Russian Scientists and Rogue States

Does Western Assistance Reduce the Proliferation Threat?

Deborah Yarsike Ball and Theodore P. Gerber

The collapse of the Soviet Union in 1991 engendered widespread concern that Russian nuclear weapons and material could end up in the hands of proliferants or terrorists. The ensuing decline in border security and the diminution of the role and power of the formerly ubiquitous security services significantly reduced the ability of Russia to safeguard these weapons and material. Another threat, the focus of this article, took a human form: Russian scientists with knowledge about nuclear, chemical, and biological weapons suddenly had greater leeway to visit or emigrate to any country of their choice, including so-called rogue nations seeking to produce weapons of mass destruction (WMD).[1] And because of the greater ease with which Russian scientists could interact with the outside world, they could even sell their knowledge while remaining at home.

Russia inherited the largest WMD complex in the world, with little government support for sustaining it at anywhere near Cold War levels. As a result, Russian science fell into a protracted crisis: salaries plummeted, funding for research dropped sharply, and the number of students pursuing careers in science dwindled. These developments gave Russian scientists both greater incentives and greater opportunities to sell their knowledge to governments or terrorist organizations that harbor hostile intentions toward the United States and other Western democracies.

In response, the United States and other Western governments created a

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1. Restrictions on travel existed for weapons scientists, but the laws were not strictly enforced in the early days after the fall of the Soviet Union. Moreover, if a scientist is determined to move abroad, there are numerous ways to do so, including purchasing a fake passport. Today a passport is issued to a weapons scientist five years after the scientist has left weapons-related work.

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host of nonproliferation assistance programs designed to reduce the likelihood that Russian scientists would sell their WMD knowledge to rogue states or terrorists. Yet to date, there have been no studies that present empirical data assessing the impact of these programs on the threat of Russian WMD brain drain.[2]

Our data from an unprecedented survey of 602 Russian scientists indicate that the brain drain threat from Russia should still be at the forefront of policymakers' and the public's attention: roughly 20 percent of Russian physicists, chemists, and biologists say they would consider working in Iran, Iraq,[3] North Korea, or Syria—nations that, for the sake of brevity, we refer to as "rogue."[4] To be sure, the vast majority of Russian scientists feel a great weight of responsibility for how their WMD knowledge is used and would not help rogue states or terrorists acquire weapons of mass destruction. Yet given the enormous security implications, the possibility that one-fifth of the scientists would consider working in rogue countries is cause for concern.

The question that remains is: have Western efforts to stem the willingness of Russian scientists to sell their WMD expertise to rogue countries been effective? The data reveal that U.S. and Western nonproliferation assistance programs do indeed work. They significantly reduce the likelihood that Russian scientists would consider working in such countries. To our surprise, the data also suggest that Russian, as opposed to Western, grants do not lessen such scientists' propensity to work in these rogue countries.

We begin by examining the nature of the threat and provide some background information on several Western grant assistance programs aimed at keeping Russian WMD scientists employed in Russia by providing them with research grants. Next we describe how the survey was implemented and dis-

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2. One prior study that examined the potential for the migration of Russian scientists is Valentin Tikhonov, *Russia's Nuclear and Missile Complex: The Human Factor in Proliferation* (Washington, D.C.: Carnegie Endowment for International Peace, 2001). This study, however, did not look at the impact of Western grants on the likelihood of migration. Although the findings are interesting, the analysis is limited to univariate and bivariate distributions; however, multivariate analysis is necessary to understand the effects of key variables on the willingness of Russian WMD scientists to migrate.

3. At the time of the survey, the 2003 Operation Iraqi Freedom had not yet begun, and the U.S. government considered Iraq a rogue state.

4. When we asked Russian scientists about their inclinations to work abroad, we did not use the term "rogue states." In addition, when we refer to "going rogue," we do not necessarily mean that the scientists would work in an unauthorized or clandestine manner for these nations. Rather, we are merely testing their general willingness to work for these countries. The survey was conducted from November 2002 to January 2003.

cuss how we measured the key variables. We then present the survey results, briefly examine the policy implications, and point to areas requiring further research.

The Decline of the Russian Scientific Establishment

The Russian scientific establishment, once highly respected throughout the world, has experienced a precipitous drop in its prospects and status since the demise of the Soviet Union.[5] Between 1991 and 1994, federal funding for scientific research declined by roughly 75 percent and has since remained at that level.[6] Unlike in the West, where science has numerous commercial sources of funding in addition to federal funds, in the Soviet Union, federal funds provided the vast majority of support. In fact, at the end of the 1980s, the Soviet federal budget provided approximately 97 percent of funding for science.[7] Moreover, the majority of those funds were devoted to the defense sector. Because Soviet research and development did not focus on feel-good consumer items, such as microwave ovens and espresso makers, Russia's

5. On the numerous problems that confronted Russian science during the 1990s, see Peter Aldhous, "A Scientific Community on the Edge," *Science,* May 27, 1994, pp. 1262–1264; Peter Aldhous and Alexander Dorozynski, "Saving Russia's Threatened Biological Heritage," ibid., p. 1266; Daniel Clery, "A Once-Favored Discipline Has the Furthest to Fall," ibid., pp. 1268–1270; Vladimir Pokrovsky, "Russian Science in the Balance," *Nature,* September 15, 1994, pp. 195–196; Peter Kneen, "Science in Shock: Russian Science Policy in Transition," *Europe-Asia Studies,* Vol. 47, No. 2 (1995), pp. 281–303; Vladimir Zakharov and Vladimir Fortov, "Science in Russia Is Already in a Coma," *Science,* May 5, 1995, pp. 693–694; S.A. Lebedev and S.A. Milenin, "The Crisis of Russian Science and Ways to Solve It," *Russian Education and Society,* Vol. 38, No. 10 (October 1996), pp. 6–23; Michael Freemantle, "Russian Science on the Rack," *Chemical and Engineering News,* December 22, 1997, pp. 25–34; Carol Matlack, "Up from the Wreckage of Russian Science," *Business Week,* October 27, 1997, pp. 153–154; I.G. Ushkalov, "'Utechka Umov' I Sotsial'no-ekomonicheskie Problemy Rossiiskoi Nauki" [Brain drain and social-economic problems of Russian science], *Vestnik Rossiiskoi Akademii Nauk,* No. 67 (1997), pp. 150–153; A.V. Iurevich and I.P. Tsapenko, "Funktsional'nyi Krizis Nauk," [Functional crisis in science], *Voprosy Filosofii,* No. 1 (1998), pp. 17–29; Toni Feder, "New Minister Is Unlikely to Resuscitate Russian Science," *Physics Today,* Vol. 51, No. 8 (August 1998), pp. 54–55; Carl Levitin, "Pay Crisis Drives Russian Scientists Abroad," *Nature,* October 15, 1998, p. 627; A. Varshavskii, "The Socioeconomic Problems of Russian Science," *Problems of Economic Transition,* Vol. 42, No. 5 (1999), pp. 56–80; and Vladislav Borobyev and Yekaterina Dobrynina, "Unit of Measure—The Mind," *Rossiyskaya Nauchnaya Gazeta,* February 10, 2004, translated in Foreign Broadcast Information Service (FBIS), CEP 20040210000290, February 10, 2004.

6. L. Gokhberg and L. Mindeli, eds., *Nauka Rossii v Tsifrakh, 1999* [Russian science in numbers, 1999] (Moscow: Tsentr Issledovanii I Statistiki Nauk, 1999), p. 44.

7. Irina Dezhina and Loren Graham, "Russian Basic Science after Ten Years of Transition and Foreign Support," Working Paper No. 24 (Washington, D.C.: Carnegie Endowment for International Peace, February 2002), p. 7.

scientific community was hit especially hard by the crumbling of the defense sector that followed the Soviet collapse. With few alternative sources of financing, Russia's scientific establishment was decimated: salaries fell sharply, equipment and laboratories deteriorated, supplies became scare, and basic necessities such as electricity and phone service were available only on a limited basis. Many scientists were forced to take second jobs to support themselves and their families, a situation hardly conducive to the rigors of laboratory work. In addition, they had difficulty keeping abreast of the latest research; in 1993 the Russian scientific community spent a mere $500,000 on subscriptions to foreign journals, as compared to $25 million in 1990.[8] By 1995 Russian research libraries contained only one-tenth of previously available scientific journals.[9] This dire situation led two prominent Russian scientists in the mid-1990s to declare, "The common understanding is that science in Russia is now in a state of crisis. This, however, is an exceptionally rosy view of its condition. . . . it would be more accurate to describe its current condition as comatose."[10]

Under such conditions, many Russian scientists sought professional opportunities abroad or remained in Russia and entered other fields,[11] such as business, finance, or computer programming. According to some estimates, the number of Russian scientific researchers declined by more than 50 percent: from 993,000 in 1990 to 417,000 in 1998.[12] Most estimates suggest that the majority of scientists stayed in Russia. Nevertheless, the steady flow, or brain drain, of Russian scientists moving abroad began to cause great concern among Western nations. And with the future of science in Russia looking bleak and few apparent prospects for non-defense-related employment, the West was even more concerned that those scientists who remained in Russia and

8. I.G. Ushkalov and I.A. Malakha, *Utechka Umov: Prichiny, Masshtaby, Posledstvii* [Brain drain: Reasons, scale, consequences] (Moscow: Editorial URSS, 1999).
9. Carl Levitin, "Russian Scientists Threaten Campaign of Protests over Funding," *Nature,* September 14, 1995, p. 94.
10. Zakharov and Fortov, "Science in Russia Is Already in a Coma," p. 693.
11. President Vladimir Putin recently noted that Russia was losing much of its scientific talent to professions that provide better remuneration in Russia, such as business and politics. He also averred that although only 2 percent of scientists who leave the field choose to go abroad, their number includes some of Russia's most highly skilled and youngest scientists. See February 9, 2004, Itar-Tass, from Johnson's Russia List #8057, February 10, 2004.
12. Ushkalov and Malakha, *Utechka Umov,* p. 51; and Gokhberg and Mindeli, *Nauka Rossii v Tsifrakh, 1999,* p. 28. Oleg Bukharin notes that the loss of personnel in the closed nuclear cities was less than at the other institutes within the weapons complex. See Bukharin, *Russia's Nuclear Complex: Surviving the End of the Cold War,* report for the Program on Science and Global Security (Princeton, N.J.: Princeton University, May 2004), p. 17.

continued to live under harsh economic conditions would be tempted to sell their knowledge to rogue countries or terrorist organizations in hopes of improving their standard of living.

Western Grants: Possible Unintended Consequences

As Western programs designed to keep Russian scientists at home gained momentum, they broke down many of the institutional and informational barriers that had prevented Soviet scientists from interacting with fellow scientists abroad. In 1992 few in Russia's scientific establishment had email or fax connections, and only laboratory directors and top scientists had the opportunity to travel abroad. Western assistance programs provided new telecommunications infrastructure and many more opportunities for Russians to attend meetings, collaborate with colleagues, and work with businesses abroad.[13] Ironically, by helping to integrate Russian scientists into the international scientific community, the West also helped to expose Russian scientists to those willing to pay for their WMD expertise. Now, it is easier for many to pick up a phone, send an email or a fax, and arrange a meeting in-country.

Moreover, the terrorist attacks of September 11, 2001, greatly increased Western fears about possible collaboration between disgruntled Russian scientists and terrorists. During an interview on Russian television in October 2001, Gen. Igor Valynkin, commander of the 12th Main Directorate, the organization that has complete control of the Russian military's nuclear weapons,[14] acknowledged that terrorist groups conducted reconnaissance operations at Russian nuclear weapons storage facilities on two separate occasions in that year alone.[15]

Western Grant Programs and Nonproliferation

Having recognized the proliferation threat posed by Russian WMD scientists barely able to eke out a living, the West responded by creating a number of

13. The U.S. government, using satellite links, set up and operated a telecommunications system in the mid-1990s for Russian scientific institutes, including in closed cities such as Snezhinsk and Sarov until the Soros fiber-optic network became available a few years later.
14. Pavel Podvig, ed., *Strategicheskoye yadernoye vooruzheniye Rossii* [Russian strategic nuclear weapons] (Moscow: IzdAT, 1998), p. 30.
15. Pavel Koryashkin, "Russian Nuclear Ammunition Depots Well Protected—Official," Itar-Tass, October 25, 2001; and "Russia: Terror Groups Scoped Nuke Site," Associated Press, October 26,

programs aimed at keeping these scientists gainfully employed at home. Funding from the international community—both government and privately based—poured forth. Programs were established to provide grants to scientists to help them effect the transition from working on projects with military applications to civilian projects. The idea behind these programs has been to encourage a highly educated technical workforce to turn its attention toward industrial work, to educate scientists about the marketplace, and to instill in them a sense of entrepreneurship. The programs' designers recognized that to be effective, they could not merely give handouts. The programs had to educate Russian scientists about Western scientific norms and integrate them into the larger Western scientific community so that they can successfully compete for contracts internationally. For Russian science to thrive in the international science arena—and in the process move away from a defense-based economy and contribute to Russia's overall economic development—it must adopt practices that are integral to Western market-based societies.[16] Thus grants must be awarded on a competitive basis; research ought to have commercial and civilian applications; and the links between different kinds of institutions should be functional (with greater interactions occurring between institutes, firms, and universities) rather than hierarchical (as was true of the state-controlled system that typified Soviet science and separated research and teaching institutes).

Collaborative efforts between Russian scientists and Western universities, industries, and governments number in the hundreds each year. A brief overview of some of the West's larger grant programs conveys a sense of their depth and breadth and reveals how they intend to advance Western nonproliferation efforts.[17] The programs have a common objective: to provide not

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2001. We thank Matthew Bunn for bringing these incidents to our attention. See http://www.nti.org/e_research/cnwm/threat/anecdote.asp; and Matthew Bunn and Anthony Wier, *Securing the Bomb: An Agenda for Action,* May 2004, http://www.nti.org/e_research/cnwm, p. 31.

16. For a detailed discussion of the institutional and cultural transformation that Russian science must undergo, see Theodore P. Gerber and Deborah Yarsike Ball, "Russian Scientists in a Changed Institutional Environment: Factors Affecting Subjective Adaptation," University of Wisconsin–Madison and Lawrence Livermore National Laboratory, August 2004.

17. For an overview and critique of the three major U.S. programs designed to encourage Russian WMD scientists residing in the ten closed nuclear cities to pursue nonmilitary-related work, see Sharon K. Weiner, "Preventing Nuclear Entrepreneurship in Russia's Nuclear Cities," *International Security,* Vol. 27, No. 2 (Fall 2002), pp. 126–158. For a more general discussion on impediments to U.S.-Russian cooperation in the area of nonproliferation and on strategies to overcome those impediments, see *Overcoming Impediments to U.S.-Russian Cooperation on Nuclear Nonproliferation: A Report* (Washington, D.C.: National Research Council, 2004).

only stopgap funding to Russian WMD scientists but also the means and incentives for former weapons scientists to reorient their focus toward sustainable civilian endeavors. Ultimately, the programs seek to help these scientists develop the wherewithal to become scientist-entrepreneurs.

International Science and Technology Center

Since its founding in 1992, the International Science and Technology Center (ISTC) has disbursed more than $600 million to more than 50,000 scientists in the Commonwealth of Independent States. Thirty-seven countries are now members of the ISTC, a Moscow-based multilateral organization that includes Canada, the European Union, Japan, Norway, the Republic of Korea, Russia, and the United States.[18] A stated goal of the ISTC is to give former Soviet weapons experts "the opportunity to redirect their talents to peaceful activities."[19] To qualify for ISTC funding, research teams must include some members with weapons-related expertise. Whenever possible, successful applicants for ISTC funding are matched with private firms that have an interest in developing and marketing the products of the research. The ISTC also provides funds for travel abroad to scientific meetings; telecommunications and computer upgrades; training seminars in entrepreneurial skills, management, and proposal development; and patent support.

Russian Transition Initiatives

The U.S. Department of Energy oversees the Russian Transition Initiatives program, which comprises two programs aimed at reducing the possible diversion of WMD expertise to terrorists and proliferants: the Initiatives for Proliferation Prevention (IPP) and the Nuclear Cities Initiative (NCI). IPP, created in 1994, develops links between U.S. industry and former Soviet weapons scientists who propose applied research projects with commercial potential with the goal of acquiring long-term employment. IPP has funded more than 14,000 WMD scientists as well as missile experts in Russia, Kazakhstan, and Ukraine.[20]

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18. In addition to Russia, the ISTC funds scientists in Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, and Tajikistan. The U.S. side of the program is run out of the State Department. For more on the history of the ISTC, see Glenn E. Schweitzer, *Moscow DMZ: The Story of the International Effort to Convert Russian Weapons Science to Peaceful Purposes* (New York: M.E. Sharpe, 1996).
19. See the ISTC web page http://www.istc.ru.
20. For more information on IPP, see the Russian Transition Initiatives website, http://www.dp.doe.gov/na-20/rti.shtml.

The Department of Energy's NCI program, established in 1998, seeks to reduce the size of Russia's closed nuclear cities and help Russian weapons experts make the transition to civilian employment by encouraging economic diversification so that weapons work is not the only type of employment available to those still living in these cities. NCI works with scientists to develop business plans, find investors, and facilitate favorable conditions for Russian business startups. NCI also focuses on improving the infrastructure of the nuclear cities.

GEORGE SOROS FOUNDATIONS

Wealthy U.S. financier George Soros has spent more than $250 billion to instruct Russian scientists in how to apply for grants and obtain funds for research. Importantly, one of his goals is to provide grants directly to scientists based on the merit of their proposed projects and to "leapfrog the hierarchical structure of science that existed in the former Soviet Union, in which senior scientists got money to disburse to more junior colleagues."[21] By rewarding projects based on merit, Soros is helping transform an opaque system into a transparent and equitable structure. Together his International Science Foundation, which operated from 1993 to 1996, and the International Soros Science Education Program have provided grants to more than 100,000 scientists.[22] Soros was one of the first to recognize the importance of science as an engine for Russia's economic development.

Soros was also instrumental in the creation of a U.S. foundation for science and engineering in the former Soviet Union, the Civilian Research and Development Foundation, established in 1995. Through a $5 million donation to the U.S. National Science Foundation, Soros helped create an organization that continues to promote international scientific and technical collaboration through grants, training, and technical support.[23]

INTAS

In 1993 the European Commission established the International Association for the Promotion of Cooperation with Scientists from the Commonwealth of Independent States and the Former Soviet Union (INTAS). INTAS's goal is to

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21. Billy Goodman, "Noted Researchers Laud Donation to Russian Science," *Scientist,* January 11, 1993, p. 1.
22. Valery N. Soyfer, "Russian Science's Comeback," *Wall Street Journal,* August 30, 2002. See also Goodman, "Noted Researchers Laud Donation to Russian Science."
23. For more information, see http://www.crdf.org.

"preserve and promote the valuable scientific potential of the Newly Independent States' partner countries through East-West Scientific co-operation."[24] INTAS also works to bring about collaboration between European industry and Russian scientists in an effort to develop products with commercial applications.

Survey Project and Methodology

Until now, information about the usefulness of Western grant programs has been primarily anecdotal and suggests that most Russian scientists and government officials value these programs. For instance, the deputy director of the Institute of Nuclear Physics, Gennady Kulipanov, has stated that almost 80 percent of its resources were devoted to research during the Soviet period and 20 percent was spent on applying the results of that research to industry. Western grants have allowed the institute to allocate "four-fifths of their time to produce industrial equipment that is sold in China, Japan, South Korea, and even in the United States, earning them more than $20 million a year."[25] Vladimir Fortov, former head of the Russian Foundation for Basic Research—a Russian institution that provides grants for basic research—declared in 1995 that "approximately 50 percent of Russian basic science is being financed today from foreign sources such as the Soros Foundation, the International Science and Technology Center, INTAS, and others."[26] Yet some in Russia have voiced suspicion about the true intent of Western grant programs, claiming they provide Western spies access to sensitive Russian facilities and enable the West to plunder Russia's intellectual treasures.[27]

Russias's overall economic situation has improved since the 1990s. A focus group survey of nineteen Russian nuclear physicists that we conducted toward the end of 2001 suggests that even Russian science has turned a corner.[28] The crisis in Russia's scientific community has given way to a somewhat improved economic situation—improvements resulting from the country's overall higher gross domestic product and from the positive effects of Western

24. See the INTAS website, http://www.intas.be/mainfs.htm
25. Quoted in Soyfer, "Russian Science's Comeback."
26. Quoted in Dezhina and Graham, "Russian Basic Science after Ten Years of Transition and Foreign Support," p. 18.
27. A.I. Kurchatov, "Pushed Out into the Street," *Sovetskaia Rossiia*, June 24, 2003, in FBIS, CEP 20030714000304, June 24, 2003.
28. Theodore P. Gerber and Deborah Yarsike Ball, "The State of Russian Science: Focus Groups with Nuclear Physicists," *Post-Soviet Affairs*, Vol. 18, No. 3 (July–September 2002), pp. 183–212.

grants and contacts. Does this positive development mean that Western grant programs are no longer needed—or even useful—to reduce the temptation of Russian WMD scientists to sell their expertise to rogue states or terrorist groups? To answer this question, we need to measure the current risk and to evaluate whether Western assistance programs have reduced that risk.

The original purpose of our survey was to evaluate the effectiveness of the ISTC's program in Russia.[29] To prepare our questionnaire, we drew on consultations with experts on Russian science in the research community and the government and on our focus group study of Russian scientists in the fall of 2001.[30] We hired a highly respected Russian firm, the Russian Public Opinion and Survey Research company (ROMIR), to conduct the survey. ROMIR translated the questionnaire, pretested it twice, and trained the interviewers in a session we observed.[31]

For our sample, we chose twenty physical, chemical, and biological research institutes that had received some funding from the ISTC and were accessible to ROMIR in terms of cost and entree, plus ten backup institutes. Both weapons-related and civilian research was conducted at our sample institutes in Soviet times. But we were denied access to the weapons research institutes within the Ministry of Atomic Energy complex.[32] No institutes that have been (and, in many cases, still are) more-or-less exclusively committed to defense research are represented in our study. This may limit the generalizability of our findings. Nonetheless, this round of our survey gives unparalleled empirical insight into the attitudes and beliefs of a wide array of currently practicing Russian scientists. Our data can provide a benchmark for future studies of the same population and for comparisons with data on institutes that primarily conduct defense-related work.

Fieldwork began on November 2, 2002, and ended on January 23, 2003. ROMIR used only experienced interviewers for this project. The fieldwork

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29. We have been impressed by the desire of State Department officials who oversee the United States' participation in the ISTC to obtain information in order to learn the extent to which their program is working. They were supportive, granted us independence in carrying out the study, and put no pressure on us to "shape" the results.
30. Gerber and Ball, "The State of Russian Science."
31. Although we focus on WMD brain drain in this article, the survey addressed a variety of topics, including respondents' views on developments in Russian science more generally as well as specific proposals to reform Russian science; the scientists' economic situations, productivity levels, grant-writing activities, and morale; broad economic and political issues; and certain aspects of the ISTC program.
32. During a recent government reorganization, the Ministry of Atomic Energy was downgraded to an agency and renamed the Federal Agency for Atomic Energy.

went smoothly, with one exception: the survey was cut short when the leadership in one institute became suspicious and ordered the interviewers to leave. ROMIR reallocated the institute's remaining sample volume to other institutes of similar profile.[33] A total of 602 interviews were completed. Two hundred thirty scientists who could not be contacted were replaced in the sample. Among sampled scientists actually contacted, 7 percent refused to participate. Among those who refused, 70 percent said they were too busy, 15 percent stated that they feared violating the institute's nondisclosure policies, 12 percent declared they had no interest in the study, and 3 percent gave some other reason. After the completion of fieldwork, ROMIR office staff called back a randomly chosen 15 percent of the respondents to verify that the interviews had taken place. All interviews were verified.

Our task of evaluating the ISTC dictated that we oversample ISTC grant recipients in order to compare them with those who did not receive ISTC grants. To avoid possible resulting biases (and the associated overrepresentation of physicists, who receive more ISTC grants than scientists in other specialties), we computed post-stratification weights, which we apply in all our analyses. The weighted sample reproduces the overall population distribution of Russian nuclear, chemical, and biological scientists—as best as we can estimate them from published sources and ISTC's data[34]—by specialty and ISTC funding. Hence the findings can be generalized to this group of scientists in Russia as a whole.

Measurement of the WMD migration threat

To assess the likelihood that a Russian scientist would consider moving to another country to work in his or her specialty, we asked the following question for each of the eight countries provided: "If you were offered a job in your field that required you to move to . . . (a country from the table below) for a year or more, would you definitely accept it, accept it depending on the work conditions, or definitely turn it down?" The countries listed in the table, which is not reproduced here, were Israel, Pakistan, Germany, Iran, Iraq, India, North Korea, and Syria.

We used the responses to this question to create a variable indicating

33. Only one of the twenty institutes we initially chose refused to participate. It was replaced by an institute from the backup list.
34. L. Gokhberg and L. Mindeli, eds., *Russian Science and Technology at a Glance: 2000* (Moscow: Center for Science Research and Statistics, 2001).

whether a scientist is a potential migrant to a rogue country. We coded respondents as potential migrants if they would not definitely refuse long-term work in all four rogue nations we asked about: Iran, Iraq, North Korea, and Syria. We also created a variable measuring potential migration to non-rogue nations—Israel, Pakistan, Germany, and India—for comparison.[35]

We examined three additional questions that may help to capture the willingness of Russian scientists to sell their WMD expertise. These questions make no reference to the scientists having to leave the country to share their expertise. In addition, they differ from the question posed above about moving abroad in that they are abstract and hypothetical questions about the actions of another scientist, not the respondent per se. Therefore the results must be interpreted with great caution.

The first question reads as follows: "A representative from an authoritarian country approaches a scientist and says that his country is threatened by a larger, more powerful one. He offers to pay the scientist to use his/her scientific knowledge to help produce chemical, nuclear, or biological weapons to be used for the country's defense. Under what circumstances (if any) should the scientist accept the work?" The respondents could choose among the following answers: (1) if the pay is sufficient; (2) if the work is scientifically interesting; (3) if the pay is sufficient and the work is scientifically interesting; (4) under no circumstances; or (5) other. We used the results to create a variable indicating normative acceptance of WMD work by a scientist for an authoritarian government. We treated all responses except "under no circumstances" as representing (tacit) normative acceptance of work by a scientist for an authoritarian government.

The second question was the same as the one immediately above except that it concerned "a representative from a democratic country" rather than an authoritarian one. We report the responses to the "democratic" version as a basis for comparison, but we do not analyze this question extensively because it has less relevance for WMD proliferation.

In the third question, a representative of a foreign firm, rather than a representative of an authoritarian or a democratic country, approaches the scientist and proposes dual-use research rather than WMD research. The variable we

35. One might argue that migration to Pakistan could be harmful from a WMD proliferation perspective, even though the U.S. government does not officially view Pakistan as a rogue nation. All respondents who expressed some willingness to take a job in Pakistan, however, were also willing to work in one of the rogue countries on our list. Note that the survey was conducted prior to the U.S. invasion of Iraq; thus it is appropriate to code Iraq as a "rogue" nation.

created indicating normative acceptance of dual-use work for a foreign firm is based on the same coding of responses to a hypothetical question as the previous two. We treat the responses in the same way, converting them into a dummy variable indicating acceptance of dual-use work for a foreign firm, which can easily serve as a front for a hostile government or terrorist organization.

Measurement of grant status

To assess the impact of foreign grants on Russian scientists, we compare scientists in four different "grant statuses." We asked respondents to indicate how many grant applications they had submitted as principal investigators (PIs) and as non-PIs to Russian sources, to the ISTC, and to other foreign sources during the past five years. We also asked them how many grants they had received as either PIs or non-PIs from each source. Using these variables, we created a measure of "foreign grant status" based on foreign grant-writing during the last five years, with the following four categories: (1) recipients of at least one foreign grant as PI (PIs); (2) recipients of at least one foreign grant, but as non-PIs (non-PIs); (3) scientists who did not receive any foreign grants but did apply for at least one (unfunded applicants); or (4) scientists who did not apply for any foreign grants (never applied). We also tested for the effects of Russian grants, using the parallel set of grant statuses.

Grant status is a key variable for determining whether respondents who applied for ISTC grants have different attitudes from those who never applied. Although our main comparison of interest is between grant recipients and nonrecipients, we break the latter group into the subgroups "unfunded applicants" and "never applied." Our interpretation of any difference between grant recipients and nonrecipients as stemming from the effects of receiving a grant is supported to the extent that grant recipients differ not only from those who never applied but also from unfunded applicants. Unfunded applicants are more similar to grant recipients with regard to other traits that may jointly influence grant status and migration propensity, and thus produce spurious correlations. For example, those who apply for foreign grants may have more foreign contacts, greater international experience, a better understanding of the grant application process, and so forth. Any of these traits could affect one's potential for migration and also one's ability to obtain grants, thus producing a misleading impression that grant status itself influences migration propensity. The main difference between unfunded applicants and recipients is grant status, whereas those who never applied probably differ from grant re-

cipients in other ways, some of which may be relevant to the outcomes in question. Thus the comparison of grant recipients to unfunded applicants is a crucial component of our analyses.

Finally, among grant recipients we expected to find some distinctions between scientists who receive grants as PIs and those who receive grants only as participants in projects proposed by others. PI status gives scientists the opportunity and resources to pursue their own research goals. It usually bears a much greater degree of professional autonomy, prestige, and possibility for accomplishment than work on a project as a non-PI participant. Thus we decided to compare PIs to non-PIs, with the expectation that the impact of grants would be most strongly evident for the former.

Survey Results

In this section we first describe the demographic and professional characteristics that serve as the key control variables in our statistical models. Variables such as job specialty, income, age, or gender could affect a scientist's attitude toward a variety of issues. We then describe another important independent variable, grant status, before assessing the WMD migration threat as well as other possible WMD threats. Once we characterize the threat, we examine the effectiveness of Western grants programs in reducing the likelihood that Russian scientists would consider working in a rogue nation. We also examine the impact of Russian grants in reducing the WMD migration threat. We conclude with a discussion of five major findings.

DESCRIPTIVE STATISTICS: CONTROL VARIABLES

We present the basic demographic and professional characteristics of our sample, which serve as key control variables in our statistical models, in Table 1. We achieved a fairly balanced sample with respect to these background variables. As mentioned above, our weights correct for the overrepresentation of physicists and ISTC recipients. The sample offers a broad spectrum of job titles, ranging from institute directors to entry-level researchers. The age distribution of our respondents illustrates the low number of new recruits to Russian science in the last decade, as well as the high number of young scientists leaving the field or Russia altogether. Correcting for the overrepresentation of physicists relative to biologists also rights the gender balance in our sample, as the latter field is more the province of women in Russia, while the former is male dominated. Around 85 percent of respondents are ethnic Rus-

Table 1. Descriptive Statistics for Control Variables, Survey of Russian Scientists, Conducted November 2, 2002 to January 23, 2003

Categorical Variables	Raw N	Raw Percentage	Weighted Percentage
Job specialty			
Physics	378	63%	45%
Chemistry	115	19%	15%
Biology	109	18%	40%
Position/Job title			
Institute administrator	21	4%	2%
Head of laboratory	112	19%	17%
Professor	47	8%	5%
Leading scientist/Docent	105	17%	19%
Senior scientist/Teacher	188	31%	34%
Scientist	75	13%	14%
Junior scientist	43	7%	8%
Other	11	2%	1%
Age			
19–30	51	9%	12%
31–40	76	13%	13%
41–50	156	26%	25%
51–60	165	28%	27%
61–78	153	26%	22%
Gender			
Male	447	74%	64%
Female	155	26%	36%
Ethnicity			
Russian	503	84%	83%
Ukrainian	22	4%	3%
Jewish	19	3%	3%
Armenian	8	1%	1%
Belorussian	6	1%	1%
Other	13	2%	3%
Declined to state	31	5%	6%
Location			
Moscow	372	62%	70%
Moscow region	65	11%	8%
Novosibirsk	61	10%	9%
Nizhnyi Novgorod	36	6%	3%
Saint Petersburg	37	6%	5%
Ekaterinburg	31	5%	5%
Wage arrears in 2002			
Yes	72	12%	15%
No	530	88%	85%

Continuous variables	Valid N	Mean	SD	Max	Min
Ln(salary)	590	7.93	.67	6.21	10.31
Ln(income from grants)	406	5.80	.97	3.00	8.59

sians. We have little reason to suspect this figure, though it is noteworthy that about 5 percent of respondents refused to indicate their ethnicity. About two-thirds of our sample work in institutes located in Moscow, and another 10 percent or so in the surrounding Moscow *oblast* (province); this reflects the actual situation in Russian science: since pre-Soviet times, Russian researchers have been heavily concentrated in Moscow.

In the weighted sample, 15 percent of the scientists reported having experienced some delays in the payment of their salaries during 2002. This figure suggests a major improvement of the situation relative to the mid-to-late 1990s when six to nine months of wage arrears was common for most scientists. Moreover, in 2002 Russian scientists received close to the average monthly wage of $100 for all Russians during that year. Russian salaries are measured in rubles per month: taking the exponential of the mean logged salary in our sample yields a geometric mean salary of 2,779 rubles. This amounts to roughly $100 at the average exchange rate for 2002.

Russian scientists typically earn no more than the national average; by implication many earn less than the average. Russian scientists can supplement their salaries, however, with income from grants. Of our 602 respondents, 406 reported earning at least some salary from grant sources during the previous three months.[36] Because most foreign grants are denominated in dollars, we asked respondents to report their last three months' grant earnings in that unit. Taking the exponential, we find that the geometric mean among those reporting some income from grants is about $330 over three months, or $110 per month. Accordingly, those Russian scientists who receive income from grants tend on average to double their earnings. This alone testifies to the clear impact that grants have on the situation of Russian scientists.

GRANT STATUS

The survey reveals the crucial role that grant-based financing has rapidly come to play in Russian science since the Soviet collapse (see Figure 1). Even correcting for the oversample of ISTC recipients, we find that 13 percent of respondents received at least one foreign grant as PIs during the last five years, while 28 percent received at least one foreign grant but only in their capacity as project participants (non-PIs). Thus by our best estimate, more than 40 percent of Russian physicists, chemists, and biologists in institutes that were not part of

36. Here we refer explicitly to grant money that goes toward the researcher's salary—not toward equipment, travel, or other research-related expenses.

Figure 1. Foreign and Russian Grant Status, Weighted Survey of Russian Scientists

Foreign grant activity, last five years	Russian grant activity, last five years: Funded as PI	Funded as non-PI only	Applied, never funded	Never applied	Total
Funded as PI	80.2 33.7	8.2 2.4	4.8 8.9	6.8 6.1	13.3
Funded as non-PI only	27.8 24.8	55.6 33.9	5.2 20.2	11.4 21.6	28.2
Applied, never funded	39.7 24.8	41.7 17.8	13.4 36.9	5.2 6.9	19.7
Never applied	13.7 16.8	54.9 46.0	6.3 34.0	25.1 65.5	38.8
Total	31.7	46.3	7.2	14.9	

NOTE: Upper cell entries are row percentages; lower entries are column percentages.

the closed weapons complex received foreign funding during this period. That high figure reflects both the relatively wide availability of foreign grants for Russian researchers and a greater tendency of those who cannot secure foreign funding to leave science altogether or leave Russia (and thus not show up in our sample). Nearly 20 percent applied for at least one foreign grant but were never funded. This shows that there is some degree of selectivity by foreign donors: not everyone who applies receives funding.

Even larger proportions of physicists, chemists, and biologists received grants from Russian sources: 32 percent as PIs and 46 percent as non-PIs. Russian sources would appear to be less selective: only 7 percent applied without any success for Russian grants. Only 15 percent did not apply for Russian grants during the past five years. Once again, these numbers illustrate how

quickly Russian science has come to depend on grant-based financing. Overall, fewer than 10 percent of our weighted sample did not apply for any grants during this period, and nearly 85 percent received at least one grant (foreign, Russian, or both) during that period. Finally, foreign and Russian grant statuses are strongly associated: 80 percent of foreign grant PIs have also been PIs on Russian grants, while 66 percent of those who did not apply for Russian grants also never applied for foreign grants. This is not surprising; we would expect similar characteristics—ambition, drive, scientific ability—to affect both forms of grant status. Yet the strong positive association is notable because it suggests that the two forms of grants do not substitute for each other. It also implies that without controlling statistically for one type of grant, we cannot assess the effects of the other type. Thus we must simultaneously model the effects of both foreign and Russian grants on our outcomes of interest.

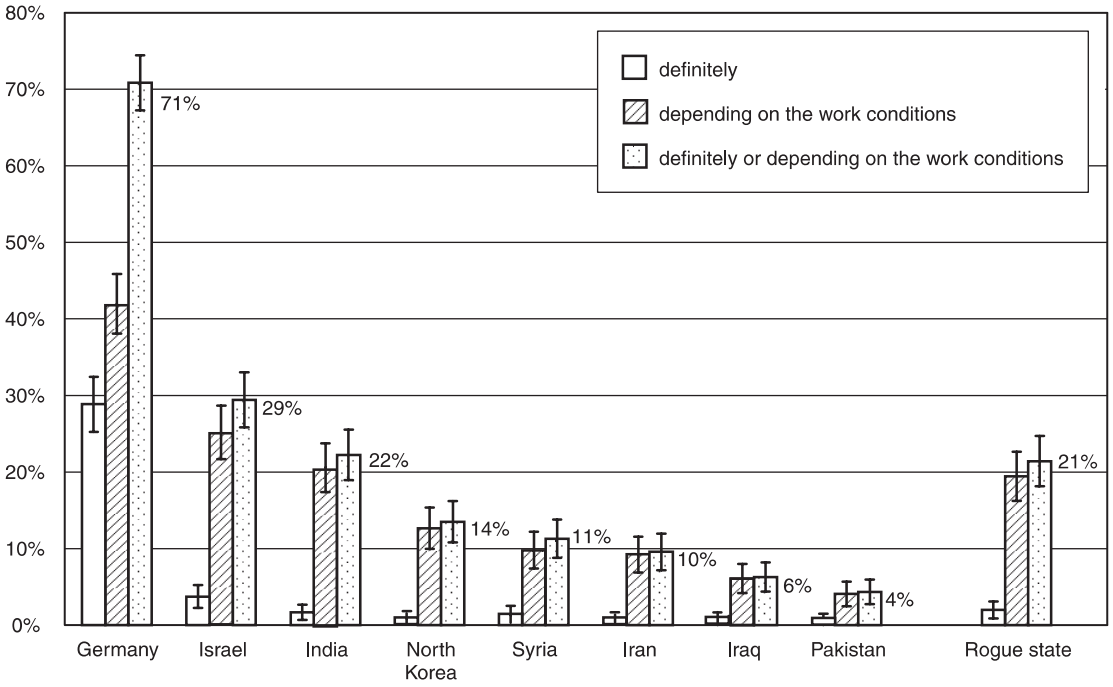
Assessment of the WMD Migration Threat

In this section, we begin by examining the percentages of Russian scientists in our sample who would take a job for at least one year in one of the eight countries we asked about (see Figure 2). Combining "definitely" and "depending on the work conditions" responses, we find overwhelming interest in taking a job in Germany (71 percent), and lower but still substantial interest in jobs in Israel (29 percent) and India (22 percent). The large number of Russian scientists willing to consider moving to Germany for at least one year gives us some confidence in the validity of the question as a measure of the propensity to work abroad. Germany has highly desirable working and living conditions, and it is politically stable. It was also not surprising that fewer scientists, though not an insignificant number, would consider moving to Israel and India. Whereas the working conditions for scientists in these countries are considered quite good, their economic and political situations make them less desirable destinations for emigration than Germany.

Yet even fewer respondents are potential migrants to any of the rogue states, ranging from 14 percent for North Korea down to 6 percent for Iraq. But if we combine the responses for North Korea, Syria, Iran, and Iraq, we arrive at a striking result: 21 percent of Russian scientists in the specialties we consider are potential migrants to at least one rogue country. Taking into account sampling variability (the 95 percent confidence interval or "margin of error"), the actual figure in the population surveyed probably lies somewhere between 18 percent and 24 percent.

Although we have no baseline against which to compare this figure, we

Figure 2. Willingness of Russian WMD Scientists to Migrate to Selected Countries to Take Jobs in Their Scientific Specialties



SOURCE: Weighted survey of Russian scientists data.
NOTE: Error bars represent 95% confidence intervals.

were surprised that more than one-fifth of our respondents openly say they would consider taking a job in a rogue nation. Of course, not all these scientists have experience doing weapons research—16 percent admit they have worked on weapons-related projects in the past ten years (and 11 percent of the weighted sample)—and some may envision working solely on civilian projects in these countries. But we doubt that many Russian scientists view work in these countries naively. Almost 14 percent, the highest for any of the rogue nations, say they would not rule out moving to North Korea for one year to work in their job specialty. This response is particularly troublesome because North Korea openly trumpets its nuclear weapons program, and it is certainly not one of the world's vacation hotspots. Russian scientists are likely aware that the North Korean government is interested in expertise that can contribute to its WMD program. A job in Iran holds little appeal for the vast majority of scientists. Only 10 percent responded that they would consider moving there. This figure is remarkably low considering the Russian government's ongoing contractual work with Iran's nuclear program through its Federal Agency for Atomic Energy (formerly the Ministry of Atomic Energy). Perhaps it is so low because Russian scientists perceive that work in Iran may contribute to the development of nuclear weapons—an outcome they do not wish to see.

The most striking finding, however, is that 21 percent of the respondents would consider working in a rogue nation. Without any concrete benchmark for comparison, an inevitable ambiguity inheres in the assessment of a number like 21 percent: is this a large number or a small number? We believe that this number is cause for continuing concern by policymakers: if one in five Russian scientists would consider taking a job in a rogue nation, there remains a considerable threat that some Russian scientists actually will do so. At the same time, one in five is quite small relative to the seven in ten who would consider taking a job in one of the four nonhostile nations we asked about. The large disparity in these two figures (21 percent vs. 71 percent) suggests that many Russian scientists who are generally open to emigrating (at least temporarily) do balk at the prospect of working in a rogue nation. This may reflect a wish to avoid doing WMD work for a government or group with terrorist motives. Of course, it could also reflect differences in salaries and living standards between the rogue and non-rogue nations.

OTHER POSSIBLE WMD THREATS

We now examine how Russian scientists view WMD work for an authoritarian government or dual-use work for a foreign company. Presumably, scientists

who disapprove of other scientists who do such work are less likely to engage in it themselves. In fact, according to our data, 87 percent of Russian scientists think there are no circumstances that justify engaging in WMD work for an authoritarian government: taking into account sampling variability, the true figure probably lies between 85 percent and 90 percent (see Figure 3). Accordingly, from 10 percent to 15 percent (our best estimate is 13 percent) think it is acceptable for a scientist to do this work under at least some circumstances—most typically if the work is both well paying and scientifically interesting.[37] Thus a somewhat smaller proportion of Russian scientists pose a WMD proliferation threat by this measure as compared to the measure of the explicit willingness-to-work-abroad questions. This may reflect the fact that the hypothetical question refers explicitly to conducting WMD research for an authoritarian government, while the migration questions refer only to conducting some type of work in the scientist's job specialty.[38]

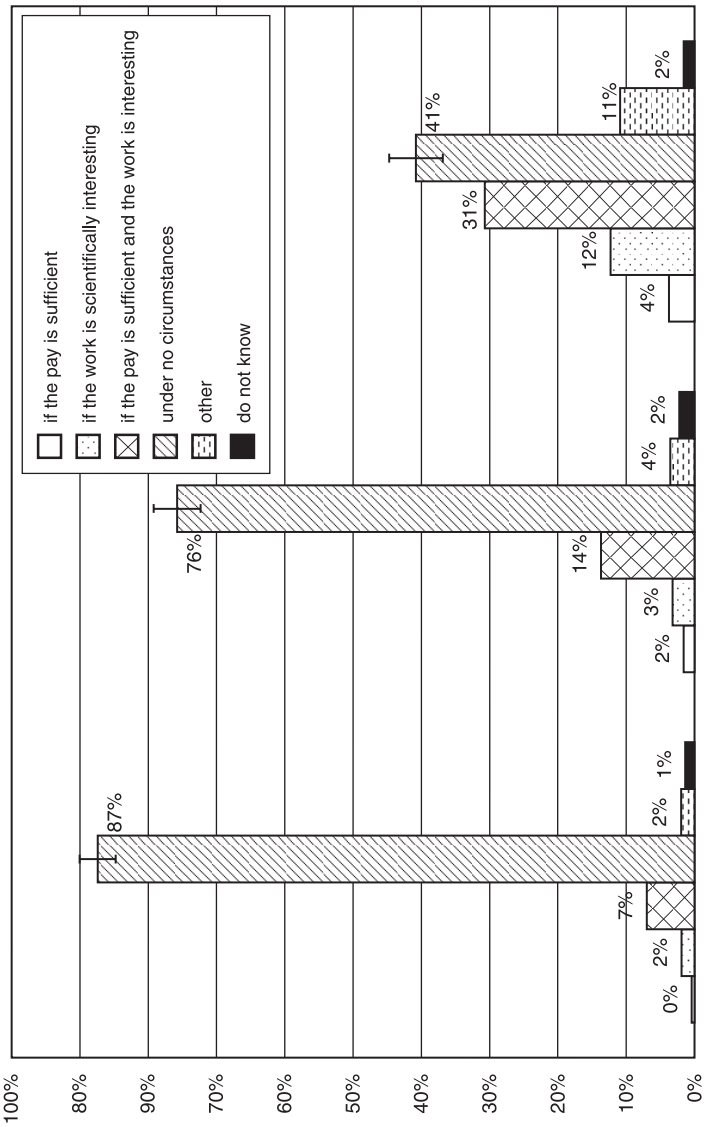
Fewer respondents (76 percent) object in principle to conducting WMD work for a democratic country. But substantially fewer—only 41 percent—say that under no circumstances should a scientist conduct dual-use research for a foreign company. This suggests that a government or organization that successfully conceals its motives by using front companies might readily lure Russian scientists to engage in work that can be used to produce WMD. In any case, these measures point to the same broad conclusions as the questions regarding willingness to take jobs in particular countries: the number of Russian scientists who represent WMD proliferation threats is relatively small, but large enough for continuing concern.

Whether based on an explicitly stated willingness to work in a rogue nation or on an expressed normative acceptance of WMD work by a scientist for an authoritarian government, our data suggest that a sizable majority of Russian scientists are unlikely to sell their expertise to rogue states. The distribution of responses to other questions measuring respondents' views on ethical issues, which we do not have the space to report here, point to the same conclusion: most Russian scientists do not pose a WMD migration threat. Our question re-

37. We do not present error bars for the other response categories in Figure 3 because our substantive focus is on the estimate of the proportions who say the work should not be conducted under any circumstances.

38. The two measures are significantly and positively associated, as one would expect if both are imperfect but valid measures of individual willingness for harmful migration: 42 percent of those who think that WMD employment for an authoritarian government is acceptable under some circumstances say they would consider taking a job in at least one of the rogue countries listed, compared to 18 percent of those who see no acceptable circumstances and 21 percent overall.

Figure 3. Under What Circumstances Should a Scientist Conduct WMD or Dual-Use Work for . . .



SOURCE: Weighted survey of Russian scientists data.
NOTE: Error bars represent 95% confidence intervals.

garding dual-use work for a foreign firm suggests that this proportion might be greater than 50 percent, but this could reflect an idiosyncratic aspect of that particular question.

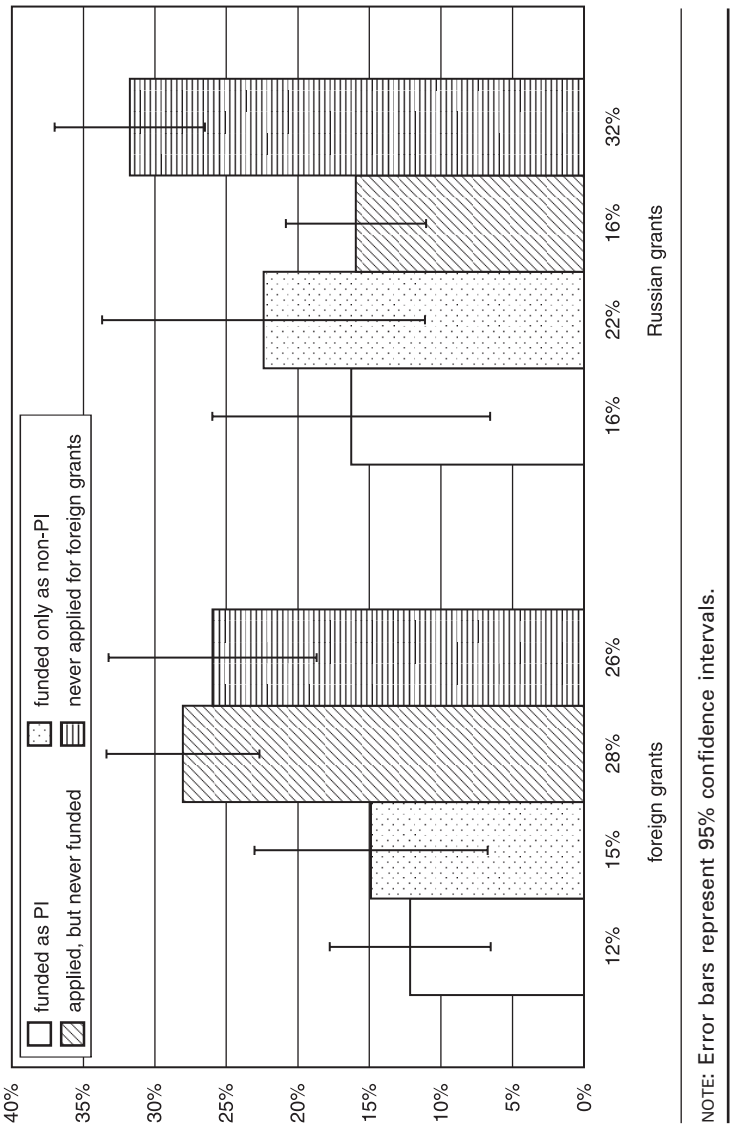
On the other hand, although the majority of Russian scientists do not represent a WMD proliferation threat, each of our measures also suggests that a substantial minority do in fact pose such a threat. As is always the case in survey research, it would be a mistake to presume that the survey results perfectly measure what they purport to measure. But when results based on different questions point to a similar conclusion, we gain confidence in the validity of the data. Accordingly, we believe our survey of Russian scientists suggests that a substantial minority continue to represent a WMD migration threat, and thus policymakers should still be concerned about the potential.

The impact of assistance programs

Even if they are concerned with the threat of WMD proliferation, policymakers have limited tools with which to reduce the potential for harmful migration by Russian scientists. Our data permit us to assess the effectiveness of existing grant programs in accomplishing this goal. The simplest way to do so is by comparing the sample percentages of scientists within each foreign grant status category that could potentially be a WMD proliferation threat based on our three measures (see Figure 4). Recall that we distinguish four grant statuses: funded as PI, funded as non-PI, unfunded applicant, and never applied. Among the first two, 12 percent and 15 percent, respectively, would consider taking a job in a rogue country. The corresponding figures for those in the latter two categories are 28 percent and 26 percent. As can be gleaned from the 95 percent confidence intervals around these estimated percentages, the differences between the two groups of nonfunded scientists are not statistically significant, nor are the differences among the two groups of funded scientists. The differences between funded (whether as PI or non-PI) and nonfunded (whether applied or not), however, are statistically significant.

These results strongly suggest that participation in foreign grant programs reduces the willingness of Russian scientists to "go rogue." The key dividing line with respect to this measure falls between those who have received foreign grants and those who have not. This pattern bolsters the interpretation that actually receiving a grant reduces the inclination of a scientist to work in a rogue country. The main alternative interpretation—that the apparent effect of a grant is actually due to self-selection into the applicant pool—is undermined by the finding that in their stated willingness to migrate to a rogue country,

Figure 4. Percentage of Russian WMD Scientists Who Might Take Jobs in a Rogue Country, by Foreign and Russian Grant Status



NOTE: Error bars represent 95% confidence intervals.

unfunded applicants (those who applied for a grant but did not receive one) do not differ statistically from those who never applied: if Russian scientists who are initially predisposed against working in a rogue nation are more likely to apply for foreign grants in the first place, we would expect a statistically significant, negative effect of being an unfunded applicant relative to having never applied. The absence of such an effect therefore contradicts the "selection" explanation of the net differences between recipients and nonrecipients of foreign grants. Perhaps the effect of foreign grants applies to migration in general? In fact, there are no statistically significant differences by grant status in the percentages of who might migrate to a non-rogue country. Thus the influence of foreign grants applies specifically to migration to rogue countries, not migration in general.[39]

The effects of foreign grant status on the other two measures of proliferation threat are somewhat more ambiguous. Only 6 percent of PIs say a scientist should engage in WMD-related work for an authoritarian government under certain circumstances, lower than the percentages for the other three grant statuses: 11 percent of non-PIs, 20 percent of unfunded applicants, and 13 percent of the never applieds. The contrast between PIs and other scientists grouped together is statistically significant, a finding that holds in our multivariate model. This provides some evidence that PIs are less prone to work for authoritarian regimes. The relatively large percentage of unfunded applicants who endorse WMD work for an authoritarian government might reflect a "sour grapes" type of effect: those who are turned down in their applications for foreign funds become embittered and lose some of their scruples about working for authoritarian regimes. As for dual-use work for foreign firms, the pattern of variation is too complex to conclude that grants have any effect at all.

What about Russian grants? Perhaps they also diminish Russian scientists' willingness to work in rogue nations. In fact, our data suggest that Russian grants do not affect WMD migration potential. In our sample, 32 percent of

39. We ruled out another alternative interpretation—that both grant status and proliferation potential are jointly influenced by other variables—by verifying our results using a multivariate statistical model (logistic regression). We assessed the effects of foreign grant status after controlling for Russian grant status, age, gender, ethnicity, place of residence, scientific specialty, administrative position, and income. Based on our final model, scientists with mean values on all these variables have a 25 percent probability of saying they would consider moving to a rogue country if they have not received funding from foreign grants, versus an 11 percent probability if they have received funding. We verified all our findings with multivariate models and found no substantive deviations from the patterns present in the bivariate comparisons. We do not have the space to report these results and will provide them upon request.

those who never applied for Russian grants would consider taking a job in a rogue country, compared with 16 percent of those who applied but were not funded, 22 percent of those who were funded only as non-PIs, and 16 percent of those who were funded as PIs. The differences among all three latter categories, however, are not statistically significant: those who applied for Russian grants but did not receive them are no more or less likely to consider going rogue than those who received them as non-PIs or PIs.[40] The implication is that for WMD migration propensity, Russian scientists who have never applied for Russian grants differ from those who have applied, but actual participation in Russian grant programs has no impact. There is no significant variation by Russian grant status on our other two measures of WMD proliferation threat. In short, Russian grants do not reduce the risk that a Russian scientist will conduct WMD research for governments or organizations that are hostile to the United States.

Conclusion

The number of Russian scientists who represent a WMD proliferation threat is relatively small, but large enough for continuing concern on the part of policymakers. The majority of active Russian scientists are highly responsible when it comes to sharing their WMD knowledge. They are unlikely to move to a rogue nation—Iran, Iraq, North Korea, or Syria—and they disapprove of selling their WMD expertise to authoritarian regimes. Yet WMD brain drain from Russia continues to jeopardize international security because a sizable minority of scientists pose a threat.

Until now, we had no data for assessing whether foreign grant programs aimed at reducing the WMD brain drain threat had any impact. Our data provide solid empirical evidence that these programs do indeed reduce the potential for WMD brain drain. Our study yields five major findings. First, the majority of active Russian scientists are unlikely to migrate to rogue countries or sell their WMD expertise to hostile governments. Second, sizable minorities do, however, pose a threat: 21 percent would consider taking a job that would require moving to one (or more) of four rogue states; 13 percent deem WMD work for an authoritarian government acceptable under some circumstances; and 59 percent view dual-use work for a foreign firm as acceptable under cer-

40. Our logistic regression models confirmed that this pattern obtains even when our control variables are held constant.

tain circumstances. Third, foreign grants significantly reduce the likelihood that Russian scientists will be tempted to move to a rogue nation and work in their area of technical expertise. Fourth, foreign grants reduce the probability, at least in some cases, that Russian scientists approve of conducting WMD work for an authoritarian government under some circumstances. They do not affect views on dual-use research for a foreign company. Fifth, Russian grants have no effect either on the likelihood that scientists will go rogue or on any other measure of proliferation threat.

The findings suggest that foreign grant programs should be maintained and even enhanced. They have had an impact, but there is more to be done. First, initiatives directed at younger Russian scientists are especially needed. Other results we do not report here show that these scientists do not feel as strong a sense of responsibility toward their profession or Russia as their more senior counterparts. They are more willing to pick up and move abroad, including working in a rogue nation.

Second, the finding that a majority of Russian scientists would accept work for a foreign firm engaged in dual-use technology development points to the need for vigilance in exposing companies that could pose as fronts for terrorist organizations or rogue nations. Such private companies may stand ready to lure Russian scientists to engage in work that can be used to produce WMD.

Third, further research is required to determine why Russian grants had no effect on Russian scientists' willingness to work in rogue countries. This was, perhaps, the most astounding finding of the study and suggests that the original reason for establishing the Western grant programs, namely as quick fixes to relieve economic desperation at home, may no longer be a suitable model now that the Russian economy has bounced back. If money, in the form of grants, was the primary factor leading to a decrease in the likelihood of Russian WMD scientists going rogue, then we would expect to see the same effect of Russian grants as we do Western grants. This finding indicates that there is something about Western grant programs, other than grant money, that is affecting Russian scientists' attitudes.

Western grants appear to be effecting a shift in attitudes away from a Soviet orientation to a new, Western orientation, where block funding is being replaced by competition for grants and contracts; hierarchically administered institutes are giving way to horizontal links with other institutes, universities, and firms; functional differentiation of organizations is being replaced by functional integration of organizations; and emphasis on military research and separation from the international scientific community are giving way to civilian

research and full integration into the international scientific community.[41] Hence Western grants have a normative impact. By exposing Russian scientists to Western norms, they facilitate the acceptance of Western ways of conducting science and give scientists a stake in the emerging institutional environment. Receiving a Western grant may provide scientists with solid proof that they can successfully compete internationally; Western grants may provide the necessary hope for scientists that they will ultimately succeed in Russia. Yet understanding the mechanisms that are affecting the subjective adaptations of Russian scientists requires further exploration.

Thus the United States and the West must remain engaged with Russian WMD scientists until they are able to find support for their research from competitive, civilian-oriented, privately funded projects. The alternative is that some of these scientists may migrate to countries or collaborate with organizations that harbor hostile intentions toward the United States and other Western democracies. Western assistance programs work to reduce the threat of WMD brain drain. But their task is not complete. Now is not the time to pull back.

41. Gerber and Ball, "Russian Scientists in a Changed Institutional Environment."