

Historians also stress the importance of military end use as a stimulus to technological innovation. The spoked wheel and the precision manufacture of a friction-reducing hub and axle were invented for the armed chariot (in Mesopotamia, in 1800 B.C.). The same is true for the wooden pulley blocks designed for the British Navy that would later stimulate development of the machine tool industry, as well as for the common ship designs of merchant and military fleets in recent centuries. Military mapmaking significantly advanced cartography, but hardly in isolation from civilian application.[99]

Military applications profoundly affected the development of civilian products, but there is no clear evidence that military products uniformly or even routinely originated from military enterprise. There is no reason to believe that military products were inherently more performance-oriented, thereby elevating the sophistication of military over civilian products. Indeed, major technological innovations in the form of new products have for centuries been as likely to derive from civilian as from military activities.

Like the products they enhanced, process technologies often originated in civilian designs as well. For example, breech-loading artillery pieces were developed in the 1850s (too late for the Crimean War) when Henry Armstrong, a Newcastle hydraulic equipment manufacturer, rightly observed that military manufacturing processes were inferior to civil engineering standards. He took it upon himself to do better, and did. Likewise, Henry Cort's revolutionary "puddling" process for iron smelting, which permitted contamination-free extrusion, rapidly became the state of the art for cannon manufacture throughout Europe after the 1780s, but it was not first developed for the military. Much was. Napoleon I offered a prize for a practical method of preserving field rations, and the winner, Nicholas Appert, is credited with spawning the canning industry. Likewise, Henry Bessemer's converter technology was developed in 1857 in response to a challenge from Napoleon III for a cheaper, stronger steel. Bessemer's process, first employed for artillery pieces of his own design, thereupon transformed both commercial and military products.[100]

Similarly, interchangeable standardized parts originated in the system named for French general Jean-Baptiste de Gribeauval, who in 1765 introduced the idea for small arms manufacture in French arsenals. By 1798, when Eli Whitney received a War Department contract for machined interchangeable parts, standardization was already on the verge of wide diffusion to civilian manufacturing.[101] The first industrial machine tool, the boring machine, was invented in 1734 by a Swiss engineer, Jean Moritz, who had been hired by the French to make cannon barrels lighter, more accurate, and more uniform. His machine was later adopted by John Wilkinson in Great Britain.

The cross-national interdiffusion of military and civilian process technologies was already under way well before the French Revolution. It was carried further

when, in the 1850s, British Parliament dispatched a group to study the "American system" of manufactures that originated in the arsenals of New England, where mechanized production technologies diffused to sewing machines, bicycles, typewriters, and ultimately automobiles.[102] In short, systematic spin-off in metallurgical, mechanical, and chemical process technologies seems a recent development in the history of technology. In fact, it may be merely one part of a longer process of institutional change and interdiffusion—the result of a shifting institutional locus of research. It may not have been systematic by policy design.[103] Let us therefore turn briefly to the development of the institutions of economy and technology, institutions that enhance or retard this interdiffusion, as a way to place the Japanese story in comparative context.

Even the Institutions Are Similar

The comparative historical evidence suggests several major transformations in the institutional locus of arms production and in their technological contribution to the general economy. Moreover, Japanese and Western transformations are similar in many important respects. Each is accompanied by shifts in the ways governments thought about the relationship of technology to national security. The first transformation was from artisanal to mass production of armaments. As arms were produced in factories, new skills were created and diffused, new demand was generated, and new flows of credit and tax revenues enhanced the general economy. "War and the heavy costs of waging it accelerated the entire process [of wealth creation]. . . . Indigent and underemployed men do not buy cannon and other expensive industrial products. But by putting indigent thousands into the army and navy and then supplying them with the tools of their new trade, effective demand was displaced from articles of personal consumption towards items useful to big organizations—armies and navies in the first place, but factories, railroads, and other such enterprises in times to come."[104]

Not until the eighteenth century were armaments routinely manufactured in factory settings, in large batches, using machined and standardized parts. Modern production methods did not, however, settle the matter of state versus private ownership. State-owned and -operated military production had been undertaken in twelfth-century Venice; by the sixteenth century, the dukes of Lorraine had established the first integrated arsenal at Nancy, where they housed hundreds of artisans and the furnaces, forges, foundries, mills, and shops that served them.[105]

Alexander Hamilton was wary of relying on private entrepreneurs for the production of weapons: "There appears to be an improvidence in leaving these essential implements of national defence to the casual speculations of individual adventure. . . . As a general rule, manufactories on the immediate account of government are to be avoided; but this seems to be one of the few exceptions which that rule admits."[106]

Still, by the late nineteenth century government arsenals had lost their technological edge to innovative private entrepreneurs, individuals who (it is ironic to note) were often trained in national military academies.[107] Samuel Huntington reports that, before the Civil War, West Point made greater contributions to civil engineering than to military tactics, and its graduates were more distinguished in civilian than in military pursuits: "West Point produced more railroad presidents than generals."[108] In fact, the initial effort to establish a professional peacetime military came from Hamilton during the presidency of George Washington. Hamilton lobbied vigorously for a military university and, although Congress rejected his proposals as "too advanced for public opinion," they ultimately were accepted.[109] West Point became the first engineering school in the nation, a school serving both military and civilian employers.

In any event, private manufacturers were now supplying better arms more cheaply than even the most advanced government arsenals in Europe. Such entrepreneurs as Krupp, Vickers, and Armstrong shifted the institutional locus of arms manufacture through their willingness to take risks and to "revolutionize armaments simply by bringing military technology to the level of civil engineering."[110] Walter MacDougall playfully notes the irony of this transformation: ". . . technocracy turned the state into the role of the venture capitalist and the private firm into the performer of the public service!"[111] Despite efforts to save them, government arsenals became less innovative and less able to attract treasury support for capital investment. The state of the art in arms manufacture was securely in the private sector by the turn of the twentieth century.[112] Moreover, the gap widened not only between government arsenals and private arms factories but between arms and civilian manufacturers as well. Although the Crimean War (1854–1856) had provided British and French inventors and civil engineers with an unprecedented range of opportunities for spin-on, "by the 1880's, military engineering had begun to forge ahead of civil engineering, reversing the relationship of thirty years before."[113] By 1900 the research budgets at major British arms manufacturing firms were 6–12 percent of net profits, significantly higher than at civilian manufacturing firms.

These shifts invited the next major institutional transformation in the production of weapons—the emergence of an intimate and sophisticated military-industrial complex.[114] First, in late nineteenth-century Europe, military procurement began to dwarf most private enterprise in both scale and scope. As a result, it became ever more central to the development of technology and to the economic activity of industrial states. Second, military procurement revealed itself as a highly politicized process inviting collusion between public officials and private entrepreneurs. In practice, collusive entrepreneurs recreated the noncompetitive environment in which state arsenals had enjoyed monopoly power. And third, the transition to private arms manufacture marked a transition

to a global arms trade. Prussia and Russia grew dependent on Krupp, as France and Britain tried unsuccessfully to maintain a state monopoly.[115] This monopoly was broken by the 1880s, and thereafter the integration of the global arms market accelerated technological diffusion.

This development stimulated what seemed to be a later stage in the evolving relationship between the civilian and military economies: the state intervened directly in support of weapons research and development. Government funding of military R&D, comparatively modest before the turn of the century, reached record levels once governments began to guarantee procurement routinely.

At this point, writes McNeill, "tactical and strategic planning began to shape warships instead of the other way around." By 1887, private firms accounted for half of all European arms production. But invention became ever more dependent on political direction. There is ample evidence that capitalists throughout Europe encouraged workers to demand more arms production, for "no parliament could long resist pressures from unemployed voters, backed up by entrepreneurs eager for government contracts."[116]

It seemed that military planners had finally achieved an optimum institutional setting for the development and procurement of weapons systems. They had navigated between the Scylla of democracy (by accommodating workers' demands for jobs) and the Charybdis of efficiency (by acknowledging that private entrepreneurs could be more innovative and flexible than state arsenals). Since antiquity armies had been eager users of any technological advantage; by the turn of the twentieth century, it seemed, they could have access to and could determine the nature of military technology in a systematic and economically efficient manner. To further this arrangement, in World War I scientists were commissioned into the armed forces, and by World War II civilians were managing science for the military.[117]

As we see in Chapter Three, Japanese arms production followed this same general course of institutional development. Arsenals first established by feudal lords were taken over by the shogunate in the early nineteenth century and then transferred to the control of the young Meiji state as it assumed the commanding heights of the industrializing Japanese economy. By the 1880s, entrepreneurs were eager (and finally judged competent) to receive the state's largesse; the success of textile exports notwithstanding, privately owned defense plants were soon the most technologically sophisticated manufacturers in Japan.

Incredibly, in the United States, the research and development budget of the Department of Agriculture remained larger than that of the military agencies as late as 1940. At that time virtually all federal R&D was still being done in federal laboratories by civil servants. Soon, however, three-quarters of all federal research was being undertaken in the private sector, usually at government direction. Nathan Rosenberg nicely captures the general relationship between the civilian and the military economies as it evolved between 1900 and 1980: "While the federal government now plays a larger overall role in the financial

support of R&D activities than it did before World War II, the actual performance of R&D has been predominantly in the hands of private institutions."[118] Of course, private ownership did not guarantee that technology developed for military use would find civilian applications. In fact, U.S. private institutions seemed no better suited than government arsenals to facilitate the interdiffusion of technology. The successful application of dual-use technology requires more than private ownership. It requires a strategic commitment to the diffusion of innovation, and it requires an institutional, as well as ideological, infrastructure to nurture it.

Nurturing by Design and by Externality

It is indisputable that the U.S. federal government, and the Department of Defense in particular, has been a signal influence in nurturing the development of U.S. technological capabilities. In the chemical industry, for example, wartime demands for substitute materials stimulated enormous investments. There were some cases, as with DuPont in 1940, in which the federal government directly paid firms to build new capacity, and others in which the government stimulated the diffusion of new polymer technology by establishing cooperative research projects. John Kenly Smith reports that "during the war the U.S. government removed the obstacles to technological change. . . . If this had occurred in peacetime it would have been an enormously successful application of industrial policy of the type Japan has been using to build up key domestic industries in the postwar era."[119] More recently, as Maryellen Kelley and Todd Watkins have discovered, most defense contractors are simultaneously engaged in civilian markets, and, compared to plants that are not suppliers to the DOD, U.S. defense plants are more modern, more efficient, more productive, and more creative in human resource management and in collaboration with other firms. Kelley and Watkins conclude that defense production during the Cold War had widespread positive effects for the general economy, suggesting that Cold War defense production gave birth in the United States to "defense industrial *keiretsu.*"[120] But we ought not conceive of U.S. practice as fully consistent with the technology and security ideology that characterizes Japanese beliefs and informs Japanese practices. We can isolate and explore the differences by briefly reviewing two cases in which similarities seem greatest: aerospace and microelectronics.

Aerospace. Nowhere has the U.S. government nurtured industry more extensively than in aircraft and defense products. The U.S. aircraft industry has been more research-intensive than any other industrial sector in the United States except electronics, and well into the 1980s nearly three-quarters of U.S. aircraft R&D was federally funded. Aerospace has been the largest beneficiary of military R&D spending in the postwar period: the U.S. aerospace industry

never had to pay more than one-quarter of its R&D expenses and in most years paid less than one-fifth.[121]

Indeed, government support began almost as soon as the aircraft was invented. The first federal program for aircraft research, the National Advisory Committee on Aeronautics (NACA), began to support the design of military and civilian aircraft in 1915, and the development and sale of military aircraft was the single most important U.S. government policy affecting the competitiveness of the commercial aircraft industry. Military procurement helped boost production runs; it lowered capital costs by underwriting production equipment; military programs created whole generations of aerospace engineers. The NACA program to pool research results and promote extensive cross-licensing was the most "Japanese" of all U.S. aerospace policy, in part because it was administered for the government by the industry association and in part because it was a determined effort to nurture and diffuse technology. After NACA became NASA, costs would be pooled through joint use of wind tunnels at NASA research and test facilities (worth an estimated $10 billion in 1991) in the design and testing of *every* commercial aircraft built in the United States.[122] Some of the most successful commercial aircraft products were spun off from military systems, and the effects may have been even greater at the components level. Some examples:

- The Boeing 707 and KC-135 were developed from a common prototype and shared 20 percent of tooling costs.
- The core of GE's largest commercial engine was originally developed for the C-5 military transport, and the core of its medium-sized commercial engine was originally developed for the B-1 bomber.
- McDonnell Douglas sold sixty DC-10s to the DOD as air-refueling tankers to keep production lines open.
- The Boeing 747 design team first worked together on the C-5A program competition.
- Loan guarantees to Douglas in the 1960s and Lockheed in the 1970s ensured that the companies would remain players in the aerospace business.[123]

Before we conclude that U.S. practice is just like Japan's, only more successful, several observations are in order. With some exceptions, postwar U.S. policy has been of *incidental* benefit to the commercial aerospace industry. U.S. dominance of the global commercial aerospace market was an externality of a military and space effort that generated enormous indirect benefits. As Theodore Moran and David Mowery conclude, American public support for the civil aerospace industry was indirect and unplanned. Neither NASA nor the Defense Department, which had done so much to nurture U.S. industry, was mandated to link benefits to the maintenance of a full spectrum of technological

and industrial capabilities. To the contrary, as George Eads and Richard Nelson note, the federal government has always stopped short of providing funds for the development of commercial products. Although the government was generous in providing infrastructure for the aircraft industry in the 1920s and 1930s, in the 1940s Congress refused to appropriate funds for the construction of jet transport prototypes, despite a widespread concern that American companies would lose ground to the British.[124]

One must therefore measure the benefits to industry against the opportunity costs. Throughout the Cold War the DOD aggressively promoted basic research in universities, and by the 1980s its Manufacturing Technology (ManTech) Program was the largest technology diffusion program in the federal government. Yet, the Office of Technology Assessment of the U.S. Congress concludes that "the defense business has generated benefits for and imposed extra costs on firms also involved in commercial work. These benefits have been far less than they could have been if promoting commercial competitiveness had been a major policy goal."[125] This contrasts to postwar Japanese experience, where the nurturance of domestic manufacturers has not distinguished commercial from military end use. While the Japanese sought to facilitate technology "diffusion," the Americans worried about its "proliferation." A large portion of the DOD aerospace budget was spent on prime contracting firms that had no significant commercial activities and whose manufacturing practices were not concerned with designing for manufacturability. Consequently, although there was considerable dual-use production at the supplier level, the distance between the military and commercial economy seems to have widened in the United States as it was narrowing in Japan.

Two final observations are relevant to the difference between the United States and Japan. NASA programs generated research freely available in the open literature. Like the research of American universities that believe they can best serve the national interest by remaining open in the international marketplace of ideas, NASA reports have circulated to the benefit of domestic firms and their foreign competitors.[126] And, as if to underline differences between U.S. and Japanese ideologies, the NACA joint research initiative that most resembled Japanese practice was canceled in 1975 by the Justice Department as a violation of U.S. antitrust law.

Microelectronics. Congress and the federal government have been aware of the decline in spin-off externalities and of the desirability of nurturing domestic manufacturers in new ways. In the face of foreign—particularly Japanese—competition in the 1970s and 1980s, the DOD began to experiment with methods of sustaining a domestic technology base. Some of its initiatives—such as support for SEMATECH and other consortia through the Defense Advanced Projects Research Agency for dual-use technologies—resemble Japa-

nese modalities, but DOD programs have had to face the intransigence of American ideas about technology and security in the Cold War context. Microelectronics provides an example.[127]

It became clear to the Department of Defense in the late 1970s that U.S. industry was rapidly losing the capability to produce the components and subsystems on which U.S. military systems and national preparedness depended. Aware of an increasing reliance on Japanese integrated circuits, the DOD determined that Japanese research consortia, like the Very Large Scale Integrated Circuit (VLSI) Project, were a key to solving the problem. U.S. chip design and manufacturing was still highly innovative, but most firms were merchant houses without direct links to final applications of their products. The DOD reasoned that advances in microelectronics circuitry are better stimulated by users than by designers and producers, because they have a clear understanding of the performance requirements of the whole system. The challenge was to bring suppliers and integrators together in such a way that the capabilities of each would enhance the other, thereby benefiting the DOD.

In 1979 the DOD initiated the Very High Speed Integrated Circuit Project (VHSIC), the largest single microelectronics program ever undertaken by this department. After several months of consultation, negotiation, and exhortation, nine contractors were selected for "Phase Zero" studies. Five of the nine were teams of systems integrators and components manufacturers. The remaining four were firms that did both. Firms fully expected that any technological gains made in this program could be used in the commercial market; indeed, the DOD directly promised commercial payoff. As a result, participants integrated the VHSIC project into their mainstream commercial activities.[128]

Six winners—four teams and two solo entrants—moved into Phase One. The DOD provided specifications for military systems that would use VHSIC chips, but it purposely did not specify a preferred process technology. As a result, the six entrants investigated a wide range of technologies. Some, such as IBM, focused on developing a single chip; others, such as the TRW/Motorola team, sought to develop a family of chips. The DOD encouraged this design and development competition, but it also encouraged the sharing of information. A central data base was established for all VHSIC reports, and at semiannual meetings the participating contractors reported their progress and problems. In addition, the DOD sponsored three-day workshops nationwide for nonparticipants, to diffuse the VHSIC technology. Some twenty-five different firms, from merchant semiconductor houses to systems integrators, shared more than $1 billion in VHSIC support and technology.

There was only one cloud on the horizon: classification. Participating firms invested about $300 million of their own funds in the hope of reaping commercial benefit. Several potential participants, including Intel, refused to join, concerned that the military program would divert scarce resources from more profitable use and that the Defense Department would restrict the application of results.

The concern proved well founded. Defense, fearing that premature commercialization would allow Soviet duplication of the advances made in the program, restricted the integrated circuits and the process innovations that helped create them.[129]

In many aspects of the program the DOD seemed perfectly in tune with the Japanese ideology: there seems nothing immutable about U.S. practices or values. Indeed, until the very end, when the department classified VHSIC technology, it seemed that the federal government would be able to change the institutions and ideology of American technology. But ultimately the problem in microelectronics was not unlike that in aerospace. In neither case could private firms use the same research to develop products for both the military and the commercial marketplace. In both cases firms were forced by government concern with secrecy and classification to segregate their activities. In both cases, concludes Anna Slomovic, "the interests of the contractors and the interests of the DoD are in conflict: while the DoD wants to restrict commercial applications and to disseminate the technology within the defense contractor base, the program participants want to use VHSIC technology in commercial applications and to restrict their rivals' access to the technology." The result of this (largely irreconcilable) difference was enormous opportunity cost and spin-away. U.S. producers were left grumbling that the real winner would be Japanese competitors, whose investments in integrated circuits were unencumbered by government restrictions. They had no alternative but to construct an elaborate parallel system of microelectronics R&D—"supported with massive documentation"—to avoid DOD restrictions on their commercial products.[130]

The military and commercial microelectronics markets have evolved differently. Slomovic provides an elegant summary of the differences, many of which resonate with structural differences in aerospace markets:[131]

Commercial	*Military*
Short product lifetime	Long product lifetime
Volume production	Batch production
Standardized products	Customized products
Emphasis on cost	Emphasis on performance
Market price	Regulated price

Inasmuch as the commercial market has become nearly as demanding as the military market, components designed for one easily meet the requirements of the other. Thus, although dual-use production is found throughout the U.S. and Japanese economies—especially among components manufacturers—roadblocks of the sort thrown up by the U.S. Defense Department are unthinkable in Japan, where the technology highway is designed to maximize not only speed but access as well.

Can We Make the General Case?

I have now identified resonances between Japanese technology ideology and Western, particularly U.S., practice. We have seen, in the process, how the evolving institutions of military production in the United States, and leadership of an anti-Soviet alliance, made the adoption of that ideology problematic during the Cold War. The question remains, however, whether the Japanese technology highway—and the beliefs that enable it—is a specific or a more general phenomenon. This chapter ends with an attempt to answer the question.

Every industrial nation defines its national security to include the capability to produce weapons of its own design. All nations feel more secure when their defense industrial base can produce equipment autonomously. It is unexceptional that Japan, or any nation, should pursue autonomy to reduce its vulnerability. It is less clear, however, that every industrial nation has combined a concern for national security and technological independence in a set of coherent beliefs which, taken together, form an ideology guiding (or at least justifying) decisions about general industrial structure, technology transfer, and economic growth. Some nations, like the United States during the Cold War, place power alongside wealth in calculating national security. The former Soviet Union went much farther in tipping the balance toward guns over butter. Japan moved in the other direction: "rich nation" finally achieved precedence over "strong army." It is beyond the scope of this study to demonstrate in detail the ubiquity of the Japanese technology and security ideology across each industrial sector. Nonetheless, it is necessary to show that the Japanese ideology goes beyond the arms and aircraft industries. I therefore review evidence from two sectors, computers and steel, each central to Japanese postwar economic development.

Computers

The computer industry first received public attention in a MITI advisory commission report in December 1956, which became the foundation of the Basic Law for the Promotion of the Electronics Industry (Denshinhō) promulgated in June 1957.[132] The new law established both the MITI-supervised Council on the Electronics Industry and the Electronics Industry Section (Denshi Kōgyō Ka) in MITI's Heavy Industry Bureau in August 1957. This section, working closely with the Electronics Industry Association of Japan, became the general headquarters for the postwar development of the Japanese electronics/information industry. The Denshinhō set as its first specific policy goal the indigenization of electronics technologies. The law sought to reduce royalty payments for licensed technologies and to foster collaboration among domestic firms.

The development of the Japanese computer industry attests to the power of interfirm research collaboration and business-government cooperation. In an industry in which technological frontiers are pushed back with astonishing regularity, Japan's producers have moved from laggard to vanguard. Cooperation in research and development has played an integral part in this technological success story. As Ken-Ichi Imai explains, the industry was both targeted and nurtured: "Behind . . . corporate [investment] decisions is the important role of MITI's fostering of computer makers. These investment decisions were supported not only by publicly created demand and subsidies, but also through the creation of expectations in the business community regarding future opportunities in the information industry."[133]

Japanese manufacturers started out far behind. Not only have they had to match the competition's rapid innovative pace, they have had to exceed it in order to close a wide technological gap. Nor did the global leader, IBM, stand idly by. IBM was more the hunter than the sitting duck, repeatedly introducing new generations of products which rendered existing Japanese products—and often prototypes of machines not yet in production—obsolete. According to Wakasugi Ryūhei, "IBM aggressively introduced new products to the market in an attempt to overwhelm domestic makers with its technological superiority and win a monopoly. . . . In response, the domestic makers' strategy was to close IBM's technological lead, and to supply competing products as quickly as possible."[134]

Because of the intensity of the technological challenge and the potential commercial rewards, it is not surprising that the computer industry has, with government support, organized more consortia than any other industry. MITI has provided substantial incentives for collaborative research, covering anywhere from 50 to 100 percent of costs. Certainly, it would have been more "efficient" for Japan to buy its computers abroad. For much of the period 1960–1990, IBM's offerings had been less expensive, more reliable, and more powerful than any manufactured in Japan. But MITI took a dynamic view of efficiency, one consistent with the Japanese technology and security ideology. Public officials and firms regularly sacrificed immediate consumption opportunities in favor of future productive potential and channeled vast resources to the industry.

Six firms dominate the Japanese computer industry: Fujitsu, Hitachi, NEC, Toshiba, Mitsubishi Electric, and Oki Electric. These same firms have participated in virtually every MITI-sponsored venture since the mid-1960s. What is more, they have been the *only* participants in these ventures. Prior to the 1980s, efforts to gain admittance by electronics giants such as Sharp and Sanyo were rebuffed by MITI, which served as the industry's gatekeeper. Research consortia, and the technological diffusion they encourage, were the crucial weapon in the battle between Japanese computer makers. In fact, from the first consortium in 1962 to the celebrated VLSI Project of the late 1970s, every research consortium was targeted at some segment of IBM's technological advantage (Table 2.2).

Japanese consortia were a boon as the domestic computer industry continued to eat away at IBM's technological advantage. At the beginning of the FONTAC

Table 2.2. Japanese consortium responses to IBM

	IBM product	Japanese response	Japanese product
1962		Computer Basic Technology Research Assoc. (FONTAC)	
1964	360 series		
1965			FACOM 230-50
1966		Super High-Performance Computer Project	NEAC 2200, TOSBAC 5000
1967			HITAC 8000, FACOM 230-60
1968			
1970	370 series		
1971	370VS series		
1972		New Series Project	
1973	370/VS enchanced		
1974			M series, ACOS series
1975			COSMO serioes
1976		ERA in VSLI	
1977	303X series		
1978			M-200, ACOS-900
1979			M130F-160F, M140H-160H, ACOS 250

Source: Wakasugi, 1987, p. 24; Anchordoguy, 1980.

Note: The dates of model introductions are somewhat deceptive because there can be as much as three years between new product announcements and the beginning of volume production.

Project, the Japanese had nothing to compete with what for IBM was an aging model, the 1401 series. Three years later, FONTAC had helped the Japanese match the 1401 series, but IBM had already moved to a new generation of products. The Super High-Performance Computer consortium lifted Japanese industry into the same product generation as IBM, although just barely. IBM introduced the 370 series shortly after Japanese competitors for the 360 hit the market. By the end of the New Series Project, however, IBM's lead had been narrowed to two or maybe three years, and protectionism was becoming less necessary for Japanese sales. With the VLSI microelectronics consortium, Japan forged ahead in semiconductors. The consortia of the 1980s and 1990s were designed to push back technological frontiers rather than to match results achieved elsewhere.

Consortia have been important, but other tools have had significant effects: government subsidies, depreciation allowances, foreign licenses, protectionism, and demand-side programs to promote the use of domestic machines.[135] For example, the Japan Electronics Computer Company was established by MITI to purchase hardware from equipment manufacturers and to rent it at cost—as much as 40 percent below IBM's price—to domestic users. In its first two decades, the company purchased over $7 billion of Japanese computer

equipment, thereby nurturing both the manufacturers, who enjoyed stable markets from which they could develop economies of scale, and the users, who gained access to advanced information and computing capabilities at a discount. In the 1960s Japan Electronics accounted for two-thirds of all computer rentals in Japan, and Japanese government subsidies and tax breaks accounted for nearly half the industry's capital investment. These proportions increased in the early 1970s and finally receded as the industry became fully competitive. Licensing agreements signed in the early 1960s by American firms wishing to sell or produce in Japan helped start the industry. MITI refused to permit IBM and Texas Instruments to establish wholly owned subsidiaries in Japan unless they agreed to license their technologies to Japanese firms.[136] In the early 1970s, Japan's computer makers again received a shot in the arm from American producers, this time in the form of technology needed to make IBM-compatible machines, provided at low cost by computer manufacturers in difficulty or about to exit the industry (GE, RCA, Amdahl, Honeywell). In the 1980s, having reached the technological forefront—a euphemism for successful indigenization—Japanese business and government readapted consortia and other institutional tools to meet new challenges.

It is important to note that any depiction of a monolithic MITI-industry alliance to battle the foreign menace is overdrawn. MITI and NTT (Nippon Telegraph and Telephone), until the latter's privatization in 1985, were the two government agencies most responsible for nurturing the computer industry. Their relationship was both cooperative and competitive. They shared a common goal and a common set of enemies (the tight-fisted Ministry of Finance and American lobbyists demanding open Japanese markets). They tended to sponsor complementary rather than duplicate research. Yet the relationship was not without conflict. The distinction between research to develop prototypes and research for commercial purposes, their working division of labor, has led to important turf battles. MITI's celebrated VLSI project, for example, was targeted not only at IBM but at NTT, the latter having established a VLSI consortium a year earlier. MITI tried to absorb NTT's VLSI consortium into its own, but NTT refused to go along.[137]

Another source of conflict is the fact that NTT's family of telecommunications suppliers is not identical to MITI's clientele. Oki Electric was barred from the VLSI consortium but later gained access to VLSI technology through its work with NTT.[138] Fujitsu also used NTT to circumvent MITI. During the New Series Project, Fujitsu sought to cut a deal with Amdahl, an American company founded by the IBM engineer who had designed the 360 series. Amdahl was seeking to make a machine compatible with the 370 series but desperately needed additional capital. Fujitsu saw a golden opportunity to gain access to vital technology, but MITI refused to fund the Amdahl venture because it wanted Japanese firms to develop indigenous technology, and Fujitsu was the only firm at the time with "pure national technology." Fujitsu signed the deal

nonetheless and invested some $54 million in Amdahl from 1972 to 1976 because NTT agreed to purchase Fujitsu machines that used Amdahl's technology.

Conflicts and double-dealing are by no means confined to the public sector. Fujitsu's relationship with its ostensible partner at the time, Hitachi, was replete with dirty tricks. One Fujitsu executive described the relationship with Hitachi in terms that were far more honest than the relationship itself: "While above the desk we were shaking hands, below it we were kicking. . . . with one hand we were shaking hands and with the other hand hitting each other."[139] Conflict has been at least as widespread on the private as on the public side. Depiction of a monolithic Japanese computer industry overlooks these tensions and therefore understates the difficulties and limitations of research collaboration. Nonetheless, it is abundantly clear that the Japanese computer industry was affected profoundly by strategic choices made by business leaders and bureaucrats, often in close consultation and always in terms of a common technology and security ideology.

Steel

The Japanese steel industry has always been the object of public nurture, and its health has always been identified with Japanese national security. Modern Japanese steelmaking took its first tentative step in Saga, when the *han* government built the first reverberating furnace in 1850 to forge cannon. The technology was, however, preindustrial, relying on charcoal, water wheels, and poor-quality Japanese pig iron. Four years later, the Satsuma *daimyō* ordered construction of Japan's first modern blast furnace, which, like the Saga reverberator, was based on a Dutch design. In 1874 the Meiji government built the Kamaishi Ironworks on the site of the coal mines in Iwate using imported equipment and instructors. Despite a variety of technical problems, one historian of technology claims that "the iron produced at Kamaishi was equal to the world's best-quality iron, manufactured by Krupp in Germany, and it was usable for military purposes."[140]

This seems a bit overstated, for by the late 1880s imported iron and steel still accounted for four-fifths of consumption in Japan. Concerned about excessive dependence on imports, the Navy installed a five-ton open hearth furnace at the Yokosuka arsenal in 1890 and assigned its engineers to redesign the Kamaishi mill. In the mid-1890s, confronted with a steel shortage during the Sino-Japanese War because the great powers denied Japan weapons, the government accelerated its advance toward self-sufficiency in steel.[141] In 1897 it built the Yawata steel mill (today's Nippon Steel, the world's largest integrated steelmaker). The largest mill in Asia, with a capacity of 60,000 tons, Yawata was still less than 1 percent the size of U.S. Steel. The Yawata works—Japan's first Bessemer furnace—was built in Kyushu by the government and managed by the Imperial Navy, even though the Ministry of Railways would be its largest customer from 1915 to 1932. But naval demand was hardly trivial. After the Russo-Japanese War in 1905, Japan's shipyards switched to steel hulls, and several private entrepreneurs, including Kobe Steel, Sumitomo Iron Works, and Nippon Kokan, entered the market. The joint public-private Nippon Steel at Yawata, like all national policy companies, was forbidden from competing directly with private industry.[142]

Yawata was responsible for both indigenizing and diffusing modern steelmaking technology throughout Japan. Indigenization began at once. Production equipment provided by the German Gutehoffnungshutte was accompanied by twenty skilled foremen, all but one replaced by Japanese specialists after their training was complete. According to Hayashi Takeshi, who describes the initial problems encountered at Yawata, "the teachers were poor and the students excellent." The experience at the Yawata mill was Japan's first major success with replacing foreign teachers and designs with indigenous ones, and their lessons quickly diffused. Private firms, in Tsurumi's words, "relied upon engineers hired away from the Yawata Steel and the government-owned arsenal plants."[143]

Most of the nation's steelmaking relied on open hearth technology, and about 40 percent was Bessemer technology. The production of acid steel required high-grade hematite and coke, neither of which was available domestically. The government nurtured private producers by paying more than the open market price: in 1919 the military paid 8.5 percent more than private firms for steel, and by 1926 the difference was 19 percent.[144] In 1934 Nippon Steel was established as a "national policy company" to consolidate the depressed industry, to increase production, and to achieve self-sufficiency.

After the Pacific War, government policy faced an utterly devastated industry. As Thomas McCraw and Elizabeth O'Brien note, the government viewed steel as a strategic industry, essential for a high value added and stable economy and requiring considerable business-government coordination. They report that, in the view of industrial policy bureaucrats, "the Japanese domestic market must play a vital function: it must become a greenhouse where the essential factors of competition—supply, demand, and price—could be carefully controlled. Like sunlight, temperature and humidity, they might be adjusted up or down, in order to nurture the development of Japanese steel companies."[145] Industry benefited from and carefully negotiated the scope of government activities. By the 1970s the same five firms that had dominated the wartime steel industry, producing under 10 million tons a year and mostly for the military, dominated an industry that produced—with unparalleled efficiency and at the lowest cost—more than 100 million tons a year, almost entirely for the commercial economy.[146]

The first element of the nurturance strategy was the "priority production system" (*keisha seisan*) developed by a group of young economists affiliated with the new Economic Stabilization Board. They identified the interdependence

of steel and coal as the critical bottleneck impeding recovery of the domestic economy. There was not enough coal production to feed the mills, and not enough steel production to modernize the mines, so the board targeted both through the use of preferential import exchange rates and funds from the Reconstruction Finance Bank.[147] The government reintroduced wartime price controls, and the reconstruction bank subsidized the difference between production costs and sales prices.[148]

After a year of negotiations among MITI bureaucrats and representatives of the coal and steel industries, and after the breakup of Nippon Steel by Occupation order, the government announced its "Outline of the Policy for the Rationalization of the Iron and Steel Industry and the Coal Mining Industry" on 24 June 1950, the day before the outbreak of the Korean War. The combination of targeted industrial policy and increased special procurement by the U.S. military boosted the fortunes of Japanese steel producers. Other legislation aimed at making Japan self-sufficient in steel: the Foreign Investment Law of 1950, the revision of the Special Taxation Measures Law in 1951, and the Law for Acceleration of Rationalization of Enterprises in 1952. The Foreign Investment Law carefully guided foreign banks toward loans while discouraging direct foreign investment. In addition, public financial institutions, such as the Japan Development Bank, provided low-rate loans and occasionally guaranteed the loans of private financial institutions.

A Japanese economic bureaucracy and heavy industry that believed in managed markets and limited competition often referred to nurturance as "rationalization." Three major rationalizations of the steel industry were undertaken between 1951 and 1965. Each was directed at increasing production and at licensing foreign technology. By the 1970s, Japan was exporting not only the world's lowest-cost steel but production equipment as well.[149]

The First Rationalization Plan (1951–1955) focused on modernizing the rolling mills of existing firms, even as ambitious firms such as Kawasaki Steel struck out on their own, against MITI's wishes. Both hot and cold mill technologies were licensed and diffused with government support from the newly formed Japan Development Bank and from city banks that followed the new bank's lead.[150] During this plan period, imported machinery accounted for some 60–70 percent of the total machinery purchased by the Japanese steel industry. The burden of these purchases was eased by tax measures that allowed the firms to depreciate the equipment rapidly (nearly half within five years) and by an exemption of designated equipment from import duties. MITI was determined to provide domestically the materials needed by higher value-added industries such as automobiles. Ira Magaziner and Thomas Hout report that about one-fourth of all capital investment originated through exemptions, and up to two-thirds was derived from debt provided overwhelmingly by government financial institutions. Moreover, the government countenanced price fixing by the largest firms to encourage investment in new capacity.[151] Capacity doubled.

The Second Rationalization Plan (1956–1960), drawn up by the industry itself, nurtured the export competitiveness of the Japanese iron and steel industry. It entailed several varieties of officially sanctioned cartels, organized by and for the largest producers. Now the main goal was to follow the lead of independent Kawasaki Steel in the direction of integrated mills and reliance on iron ore rather than scrap, which was a less efficient and more unstable feed stock. The second plan supported the acquisition of even more foreign technology, again for indigenization. Integrated seaside mills were built for easy access to raw materials and to export markets. Once again, capacity doubled. Most important, however, was the introduction of basic oxygen furnace (BOF, or LD converter) technology. The BOF, a low-scrap, low-energy, and low-cost steelmaking process, was invented and first commercialized by two Austrian firms in 1952. Researchers from Nippon Kokan (NKK), one of the top three steelmakers, first realized its attractiveness to Japanese producers. After learning of the technology by scanning the professional journals, NKK moved vigorously in 1955 to license the BOF technology from Alpine Steel (Oesterreichiesh—Alpine Montaggesellschaft). Yawata was also interested and sought a similar license from the second Austrian firm. At this point MITI intervened. The ministry arranged for NKK to be the single licensee and for other Japanese firms to license the technology through NKK in what is called "bloc introduction" (*ikkatsu dōnyū*)—a single window for the introduction of technology. To diffuse the technology, MITI established an "LD committee" of representatives of private steelmakers to supervise the licensing, to share technological information about its adaptation, and to divide royalty fees to Alpine.[152] Under this arrangement, Japanese steelmakers enjoyed equal access to BOF at half the cost to U.S. firms. Partly as a result, Japanese firms were the first to introduce this advanced steelmaking technology (Table 2.3).

A similarly cooperative diffusion of licensed know-how obtained in the case of continuous casting, another key steelmaking technology. Sumitomo Metals acquired the know-how from the Swiss Concast A.G., and the technology was licensed to the other Japanese manufacturers. Former Kawasaki Steel president Iwamura Yoshio reflects on the traditional ability of Japanese steelmakers to cooperate: "The Japanese iron and steel industry community has been good at mutual coordination. [Through our industry associations we] . . . open our technologies and know-how. In short, it is competition within cooperation."[153]

Another element in the strategy was protection. Until the late 1960s, the tariff structure on steel zero-rated the import of iron ore and scrap, whereas rolled steel and other finished products incurred a 15 percent nominal duty.[154] Imported machines continued to be exempted from import taxes under 1951 legislation. During the Second Plan, tax exemptions were 15 percent of the total costs of the imported machines and 10 percent of the total costs of plant and equipment investment. Domestic manufacturers were enticed through public policy to accept local steel. Manipulation of capacity and prices continued

Table 2.3. Comparative adoption rate of BOF technology (percentage of total capacity)

	U.S.A.	Japan	EEC
1960	3.4	11.9	1.6
1965	17.4	55.0	19.4
1970	48.1	79.1	42.9
1975	61.6	82.5	63.3

Source: Yonekura, 1989, p. 58. By permission of the author.

through MITI-sanctioned cartels and advisory commissions, with the full cooperation of the industry association.

The Third Rationalization Plan (1961–1965) was essentially a compilation of the expansion plans of individual steelmakers, carefully negotiated before submission to MITI. By 1965 Japanese steelmakers had surpassed West German and British production levels, and by 1970 Japan was third only to the United States and the Soviet Union in steel production. The industry itself was eager for new legislation, proposed first by Nagano Shigeo, president of Fuji Steel, that would further consolidate the firms. Nagano sought consolidation into just two major corporations, a move opposed by the Fair Trade Commission; MITI and the industry supported the reconsolidation of Yawata and Fuji into New Nippon Steel. Contrary to what one might expect from domestic competitors facing the creation of the world's largest firm with the support of their own government, the other firms "supported the merger [because] they were tired of cut-throat competition and wanted the new firm to assume strong price leadership."[155] The world's largest competitor would be a buffer against "fierce competition": the notion makes sense only in the context of the Japanese security and technology ideology. The New Nippon Steel (Shin Nittetsu) was established in 1970, and MITI continued to provide low-interest loans, rapid depreciation allowances, and support for price and capacity cartels. It also continued to supervise and encourage the diffusion of new technology.

Much of the credit for this success goes to the determination of entrepreneurs. As Seiichirō Yonekura notes, "No matter how well-conceived the government's plans might have been, it was private firms that carried them out. It was not the government but private firms that invested tremendous sums of money into systematic innovations and achieved clear productivity and quality gains. . . . It is possible that overemphasizing the role of the government may lead to overlooking the true essence of the steel industry's development."[156] No matter how true, no matter how often repeated, the observation begs an important question. Why are Japanese entrepreneurs flexible vis-à-vis the introduction of new technology? What distinguishes their success from failures in Europe and North America, much less the late Soviet Union?

One answer lies in values and beliefs, and their effect on institutional development—in short, in ideology. Japanese steelmakers, like entrepreneurs in other sectors, believed that their decisions had a public consequence; they had a responsibility to do more than maximize profits for their shareholders. Likewise, MITI felt a responsibility to do more than maximize low prices for consumers. As a result, both were willing to accept policies which, though not economical in the short run, would strengthen the industry and the entire economy in the longer term. McCraw and O'Brien draw a trenchant comparison between U.S. and Japanese ideas in this sector, and more generally: "For the United States . . . excess supply, price-cutting, and the risk of losses were considered inevitable, and even beneficial—to steel as well as to other industries. Price wars were viewed as boons to consumers. To Japanese bureaucrats working within MITI, however, the disorder that accompanied such normal market operations, when applied to the Japanese steel situation, would produce investment choices that were deleterious to the entire steel industry—and by extension, to the Japanese economy."[157] MITI guidance or even corporate prescience may be less important than a shared belief that the nation is served by enhancing the industrial technology and production base, and that enhancement can be collaborative.

In these brief historical accounts of two of modern Japan's basic industries, steel and computers, we have seen mixtures of the three elements of Japan's security and technology ideology.[158] Autonomy, diffusion, and nurturance are ubiquitous in the public and private strategies of Japanese industry.

Consider other examples: in the case of petrochemicals, MITI used the Foreign Investment Law to postpone the licensing of foreign technology until the firms were judged ready to indigenize, according to a senior MITI official. Petrochemical industrial development involved four "nurturing plans" under which the effective acquisition of foreign technology required close coordination between government and business—what Tanaka Masami calls "institutional networks"—and the nurturing of "local technological capacity" through joint ventures with foreign firms willing to transfer know-how.[159] Also central to nurturing and diffusion was the indigenization of production equipment. Again, MITI's Tanaka: "Many of the machines involved in technology introduction by domestic enterprises were replaced by domestically manufactured ones shortly after introducing the technology . . . [because] domestic machines do not have to be transported . . . [and because] close collaboration between the petrochemical and machine industries not only unraveled knowledge that had been embodied, but also became a major factor in generating improved machines."[160]

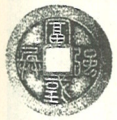
The same calculus has applied to the space industry. In April 1955, Japan's first rocket, the so-called pencil rocket, was successfully launched by Tokyo University scientists with the financial and technological support of the Prince Automobile Company—formerly Nakajima Aircraft and by the mid-1960s part

of Nissan. During that year, the first formal budgets for space development were made available by the Ministry of Education, and in 1958 the Japan Defense Agency approved its first rocketry budget. By 1960, MITI had its share, and in June 1961 Keidanren—the Federation of Economic Organizations—had initiated space promotion activities.

From the very beginning, two formal—and oft-repeated—rules guided the development of space. The first was that space be used only for peaceful purposes. The second was that the Japanese space effort be guided by the goal of autonomy (*kokusan*). The first was constantly challenged by industry. In 1968, for instance, the Japan Ordnance Association declared that "it is necessary to promote scientific utilization of space in order to modernize our national defense."[161] This view was never openly embraced by the government, although the nation's missile budget exceeds its space budget and the firms that build missiles for the Japan Defense Agency build rockets for the "peaceful utilization of space" on the same shop floors.

The second is openly embraced at every turn. An official of the National Space Development Agency of Japan has written: "Our space programs have been developed by digesting and applying the technologies imported from the United States, and we have recorded considerable performance. However, based on these advances, [from here on] we have to overcome the technological dependence and build the space programs with our own technologies. This is the way we shall become a technological nation."[162] The space industry has been nurtured by government policy since the 1950s and sustained the goal of autonomy. Once their tutelage was no longer needed, U.S. engineers brought to Japan to teach rocketry under license contracts were dismissed just as the foreign technical advisers (*oyatoi gaikokujin*) of the Meiji era had been.[163] MITI encouraged the formation of an industry consortium, the Rocket Systems Corporation—led by Mitsubishi Heavy Industries—in 1990 to act as a demand-side bulk purchaser of rockets, like the Japan Electronics Computer Corporation described earlier. The National Space Development Agency supervises and supports a separate consortium, and the Ministry of Posts and Telecommunications subsidizes insurance for satellite manufacturers and users. The same firms that pioneered Japan's shipbuilding, electrical equipment, and machinery industries through technology licensing and indigenization in the prewar period—Mitsubishi, Toshiba, NEC, Nissan, Nakajima, and so on—are pioneering commercial uses of space and military uses of jet propulsion. William Wray asks "whether Japan's rise as a participant in space ventures will occur through international cooperation or through the autonomous route of domestic production (*kokusan*)."[164] But if the account I have given is generalizable and can serve as a guide, the polarities of autonomy and international collaboration offer a false dichotomy. Both are central to the technonational ideas that have informed the strategic choices of public and private leaders throughout Japan's modern history. Both are embodied in the institutions and the protocols of the Japanese economy.

CHAPTER THREE



Military Technonationalism and Arms Production in Imperial Japan

Military technonationalism, with its national commitment to the indigenization, nurturance, and diffusion of know-how, was central to the Japanese industrial revolution. It was stimulated by persistent global arms races and has informed both the public and the private institutions of the Japanese economy. In this chapter I explore the early relationship of Japan's technology ideology to its military production by tracing the development of the modern arms industry in Imperial Japan, from the Edo period to the end of the Pacific War.

Arms and the Edo Court

Long before the establishment of the Tokugawa shogunate in 1600, Japanese swords and armor were already the finest in the world. Armorers and swordmakers were respected for their artistic skills as well as for their products. Saint Francis Xavier remarked in 1552 that the Japanese "prize and honor all that has to do with war, and there is nothing of which they are so proud as of weapons."[1] Although arms production remained artisanal well into the Tokugawa (Edo) period (1600–1868), an active export business had emerged long before. According to Noel Perrin, "For two hundred years [Japan] had been the world's leading exporter of arms. The whole Far East used Japanese equipment. In 1483, admittedly an exceptional year, 67,000 swords were shipped to China alone."[2]

Firearms were introduced in the mid-sixteenth century by either Dutch or Portuguese merchants. The 3.5-foot muzzle loader they left behind on Kyushu,

NOTES

Notes to Chapter One

1. The epigraph is from *The Quotation Dictionary,* ed. Robin Hyman (New York: Macmillan, 1962), p. 122. In addition, note the statements of Paul Joseph Goebbels, 17 January 1936, in Berlin: *International Thesaurus of Quotations,* ed. Rhoda Thomas Tripp (New York: Thomas Crowell, 1970).

2. Mutianus, see *Oxford English Dictionary,* s. v. Money. Bacon, see Braudel, 1973, p. 840, as cited in Kapstein, 1989. Colbert cited in Earle, 1986, p. 217. Kaldor, 1981.

3. Gansler, 1988a. For an official justification of why U.S. forces "must be provided with technologically superior equipment," see the Report of the Secretary of Defense Frank C. Carlucci to Congress on the Amended 1988/89 Biennial Budget submitted February 18, 1988. Washington, D.C.: U.S. Government Printing Office.

4. McNeill (1982) speaks of "the industrialization of war." Consider that three F-16 fighters carried as much ordnance in the 1980s as did an entire squadron of B-17s during World War II.

5. Najita, 1980, p. 6.

6. I acknowledge that such counterfactual claims are notoriously difficult to sustain, and there is little reliable research on the ideological basis of U.S. technology policy. See Hall, 1989, on the political power of Keynesian ideas, and Hart, forthcoming, for one historical treatment of the roads not taken.

7. Histories of modern economic theory rarely mention military production. See, for example, the surveys in Gide and Rist, 1948; Schumpeter, 1954; Barber, 1981; and Niehans, 1990.

8. Friedman, 1980.

9. Smith, 1937, pp. 668–69, 315.

10. List was uncomfortable with the label "mercantilist," for he intended national regulation of trade to be a temporary measure. See Hirst, 1965, p. 123. Also note that "national economists" like List and Alexander Hamilton departed from classical

mercantilism by stressing the self-sufficiency in arms manufacture as much as self-sufficiency in commercial production. Moravcsik, 1992, p. 29.

11. The first quotation is cited in McCormick and Bissell, 1984, p. 19; the second is from List's *National System,* cited in Earle, 1986, p. 218.

12. Quotations from Hirst, 1965, p. 127; List, 1922, p. 117. It is both interesting and characteristic of List that he would modify this criticism of Smith by suggesting that productive and unproductive labor vary less by the function than by the nation. In Spain, he argued, lawyers, priests, and even scientists are unproductive; musicians "serve only to make idleness to the idler more agreeable." In the United States, by contrast, these are each productive occupations. See List's Letter Five in *Outlines of the American Political Economy* (1827), reprinted in Hirst, 1965, pp. 208–9. Earle (1986, p. 244n) argues that List consistently misrepresented Adam Smith's views and "hopelessly confused *Smithianismus*—which was what anybody said Smith had said—with Smith's own ideas." The young List was an adherent of free trade. Only later did he develop his views on tariff as a "nursery." See Hirst, 1965, p. xvii.

13. In Letter One of *Outlines of the American Political Economy,* reprinted in Hirst, 1965, p. 154.

14. In Letter One of *Outlines of the American Political Economy,* reprinted in Hirst, 1965, p. 155.

15. See Viner, 1948.

16. Quotations from Letter One of *Outlines of the American Political Economy,* reprinted in Hirst, 1965, pp. 162–64, and from Letter Seven, reprinted in Hirst, 1965, p. 220.

17. From List's *National System,* cited in Earle, 1986, p. 249.

18. Marx, 1906, p. 70. This is not to suggest that he agreed with List. In his biography of Marx, McClellan reports that Engels and Marx agreed to prepare a critique of List and the national economists but failed to get around to the task (1973, p. 139).

19. Marx, 1969, pp. 300–301.

20. Engels, 1935, pp. 189–96.

21. Luxemburg, 1968, pp. 454, 465–67.

22. See Plotnik, 1937.

23. Mumford, 1934, p. 90.

24. Sombart embraced much of the Marxist method, embroidering its materialism considerably. Of Marx he opined: "As bluntly as I decline his *Weltanschauung,* . . . so unreservedly do I admire him as a theoretician and historian of capitalism" (cited in Plotnik, 1937, p. 21). Engels reportedly appreciated Sombart's separation of Marx the theorist from Marx the political activist. He wrote: "It is the first time that a German University professor has achieved the feat of seeing in Marx's writings, by and large, what Marx actually said, and that such a one declares that criticisms of Marx's system cannot be conceived as a refutation—'let political polemicists bother with that'—but as a continuation and further development" (cited in Plotnik, 1937, p. 33).

25. For a detailed account of Sombart's view, see Roland, 1985, and Smith, 1985. Plotnik (1937) reviews Sombart's life and economic theory. *Krieg und Kapitalismus* was not translated into English, hence I rely on these secondary sources.

26. Weber, 1950, p. 309. Note above how McNeill (1982) disputes this.

27. Weber, 1950, pp. 309, 307–8.

28. Mumford (1934) and McNeill (1982) echo Weber. For Mumford, the army is a model for a disciplined and hierarchical division of labor based on established roles and

functional organizations. McNeill likewise speaks repeatedly of the development in seventeenth-century Europe of a military-commercial complex in which the bureaucratization of the military spun off to foster norms of obedience and efficiency, in turn facilitating the generation of wealth. In particular, he focuses on ways the drilling of troops created social bonds and a sense of the larger community and nation. Once soldiers were willing to obey (indeed, to die) for unseen superiors, there existed "a new Leviathan . . . certainly one of the major achievements of the seventeenth century, as remarkable in its way as the birth of modern science" (p. 133).

29. Later in this chapter, see the way "military Keynesianism" (a macroeconomic concept) and spin-off (a microeconomic concept) have been conflated.

30. Keynes, 1940, pp. 157–58.

31. McNeill (1982, pp. 262–70) notes how Gladstone, concerned about Britain's declining naval power and elected on a platform of assistance to the unemployed, tried to "kill two birds with one stone": in the face of the 1884 depression, he embarked on a program of naval buildup to enhance Britain's sea power and to put dock workers in the yards. Kahler (1988) makes the point that the impact of military Keynesianism on national economic performance is apt to be very different for a developing economy (such as Japan in the 1930s) than on a mature, even hegemonic one (the United States in the 1970s). Note, however, how Schumpeter criticized Keynes's "propensity to apply theory directly to policy, 'the habit of piling a heavy load upon a tenuous groundwork'" (McCraw, 1991, p. 338).

32. Kahler (1988, p. 423) calls this "Keynes in uniform."

33. Tirman, 1984, p. 6.

34. Albrecht, 1988, pp. 38–39.

35. Gaddis, 1982, p. 94.

36. Kaldor (1981, p. 62) cites documents developed by groups such as the Aircraft Industry Association and the National Planning Association which long before the Korean War mobilization supported military production to stimulate the demobilizing economy.

37. Casagrande, 1992, p. 121.

38. Hall, 1989, p. 5.

39. Cited in McCraw, 1991, pp. 388–89. McCraw properly points out that this foreshadowed the industrial policy debate in the United States in the 1980s and underlines the difference between policymaking in the United States and Japan. See Swedberg, 1991, for an excellent biography of Schumpeter.

40. Schumpeter, 1950, pp. 83, 86. Schumpeter much preferred analysis of the real world of oligopolies and imperfect information, of development punctuated by business cycles and technological innovations.

41. Schumpeter, 1950, pp. 84–85.

42. See Swedberg, 1991, p. 78, and Chapter Two of this book for more on this point. Ozawa (1974) was one of the first economists to characterize Japanese development in Schumpeterian terms.

43. Given that Schumpeter was himself a "fervent nationalist," this may be redundant. See Swedberg, 1991, p. 65.

44. Dosi, 1982; Dosi et al., 1988; Dosi et al., 1989; and Freeman, 1987, inform this section. See too the excellent discussion by Mowery and Rosenberg (1979) regarding the naive and confused literature on "demand pull" versus "technology push."

45. Dosi, 1982, pp. 152, 148; Freeman, 1987.

46. See Freeman, 1987, for a complete comparison of the major paradigmatic transformations.

47. Dosi, 1982, p. 155.

48. The best syntheses of this literature include Gilpin, 1981; Posen, 1984; Evangelista, 1988; Hopf, 1991; Levy, 1984; Van Evera, 1984; Quester, 1977; Jervis, 1978; Steinbruner and Carter, 1975; Allison and Morris, 1975.

49. Sidney Verba in Pye and Verba, 1965.

50. Gourevitch, 1986, p. 63.

51. Berger, 1991.

52. Gourevitch, 1986, pp. 233–34.

53. Sabel, 1991; Hobsbawm and Ranger, 1983. I am grateful to my colleagues Hayward Alker, Peter Perdue, and Barry Posen for the concept of "the political use of history."

54. For a similar formulation in the case of Japan, see Gluck, 1985.

55. Kaldor, 1990, pp. 212, 192.

56. See Schnee, 1978, for an analytically crisp differentiation among the various purported benefits of spin-off. See Alic et al., 1992, for another treatment of spin-off as a paradigm.

57. Nef (1950, p. 176) does not use the word "spin-off"; emphasis added.

58. In their 1990 study of the Japanese space program, Morino and Kodama conclude that "spin-off effects are more in fundamental design procedures, development management, and improvement of an engineer's potential rather than in the products themselves" (p. 7).

59. Kurth, 1990, p. 21. As we see in Chapter Two, military Schumpeterianism in the United States was unintended and unidirectional, whereas in Japan it was bidirectional.

60. Albrecht, 1988, p. 40.

61. See the essays in Smith, 1985, for numerous contemporary and historical examples. The entire Smith volume proceeds from the premise that technological innovation in the industrial economies originated in (spun off from) military enterprise. See also Berkowitz, 1988, and Berlincourt, 1989, p. 7. In addition, see the magazine *Spin-off*, published by NASA's Office of Commercial Programs Technology Utilization Division: the cover of the 1987 edition displays the 12-meter America's Cup winner "Stars and Stripes" with NASA-engineered side grooves that were designed to reduce drag. NASA (1987, p. 59) claims "tens of thousands" of aerospace-originated innovations spun off from the government to the private sector, the latest in a long series of claims that Etzioni (1971) labeled "extravagant." NASA was aided in making these claims and in producing its glossy magazine by a New York public relations firm (*Wall Street Journal*, 12 September 1962). See Alic et al., 1992, chap. 3, for an excellent (and appropriately critical) review of the claims made by NASA and the DOD. Cowan, 1990, shows how inferior light water reactor technology dominated the civilian nuclear power program because of the head start provided by military R&D.

62. During the Vietnam War and well into the Reagan years, U.S. research universities received considerable portions of their sponsored research support from the DOD. In 1989, this support accounted for 17 percent of MIT's on-campus research and nearly 60 percent of total MIT research.

63. Chandler, 1977. It is interesting that List anticipated the influence of rail systems by nearly a century and linked it to national security. Earle (1986, p. 254) calls List's discussion of the influence of railways on the balance of military power "the single greatest contribution that List made to modern strategy." Fuller (1945, p. 114) places List's ideas about railroads and warfare in a broader context. Sometimes these institutions are designed, post hoc, to squeeze technology from the military and to diffuse it to the civilian sector. Virtually every European and U.S. government science-based agency has felt it necessary (undoubtedly to justify their budgets) to create an office to spin off their research. See Udis, 1978, for a partial list.

64. Gansler, 1989, p. 92.

65. Kelley and Watkins, 1992.

66. Smith, 1985; McNeill, 1982; Nef, 1950; and Trebilcock, 1969.

67. Smith, 1985, p. 1. Smith considers quality testing "an integral part of the military enterprise [where] the military has traditionally exercised its greatest influence in shaping the American industrial system" (p. 17).

68. On chips, see Flax, 1988, pp. 130–31. On machine tools, see Stowsky, 1986.

69. McNeill, 1982, pp. 177, 211–12, emphasis added.

70. Mumford, 1934, pp. 93–94.

71. Sen, 1984, pp. 249–50.

72. Roland, 1985, p. 364. Rosenberg (1987, p. 174) makes an important point about the way defense procurement can distort the impact of defense R&D: "The vast benefits that are sometimes perceived as flowing from military R&D are, in fact, the product of military R&D *plus* procurement, often on a massive scale. The willingness of private industry to commit substantial resources to technological change in a particular sector has been dominated by the intense awareness of the possibility of large potential markets for military products. . . . Without the huge pull of defense procurement . . . the impact of military R&D spending by itself would have been smaller."

73. See van Creveld, 1989, chap. 3, for a discussion of early military communications.

74. Cited in Fuller, 1945, p. 112, and McNeill, 1982, p. 226. See also Trebilcock, 1969, for additional details on the obstruction of innovation by conservative cannon masters and defense bureaucrats in the eighteenth century. For a more contemporary example of resistance to technological change by military planners, see Douglas, 1985, on U.S. Navy fears that adoption of wireless communication would undermine the traditional hierarchy of command and control. Once adopted, however, the benefits accrued to the military and civilian sectors alike: "Radio's technical and institutional fortunes depended almost entirely on military enterprise" (p. 119). Posen, 1984, p. 55, provides additional support for this point.

75. See Schnee, 1978, for a systematic and well-informed review of these relationships. See Chapters Two and Three of this book for Japanese parallels.

76. Berlincourt, 1989, p. 6.

77. Weidenbaum, 1974, pp. 49, 134.

78. Berlincourt, 1989, p. 6.

79. Donnelly, 1989, p. 4.

80. Rosen (1991), for example, finds that military innovation has much less to do with the capabilities of either enemies or civilian scientists.

81. Kelley and Watkins, 1992.

82. Solo, 1962, p. 50.

83. Solo, 1962, p. 49.

84. There is also the moral disjuncture between production for destruction and

production for creation which commonly appears in theological and literary work and in social commentary. The socially retrograde role of "death merchants" is dramatized by George Bernard Shaw in *Major Barbara.* Mumford, in *Technics and Civilization,* argues that the soldierly habits, thoughts, and practices that characterize modern society were an "unfortunate" development, for the hidden consequence of order and hierarchy is dehumanization and authoritarianism.

85. Quote from Stowsky, 1986, p. 5. This section draws heavily on the work of the leading critics of the spin-off paradigm: Solo, 1962; Etzioni, 1964; Melman, 1971; Udis, 1978; Kaldor, 1981; Fallows, 1981; Dumas, 1986; Rosenberg, 1987; and Gansler, 1988a,b; Alic et al., 1992; and Stowsky and Laird, 1992.

86. Alic et al., 1992, p. 163.

87. Watkins, 1989, p. 18; Kelley and Watkins, 1992, provides survey data that show dramatic differences between defense and nondefense production capabilities, with the former being more advanced. See also Alic et al., 1992, pp. 142–53, for another list of "factors impeding dual-use relationships."

88. Solo, 1962, pp. 55–56.

89. See U.S. Congress, Office of Technology Assessment, 1990, p. 29.

90. Rosenberg, 1987, p. 175.

91. Hartley and Singleton, 1990, p. 154.

92. As cited in Gaddis, 1982, pp. 133–34.

93. Berlincourt, 1989, p. 5.

94. Rosenberg, 1987, p. 181.

95. Flax, 1988, p. 132.

96. Critics of "Pentagon capitalism" such as Melman have seized on this problem: "In a civilian-oriented enterprise, decisions about industrial research are based upon the characteristics of civilian products and their sales potential. . . . the amount of money spent on research by the firm must be controlled by the amount the sale of the product brings. In the case of the military-industrial firm, new technology is freed from cost constraint, for the new military technology is justified as an end in itself" (1971, p. 73). See also Galbraith, 1967; Melman, 1970; Gorgol, 1972; Tirman, 1984; Noble, 1985; Oakes, 1971; Holdren and Green, 1986; Burns, 1971; and Slomovic, 1991.

97. Melman (1971, p. 72) refers to this as a "trained incapacity." See also Stowsky, 1986.

98. Burns, 1971, p. 115.

99. U.S. Department of Defense, Technology Assessment Team, 1988, pp. i-ii.

100. Kaldor, 1981, p. 3.

101. Kaldor, 1981, p. 19.

102. Kaldor, 1981, p. 5.

103. See Noble, 1984; Stowsky, 1986; and Ayres, 1988.

104. Smith, 1985, p. 6.

105. Holdren and Green, 1986, p. 16.

106. Solo, 1962, pp. 53, 56. Etzioni, 1971, is another early voice warning of spin-away.

107. Stowsky, 1986, p. 4.

108. Udis, 1978, p. 20; Kelley and Watkins, 1992.

109. Weidenbaum, 1974, p. 138.

110. Gummett and Reppy, 1988, pp. 3–4.

111. Berkowitz (1988, p. 59) offers a nice snapshot of the changing relations of the military and civilian economies: "Although the defense community is still ahead in certain technologies, such as supercomputers, there are more and more areas in which the military actually lags the civilian sector. Ship navigation is a case in point. The bridges of civilian ships tend to be more automated and to use fewer personnel than those of naval vessels."

112. Gansler, 1988b, p. 251.

113. Casagrande, 1992, pp. 116, 120.

114. Udis, 1978, p. 254.

115. Nef, 1950, pp. 26–27. Nef adds that bronze was developed for church bells and only later was used for cannon, and he takes special aim at Sombart's claim that military demands led to the centralization of capitalist economies. Nef shows that large factories and artisanal shops coexisted in ordnance as well as in textiles into the modern era. He refutes Sombart's view of the link between war and human progress. Nef argues that as early as the seventeenth century commercial rather than military markets were more productive of innovation and technological advantage: "Military requirements raised fewer technical problems than the *more continually insistent needs* for powerful machinery, better furnaces, and artificially treated raw materials in connection with industries which flourished more in peace than in war" (1950, p. 176, emphasis added).

116. Van Creveld, 1989, p. 154.

117. Van Creveld, 1989, p. 220. Van Creveld does not, however, distinguish between civilian inventors and civilian applications. Examples of the former became far more numerous than those of the latter as the Industrial Revolution proceeded.

118. Fuller, 1945, p. 135.

119. *Aviation Week and Space Technology,* 6 June 1988.

120. Upgrade plans will make this 86 percent. *Defense News,* 6 March 1989.

121. Fox, 1988, p. 10. Fox quotes an Air Force general who claimed: "In the past, the Air Force used to buy airplanes and add electronics."

122. Slomovic, 1991, p. 164.

123. For a discussion of the Packard Commission Report, see Gansler, 1988a,b.

124. Gansler, 1988a, p. 70. *Defense News,* 6 March 1989, reported that a study commissioned by the Navy in 1989 concluded that Navy computers were "on average far behind the commercial state of the art." The study recommended savings of millions to be achieved by abandoning military performance specifications for computer systems.

125. Blackwell, 1989; U.S. General Accounting Office, 1991; U.S. Department of Commerce, Bureau of Export Administration, 1992.

126. And each was nurtured by military procurement. Nearly half of all semiconductor sales in 1960 were absorbed by the federal government, see Baldwin, 1980, p. 69. Likewise, 20–30 percent of machine tools were procured directly or indirectly by the U.S. government in peacetime. Holland, 1989, p. 270.

127. Alic (1989a) contrasts the initial application of polymer matrix compound in the United States (missiles and later aircraft) with its initial application in Japan (golf clubs and tennis rackets, and later missiles and aircraft). Japan is the leader in both cost and quality in many materials that have spun on in just this way.

128. Herring, 1985.

129. See Chapter Two of this book.

130. U.S. Department of Defense, Advanced Research Projects Agency, 1993.

Notes to Chapter Two

1. Kobayashi, 1922, p. 161.
2. Maema, 1989, p. 254.
3. Ueda, 1991, pp. 4, 14.
4. Nakayama, 1991, p. 201.
5. *Kotowaza Daijiten* (Tokyo: Shogakkan, 1982), p. 1009.
6. During this period, the Mito *han* issued a coin called *fukoku kyōhei sen,* with the four Chinese characters embossed on it. See the photo on p. 81.
7. Takebe, 1991.
8. Fujii, 1973, pp. 189–92. In 1848, Sakuma built a rifle on his own; see Shibunkaku Bijutsukan, 1991, p. 47.
9. Fujii, 1973, pp. 192–95. Fujii also summarizes the writings about *fukoku kyōhei* by Yokoi Shōnan (1809–1859).
10. Yano cited in Kobayashi, 1976, p. 168.
11. Note that Shibusawa did embrace the Confucian ethic of service and the supremacy of public interest. Shibusawa was not a born samurai; he was himself a bureaucrat who resigned to devote himself to business in the belief that the old merchants were unfit as agents of modernization. See Marshall, 1967, p. 10, for more on the "hostile tradition"—approbatory social values toward the merchant class this new elite had to overcome.
12. The Chinese character *shoku* is often used in words that connote reproduction (*seishoku*), breeding (*hanshoku*), cultivation (*yōshoku*), and diffusion (*hashoku*). *San* refers to birth, property, and yield. The characters reversed, *sanshoku,* combine to mean "breeding." The character *kō* connotes revival, prosperity, and growth. *Gyō* refers to industry. Together they speak to a program of industrial nurturance. The *Heibonsha Daikokugo Jiten,* vol. 7, 1985, p. 609, defines *shokusan kōgyō* as "the ideal aiming at [creating] a rich nation and strong military through the cultivation of production and the promotion of industry." The *Encyclopedia Nipponica,* vol. 12, 1986, p. 205, defines it as "the policy of nurturance and protection of capitalism as promoted by the Meiji government."
13. See, for example, Maruyama, 1974.
14. Takeda, 1982, p. 49. See also Kawaura, 1970, pp. 202–3, where it is noted that "*shokusan kōgyō* was the condition for national power (*kyōhei*) and wealth (*fukoku*)."
15. Igarashi, 1976 and 1983. Differences over the pace of *shokusan kōgyō* notwithstanding, Kido was instrumental in drafting the Charter Oath of the Emperor Meiji and in helping create the centralized Meiji state.
16. Idditti, 1940.
17. From Ōkubo's own account, quoted in Brown, 1962, p. 189. The Iwakura mission argued for Prussia as the appropriate model for emulation.
18. Quoted in Morikawa, 1976, p. 12.
19. Tsurumi, 1978, p. 33.
20. Marshall, 1967, pp. 15–16.
21. Allen, 1981, p. 170.
22. See Mason, 1992, pp. 24–26, for more on this point. Maeda's views on the need to organize small producers and to rationalize production and distribution methods represent a powerful strain of Japanese industrial policy thinking. The first producers' association regulations (Dōgyō Kumiai Junsoku, 1884) were developed during Maeda's tenure at the Ministry of Agriculture and Commerce. Among Maeda's colleagues at the time was Takahashi Korekiyo, the interwar finance minister. In fact, it was Takahashi, then a young bureaucrat, who represented Maeda in the failed negotiations over the fate of the regional industrial bank. This account of Maeda is based on the unpublished work of David Ambaras of Tokyo University. Interview, 9 July 1992, and Mitani, 1980.
23. Allen, 1981, p. 79.
24. Allen, 1981, p. 125. See also Allen, 1965, p. 5.
25. Bailey, 1983, p. 104.
26. This paragraph is based on Marshall, 1967, pp. 22–24; quotation from p. 24.
27. Asher, 1991; Nakamura, 1989; Allen, 1965, p. 2.
28. I am grateful to David Ambaras for helping me make this connection.
29. This account is based on Shōkōshō Rinji Sangyō Gōri Kyoku, 1931, pp. 21–22. I am grateful to Sheldon Garon for bringing it to my attention. See also Mason, 1992, p. 59.
30. Shōkōshō Rinji Sangyō Gōri Kyoku, 1931, p. 72.
31. Allen, 1981, p. 142. The Keynes coincidence is noted in Allen, 1965, p. 3. For more on how Takahashi's view of *shokusan kōgyō* was linked to protectionism and on his view of the military, see Mitani, 1980. On the February 26 incident, see Chapter Three.
32. Hoshino, 1956, p. 5. Many Japanese are uncomfortable with the translation of *gijutsu rikkoku* as "technonationalism"; see page 48 below.
33. Allen, 1981, pp. 173–74.
34. Kobayashi, 1981, p. 245.
35. Najita, 1980, pp. 2–6.
36. Drifte in Chapman et al., 1982, pp. 92–93.
37. Fukuzawa, 1973, p. 192.
38. Fukuzawa, 1973, chaps. 4, 5, 10; see also Kamitani, 1988.
39. Lockwood, 1955, p. 9. Another of the five Articles of the Charter Oath states that "the whole body of the community, high and low, shall unite in efforts for economic development." See Idditti, 1940, p. 94.
40. Tsurumi, 1978, pp. 47, 44.
41. Tsurumi, 1978, pp. 34, 47, emphasis added.
42. These principles are clearly stated (and referred to as such) in Adachi, 1981, p. 14.
43. Hayashi, 1990, p. ix.
44. See the final section of this chapter, Chapter Eight of this book, and Anchordoguy, 1989, for computers; Mason, 1992, for automobiles and electronics; Lynn, 1982, for steel; Tanaka, 1992, for petrochemicals; Samuels, 1987, for nuclear power. The catch phrase is from Mainichi Shimbunsha, 1984, p. 302.
45. Tanaka, 1992, p. 5.
46. Allen, 1965, p. 109. Ozawa, 1974, p. 19. In 1990 the ratio of imports to exports of technology from the United States was more than 2.5 to 1. See the Joint Publication Research Service translation of a report by the Agency of Industrial Science and Technology: *Major Indices of Japanese R&D Activity,* JPRS-JSP-93-003, 21 January 1993.
47. Ozawa, 1974, p. 17.
48. This organization, established by industry, continued to organize semiannual "Made in Japan Weeks" throughout the 1960s.

49. Keizai . . . Iinkai, 1976, pp. 31–33.
50. Bobrow and Hill (1991) confirm this with aggregate time series budgetary data. They find that "autonomy" and "dependence" explain a significant portion of Japan's fiscal policy and conclude that it is "Japan's intention to pursue national autonomy within acceptable levels of military dependence and budgetary restraint" (pp. 55, 39).
51. See *Aerospace Japan Weekly*, 30 March 1992.
52. Quoted (and so labeled) in Ōtsuki and Honda, 1991, p. 294.
53. Ueda, 1991, for example. Official Japanese data on science and technology routinely report levels of foreign dependence. See, for example, chart 4–18 for levels of dependence of Japanese semiconductor manufacturers in Tsūshō Sangyōshō, 1992. Note also that this table was omitted in the official English translation. See also Green, 1993, for a review of how U.S. technoprotectionism feeds Japanese technonationalism.
54. Ueda, 1991, p. 11. On accelerated *kokusanka*, see Jikibō . . . , 1990.
55. Nihon Kikai Kōgyō Rengōkai and Kōkū Kokusai Kyōdō Kaihatsu Sokushin Kikin, 1991, p. i. The author is Yoshiyama Hirokichi.
56. Mitsubishi Research Institute, survey, 1987, p. 34.
57. Interview, 26 December 1992. For the translation of *gijutsu rikkoku* as "technonationalism," see Matsumoto's review of Kamitani, 1988, and Nakayama, 1991, pp. 200–201.
58. Nakayama, 1991, p. 200.
59. Inoguchi, 1991, p. 93.
60. Alexander, 1993, p. 1.
61. Tanaka, 1991, p. 112.
62. Commission on the History of Science and Technology Policy, 1991, p. 22. See also Tsurumi, 1978.
63. See Lynn and McKeown, 1988, for more on the history of trade and industry associations in Japan. See Samuels, 1987, for a look at their role in energy policy.
64. Tsurumi, 1978, p. 44; Kobayashi, 1922, p. 166.
65. Maema, 1989, p. 160.
66. Nihon . . . Kōgyōkai, 1987, p. 57. See also Bōei Kiki Sangyō . . . Iinkai, 1968, p. 49, and Keizai . . . Iinkai, 1970.
67. Keizai . . . Iinkai, 1970, p. 180.
68. Kikai Shinkō Kyōkai, 1965. This survey covered five defense sectors: aircraft, electronics, ordnance, vehicles, and shipbuilding. Even the testing and measuring instruments used for defense production were used simultaneously for commercial projects.
69. These project teams and study groups are often organized through the "technology headquarters" (*gijutsu honbu*) of the firm. Interviews with senior technology managers: Shin Meiwa, Mitsubishi Heavy Industries, Mitsubishi Electric, Toshiba, September–December 1991. See Chapter Eight of this study for case studies of intrafirm technology diffusion.
70. See Levy and Samuels, 1991.
71. Freeman, 1987, p. 31.
72. This is consistent with the conclusions in Hane, 1992.
73. Kagamigahara field study, December 1991.
74. A discussion of bottom-up engineering in the automobile industry is provided in Womack et al., 1990, pp. 104–37; Nishiguchi, 1993.
75. See Nippon Bōei Sōbi Kōgyōkai, 1991, for the reported numbers of suppliers.

76. Mitsubishi Research Institute, survey, 1987, p. 24.
77. Tanaka, 1992, pp. 4–5.
78. Interview, December 12, 1991, with a former Ishikawajima-Harima engine designer, and interview, Director, Japan Aircraft Technology Association, November 27, 1992.
79. Nihon Kōkū Uchū Kōgyōkai, 1987, p. 73.
80. Elsewhere I have characterized this process of iterative bargaining among stable public and private actors as "reciprocal consent." For a more extended discussion of efforts to describe the Japanese economy's networks of power and authority, see Samuels, 1987, pp. 279–82. For an important theoretical treatment, see Sabel, 1991.
81. Friedman, 1993, compares the apparent commitment of Japanese and U.S. firms to their supply network. He finds that large firms in America much more readily exercise the "exit option" to adjust to market changes, whereas Japanese firms have been induced by the political and economic relationships they have developed with the supply networks to jointly develop solutions to market difficulties. Basic concepts of exit, voice, and loyalty in response to change were first set forth in Hirschman, 1970.
82. See Lesbriel, 1991, and Samuels, 1987, chap. 3, for accounts of this process.
83. The best general sources on comprehensive security are Chapman et al., 1982; Bobrow and Hill, 1991; and Barnett, 1984.
84. Barnett, 1984, pp. 10–11.
85. Green, 1993, p. 164.
86. See, for example, Sekai Heiwa Kenkyūjo, 1991, a report compiled by a group including retired self-defense force Generals which urges greater appreciation of the relationship between advanced technology and national security. Also see Jikibō . . . , 1990; Inoguchi, 1991; Kinoshita, 1988; Tsūshō Sangyōshō, 1988; Ueda, 1991.
87. Ueda, 1991. General Ueda's writings refer repeatedly to "invisible technologies" (*me ni mienai gijutsu*) that are never clearly defined.
88. Chinworth, 1992, p. xiii.
89. Schumpeter quoted in McCraw, 1991, p. 390. McCraw notes that Schumpeter's first book, *Das Wesen und der Hauptinhalt der theoretischen Nationalokonomie* (The nature and substance of theoretical economics), 1908, was never translated into English but appeared in Japanese in 1936. He notes, moreover, that Schumpeter spent several months lecturing in Japan in 1931 and declined an offer for a prestigious guest professorship.
90. McCraw, 1991, p. 390; List, 1922; Marshall, 1967, p. 17. According to Mitani Taichirō, Takahashi Korekiyo, one of Japan's most prominent architects of *shokusan kōgyō*, saw a link between Smith and List. Takahashi wrote in 1925 that "List simply filled in the theoretical gaps Smith left open." Mitani, 1980, p. 34.
91. Jean Baptiste Colbert, Louis XIV's chief minister, sought in the 1670s to make France a self-sufficient arms manufacturer. He hosted foreign experts, created state arsenals, and licensed monopolies to French producers. See Moravcsik, 1992, and Cole, 1939. Later, at the start of the Industrial Revolution, the French hired English and Scottish inventors and machinists with Manchester experience. They tried unsuccessfully to persuade Watt and Bolton themselves to emigrate. Napoleon was every bit the technonationalist as any Meiji leader. See Sen, 1984, chap. 4.
92. Walker, 1988, p. 4.
93. Quoted in Tucker, 1990, pp. 125–26.
94. By the 1970s Congress mandated through the Culver-Nunn legislation that the

DOD consider offshore procurement, and by the early 1980s the bipartisan Roth-Glenn-Nunn Amendment encouraged the DOD to explore new ways to cooperate with NATO allies by transferring technology and promoting military production abroad. In 1985 Congress earmarked $100 million exclusively for cooperative defense R&D between U.S. and European firms. See U.S. Congress, Office of Technology Assessment, 1990.

95. See the analysis of dependencies in microelectronics, production equipment, high resolution displays, and advanced materials in Institute for Defense Analysis, 1990; for analysis of dependencies in HARM missile production, see U.S. Department of Commerce, 1991.

96. Interview, Mitsubishi Heavy Industries aerospace plant manager, Nagoya, 18 December 1991.

97. I use the term "interdiffusion," introduced in Flax, 1988, to describe technology transfer between the military and the civilian economies. See van Creveld, 1989, pp. 321–35, for a review of the literature on technology and war. Fuller, 1945, is also helpful.

98. McNeill, 1982, p. 98. Ayres (1988, p. 8), on the other hand, writes that "diffusion of manufacturing technology from military contractors to civilian manufacturers was quite slow in the 19th century except where the military contractors themselves undertook to produce for the civil market (as in the case of Remington typewriters)." McNeill, 1982, p. 81; see also van Creveld, 1989; Trebilcock, 1969, p. 485.

99. For these and other examples, see McNeill, 1982; Alic, 1989a; Trebilcock, 1969; and van Creveld, 1989.

100. See Fuller, 1945; Mumford, 1934; Birch, 1968.

101. Landes (1965) notes that, whereas rifle manufacture elsewhere fostered the development of interchangeable parts, in Great Britain the arms makers were rather more resistant to these practices, favoring craft production well into the Industrial Revolution. For more on the controversy concerning whether Eli Whitney deserves credit for introducing interchangeable parts, see Gordon, 1988; Landes, 1969; and Hounshell, 1984. See also Fuller, 1945.

102. Ayres, 1988, pp. 3–4. See also Gordon, 1988. Nef, 1950, offers negative assessments of the net effect of military spending and its effect on technological development; see also Hyde, 1970; Landes, 1965; Saul, 1967; and Habakkuk, 1962. McNeill is critical of this view: "Only if one assumes that some other stimulus would have put the entire labor force to work and endowed the formerly underemployed portion of the British public with an effective purchasing power equivalent to that exercised by the British army and navy, does it seem plausible to assume that in the absence of war the pace of British industrialization would have equaled or exceeded that which actually occurred" (1982, p. 210). Among others who, following Sombart, posit (but may not celebrate) the direct contribution of war to technological development are Mumford (1934), Fuller (1945), and Smith (1985). Mumford (1934, p. 90) argues that military demand fostered mass production, in turn stimulating the growth of military establishments and the advance of capitalism. To Fuller (1945, p. 170) "war becomes the prime mover in a technological civilization."

103. See also Trebilcock, 1969, p. 478.

104. McNeill, 1982, p. 211; at p. 292, n. 50, he cites Trebilcock's work. Also see Chandler, 1977, on railway enhancement of the development of North American capitalism. Others, such as O'Connell (1985), credit the U.S. Army Corps of Engineers with the development of the modern rail system in the United States.

105. Nef, 1950, chap. 4.

106. From Hamilton's "Report on Manufactures," quoted in Earle, 1986, p. 235.

107. Van Creveld (1989, pp. 144–45) notes that the most literate groups in fifteenth-century Venice were barbers, clerks, and naval officers, and that professional skill in mathematics and navigation distinguished military officers as an intellectual elite. Mumford (1934, p. 88) writes that "war established a new type of industrial director who was not a mason or a smith or a master craftsman—the military engineer."

108. Huntington, 1957, pp. 198–99. Huntington also notes that West Point educated more engineers than any other institution in the United States in the first half of the nineteenth century, and that its curriculum, modeled on that of the Ecole Polytechnique (rather than St. Cyr), was in turn the model for engineering curricula at Yale and elsewhere throughout the United States.

109. Quotation from Miller, 1959, p. 482.

110. McNeill, 1982, p. 278.

111. MacDougall, 1985, p. 439.

112. McNeill (1982, p. 270) tells the story of John Fisher, British director of naval ordnance, who tried unsuccessfully to secure funds sufficient for the Woolwich arsenal to compete with the emerging private arms manufacturers. Arms manufacture and the supplying economy are more profitable during war than peace. McNeill (p. 144) reports that "European rulers . . . were in the happy and unusual position of not having to choose between guns and butter but could help themselves to more of both, while their subjects—at least some of them—were also able to enrich themselves." Koyama (1972, pp. 154–55) provides indexed, comparative data on war's stimulation of private economy:

	Prewar	Postwar
Crimean War, 1852–1857 (U.K.)		
Steel	100	135
Exports	100	156
Civil War, 1860–1866 (U.S.)		
Steel	100	147
Exports	100	107
Coal	100	199
Sino-Japanese War, 1893–1896 (Japan)		
Coal	100	152
Exports	100	131
Imports	100	194
Russo-Japanese War, 1903–1906 (Japan)		
Coal	100	128
Exports	100	146
Imports	100	483

Weidenbaum (1974) notes that stock markets always rise in wartime, and Kaldor (1981) shows that nearly half the top 100 firms in the United States include defense contractors.

113. McNeill, 1982, p. 223.

114. McNeill (1982, p. 37) notes that Yuan dynasty officials, fearing generals and merchants alike, aborted the introduction of coke-fired ironmaking technologies: "The civil officials who disdained captains of industry actively distrusted and feared captains of men." Both groups were kept from concentrating their power. Van Creveld (1989,

p. 143) also describes the role of "free companies," the skilled warriors rented to the highest bidder.

115. Within five years of the privatization of the state arsenals in mid-nineteenth century Prussia, British steel was no longer imported and weapons had become an export item. By 1880, Krupp had become the world's leading arms exporter, and "the technological disparity between the public and private sectors was becoming a matter of serious military concern," especially because some private producers, shut out of domestic markets, were selling better weapons abroad than were being built and deployed at home (Moravcsik, 1992).

116. McNeill, 1982, pp. 278, 270.

117. Glantz, 1978. See also General Eisenhower's memorandum of April 1946, "Scientific and Technological Resources as Military Assets," reprinted in Melman, 1970.

118. Rosenberg, 1987, p. 166. Modern Germany is an extreme example: virtually all military R&D has been done in civilian facilities, private firms, and universities. See Udis, 1978, p. 256.

119. Smith, 1988, p. 320.

120. Kelley and Watkins, 1992.

121. Mowery, 1987, pp. 31–32; Rosenberg, 1987, p. 178.

122. This account is based on U.S. Congress, Office of Technology Assessment, 1991.

123. These examples are from U.S. Congress, Office of Technology Assessment, 1991; Mowery, 1987; Moran and Mowery, 1992; and Eads and Nelson, 1971.

124. Moran and Mowery, 1992, p. 137. See also Mowery, 1987, pp. 46–47; Eads and Nelson, 1971, p. 407.

125. U.S. Congress, Office of Technology Assessment, 1991, p. 346.

126. For a report on the international and national roles of one U.S. research university, see Faculty Study Group, 1991. The U.S. Congress, Office of Technology Assessment (1991, p. 347) concludes that "NASA's technological advances can provide U.S. firms with a competitive advantage only if they are able to *apply* the technology before their foreign competitors. The record has been mixed."

127. This section is based on Fong, 1986, and Slomovic, 1991.

128. According to Fong (1986, p. 276), VHSIC project directors for Texas Instruments, Motorola, and National Semiconductor, for example, reported to the firms' nonmilitary divisions.

129. Slomovic, 1991, p. 39.

130. Slomovic, 1991, p. 40.

131. Slomovic, 1991, p. 12.

132. This section is derived from Levy and Samuels, 1991.

133. Imai, 1989, p. 11.

134. Wakasugi, 1987, p. 14.

135. See Imai, 1989; Anchordoguy, 1989.

136. Mason, 1992.

137. Anchordoguy, 1989, pp. 170–76.

138. Anchordoguy, 1989, p. 290.

139. Quoted in Anchordoguy, 1989, p. 133. For dirty tricks, see Yamamura, 1986b; Doane, 1984, pp. 162–63; and Anchordoguy, 1989, pp. 132–40.

140. Hayashi, 1990, p. 96.

141. Hayashi (1990, p. 104) reports that there was a similar concern ("bitter experience") about dependence on foreign weapons after the Satsuma rebellion in 1877 which helped stimulate indigenization of steelmaking technology.

142. For more on how public policy companies served the private sector, rather than displacing it as in Europe, see Samuels, 1987.

143. Hayashi, 1990, p. 99; Tsurumi, 1978, pp. 43–44.

144. Satō, 1967, p. 66. These data also show that the Imperial Navy, by owning and managing its own mills, paid significantly less for steel than did the Imperial Army—as little as 56 percent of the Army's price in 1918.

145. McCraw and O'Brien, 1986, pp. 93–94.

146. See Yonekura, 1989, and Lynn, 1982, for arguments about business's independence from bureaucracy. See Magaziner and Hout, 1980 and McCraw and O'Brien, 1986, for a view that stresses negotiations between business and a powerful state.

147. See Samuels, 1987, pp. 92–95, for details on the operation of the priority production program in coal; in particular, note that the entrepreneurs who benefited from the program's largesse both responded to and shaped the initiative.

148. Yonekura, 1989, p. 18.

149. Hayashi, 1990, p. 16.

150. Yonekura (1989, p. 29) reports that the Japan Development Bank accounted for less than 10 percent of all loans to the iron and steel industry during the first rationalization program, but that "it had an important 'pump-priming' effect, since the Ministry of Finance asked commercial banks to extend cooperative loans to the key industries."

151. Magaziner and Hout, 1980, pp. 58–61. There is some dispute as to whether MITI was convinced that steel would be an export success. Yonekura (1989, p. 28) says no. McCraw and O'Brien (1986) argue that MITI had exports in mind for the steel industry from the beginning.

152. Lynn, 1982, pp. 67–89.

153. Quoted in Mainichi Shimbunsha, 1984, p. 333.

154. Encarnation, 1992, p. 57.

155. Yonekura, 1989, p. 44.

156. Yonekura, 1989, p. 9.

157. McCraw and O'Brien, 1986, p. 95.

158. Many other, equally rich examples can be cited. Consider, for example, the debate between Oki Kibatarō, founder of today's Oki Electric, and Iwadare Kunihiko, the first chairman of Nippon Electric, today's NEC. In 1896, a foreign business manager of Western Electric named H. B. Thayer negotiated a deal to sell telephones in Japan. Western Electric planned to establish a joint venture with a Japanese firm and targeted Oki Kibatarō as its partner, but Oki turned down the offer, reportedly out of a strong sense of technonationalism. Western Electric, with Iwadare and other Japanese entrepreneurs, then established NEC as Japan's first foreign-affiliated joint venture in 1899. The Japanese entrepreneurs who went into this joint venture with foreigners felt a national purpose. According to NEC's official history, "Iwadare agreed with Oki on the national importance of the communications business. It was the most important business for national security, and thus Iwadare believed he was promoting the joint venture as part of *fukoku kyōhei.* But, he believed, 'For that very purpose, we have to open our

doors, import foreign technologies, digest them, make our own, and then catch up with the foreigners.'" Nippon Denki Kabushiki Kaisha . . . Iinkai, 1972, p. 27. For a fuller account see, Chokki, 1991, and Mason, 1992, pp. 27–35.

159. Tanaka, 1992, p. 11.

160. Tanaka, 1992, pp. 15–16.

161. Kihara, 1977, p. 5.

162. Suzuki, 1980, pp. i–ii. See also the open enthusiasm for space *kokusanka* in Kukita, 1990.

163. This observation is in Wray, 1991, p. 463.

164. Wray, 1991, p. 464.

Notes to Chapter Three

1. Quoted in Perrin, 1979, p. 8. See Sakakibara, 1962, and Robinson, 1961, for more on the traditional art and manufacture of Japanese swords.

2. Perrin, 1979, p. 10.

3. Kobayashi, 1922, pp. 5–6.

4. This claim is by Perrin (1979, p. 4). Kobayashi (1922, pp. 6–7) suggests that guns were not used during the Japanese civil wars because they were seen as cowardly under the Bushido code.

5. Perrin tells this story eloquently. He compares the Teppō Bugyō of 1607 to the gun control bureaucracy of Henry IV in France at about the same time (1979, p. 58).

6. For a summary of Sawada's argument, see "Meiji no Gijutsu Rūtsu wa Teppō" (Guns were the roots of Meiji technology), *Nihon Keizai Shimbun,* 1 July 1991, and in the short museum guide to his collection: Shibunkaku Bijutsukan, 1991.

7. As reported in Kobayashi, 1922, pp. 12–13. Note how closely this matches Alexander Hamilton's *Report on Manufactures,* both by date and substance.

8. Its manufacture, like the production of seagoing vessels, had been banned by an isolationist shogunate for nearly 250 years. Yamazaki, 1961, p. 20.

9. Satsuma's success with military industrialization inspired its native son Ōkubo Toshimichi, who as Meiji home minister would initiate the *shokusan kōgyō* program. As Brown (1962, p. 186) observed, "The Satsuma experience . . . demonstrated that government control of the investment process could lead to rapid economic development. In turn, economic development was the source of military strength."

10. Fukasaku, 1988, indicates ten wooden copies; Blumenthal, 1976, indicates sixteen. See also Kobayashi, 1922, p. 16.

11. Cornwall, 1970, p. 38; Blumenthal, 1976, p. 133. It is more than a historical footnote that the Nagasaki yard, where the hull of the *Chiyoda-gata* was laid, is today the largest yard of Mitsubishi Heavy Industries, Japan's leading defense contractor, and that the engine was manufactured at the Ishikawajima factory, today Japan's largest engine manufacturer.

12. Fukasaku, 1988, p. 50.

13. Kobayashi, 1922, p. 28. Engineer quoted in Yamazaki, 1961, p. 20.

14. In Dower, 1975, pp. 232–33.

15. Koyama, 1972, p. 56.

16. Yamazaki, 1961, p. 17, provides a full list of the government arsenals.

17. Nakayama, 1978, p. 221.

18. In Dower, 1975, p. 229. This reading is widely embraced in Japanese historiography, dominated by Marxist economic historians. See Ōuchi, 1970; Yamada, 1934; and Uchida, 1949.

19. See Rosovsky, 1961, pp. 25–26; Nakayama, 1978, p. 221; and Yamamura, 1977, p. 116.

20. Despite the privatization of government factories, national debt mounted with each mobilization. Government expenditures trebled between 1893 and 1903, and neither taxes (raised disproportionately from peasants and merchants) nor the Chinese indemnification were sufficient. More than half the government borrowing was for armaments. See Lockwood, 1955, p. 35.

21. Takahashi, 1990, p. 25. The Navy speeded up its expansion program dramatically.

22. Blumenthal, 1976, p. 135.

23. For a broader analysis of how private firms and state negotiate market jurisdiction and control, see Samuels, 1987.

24. Although the Army was largely independent of foreign suppliers by 1905, the Navy remained dependent on Western technology; the last imported British battle cruiser arrived in 1912. Nearly 90 percent of the Imperial Navy's tonnage was imported between 1897 and 1907, though the proportion dropped to under 20 percent between 1908 and 1916 (Koyama, 1972, p. 106). For details on ship production in this period, see Kobayashi, 1922, pp. 55–62. See also Smith, 1955, for an account of the state-owned factories.

25. Rosovsky, 1961, p. 27.

26. Kobayashi, 1922, p. 170.

27. Quoted in Yamamura, 1977, pp. 126–27. See Evans and Peattie, forthcoming, chap. 2, for more on the difficulties the Navy encountered trying to expand during this period.

28. The first Western shoe factory in Japan was built in Tokyo to produce military footwear in 1902. The first military uniform factory was built two years later. Until then, military footwear and uniforms were made by craftspeople who lived near the bases and worked at shops in their homes. Kobayashi, 1922.

29. See Naikaku Tōkei Kyoku, 1916, p. 208, and Naikaku Tōkei Kyoku, 1905, pp. 402–3.

30. Yamamura, 1977, p. 113.

31. In 1873, Tanaka Hisashige established a small "machine-making factory," with technical assistance from the Navy, to provide torpedoes. This firm, Shibaura Seisakusho, now a small telegraph transmitter workshop in Tokyo, later decided to use foreign licenses as "the shortest way to upgrade its technological capability." Its main customer was the commercial market for electric power generators, but the government was critical in nurturing the firm that would later become one of the world's most sophisticated integrated manufacturers of electrical and aerospace equipment, Toshiba: "By 1901 Shibaura's own technological capabilities had managed to produce a 150-kilowatt, three phase current dynamo for the Yokosuka Naval Arsenal. Although procurement . . . was through open bidding (in which General Electric participated) the actual order was placed with Shibaura in order that the Japanese Navy might provide Shibaura with the opportunity to gain experience in the manufacture of such large-scale equipment." Tsurumi, 1978, p. 45. The case of Nikon is examined in detail in Chapter Eight.

32. Tamura, 1982; Yamazaki, 1961, p. 19.