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ARMS PRODUCTION IN THE THIRD TIER: AN ANALYSIS OF OPPORTUNITY AND WILLINGNESS

DAVID KINSELLA

School of International Service
American University
Washington, DC 20016, USA

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Major determinants of third world military industrialization operate at the domestic, regional, and global levels. I summarize these and then examine their relative importance by analyzing time-series cross-section data for twelve arms producers from 1968 to 1990. Overall, there is considerable support for the various factors identified in the literature. However, my findings do highlight the importance of opportunity, perhaps more than willingness, as an explanation for changing levels of third tier arms production. Resolution of the tensions that drive regional militarization and the eruption of military conflict should have some positive effects on restraining the expansion of arms production capacity. But there also seems to be a certain inevitability to the process, a process that is limited primarily by states' resources, industrial capacities, and access to weapons-production technologies.

KEY WORDS: arms production, military industrialization, military technology, arms trade, third tier

For the past decade or more, select companies from Israel, India, South Africa, and South Korea have been among the world's most prolific weapons manufacturers. In 1998, Israel Aircraft Industries had arms sales of more than $1 billion, a level attained by fewer than thirty other firms globally. Other Israeli firms (Rafael, Israel Military Industries, Elbit Systems, and Tadiran) have consistently ranked among the world's top 100 defense companies as well. Principal manufacturers in what analysts have called the "third tier" of arms producing countries also include South Africa's Denel Group, India's Hindustan Aeronautics, and Singapore Technologies. These companies produce a wide range of military equipment: aircraft, armored vehicles, missiles, and military electronics, not to mention artillery, small arms, and ordnance. They are based in the leading third tier members of a fairly elite club—there are typically fewer than twenty countries represented among the world's top 100 defense firms—but there are several other developing countries with significant arms production capacity.[1] For at least some countries outside the OECD, military industrialization appears to be proceeding apace.

This article is about the forces driving that process. My focus is on what motivates state leaders in their efforts, and also on what constrains them. The determinants of arms production in the third tier may be located at various levels: domestic politics and economics, regional security dynamics, and global technological and cultural diffusion. Although I will discuss each of these briefly, the article's main contribution is a quantitative empirical analysis of their relative importance in explaining the military industrialization process in twelve countries from 1968 to 1990. There are very few such analyses in an otherwise diverse empirical literature on arms production outside the OECD.[2] While the case-based literature has identified the political, economic, and security-related factors that promote or inhibit the development of a domestic arms production capacity in developing states, a different kind of research is needed to ascertain whether short-term variation in these factors *within* the third tier can account for the annual output of their weapons industries. Are the empirical regularities in the military industrialization process such that they can be analyzed in order to predict third tier arms production in the short run?

This study examines indigenous and licensed arms production in Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Pakistan, Singapore, South Africa, South Korea, and Taiwan. These are the only developing states for which reasonably complete quantitative data are available. A time-series cross-section analysis lends considerable support to what the literature identifies as correlates of third tier arms production. It shows that domestic economic and political-economic factors both drive and limit military-industrial output, as do regional security dynamics. Access to weapons technology, in the form of arms transfers and licensed production, also matters. Interestingly, although military-technological diffusion is usually linked to an increasingly competitive international arms market, changing levels of third tier arms production are more closely associated with a concentration of foreign arms suppliers. Along with the importance of industrial capacity, this is the most robust finding. Finally, although I do make an attempt to distinguish between the diffusion of technology and the diffusion of global military culture, a more nuanced empirical examination of this facet of military industrialization is in order.

HISTORICAL CONTEXT

A summary of the historical process of global arms production and military-technological diffusion will serve to illustrate why it makes sense to analyze third tier arms producing countries as a group. Krause (1992) suggests that the global arms transfer and production system has evolved in three waves. The first wave took place from the fifteenth to the seventeenth century, a span of time that included the so-called Military Revolution. The second wave, this one associated with the Industrial Revolution, began in the middle of the nineteenth century and lasted until the early twentieth. We are currently in the midst of the third wave, which commenced with the end of World War II.

During each of these three periods, Krause identifies an evolutionary dynamic consisting of five phases. Phase one is characterized by significant military-technological innovation and states best equipped to harness this technological change emerge as the leading centers of global arms production. They make up the "first tier" of arms producers "able not only to innovate and advance the technological frontier, but also to produce weapons systems for all military applications" (Krause, 1992, p. 27). During the Cold War period, the first tier consisted of the United States and the Soviet Union; now it may well consist of the United States alone.

Phase two witnesses a rapid expansion of the global arms trade in response to rising demand for the advanced weaponry produced in the first tier. Along with the expansion of the arms trade comes the diffusion of military technology, but it is controlled due to the desire of first tier producers to maintain their technological advantage and thus their capacity to use arms transfers as a means of leverage in the pursuit of foreign policy goals. Over time their grip on military technology loosens and, in phase three of the evolutionary dynamic, increased demand for arms production capacity, and not just finished systems, gives rise to a "second tier" of weapons suppliers. These countries are capable of manufacturing the full range of military equipment, including the most advanced systems, but are generally not responsible for innovations at the military-technological frontier. In the second tier, there is a strong incentive to export weapons in order to supplement domestic demand and reduce the unit costs of production. Countries like Britain, France, Germany, and now Russia are the leading members of the second tier in the current period.

As a consequence of fiercer competition in the international arms market, the fourth phase described by Krause involves a still wider diffusion of military technology throughout the system. Now there emerges a "third tier" of arms producing states. Their capacity varies, but a common limitation is the need to import the designs, machinery, and often some of the key components necessary for the domestic manufacture of advanced weapons systems. Some states in today's third tier are capable of producing a rather wide range of weaponry (e.g., Brazil, India, Israel), while others are engaged in a narrower range of production (e.g., Chile, Indonesia, Pakistan, Singapore). In the fifth and final phase, military-technological diffusion slows and the arms-production hierarchy solidifies. Although this is perhaps a reasonable characterization of the contemporary arms transfer and production system, the seeds of phase one of a new wave may exist in what many have been calling the Revolution in Military Affairs (RMA), currently underway (Metz and Kievit, 1995; Carus, 1994).

EXPLAINING MILITARY INDUSTRIALIZATION

Although the historical evolution of the contemporary arms production system described by Krause (1992) may invite competing conceptions, its current three-tiered structure is not terribly controversial. Others have described it and have identified similar memberships (e.g., Anthony, 1993; Buzan and Herring, 1998).[3] In addition, cross-sectional quantitative studies have confirmed that many of the factors identified in the literature as conducive to domestic arms production are indeed associated with membership in the third tier (e.g., Peleg, 1980; Neuman, 1984).

The present study starts with that knowledge and asks whether the same set of factors that explain the desire and capacity to initiate domestic arms-production programs also explain variation in the level of output once the programs are underway. As industrializing members of the third tier—OECD countries like Australia, the Czech Republic, Poland, and Spain have been classified as third tier producers as well—there is an extra degree of homogeneity among the twelve producers analyzed here. Since my purpose is to examine arms production within the third tier over time, I am not treating these twelve as a sample from a larger population. The fact that some third tier countries are not part of the group under study is probably not of great consequence. Their exclusion, which is largely a matter of data availability, introduces no obvious bias and is not likely to taint my inferences about military industrialization.

In this section, I start with a discussion of regional security dynamics since these provide a relatively straightforward explanation for a state's decision to pursue an indigenous arms production capacity. I will then turn to domestic forces, both economic and political-economic. Finally, I take up global processes involving the diffusion of weapons technology and culture.

Regional Security Dynamics

Developing states arm because they perceive threats to their national security. Here their behavior is no different from state behavior in general, and we need look no farther than to realist theory for the immediate forces driving third world arms production. Ensuring national survival in an anarchic international system means confronting the security dilemma. States arm to protect themselves, but in doing so they provoke similar behavior on the part of their neighbors. The resulting arms spiral is fed by weapons acquisition in all its forms. Domestic arms production is one form, and we might even expect to observe states responding in kind to regional competitors' military industrialization efforts. Action–reaction processes have in fact been observed at the level of arms importation (Mintz, 1986; Kinsella, 1994, 1995). Still, this sort of symmetry is not necessarily predicted by realist theory, which has states responding to the military *capability* of their neighbors, whatever its source. That is, domestic arms production complements arms importation, and likewise is driven both by competitors' arms production and by their imports.

Recent or current involvement in military conflict provides the most obvious incentive to acquire weaponry. To the extent that warfare is sporadic, there may not be much motivation for military industrialization if immediate demands for armaments can be met by existing stocks or by imports. But for states engaged in enduring rivalries—generally hostile relations punctuated by overt militarized disputes—the impetus to develop an indigenous arms production capacity is much greater. The persistent need for weaponry that accompanies involvement in enduring rivalry accentuates the potential costs of being dependent on arms imports. Domestic arms production "is likely to increase the autonomy of decision-making in regard to war and peace" (Ayoob, 1995, p. 147). There is consensus in the literature on this point. Indeed, for Katz (1984, pp. 4–5), "[t]he most important factor driving LDCs to produce arms can be summarized quite easily: autonomy" (see also Brzoska, 1989; Ross, 1988).[4]

So although regional conflict drives arms acquisition, it is regional conflict combined with the uncertainty of arms imports that drives military industrialization. Krause (1992, p. 162) in fact identifies a "near-perfect relationship between state's having been involved in a conflict and/or subjected to embargoes and its initiation of weapons production."

Domestic Forces

There are two sets of forces operating in domestic society, which I classify loosely as economic and political-economic.

Economic Factors

Like the regional security dynamics driving military industrialization, identifying the basic economic factors involved is relatively easy. In contrast to regional security concerns, which provide incentive for arms production, these operate as constraints on state leaders' ability to realize their desired levels of military industrialization. In short, weapons production rests on some minimally required capital and resource base, and "no Third World country can hope to support arms production if it does not already possess a reasonably strong, diversified industrial sector" (Ball, 1988, p. 358). As a general observation, again there is consensus in the literature on this score. Some researchers have gone further in attempting to identify more precisely the industrial production capacities required for military industrialization. For example, Wulf's (1983, 1985) "relevant industries" consist of manufacturing capacity in the following sectors: iron and steel, non-ferrous metals, metal products, non-electrical machinery, electrical machinery, and transportation equipment. These and similar criteria have been used to generate lists of countries with the highest potential for military industrialization (see also Kennedy, 1974, chapter 15; Brzoska, 1989; Brauer, 1991).

The degree of indigenization that characterizes a state's domestic arms production varies, of course, and the importance of industrial capacity generally increases as states seek to expand the indigenous content of their weapons systems. Stages in the evolution of domestic arms production capacity are fairly well established. Ross (1994) identifies five (see also Brzoska, 1999, p. 148; Wulf, 1985, p. 330):

1. assembly of imported arms
2. production of weapons components under license

3. production of complete weapons systems under license
4. modification, redesign, or reproduction of foreign weapons systems
5. production of indigenously designed weapons systems.

As Ross and others have pointed out, there is a significant hurdle to be cleared in moving from licensed to indigenous production. For technologically advanced weapons systems, indigenous design and production requires not only industrial capacity, but also diverse and sophisticated research and development facilities. Much of what is labeled "indigenous" in fact consists of technologies and components imported from more advanced arms producers. So despite the considerable progress made by the leading third tier arms producers, many predict a continuing and pronounced global hierarchy in the design and production of the most advanced weaponry (Neuman, 1984; Anthony, 1993; Krause, 1990, 1992; Brzoska, 1999).

For those countries with the industrial and technological capacity to establish domestic arms production programs, sustaining them requires continued demand for these industries' military products. Production runs must be sufficiently long to bring unit costs down to profitable levels if military industries are to survive, especially in the context of declining subsidies from the state. This is a universal imperative, of course, and it is why so many of the world's leading arms producers have turned to the export market to supplement domestic demand. That the arms export market is populated by first and second tier arms producers presents third tier aspirants with significant barriers to entry, but some have identified market niches for less sophisticated and inexpensive systems (e.g., Brazil) or sophisticated components (e.g., Israel). Even a major third tier producer like India, which traditionally placed less emphasis on arms exports, has come to appreciate the importance of developing an arms export capacity to help sustain indigenous programs.

Political-Economic Factors

One constraint facing an arms-producing state is the its industrial capacity, evaluated in strictly economic and technological terms. But the literature has also drawn attention to the capacity of the state itself to mobilize resources in defense of national security, and this includes resources necessary for military industrialization. Barnett (1990, pp. 539–540), in examining the case of Israel, has commented that "even the presence of the necessary industrial and technological infrastructure does not provide the state with access to its required war matériel from domestic sources since the means of production are controlled by private actors." The extent of private control does vary somewhat across third tier arms producers, but the more general point is valid even in cases where the state is more actively involved in the production process: the state's ability to mobilize resources, including its extractive capacity, figures in the success of military industrialization, whether resources are to be allocated to private, state-subsidized, or state-run enterprises (Ross, 1994, pp. 104–106).[5]

The role of the military in the development of an indigenous arms production capacity is open to debate. Most would agree with Brzoska (1989, p. 522) that the armed forces "have generally supported domestic arms production," although there are noteworthy exceptions. The reason has less to do with enhancing their war-fighting ability—better equipment can usually be acquired from foreign sources—than with the tendency of reform-minded military governments to use domestic arms production to promote industrial development, an essential element of state building (Ayoob, 1991, 1995). A great deal of empirical research has examined whether or not "[f]rom an economic point of view [arms production] has a number of attractive features because it tackles some of the structural obstacles to development" (Kennedy, 1974, p. 301). But even the most ardent critics of this view acknowledge that the possibility of military-led industrialization provides a powerful impetus for domestic arms production, and that the states most likely to head down this path are those in which the military occupies a prominent role in society (e.g., Ball, 1988).

The question remains as to the military's effectiveness in promoting domestic arms production. States most susceptible to military influence, including military rule, might be expected to allocate resources in pursuit of military industrialization. Although these same states might also have formidable extractive capacities vis-à-vis society, this is not a foregone conclusion. As Barnett (1990, p. 545) points out, "[a] state with a high degree of legitimacy is better able to mobilize societal resources" (see also Barnett, 1992). Legitimacy is often lacking in the case of military governments and civilian governments perceived to be under excessive military influence. So the same states that prefer to allocate a larger share of resources toward military production may in fact have fewer resources to allocate.

Global Diffusion of Military Technology and Culture

Through their interaction with other actors in international society, states acquire both preferences and capabilities. Military capabilities in particular are acquired through the diffusion of technology. Krause (1992, pp. 18–25) describes three dimensions of military technological diffusion: material transfer (technology I) involves the diffusion of finished systems and the ability to *operate* weapons technology; design transfer (technology II) is the diffusion of basic engineering know-how used to *reproduce* weapons technology; and capacity transfer (technology III) is the diffusion of scientific knowledge and technical expertise used to *adapt* weapons technology.[6] The bulk of third tier arms production derives from design transfer. The obvious conduit for all three types of technology transfer is the arms trade. Material transfer pretty much dictates that recipients have or will soon acquire the ability to operate the weapons technology. Design transfer can accompany arms imports by way of reverse engineering, but less covert means of design transfer are embodied in licensed and co-production agreements (Bitzinger, 1994; OTA, 1991; Louscher and Schwarz, 1989; Louscher and Salomone, 1987).

Those who predict that existing stratification among arms producers will become less rigid, and third world states more autonomous, point to enhanced competition among suppliers in the international arms market and the leverage this affords recipients (e.g., Ross, 1984, 1988; Steinberg, 1989; Rosh, 1990). Material transfers have become increasingly sophisticated, while the technological gap between what is procured by the world's best equipped armed forces and what is exported to third world states continues to narrow. More important for military industrialization is the willingness of arms suppliers to participate in design transfer in an effort to sweeten the deals they can offer potential customers in the third world, a development that Klare (1983) has referred to as the "unnoticed arms trade." Again, there is not much dispute in the literature about this empirical trend (see Bitzinger, 1994), or about the global diffusion of military technology which has accompanied changes in arms-transfer practices. However, many analysts do doubt whether "military import substitution" will significantly alter well established patterns of third world military dependence (e.g., Lock and Wulf, 1979; Neuman, 1984; Krause, 1992).

In contrast to the diffusion of military technology, which amplifies the opportunities for military industrialization in the third world, the global diffusion of military culture affects states' very preferences in this regard. The discussion so far has focused on the *material* dimension of advanced weapons and the capacity to manufacture them—the implications for warfighting capabilities, industrial developments, and so on. There is also an ideational or *symbolic* dimension. Kaldor (1981, p. 144) has remarked that the possession of advanced weaponry "allows for an ordering of international military relations, conferring political influence, merely through perceptions about military power," and that participation in this weapons *system* provides "a form of international legitimacy for Third World governments." According to Sagan (1996/97, p. 74), "military organizations and their weapons can therefore be envisioned as serving functions similar to those of flags, airlines, and Olympic teams: they are part of what modern states believe they have to possess to be legitimate, modern states." In short, high-tech military equipment, whatever its performance characteristics in the field, has "symbolic throw weight" (Suchman and Eyre, 1992, p. 154). There is no great leap involved in suggesting that the capacity to manufacture this weaponry is also imbued with symbolic capital. When the Indian Space Research Organisation successfully test-launched its Agni-II intermediate-range missile in 1999, Prime Minister Atal Behari Vajpayee described the event as "a symbol of resurgent India," and reassured the nation that "Yes, we will stand on our own feet."[7]

The arms trade is frequently identified as a mechanism for military-cultural as well as military-technological diffusion to the developing world. It is said to promote "technologism," that element of global military culture which leads to the "symbolic valuation of advanced over alternative technology" (Wendt and Barnett, 1993, p. 339; see also Wulf, 1979; and Kaldor, 1981). At a more general level, some have sought to link the movement toward isomorphism in military organization and procurement to states' immersion in a world culture dominated by Western (Weberian) notions of rationality. They argue that although rationalized organizational and bureaucratic structures accompanied modernization in the West as the most efficient means to manage economic and technological change, these formal structures have become ends in themselves, notably in the developing world where states are anxious for recognition as respected members of international society. Sociologists interested in understanding this process of cultural diffusion have looked at the degree to which new states are exposed to external sources of legitimation (see Finnemore, 1996). Diplomatic practice, membership in international organizations, and other forms of participation in international society condition acquired preferences for certain forms of social organization and capability over others, including forms of military organization and capability (Eyre and Suchman, 1996). Military training and assistance programs are also obvious places to look for the "socializing" forces driving arms production in the third tier (Mullins, 1987; Luckham, 1984).

Perhaps more than any other dimension of the military-industrialization process, the role of military-cultural diffusion would seem to throw up the most significant roadblocks to systematic empirical research. Even when the vehicles for cultural diffusion can be readily identified and measured, if they double as vehicles for the spread of military technology, as is the case with the arms trade, disentangling these effects presents a serious challenge indeed.

Hypotheses

The major determinants of third tier arms production can be organized in reference to opportunity and willingness. *Opportunity* refers to the "total set of environmental constraints and possibilities," while *willingness* is shorthand for the "willingness to choose (even if the choice is no action), and to employ available capabilities to further some policy option over others" (Most and Starr, 1989, p. 23). Any reasonably comprehensive explanation must consider what motivates developing states (makes them willing) to produce arms domestically, and what environmental conditions expand or limit their opportunities to do so. Based on the previous discussion, Figure 1 lists the domestic, regional, and global forces driving third tier military industrialization according to whether they fall into one or the other category of explanation.

At the domestic level, I expect that higher levels of military influence in governance will serve to increase the level of domestic arms production, due either to the military's desire to protect its own institutional interests or to its desire to promote military-led industrialization. I also expect that greater industrial capacity, arms export capacity, and mobilization of

	Willingness	**Opportunity**
Domestic	military influence	industrial capacity export capacity resource mobilization
Regional	conflict militarization	
Global	arms market	arms transfers technology transfer

Figure 1 Determinants of Military Industrialization

military-targeted resources each provide greater opportunities for expanding weapons production. At the regional level, I hypothesize that states are motivated to increase weapons production in response to both armed interstate conflict and militarization. (Note that I have not identified factors affecting the opportunity to increase domestic arms production operating at the regional level.) Finally, at the global level, I expect that third tier states increasingly value military industrialization—emblematic of modern statehood—as a consequence of greater interaction with other, militarily advanced states in international society, especially in the international arms market. I hypothesize that their opportunities to increase domestic arms production also are enhanced through participation in the arms market. Here the transfer of military technology is instrumental. Arms imports embody varying degrees of technology transfer, and I expect that technology is diffused even more in an environment where competition among suppliers overcomes the aversion to transfer manufacturing capacity and know-how in addition to finished systems.

RESEARCH DESIGN

I now turn to operationalizing and testing these hypothesized processes. My analysis is both spatial and temporal. In constructing a database for analysis, I have selected as my cases leading third tier arms producers—Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Pakistan, Singapore, South Africa, South Korea, and Taiwan—observed from 1968 to 1990. My goal is not to determine whether the factors I have identified predict which developing countries will produce arms and which will not. Rather, I want to examine whether these factors explain, for military-industrializing states, changes in the level of arms production over time. Generalizing my results to other states, including non-arms producing states, is not the intention of this analysis. More appropriate are conjectures about future arms-production dynamics among these twelve.[8]

Measurement

The dependent variable is, of course, arms production in the third tier. Data on domestic arms manufacturing in the developing world are collected by SIPRI, which keeps track of both licensed and indigenous production programs in the form of "registers." The first and only comprehensive list of both types of domestic production appeared in

Brzoska and Ohlson (1986), although data for selected countries are sometimes reported in the *SIPRI Yearbook*. Registers of licensed production have appeared regularly as a part of SIPRI's arms trade registers. The data used here are from Anthony (1993, Table 17.1). They represent annual dollar-valued production output from 1965 to 1990, and they are generated by applying a price to items appearing in the registers. As Anthony (1993, p. 369) explains, "the estimates are not a proxy...for actual production costs," but instead are "based on technical comparisons of weight, speed, range, year of development and year of production between these systems and those for which production costs are available (usually systems produced in the United States)." This presents no particular problem for the present analysis.[9]

Separate statistical analyses are conducted for all domestic production (i.e., including licensed production) and indigenous production only. Indigenous arms production is really the ultimate goal of states pursuing military industrialization and it is a capacity that is considerably harder to achieve. For that reason we might expect that indigenous weapons production is somewhat less responsive to factors that increase either the willingness or opportunity to push military industrialization. Table I shows for each state the initial full-production year for major categories of indigenous weaponry. It seems to confirm what analysts generally suggest, namely, that artillery production is a fairly modest accomplishment, while indigenous manufacture of large integrated systems like warships, jet aircraft, and main battle tanks is considerably more difficult. The table also shows estimated employment in arms-production enterprises and expenditures on military research and development.

The independent variables come from each of the broad categories of factors discussed in the first half of the article: (1) domestic economic, (2) domestic political-economic, (3) regional security, and (4) technology and culture diffusion. Some variables tap motivation—the willingness of third tier states to increase domestic arms production—while others measure opportunity.

Domestic Economic Variables

Industrial capacity is measured as the value added by industry (manufacturing, mining and quarrying, construction, utilities) and comes from the World Bank's *World Development Indicators*. Data for Taiwan are not released by the World Bank; this time series was computed from data published by the U.S. Department of Labor and the Taiwanese government.[10] Although disaggregated information on manufacturing in

Table I
Indigenous Arms Production in the Third World

Producer	First Year of Production						Employment (thousands)	Military R&D ($US millions)
	Jet Aircraft	Battle Tanks	Armored Vehicles	Guided Missiles	Large Artillery	Major Warships		
Argentina	1987	—	1980	1978	1978	1943	20	70
Brazil	1986	1985	1974	1987	1969	1983	25	250
Chile	—	—	1984	—	—	—	6	n.a.
Egypt	—	—	1966	1982	1981	—	60	80
India	1963	1995	—	1993	1980	1978	250	400
Indonesia	—	—	—	—	—	—	30	100
Israel	1971	1977	1975	1970	1968	—	50	600
Pakistan	—	—	—	—	1990	—	50	300
Singapore	—	—	—	—	1986	—	18	n.a.
South Africa	—	1991	1973	1975	1979	—	80	120
South Korea	—	1987	—	—	1976	1980	60	600
Taiwan	1982	—	—	1979	1976	—	40	500

Note: Figures for employment and military R&D are for 1993.
Source: Production years from Anthony (1993), Table 17.2; employment and military R&D from Brzoska (1999), Tables 2 and 4.

"relevant industries" might allow for the construction of a truer indicator of arms production potential, these data are quite incomplete for the countries and time period analyzed here. In any event, there is a very high correlation between aggregate manufacturing output and output in the specific sectors that are most important for domestic arms production, so using overall industrial production is a good choice of indicator.[11] A second domestic economic variable, arms export capacity, is measured as the value of actual arms exports. These data are published by the U.S. Arms Control and Disarmament Agency (ACDA) in its annual *World Military Expenditures and Arms Transfers*.

Domestic Political-Economic Variables

Systematic data on military influence are not readily available, so as a surrogate I use the autocracy score from the *Polity III* database, which is a scaled (0–10) measure of political closedness (Jaggers and Gurr, 1996).[12] My assumption is that higher levels of autocracy correlate with greater military influence in governmental affairs, including resource allocation. Defense expenditures, as reported by ACDA, are used to measure the government's allocation of resources to military production. It too is imperfect, since a large chunk of any state's defense budget goes to the maintenance of personnel and infrastructure, and some to procurement from foreign sources, but in the absence of a direct measure of resources devoted strictly to domestic procurement (including R&D) this is the best alternative.

Regional Security Variables

My measure of regional conflict is the average number of militarized interstate disputes that the state was involved in during the previous three-year period. Since wars, or even lesser military conflicts, do not vanish so quickly from memory, a three-year moving average allows for the possibility of a lingering impact on domestic arms-production decision-making. Data come from the *Militarized Interstate Dispute* (MID) dataset maintained by the Correlates of War Project. I also include two measures of regional militarization. The first is the total value of arms imported by other states in the region, as reported by ACDA. The second is the value of arms produced in the region. Since I only have arms production data for twelve countries, this regional variable draws on a varying subset of these twelve. For a given country, arms production in its region consists of total output of any of the remaining eleven third tier producers that inhabit the same region. For each state, the regional actors assumed to be relevant in

Table II
Third World Arms Producers and Relevant Regional Actors

Producer	Regional Actors
Argentina	Bolivia, *Brazil*, *Chile*, Columbia, Paraguay, Peru, Uruguay, Venezuela
Brazil	*Argentina*, Bolivia, *Chile*, Columbia, Ecuador, Paraguay, Peru, Uruguay, Venezuela
Chile	*Argentina*, Bolivia, *Brazil*, Columbia, Paraguay, Peru, Uruguay, Venezuela
Egypt	Algeria, Chad, Ethiopia, Iran, Iraq, *Israel*, Jordan, Libya, Saudi Arabia, Sudan, Syria
India	Afghanistan, Bangladesh, China, *Indonesia*, Malaysia, Myanmar, *Pakistan*, *Singapore*, Thailand
Indonesia	Australia, Cambodia, *India*, Malaysia, Papua New Guinea, Philippines, *Singapore*, Thailand, Vietnam, South Vietnam (until 1975)
Israel	*Egypt*, Iran, Iraq, Jordan, Lebanon, Libya, Saudi Arabia, Syria
Pakistan	Afghanistan, Bangladesh, *India*, Iran
Singapore	Cambodia, *India*, *Indonesia*, Malaysia, Philippines, Thailand, Vietnam, South Vietnam (until 1975)
South Africa	Angola, Botswana, Mozambique, Namibia, Zambia, Zimbabwe
South Korea	China, Japan, North Korea, *Tawain*
Taiwan	Cambodia, China, *Indonesia*, Japan, Malaysia, North Korea, Philippines, *Singapore*, *South Korea*, Thailand, Vietnam, South Vietnam (until 1975)

Note: Data for countries listed as regional actors were used to construct the variable for regional arms imports. Data for countries in italics were used to construct the variable for regional arms production.

its security calculations are listed in Table II. I have not attempted to distinguish between friend and foe, although refinement along these lines is certainly possible.[13] The measure of regional arms production may seem somewhat problematic since there are some major arms producers that are not among the twelve states for which I have production data: China, Australia, and Japan are the most obvious omissions. However, my intention is to capture the effects of any separate competition between states of comparable military-industrial development.

Technology and Culture Diffusion Variables

Three variables used as indicators of military technology and cultural diffusion are based on the state's participation in the international arms market. Military technology is embodied in the transfer of complete weapons systems, so as one indicator I use the total value of arms imports reported by ACDA. Another indicator of technology diffusion is the degree to which a third tier country's arms-import portfolio is diversified. The assumption is that a more even distribution of arms imports among a larger number of suppliers is a sign of greater supplier competition, creating an environment in which the importer is in a better position to demand technology transfers along with finished systems. I use this index of arms import diversification:

$$\text{Diversification} = \left[1 - \sum_{i=1}^{n}\left(\frac{t_i}{T}\right)^2\right] \times 100.$$

The value of arms transferred from a particular supplier, t_i, is expressed as a share of all arms imports, T. Squaring this ratio for each supplier summing over all n suppliers gives a measure of import concentration (Catrina, 1988, p. 199; also Kinsella, 1998); subtracting from one converts this to an index of diversification. The rescaled index ranges between 0 and 100, with higher values indicating diversified arms-import portfolios and lower values indicating concentrated ones. A third measure of technology diffusion is licensed production. Since licensed production is part of overall domestic arms production, I consider its impact only when examining indigenous production separately.

Third tier states' arms-import relationships have also been identified as fostering the transfer of military culture, and arms imports and licensed arms production would seem to serve a dual purpose as empirical indicators of both technological and cultural diffusion.[14] One obvious difficulty is untangling the two (theoretically) distinct effects captured by a single parameter estimate. The challenge, then, is to identify an alternative measure of a state's exposure to external sources of legitimation for its domestic arms production programs. Eyre and Suchman (1996, p. 102), in an analysis of the symbolic value attached to advanced weapons inventories, whether imported or produced at home, point out that "the standard practice of most... empirical investigations is to use the number of international governmental organization (IGO) memberships as the indicator of connectedness to the world system." A state's IGO memberships are slow to change from year to year, and while such an indicator seems reasonable for cross-sectional analyses, the slight temporal variation makes it more problematic in the time-series context.[15] Instead, I opt for the number of states that supplied arms to the third tier producer during the year. This is meant as a straightforward indicator of the state's interaction with other states in the international arms market. As a measure of immersion in global military culture and exposure to external sources of legitimacy, it is certainly crude, but the cultural diffusion argument is an important one and needs to be represented in a general model of third tier arms production.[16]

Statistical Estimation

Each of the independent variables in my analysis is lagged one year to approximate a temporal order consistent with the assumed causal relationship between the dependent and independent variables. The period of analysis is 1968–1990, so the TSCS consists of 276 observations. The TSCS design overcomes the degrees-of-freedom problem I would otherwise confront in examining twelve separate time series, but it does assume that the effects of the independent variables are consistent across the twelve countries. At this point, there is no reason to question that assumption, but spatial consistency—along with temporal consistency assumed by time-series models generally—could be a subject for further investigation.

It hardly needs to be said that a model of third tier arms production cannot capture all of the significant factors involved. But the particular hazards associated with TSCS estimation, as well as the correctives, bear noting. The basic model I am using here takes the following form:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k x_{kit} + u_{it}, \tag{1}$$

where the dependent variable, y, observed for each state i in each year t, is a function of K independent variables, x, similarly observed. Although I assume that the effect of each independent variable, β_k, is consistent across the twelve states, it is clear that variables omitted from the model go far to explain their different overall levels of domestic arms production. Size, natural resources, and other factor endowments are not represented in the model, nor are intangibles like national history and culture. In the time-series context, the effects of such things are treated as constant for any individual country under investigation, but when we add a cross-sectional dimension to the analysis, it is easy to see why that assumption is likely to be violated. The most obvious way to deal with this "heterogeneity bias" is to allow the constant, α, to vary for each state i.[17] In short, although I began this study by arguing that there is a degree of homogeneity among third tier producers that makes it sensible to analyze them as a group, it would be unwise to push this assumption too far.

Model [1] also assumes that variables not included in the model produce effects, u_{it}, that are random across states and over time. But because it is clear that there are differing overall levels of arms production among third tier states, partly due to state-specific factors outside the scope of the model, we should also expect that the variability in arms production is different for different states. In this case, the distribution of error term, u_{it}, is not random; rather, it is "panel heteroskedastic."[18] When applying ordinary least squares (OLS) regression in this context, the estimated effects of the independent variables are accurate, but the estimated standard errors are not, thus compromising our inferences. Following Beck and Katz (1995), I use OLS to estimate the parameters in model [1], but accompany these with panel-corrected standard errors (PCSEs).[19]

FINDINGS

Table III shows the results of the TSCS analysis. The first set of estimates are for the effects on all domestic production, licensed plus indigenous; the second set concerns indigenous production alone. Column A consists of parameter estimates with panel-corrected standard errors. Columns B and C consist of estimates which attempt to correct for some possible remaining inaccuracies due to the temporal dimension of the data (discussed below).

Let me start with the factors affecting overall domestic arms production. Most of the results reported in column A are supportive of the arguments I reviewed in the first half of the article. At the domestic level, all of the hypothesized determinants of arms production do seem to be at work in the third tier. Increases in both industrial capacity and export capacity provide expanding opportunities for increases in domestic arms production. All raw dollar-valued data are in millions (1990 = 100), so a $1 billion increase in industrial output is associated with a $5 million increase in the value of all domestic arms production, while $10 million increase in last year's arms exports is associated with a $1.8 million increase in arms production.

The relative closedness of political and governmental institutions—and, by assumption, the potential influence of the military—is also associated with higher levels of domestic arms production. With an incremental increase in a state's autocracy score comes a $10 million increase in arms production. Military spending has a positive impact as well. The more

TABLE III
Estimated Effects on Third World Arms Production, 1968–1990

	All Domestic Production			Indigenous Production		
	A	B	C	A	B	C
Domestic Economic						
Industrial Capacity	0.005**	0.005**	0.002**	0.003**	0.003**	0.002**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Arms Export Capacity	0.177**	0.186*	0.040	0.111**	0.115**	0.029
	(0.073)	(0.098)	(0.058)	(0.052)	(0.056)	(0.044)
Domestic Political-Economic						
Political Closedness	9.610*	9.020	5.363	9.710**	9.602**	5.328
	(5.053)	(6.723)	(5.353)	(3.314)	(4.071)	(3.450)
Military Spending	0.025**	0.022**	0.010	0.024**	0.022**	0.010**
	(0.010)	(0.011)	(0.008)	(0.006)	(0.008)	(0.005)
Regional Security						
Militarized Disputes	43.561**	51.525*	19.203	27.954*	33.124	13.872
	(17.871)	(27.601)	(16.379)	(14.659)	(24.442)	(13.249)
Regional Arms Imports	0.004*	0.005	0.002	0.006**	0.006**	0.002**
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.001)
Regional Arms Production	−0.083**	−0.079**	−0.027	−0.049**	−0.046*	−0.026**
	(0.023)	(0.035)	(0.018)	(0.015)	(0.024)	(0.012)

Technology & Culture Diffusion						
Arms Import Diversification	−1.629**	−1.640**	−1.275**	−1.590**	−1.532**	−1.138**
	(0.751)	(0.679)	(0.652)	(0.607)	(0.475)	(0.554)
Arms Imports	0.152**	0.142**	0.049*	0.029	0.023	0.016
	(0.035)	(0.060)	(0.028)	(0.023)	(0.027)	(0.021)
Arms Suppliers	10.352	11.235	9.283	−2.601	−2.139	5.333
	(8.625)	(9.539)	(7.722)	(7.086)	(8.256)	(5.971)
Licensed Arms Production				0.470**	0.457**	−0.083
				(0.140)	(0.176)	(0.150)
Lagged Dependent Variable			0.621**			0.619**
			(0.078)			(0.090)
Degrees of Freedom	254	242	241	253	241	240
Lagrange Multiplier	73.71**		0.88	73.87**		0.09
Explained Variance	0.80	0.80	0.87	0.79	0.79	0.86

Notes: Estimates are for fixed effects models and do not include constants. Columns A and C are OLS estimates with panel-corrected standard errors (*in parentheses*). Estimates in column B are from OLS with autocorrelation-corrected standard errors (using a first order moving average), but no panel correction. Columns B and C cover the 1969–1990 period. The Lagrange multiplier tests the null hypothesis of no first order autocorrelation. Explained variance is for models using untransformed data with state-specific dummy variables.
* significant at the 0.10 level; ** significant at the 0.05 level.

resources devoted to military procurement (among other things), the more arms the country produced: $25 million worth of production for every $1 billion of military spending. At the regional level, the state's past involvement in military conflict and local arms inflows both influenced its level of domestic arms production. The incidence of one additional militarized dispute on average during the previous three years is associated with a $44 million increase in arms production, while a $10 billion increase in the value of regionwide weapons imports has roughly the same effect.

As to the impact of regional arms production, the finding here is genuinely puzzling. The parameter estimate is negative, which neither supports the hypothesized action–reaction dynamic nor lends itself to a very convincing post hoc interpretation. In the arms race literature, the best explanation for negative reaction parameters is, in my view, Oren's (1996): because bellicose behavior is riskier for a weaker state, the signal it sends is more credible and the state's intentions more threatening. That same behavior, when undertaken by a stronger state, may be regarded as opportunism and not a sign of serious commitment to push the issue to the brink. If we control for the level of hostile behavior directed at a state, as my analysis has done, Oren's (1996, p. 312) point is that "a weak state would appear to harbor more aggressive intentions than a strong one." What that implies for a country's defense policy is a greater tendency to balance against weaker opponents, not stronger ones—again, for any given level of hostility received. What it implies for empirical testing is a negative parameter estimate attached to the variable representing military capabilities.[20] I don't dispute the soundness of this logic, as far as it goes, but I am dubious about its applicability. In this analysis, arms production is not meant as an indicator of overall military capability; even toward the end of the period I examine, a relatively small share of the total military force fielded by third tier producers was domestically produced. For any given level of hostility, regions inhabited by other third tier arms producers should indeed be perceived as more threatening environments, since the substitution of domestically produced arms for imported ones, even where limited or halting, is designed to promote freedom of action in pursuit of foreign policy goals. Thus, I remain puzzled by this statistical result.

At the global level of technological and cultural diffusion, empirical support for the hypothesized relationships is mixed. If the diversification of foreign arms suppliers gives recipients an extra measure of leverage in their efforts to acquire manufacturing technology, this does not translate into increased production in the short term. In fact, after controlling for the other forces operating on third tier states, higher levels of arms production are associated with arms import *concentration*. An decrease of, say, 10 units on the import diversification scale is accompanied by a $16 million increase in the value of domestic arms production. There are two interpretations to attach to this finding. The first and most obvious one has to do with willingness: because dependence leaves the state susceptible to manipulation, leaders are motivated to turn inward for more of their defense needs. Second, in regard to opportunity, states may in fact have greater access to military technology in the context of more dedicated arms transfer relationships—in the extreme, patron–client relationships—than they do when sources are diversified.

The amount of weaponry the state imports has a positive impact on the amount of weaponry it produces, as expected. A $10 million increase in imports is associated with a $1.5 million increase in production. On its face, this result suggests the importance of the military-technological diffusion that accompanies the arms trade. But, as many have argued, the arms trade also involves the diffusion of military iconology. Unfortunately, I am unable to isolate the effects of this cultural transfer by focusing on states' interaction with others in the arms market (the parameter estimate for the number of arms suppliers is statistically insignificant). Either military-cultural diffusion is not a central factor explaining arms production in the third tier or my operationalization of the process is too crude to capture it.

Analysts generally identify the same set of factors as contributing to both indigenous and licensed arms production, but it is also clear that indigenous production involves a major leap in capabilities. Column A on right half of Table III shows the estimated effects on indigenous production specifically. The one difference in the specification of model [1] is that licensed production, now not part of the dependent variable, can be added as an explanatory variable representing technological (and possibly cultural) transfer. The effect of licensed production on indigenous production is positive, as expected. A $10 million increase in licensed production is associated with almost a $5 million increase in indigenous production. In contrast to domestic production overall, it is not surprising to see that the effect of arms imports on indigenous production is statistically insignificant: licensed production is a more direct measure of technology transfer than arms importation. Almost all of the model's other parameter estimates are somewhat lower in magnitude than those for total domestic production. This is not surprising either. The capacity for indigenous weapons production is harder to develop than the capacity for licensed production, which still relies on foreign sources for many of its inputs. When restricting attention to the former, production output should indeed be somewhat more sluggish in response to increases in both the motivations and opportunities for military industrialization.

Where Is the Greatest Impact?

Taken together, the domestic, regional, and global sources of opportunity and willingness explain 80 percent of the variance in domestic arms production for the twelve countries examined. It is not obvious from the parameter estimates which factors are relatively more important than others in explaining third tier arms production. However, standardized estimates—adjusted by the standard deviation of the independent variable relative to that of the dependent variable—can give some sense of this, if we take a standard deviation change to be a "typical" change.

Based on these computations, industrial capacity and arms imports are the most important factors affecting total domestic production, with a standard deviation change in each associated with a one-quarter to one-third standard deviation change in weapons output ($\beta^* = 0.32$ and 0.28, respectively). Next most important are military spending, regional conflict, and the concentration of arms imports, but their effects are equal to less than a one-fifth of a standard deviation change in production ($\beta^* = 0.18$, 0.14, and 0.13). It is interesting that the most important predictors of arms production in the third tier are those representing opportunities for arms production, as opposed to willingness: industrial capacity and technology diffusion via the arms trade. Two of the three second most important factors also affect opportunity. The most important motivating forces behind domestic arms production appear to be the state's involvement in regional conflict and, possibly, the diffusion of military culture (to the extent that this captured empirically by arms imports). For indigenous production only, standardized estimates are in the same ballpark, but licensed production substitutes for arms imports as a leading predictor of indigenous production, along with industrial capacity and military spending ($\beta^* = 0.24$, 0.24, and 0.23, respectively).

There is a remaining statistical complication that must be attended to before we can establish complete confidence in the results of this analysis. It appears that some of the factors lying outside the scope of my model—that is, factors lumped together as u_{it} in equation (1)—are correlated over time, and this serial correlation in the residual term may affect the accuracy of the estimates reported in column A, both for total domestic production and indigenous production.[21] I have approached the problem in two ways, neither of which is completely satisfactory in my view. The first solution is to re-estimate the model using OLS, this time applying a corrective for both heteroscedasticity and serial correlation (column B). The problem with this procedure is that, unlike the Beck–Katz method, it is not designed to handle the type of heteroscedasticity peculiar to TSCS data.

The second solution is to follow Beck and Katz (1996), who recommend modeling the dynamics explicitly by including a lagged dependent variable as an explanatory variable (column C). The problem with this is that last year's arms production really isn't much of an "explanation" for this year's production, even if it does account for a good deal of the variation.

The results in column B, for both domestic and indigenous production, are very similar to those in column A. In the case of domestic production, the impact of political closedness and regional arms imports, which were marginally significant before correcting for serial correlation, are statistically insignificant after the correction. For indigenous production, the only difference is that the impact of previous military disputes is now called into question. Otherwise, there is a close correspondence between both sets of results.[22] The solution recommended by Beck and Katz (1996), on the other hand, generates results that are substantially weaker than the others (see column C). Only industrial capacity, arms imports, and arms-import concentration explain levels of domestic arms production beyond what is predictable based solely on last year's production. When it comes to indigenous production, industrial capacity, military spending, regional arms imports, and arms-import concentration remain as plausible explanations.

What to make of this last set of findings? The results column C should be viewed as a more stringent test of the relationships examined in this article. Although many of the arguments considered here are supported by the evidence, those that clear this final hurdle inspire the most confidence. In fact, they would appear to meet Granger's (1969) operational criterion for a "cause": each explains variance in arms production not explained by past arms production itself. Industrial capacity, military spending, and arms-import concentration should be understood as permissive causes in this context, since each relates to opportunity. Arms imports fall into this category as well, since they often involve the transfer of military technology. However, as a vehicle for military-cultural diffusion, they may also affect willingness and thus serve as an immediate cause of third tier arms production.

CONCLUSION

I have tried to highlight the major determinants of third world military industrialization operating at the domestic, regional, and global levels. The literature on third world militarization is a rich source of insights into the dynamics involved, but there are few comprehensive empirical investigations that systematically test the impact of the various factors affecting arms production in the third tier. I have undertaken such an investigation and have found much support for the processes described in the literature.

Third tier arms production depends the state's industrial capacity and is enhanced by the state's proven ability to produce weapons for export. It is affected by the closedness of political institutions, and by implication the military's potential influence in the allocation of resources, as well as by the actual allocation of resources in the form of military spending. States are motivated to increase military production by their involvement in regional conflict and by the level of regional militarization. The transfer of military technology accompanying arms imports also affects overall domestic arms production, while foreign licensing arrangements facilitate specifically indigenous production. Finally, although I suspect that the global arms market provides a vehicle for the diffusion of military culture, my crude indicator of state interaction could provide no independent confirmation. The global diffusion of military iconology as a driving force behind military industrialization is an important notion in my view, and discerning its impact represents a major challenge for further empirical research.

Whether or not the diffusion of arms production capacity to the third world constitutes "bad globalization"—as opposed to the "good globalization" emerging within the industrialized west (Bitzinger, 1994)—depends on one's standpoint. But for those who do see this as the next proliferation challenge, an appreciation of the variety of forces driving it is necessary for the creation of effective arms control regimes. Noteworthy are my findings regarding the importance of opportunity, perhaps more than willingness, as an explanation for changing levels of third tier arms production. Resolution of the tensions that drive regional militarization and the eruption of military conflict should have some positive effect on restraining the expansion of arms production capacity. But there also seems to be a certain inevitability to the process, a process that is limited primarily by states' resources, industrial capacities, and access to weapons-production technologies. Curbing the diffusion of military technology may be an option for the international community, but given the economic and political imperatives operating on advanced arms-producing states, there is ample reason for doubt.

APPENDIX: ESTIMATING MISSING OBSERVATIONS

For the period analyzed in this article, 1968 to 1990, there are 12 states $\times$ 23 years $=$ 276 observations. Since licensed production also appears as a lagged independent variable in the analysis, another 12 observations are required for 1967. For these periods, the time series reported by Anthony (1993, Table 17.1) contain 36 missing observations for indigenous production (13%) and 87 for licensed production (31%). Many of these values, about half, we can safely assume to be zero, based on adjacent values, but that still leaves many gaps in the two series. To fill these, I use simple linear interpolation. See Table A.

I think this is a reasonable procedure for two reasons. First, eliminating these missing observations from the dataset would require restricting my analysis to the 1980–1990 period or thereabouts. Alternatively, I could examine fewer countries over a longer period—six or seven of them from 1970 to 1990. Either approach results in roughly halving the total number

Table A
Missing Arms Production Data and Means of Estimation

Producer	Missing Years	
	Indigenous	Licensed
Argentina		1971–73, 1988–89 (interpolated)
Brazil		1967–71, 1985 (interpolated)
Chile	1969–70, 1972–1980 (interpolated)	1967 (zero); 1969–70, 1972–79 (interpolated)
Egypt		1970–78 (zero)
India		
Indonesia	1969, 1971–73 (interpolated)	1967–75 (zero)
Israel		1967–75, 1988–90 (zero)
Pakistan	1968–75 (zero)	1967–76 (zero)
Singapore	1970, 1972–73, 1976–77 (interpolated)	1967, 1989–90 (zero); 1970, 1972–73, 1976–77, 1984–85 (interpolated)
South Africa		
South Korea	1968–70, 1973–74 (interpolated)	1967–74 (zero)
Taiwan	1980, 1982, 1989 (interpolated)	1967 (zero); 1980–89 (interpolated)
zero	8 (2.9%)	50 (18.1%)
interpolated	28 (10.1%)	37 (13.4%)

of observations, giving me less information with which to estimate parameters. That would also involve excluding somewhat more nonmissing observations than missing ones (if we count the assumed zeros as real values). Second, linear interpolation essentially involves filling the gaps in the time series without increasing the variance. The effect of this is probably to give an edge to the null hypotheses and to decrease the chances of making Type I errors. The null would only be disadvantaged if the true patterns for the missing years were the inverse of those for nonmissing years, a possibility I consider unlikely. In short, and in this particular case, linear interpolation of missing values would seem to offer benefits for parameter estimation that outweigh the risks.

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NOTES

1. Lists of the top 100 defense firms are published by the Stockholm International Peace Research Institute and *Defense News*, and although the lists do not match perfectly in terms of rank and revenues, they are very similar (see Sköns and Weidacher, 1999; *Defense News*, 1999).
2. Peleg's (1980) fine study is one of the few exceptions, and provides something of a model for the present examination. See also Neuman (1984). Most other empirical work consists of single or comparative case studies. They are typically qualitative analyses, but informed by a wealth of quantitative data. Some researchers eschew statistical analysis because they are wary of the caliber of the quantitative data. This concern is misplaced, since the very purpose of statistical analysis is to distinguish "signal" from "noise" in quantitative data. Another reservation involves the generalizability of findings, even those processes revealed in rather accurate quantitative data. In general, this concern has more merit in my view, but it is less relevant for the current study, which does not attempt to generalize beyond the third tier.
3. Buzan and Herring (1998, p. 43) identify two groups, full producers and part producers, but the large category of part producers is broken down further. Part producers capable of a full range of production, often at the leading technological edge correspond to the second tier in other formulations. Those producing less than the full range of weaponry (a "substantial" or "narrow" range), including those reliant on imported components, correspond to the third tier.

4. To say that third world states *seek* autonomy through military industrialization is not to say that they achieve it. Many argue that arms import substitution merely replaces dependence on weapons systems with dependence on weapons technology. See, for example, Lock and Wulf (1979), Moodie (1979), and Neuman (1984).
5. Arms industries in Argentina, India, Indonesia, Israel, Pakistan, Peru, Singapore, and Taiwan have tended to be concentrated in the public sector. Industries are more evenly distributed across both the public and private sectors in Brazil, Chile, South Africa, and South Korea (Ross, 1994, p. 106). However, according to Brzoska (1999, p. 145), in recent years "there has also been more of an economic spirit in [less industrialized countries] in general, to the detriment of governmental support for arms production."
6. A fourth category (technology IV) involves the capacity to innovate at the technological frontier, and therefore is not acquired through diffusion.
7. Vajpayee is quoted in "Over 2,000 Km Range Agni-II Successfully Test-Fired," *The Times of India*, 12 April 1999. Not surprisingly, the literature on nuclear weapons has generally been more attentive to such issues. Examples include Jervis (1989, chapter 6), Sagan (1996/97), and, from the domestic standpoint, Flank (1993/94). The literature on the symbolic motivations for conventional weapons acquisition is rather sparse. On military industrialization, it is virtually nonexistent, but see Kinsella and Chima (2001) on the symbolism attached to conventional arms production in India.
8. My database should be recognized as a time-series cross-section (TSCS) as opposed to a panel. I am not treating these countries as a sample from a larger population, about which I want to make inferences (a panel). Instead, my inference will be about processes operating on a relatively fixed number of countries—those qualifying as third tier arms producers—and the asymptotic assumptions behind these inferences derive from the length of the time series, not the size or representativeness of the country "sample." See Beck (1999) for a useful discussion of the distinction between TSCS and panel data. Note that the estimation procedure used in this analysis, "*panel* corrected standard errors" (see below), is in fact appropriate for TSCS data as well.
9. Having data on actual production costs would be useful for more precise tests of some hypotheses—like those positing the impact of industrial and arms-export capacity—because they involve questions of resource availability. But most hypotheses relate to politics, security, or technology diffusion, and are appropriately tested using data reflecting what SIPRI researchers call the "military-use value" of the weaponry. There is a different problem, however: the spotty coverage for some states. See the appendix.
10. Specifically, the series was computed from the manufacturing index released by the U.S. Department of Labor (http://stats.bls.gov/news.release/prod4.t16.htm, accessed 11 February 1998) and industry value added from Taiwan's Council for Economic Planning and Development (http://cepd.spring.org.tw/English/Economic/con9.html, accessed 11 February 1998). The industrial production index was not available for the entire period, but is highly correlated with the manufacturing index for period available ($r = 0.99$ for 1986–1996). Data for 1967–1969 are estimates based on extrapolated growth rates (based on 1970–1980 data).
11. Wulf (1985, note 6) identifies the following sectors as most relevant for arms production: iron and steel, non-ferrous metal, metal products, electrical machinery, non-electrical machinery, and transportation equipment. For five countries—Brazil, India, Israel, South Africa, and South Korea—I examined data on total manufacturing and three of these six sectors (UNIDO, 1994). Using all available data for 1960–1990 ($n = 132$), the correlations with total manufacturing are: electrical machinery, 0.83; non-electrical machinery, 0.96; transportation equipment, 0.97.

12. The autocracy score, like the democracy score, is based on evaluations of the following: competitiveness and regulation of political participation, competitiveness and openness of executive recruitment, and constraints on the chief executive. See Jaggers and Gurr (1995, pp. 471–472).
13. A systematic approach would be identify more or less threatening states based on aggregated levels of cooperation and conflict generated from an events dataset like the *World Event/Interaction Survey* (see Tomlinson, 1993).
14. There are two reasons to prefer ACDA's data on arms imports to SIPRI's in this particular context. First, although ACDA includes licensing fees as part of its definition of arms transfers, it does not include the value of the equipment produced under license, as does SIPRI. I want to keep imports separate from licensed domestic production in this analysis. Second, ACDA includes as transfers "military services such as training, supply operations, equipment repair, technical assistance, and construction" when data are available. Since all these activities are potentially involved in the diffusion of military culture—i.e., are part of Kaldor's (1981) weapons *system*—ACDA's measure is somewhat better for my purposes than SIPRI's, which is restricted to the transfer of major weapons. Note that beginning with the 1995 issue of *World Military Expenditures and Arms Transfers*, covering the period 1984–1994, ACDA includes military services in its tallies of U.S. transfers. This component was excluded from the U.S. data reported in prior issues, which was not altogether inappropriate (see ACDA, 1996, pp. 183–184).
15. Of course, it may be that cultural diffusion itself is a sluggish process and that *any* attempt to devise a measure that shows annual variation in cultural diffusion is asking too much.
16. Clearly, the number of suppliers is related to total arms imports and import diversification, though they are not highly correlated ($r = 0.09$ and 0.56, respectively). But my intention is that after controlling for the latter, any effect captured by this variable will be more thoroughly cultural.
17. This is known as a "fixed effects" model because the heterogeneity is assumed to be produced by effects that vary across individuals, but are constant for each individual over time. In practice, estimation proceeds by first transforming each variable into deviations from the country mean, but including country-specific dummy variables (and no constant) accomplishes the same thing. An alternative, a "random effects" model, treats the individual effect as a random variable. These random effects might be composed of factors that vary across individuals but not over time, as in the fixed effects model. They may also include effects that are common to all individuals, but are peculiar to certain time periods, as well as purely random effects. In order to estimate such a model, the random effects term, u_{it}, must be decomposed into its three components and the result used to correct for the heterogeneity bias in the data. I do not use a random effects model here because I cannot conceive of omitted variables that would have affected all twelve states, but where the effects were restricted to specific time periods. (An example would be a war that involved all twelve.) There are also methodological reasons to prefer a fixed effects model when working with a TSCS, as opposed to a panel (see Hsiao, 1986, pp. 41–47; Beck, 1999, p. 4).
18. I confirmed the presence of panel heteroscedasticity by analyzing the OLS residuals. Likelihood ratio tests indicate that pairwise differences in error variances are jointly significant for the twelve arms producers: for domestic production, $\chi^2 = 213.3$ ($p < 0.001$); for indigenous production, $\chi^2 = 216.6$ ($p < 0.001$).
19. Although I expect the error process in my data to exhibit panel heteroscedasticity, I still assume that the error variance is constant over time for each state. The Beck–Katz

approach is to estimate the contemporaneous spatial correlation in the error term—i.e., the tendency of shocks to affect arms production in two or more countries during the same year. Given constant error variances within each unit, the otherwise complex structure of a TSCS becomes its strength: the time-series dimension provides repeated information on the spatial correlation, which is then used to correct the standard errors (see Beck and Katz, 1995, p. 638).

20. Actually, contributors to the statistical modeling literature on arms races have probably been more often stumped by reaction parameter estimates indistinguishable from zero than by negative estimates (see Kinsella and Chung, 1998).
21. Serial correlation is indicated by the Lagrange multiplier reported in Table III. The null hypothesis is no first-order serial correlation, in the form of an autoregression or a moving average; it is rejected for both domestic and indigenous production.
22. This greatly diminishes my concern that the estimates in column A are compromised by serial correlation, or that the estimates in column B are questionable due to panel heteroscedasticity. The procedure used to compute the results shown in column B corrects for heteroscedasticity (though without taking into account the panel structure of the data) and first-order serial correlation in the form of a moving average (though not an autoregression). See Newey and West (1987).

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CONTRIBUTOR

David Kinsella is Assistant Professor of International Politics and Foreign Policy at American University. He is the author of articles on the arms trade and related topics and, with Bruce Russett and Harvey Starr, *World Politics: The Menu for Choice* (Bedford/St. Martin's, 2000).