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Scientists in a Changed Institutional Environment: Subjective Adaptation and Social Responsibility Norms in Russia

ABSTRACT. How do scientists react when the institutional setting in which they conduct their work changes radically? How do long-standing norms regarding the social responsibility of scientists fare? What factors influence whether scientists embrace or reject the new institutions and norms? We examine these questions using data from a unique survey of 602 scientists in Russia, whose science system experienced a sustained crisis and sweeping changes in science institutions following the collapse of the Soviet Union. We develop measures of how respondents view financing based on grants and other institutional changes in the Russian science system, as well as measures of two norms regarding scientists' social responsibility. We find that the majority of scientists have adapted, in the sense that they hold positive views of the new institutions, but a diversity of orientations remains. Social responsibility norms are common among Russian scientists, but far from universal. The main correlates of adaptation are age and current success at negotiating the new institutions, though prospective success, work context, and ethnicity have some of the hypothesized associations. As for social responsibility norms, the main source of variation is age: younger scientists are more likely to embrace individualistic rather than socially-oriented norms.

Introduction

How do scientists react when the institutional setting in which they conduct their work changes radically? How do long-standing norms regarding the social responsibility of scientists fare? What factors influence whether scientists embrace or reject the new institutions and norms? We examine these questions using data from a unique survey of 602 scientists in Russia, a national setting where science has endured a major crisis and science institutions have undergone sweeping changes since the collapse of the Soviet Union. Other studies and journalistic reports have analyzed the institutional features of Soviet science (Kneen, 1984; Irvine and Martin, 1985; Vucinich, 1984; Graham ed., 1990; Fortescue, 1990), the problems that befell Russian science after the Soviet collapse (Aldhous, 1994a, 1994b; Kneen, 1995; Zakharov and Fortov, 1995; Levitin, 1995a, 1995b, 1998; Freemantle, 1997; Ushkalov, 1997; Iurevich and Tsapenko, 1998; Ushkalov and Malakha, 1999; Varshavski, 1999), and the subsequent changes that have taken place in Russia's science institutions (Aldhous, 1994c; Josephson, 1994; Kerr, 1994; Gaponenko, 1995; Schweitzer, 1996, 2000; Dezhina, 1997; Levitin, 1999; Dezhina and Graham, 1999, 2000, 2001, 2005; Fortescue, 2000; Radosevic, 2003). The subjective dimensions of these institutional changes – how Russian scientists have responded to them – bear considerable theoretical and practical interest, yet they have received little attention. Therefore, here we focus not on analyzing the changes in Russian science but on assessing whether scientists embrace or resist them and how they affect scientists' views of their social responsibilities as scientists.

Our survey, which was fielded November 2002-January 2003, addresses questions we previously examined in an interview-based study of the professional orientations of Russian scientists during the Soviet era (Gerber, 2001) and a focus-group based analysis of how physicists have adapted to the new institutional environment (Gerber and Ball, 2002). We included questions in the survey assessing whether respondents embrace or reject the new science institutions that have supplanted Soviet-era institutions, as well as whether they adhere to specific norms regarding scientists' sense of duty to serve Russian national interests and larger social responsibility for how the results of their work are used. Thus, our study uses quantitative data to build upon and complement our earlier qualitative research on these topics.

Our survey is the first of its type.[1] Therefore, we have no real baseline against which to compare the results, so we cannot make strong statements about changes in attitudes. However, we can empirically describe the distribution of orientations among the reference population for our survey and examine factors that co-vary with the orientations of Russian scientists toward the new institutions. To do this, we develop and examine measures capturing the subjective orientations of Russian scientists toward "new" science institutions and toward specific social responsibility norms. We then conduct multivariate regression analyses to identify the correlates of these orientations. Before presenting our orienting hypotheses and findings, we briefly describe the changes that have taken place in Russian science since the early 1990s.

Background: Crisis and Change in Russian Science

The collapse of the Soviet Union in late 1991 precipitated a deep and sustained crisis in Russian science. State funding for scientific research contracted dramatically (see Figure 1), more, in fact, than any other sector of the Russian economy (Kneen, 1995: 289). The centralized, planning-based administrative structure of the Soviet science system collapsed, leaving most scientific research institutes to fend for themselves in the search for supplies,

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[1]Other surveys of Russian scientists (see, e.g., Mirskaya, 1995; Lebedev and Milenin, 1996; Markusova, Gilyarevskii, Chernyi, and Griffith, 1996; Zubova, 1998; Evdokimova, Kugel, and Olimpieva, 2001; Tikhonov, 2001) have been based on limited samples and have not focused on adaptation to new institutions or professional norms.

customers, and capital, all of which quickly grew scarce in the larger economic crisis and chaos associated with "shock therapy" (Gaponenko, 1995). With few commercial sources of funding to compensate for the withdrawal of state funds, a host of problems ensued.[2] Scientists experienced a sharp reduction in their salaries (Levitin, 1998; Yurevich and Tsapenko, 1998) and social prestige (Gokhberg and Mindeli, 1999: 100). Research equipment, supplies, and facilities rapidly deteriorated (Aldhous and Dorozynski, 1994; Clery, 1994; Mirskaya, 1995; Freemantle, 1997), as did access to scientific literature (Levitin, 1995a; Markusova et al., 1996; Ushkalov and Malakha, 1999). The ranks of scientists were thinned by internal and external "brain drain" (Ushkalov and Malakha, 1999; Yurevich and Tsapenko, 1999; Gokhberg and Mindeli, 2001: 40), particularly of younger and more accomplished researchers (Matlack, 1997; Letokhov, 1999), and a lack of new recruits to science (Lebedev and Milenin, 1996; Ushkalov, 1997) .

[Figure 1 about here]

The litany of problems naturally took its toll on the output of Russian science and the general morale of scientists, leading to declines in the numbers of inventions, patent applications, and publications, media reports of frustration and disillusion among scientists, and even hunger strikes and suicides by scientists in response to dire economic straits (Lebedev and Milenin, 1996; Levitin, 1995b; Holdsworth, 1996; Kovaleva, 1996; Perera, 1996; Freemantle, 1997; Feder, 1998; Gokhberg and Mindeli, 1999; Iurevich and Tsapenko, 1999). By 1999, many thousands of Russian scientists had emigrated, and the number of scientific researchers had fallen to about half the Soviet-era level (see Figure 2). Some characterized Russian science as "in a coma" (Zakharov and Fortov, 1995), and others have suggested that its very survival hung "in the balance" (Pokrovsky, 1994) or its "very existence was at stake" (Mirskaya, 1995: 709).

[2] The difficulties confronting Russian science in the 1990s are summarized by Gerber and Ball (2002: 185-188), which provides the basis for this paragraph is based. Kneen (1995) and Mirskaya (1995) also provide general English-language accounts.

[Figure 2 about here]

The crisis in Russian science generated considerable alarm, not only because it jeopardized one of the world's most celebrated national scientific communities, but also because the fate of Russian science affects international security, as well as Russia's economic and political prospects. The myriad problems in Russian science raise concerns on the part of government officials and informed observers that disgruntled Russian scientists will sell their weapons-related expertise to terrorist groups or rogue nations (Josephson, 1994; Weiner, 2002; Ball and Gerber, 2005; Vogel, 2006). Alleviating the crisis in science is likely to reduce that risk. More broadly, innovations in science and technology can attract foreign investment, help Russian products compete on the global market, and fuel sustained improvements in Russia's economic performance.

Institutional Transformation

In order to continue working in science, Russian scientists have had to adapt to a new set of science institutions.[3] The demise of the Soviet Union and the ensuing crisis in state funding led to the elimination of some fundamental features of the Soviet science system and their replacement, to some extent, by scientific institutions and practices found in some Western market-based societies. Defining features of the Soviet science system included overwhelming reliance on state financing through block grants to research institutes; the virtual absence of grants based on competition and/or allocated to individuals or smaller units; large, homogenous, and hierarchically administered institutes linked in a centralized, vertical structure; state control over the training and recruitment of new scientists; functional differentiation of organizations

[3] Throughout this article we use "institutions" in the broad sense represented in Douglass North's (1991: 97) definition: "humanly devised constraints that structure political, economic, and social interaction…both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct) and formal rules (constitutions, laws, property rights)."

into spheres emphasizing pure research, applied research, and teaching; predominance of military research; and politically-enforced seclusion from the international scientific community.[4]

These institutions made for a highly inefficient, even bloated science system: although Soviet science could claim some impressive achievements, it performed poorly relative to the number of scientists and the funds invested, based on a variety of indicators (see Irvine and Martin, 1985; Josephson, 1994; Saltykov, 1997; Graham, 1998).[5] Without the Soviet state to spend vast resources maintaining such an inefficient system, the system is not viable. The crisis in Russian science inevitably resulted when Soviet science institutions were combined with drastic cuts in the federal budget, a market economy open to global competition, and a political system that permitted citizens (including most scientists) to travel abroad.

Soviet science institutions perforce have given way to financing based on competitive grants and contracts; smaller scale, more flexible institutes with less rigid internal organization, and more horizontal links with other institutes, universities, and firms; functional integration of organizations; an orientation toward commercial and civilian research applications; and full integration in the international scientific community (Josephson, 1994; Gaponenko, 1995; Dezhina and Graham, 2002, 2005). In other words, Russian science has had to become “leaner and meaner,” more competitive and entrepreneurial, oriented mainly to civilian commercial

[4] For more detailed accounts of the Soviet science system, see Kneen (1984); Vucinich (1984), Graham ed., (1990), Fortescue (1990), Gaponenko (1995), and Gerber (2000).

[5] Consider the caustic assessment of an insider: “In the end, the Soviet Union was swamped with far more scientists than it needed….But despite the huge numbers of Soviet researchers, they made far fewer discoveries of international standing than their colleagues in the West. Soviet scientists began to judge themselves by their own standards, and everyone believed they were doing research of international quality—even when this was manifestly not the case. I knew of countless untalented researchers who could not even spell out the aims of their research, but who managed to get away with it because this inability to explain what they were doing was seen as ‘evidence’ that they were involved in very fundamental work.”(Letokhov, 1999, p.14)

applications. Russian science institutions have changed at an uneven pace. Certain features like the dominant role of the Academy of Sciences (Mirskaya, 1995; Fortescue, 2000) and reliance on block allocations from the state budget to pay salaries (Radosevic, 2003) persevere. But there has been unmistakable movement in the direction of competitive institutions.

Foreign assistance programs, most of which award grants on a competitive basis, have played a vital role in this process. Recognizing the opportunities and risks that the changes in Russian science pose for international security, Western governments and private donors have implemented bilateral and multilateral programs intended to promote the development of Russia's civilian scientific capability and thereby help keep Russian scientists gainfully employed at home. Some of the more prominent government-sponsored programs have been directed mainly toward providing support to scientists with weapons-related expertise. Examples of these include the International Science and Technology Centers (ISTC), Initiatives for Proliferation Prevention, and the Nuclear Cities Initiative. Other grant programs have been motivated by broader humanitarian or assistance concerns, such as grants funded by the George Soros Foundation, and the International Association for the Promotion of Cooperation with Scientists from the Commonwealth of Independent States and the Former Soviet Union (INTAS).[6] By allocating funding for science on the basis of competition rather than block funding, these international programs have introduced a new institution – grant-based financing – into the Russian science system.

In turn, the Russian government has itself established several grant foundations (Gaponenko 1995). Although these funds tend to offer grants that are relatively small in magnitude, roughly 5% of government allocations on civilian science are distributed via this

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[6] Schweitzer (1996) provides a detailed account of the origins and development of the ISTC. Weiner (2002) discusses the ISTC, IPP, and NCI from a critical perspective. For more information on other programs, see Dezhina and Graham (2002) and Ball and Gerber (2005).

competitive mechanism, which is based on peer review (Dezhina and Graham, 2005). More recently, several non-governmental Russian science foundations financed by private individuals or firms have arisen (Dezhina and Graham, 2005). These developments provide further evidence of a clear trend toward greater reliance on competitive grants to fund scientific research in Russia.

Other institutional changes have also taken place. Institutes have decreased in size and begun to establish their own links with other institutes and with commercial entities (Josephson, 1994; Radosevic, 2003). Russian science has opened up to the world, as Russian researchers have traveled freely to international conferences, worked abroad, and hosted their colleagues from other countries. A small number of scientists have started their own scientific businesses; a larger, if still limited number have applied for patents and sought commercial development of their research ideas while operating within state owned institutes or private companies. Some organizational reforms have been implemented, including the creation of a new science ministry (under various guises and names) to officially oversee the work of state-based scientific institutes not affiliated with the Ministries of Health, Education, or Atomic Energy, or the Russian Academies of Sciences, Medical Sciences, and Agricultural Sciences.

Our discussion thus has dealt with changes experienced by Russian scientists who worked in institutional settings outside of the Soviet military-industrial complex: research institutes administered by the Academy of Sciences, by economic ministries, or public service ministries, and also university departments (where, under the Soviet system, little research was conducted). Although Russian scientists who worked in design bureaus and development labs within the Soviet military-industrial complex were exposed to similar processes, they also experienced particular challenges. They were accustomed to greater levels of status and power than scientists who worked outside organizations explicitly devoted to military research (Cooper, 1991). They perhaps had more familiarity with competitive processes for the allocation of resources, since they often had to convince authorities to support their particular designs or innovations (Almquist, 1990). Many of them had long been cut off from civilian oriented research, and their institutes faced daunting challenges in undertaking “conversion” to civilian activities that was imposed by external authorities and circumstances (Kuzik, 1999; Ben Ouagrham, 2000; Tikhonov, 2001; Rassadin, 2002). We do not focus on the particular situation of scientists in the military-industrial complex because, as we discuss further below, our survey sample did not include them.

Subjective Adaptation

For the institutional transformation of Russian science to take hold and become self-sustaining, it will require both sustained economic growth and continuing development of market institutions, both of which must eventually replace foreign grant agencies as the main sources of demand (and hence financing) for scientific research and development. At the same time, the success of the institutional transformation of Russian science will be enhanced to the degree that scientists adapt normatively to the new institutions. If scientists “buy into” a new and largely unfamiliar philosophy regarding the goals, practices, and rewards of scientific research, they are more likely to respond positively if and when the external conditions become more favorable.

Old norms glorified “fundamental” research, collectivism, and “scientific schools;” they disdained commercial orientation and competition for grants (see Gerber, 2001).[7] Many scientists were quite happy with Soviet institutional arrangements, which guaranteed them some resources regardless of their productivity, insulated them from competitive pressures, and

[7] “Scientific schools” refer to groups of disciples who form around a great researcher—always within a single research establishment—and pursue the leader’s research agenda for decades. Many Russian scientists believe that these schools are the distinctive hallmark of Russian science tradition.

relieved them of the need to justify their work in commercial or practical terms (Graham, 1998). Scientists who accept that those arrangements are not viable and adapt to the new environment stand a better chance of thriving and helping to resuscitate Russia's scientific potential. In the new institutional context, scientists who learn to aggressively compete for funding for their work, develop an entrepreneurial sensibility, and actively seek clients—be they private firms, grant-making organizations, or state bodies that fund research on a contract basis—stand a much better chance of surviving, even thriving. Grant-based and market-based financing reward those who identify their comparative advantages by becoming familiar with work in their scientific area outside of Russia, exhibit the flexibility to tailor their work to the demands of the market, and form synergistic alliances, even if they are short-term, with other domestic and foreign researchers. Scientists who assume the state will support them regardless of the demand for or quality of their output will likely flounder.

In sum, the new institutional context calls for competitive, entrepreneurial, commercial, and international orientations that cut against the grain of Soviet-era professional norms. Therefore, the institutional changes will stand a better chance of restoring Russian science if they are accompanied by the requisite transformation in scientists' attitudes. The initial institutional changes, coupled with an improvement of the Russian economy since 1999, have arguably helped reverse the downward spiral of Russian science. Recent years have seen increases in federal spending on science, a resurgence of higher education in Russia, and improvements in some indicators of research productivity and scientific emigration. Some analysts detect a growing sense among scientists that the worst is over, as well as increasing acceptance of the new way of practicing science (Gerber and Ball, 2002; Dezhina and Graham, 2001). However, these assessments are based on focus groups and impressions, not broad data on the outlook of scientists. Thus, one goal that motivated our survey was to measure more precisely the distribution of orientations among Russian scientists toward competitive and Soviet-type science institutions and practices. By showing how widely Russian scientists have accepted the institutional transformation that is underway, we hope to provide a sounder empirical basis for taking stock of the progress made so far in the transformation of Russian science, as well as the prospects and challenges that lie ahead.

Social Responsibility: Scientists on How Their Work is Used

A second motive for our survey was to assess where Russian scientists stand with respect to professional norms regarding the social responsibility of scientists. Gerber (2001) identified a distinctive "national service" ethic among Russian scientists: many of those he interviewed reported a strong sense of obligation to serve the national interests of the Soviet Union through their work. As the basis for this obligation, they cited their debt to the Soviet state for providing them with education and training, broader patriotic concerns (including global competition for military superiority with the United States during the Cold War), or a general commitment to the well-being of their society. Similarly, a comparative analysis of Russian and American scientists who immigrated to Israel concluded that the Russians felt a stronger duty to advance their country's national interests through their research (Toren, 1988).

Did this normative commitment among scientists to do work that serves their country's national interests survive the collapse of the Soviet science system? In light of the economic desperation faced by many scientists, it would not be surprising if many came to reject such larger responsibilities in favor of more individualistic, egocentric goals. Such a development would have mixed implications. On the one hand, a more individualistic orientation on the part of Russian scientists could encourage them to think like entrepreneurs, conduct research with broad commercial and civilian applications, and look less favorably on specializations in weapons research. On the other hand, Russian scientists' traditional commitment to serve Russia's national interests could effectively mitigate any temptation to sell their expertise to hostile countries or organizations, because such entities clearly pose a threat to Russia, as well as other countries. Scientists devoted to Russia's interest could even exert moral pressure on their colleagues not to do work for unsavory clients.

The same could be said for a broader norm that scientists bear personal responsibility for how their work is used. However, the dominant tendency among the participants in focus groups that we conducted with Russian physicists was to reject the notion that scientists have this responsibility (Gerber and Ball, 2002). Asked whether they believe scientists have any particular social responsibility, all four groups exhibited discomfort, responding initially with silence or suspicion. One group then tentatively discussed the question in terms of professional ethics such as the obligation not to deceive clients or falsify results. Another concluded that social responsibility is a personal matter, not an issue of general moral standards. The other two explicitly rejected the idea that scientists bear any responsibility for how their work is used. One likened a scientist to a "prostitute" who will do whatever work clients will pay for and another agreeing with this statement by a participant: "It seems to me that everything now is determined by money and salary. There are no moral or ethical considerations, and there have not been for a long time. When people are stealing billions, it is a joke to even suggest such considerations."(Gerber and Ball, 2002: 206-7).

This last statement explicitly connects the loss of a sense of social responsibility to developments outside of science associated with the collapse of the Soviet Union. The phrase about people "stealing billions" apparently refers to the perception that the way Russia's transition to a market economy unfolded eliminated moral considerations from economic and social life, creating instead a free-for-all where the only rational response is to pursue one's own economic interests. If many scientists have the same interpretation of post-Soviet developments, then one consequence of these changes would be the decline of both versions of social responsibility on the part of scientists: duty to serve Russia and responsibility for how one's results are used. But the small and selective character (only physicists who received ISTC funding) of our focus group samples leave open the question of just how widespread such perceptions are in the broader scientific community. They also prevent us from identifying which groups of scientists are more likely and which are less likely to adhere to them. Thus, we sought to assess the extent of these norms using our survey, which we can also use to identify their correlates.

Correlates of Subjective Adaptation and Social Responsibility Norms

We expected to see a diversity of orientations among scientists. Accordingly, we also hoped to identify factors that influence what we call "subjective adaptation" –whether scientists embrace or reject (to varying degrees) the new institutions and practices. By doing so we begin to forge an understanding of the sources of heterogeneity within the Russian scientific community that might inform both theories of professional adaptation to changes in environment and policies designed to restore Russian science.

We have not seen any prior studies of Russian science that address which factors should be associated with adaptation or social responsibility, but several hypotheses seem reasonable:

Age. We expect younger scientists to adapt more readily to the new institutions because they had less exposure to Soviet-era practices and they have a longer time horizon in which to benefit from the new institutions.

Current Success. We expect that scientists who are more successful in practical and observable ways in the new conditions will subjectively adapt to those conditions more readily than those who are less successful. Concretely, this implies that recipients of Western grants and Russian grants subjectively adapt to a greater extent than non-recipients. Conversely, those who have experienced rejection by the grant system – i.e., those who applied for grants but have not received – may hold especially negative views toward the new institutions due to "sour grapes." They might also have lower expectations of making it within in the new system themselves and thus adjust their views of the new system accordingly. Other measures of success within the new institutions include receiving contracts for scientific work from foreign firms, domestic firms, or the Russian government (since contracts, as opposed to block grants to institutes, are competitively awarded), starting a scientific business, and traveling to foreign conferences: all should be positively associated with subjective adaptation.[8]

Regular salary from one's institute is ambiguous as a measure of success at negotiating the new funding institutions. On one hand, institute management may reward scientists who are more successful at obtaining grants and contracts with higher regular salaries. On the other hand, salaries may be based on seniority, personal relationships with management, or other criteria. Scientists who flourished under the old system most likely would have started out with higher salaries during the transition era, and it could be that there were few changes in the official salary structure. In some cases management might even give larger official raises to scientists who do not receive any income from grants in the name of egalitarian principles. For these reasons, the regular salary from one's institute should not necessarily be treated as a measure of success within the new institutional context. However, we do include income as an important control variable in our statistical models.

[8] Attending foreign conferences may also facilitate adaptation by increasing exposure to foreign science institutions.

Prospective success. Regardless of prior success within the new system, scientists who have better prospects of eventually succeeding (by obtaining grants and other sources of support from their research that disbursed via competitive mechanisms) are more likely to embrace the new institutions. Operationally, this leads us to expect that scientists who are more productive by conventional "Western" criteria (publications and patents) will adapt more thoroughly, as they have reason to anticipate that their current productivity will ultimately translate into future funding for their work.

Work context: Scientific field, type of organization, and position. Russian physicists had the most to lose from the institutional changes (see Clery, 1994), as they were the most privileged under the old system; therefore, they might be expected to have more negative views toward the new institutions than chemists and biologists. The institutional changes include some initiatives to enhance the research potential of university-based scientists, who, under the Soviet system, had little if any research function (Dezhina and Graham, 1999). They might therefore view the changes more positively than scientists working in research institutes. Scientists in administrative positions might feel the squeeze of dwindling state financing most acutely, and thus have more negative views toward the institutional changes.

Ethnicity. Ethnic Russians may identify more closely with the distinctive Soviet science institutions out of patriotic pride, not only because Russians were the dominant ethnic group within the Soviet Union (and thus many viewed the Soviet state as an extension of Russian national power), but also because Soviet science institutions borrowed many features from pre-Soviet Russian institutions (Kneen, 1984; Vucinich, 1970, 1984; Fortescue, 1990).

As for social responsibility norms, we expect systematic variation by age, commercial orientation, and ethnicity. Younger scientists should be less likely to adhere to social responsibility norms because they are unlikely to have been socialized to embrace the Soviet-era professional service ethic. Pure adherence to commercial goals seems inconsistent with a commitment to serve Russia or a moral responsibility for how one's work is used; thus, signs of commercial success (contract work, patents, business ownership) may be negatively related to moral responsibility. Finally, patriotism might well arouse a greater sense of duty to serve Russia among ethnic Russian scientists than among non-ethnic Russians.

Data

The US Department of State sponsored our survey, with the aim of evaluating the effectiveness of one of the largest programs of assistance to scientists in Russia and other former Soviet Republics, the International Science and Technology Centers (ISTC).[9] The ISTC is a multi-lateral organization founded by the European Union, Japan, Russia, and the United States which began operations in 1994 with the following stated objective: "Provide weapons experts in the CIS the opportunity to redirect their talents to peaceful activities."(ISTC Fact Sheet, 2008). It has pursued this objective mainly by providing grants supporting non-military, commercially-oriented research on a competitive basis to teams of scientists that must include at least some weapons researchers. As of December 2007 it had funded 2,578 proposals, totaling $785.2 million and involving 69,218 participants (ISTC Fact Sheet, 2008). In addition to research grants, the ISTC has offered travel grants, seminars and training, and commercialization and patent support. In order to conduct the survey, we worked with a Russian survey research firm called "ROMIR." We prepared a questionnaire in consultation with a wide range of experts

[9] Throughout our study, the State Department officials who oversee United States participation in the ISTC consistently demonstrated a genuine interest in learning how effective various aspects of the program are. At no time did they put pressure on us to "shape" the results in any manner whatsoever. Elsewhere, (Ball and Gerber, 2005) we report at length on the survey's findings regarding the role of foreign and Russian grant programs in reducing the proliferation threat posed by Russian scientists. Here we examine an entirely different set of variables: measures of subjective adaptation and social conscience rather than willingness to emigrate or conduct military research for foreign firms or governments.

on Russian science in the research community and the United States government. Translation and two rounds of formal pre-testing by ROMIR preceded the final version.[10]

We surveyed in "open" scientific establishments; i.e. those not currently or formerly "closed" due to concentration on weapons-related research. This does not mean that no defense-related work is conducted in these establishments—in fact, such work has always been carried out in all types of institutional settings in the USSR and Russia.[11] It simply means that these institutes conducted civilian research in addition to military research and were never formally part of the military-industrial complex, though they may have actively collaborated with institutes and production facilities within it.

We worked with ROMIR and our contacts in Russia who are familiar with the scientific establishment to draw an appropriate sample of institutes for this stage. We initially chose 20 institutes and 10 backups using several criteria. Our mandate to assess the effectiveness of the ISTC for the US State Department necessitated that we restrict our sample to institutes focused on physical, chemical, or biological sciences, corresponding to the three broad categories of weapons of mass destruction. Moreover, we had to exclude institutes whose staff had never received any funding from the ISTC, because such institutes would not have contributed nothing to the evaluation. Finally, the institutes in our sample had to be accessible to ROMIR—in terms of both actual access and cost. Given ROMIR's regional organizational structure, this meant concentrating the sample in a somewhat limited number of locations, as it would have been

[10] Although here we focus on subjective adaptation and norms of social responsibility, we note that the survey questions address a variety of topics in addition to the topics discussed herein: respondents' economic situation, grant-writing activity, productivity, morale, emigration potential, assessments of a wide array of developments in Russian science and specific reform proposals, and views on broad economic and political issues, as well as specific aspects of ISTC's programs.

[11] For example, see Ben Ouagrham-Gormley's (2006) account of how the same network of "anti-plague" institutes engaged in public health research and biological weapons research during the Soviet period.

prohibitively expensive and logistically difficult to send interviewers to institutes scattered throughout Russia's vast territory.

In light of the broad security threat posed by former weapons scientists in Russia (see Vogel, 2006), we were eager to conduct our survey in institutes that have long been "closed" defense-related establishments—i.e., institutions with a clear research focus on weapons, which still have highly restricted access. In Russia different administrative bodies oversee the closed institutes responsible for, respectively, nuclear, chemical, and biological weapons. Our efforts to gain permission to conduct our research in these three of these types of institutes met with considerable resistance on the part of these bodies. Eventually, we were able to conduct a second stage of the survey in eleven "closed" biological research institutes, where 600 scientists were interviewed March – July 2004. However, we refrain from analyzing these data in this article because the survey procedures there deviated substantially from standard practices, with unknown consequences for the validity of the data.[12]

Thus, our sample for this article was drawn from "open" research institutes and university departments in physics, chemistry, or biology that had received at least some funding from the ISTC and that were located near large cities that could be accessed by ROMIR's regional affiliates. Our sampling design omits scientists working exclusively in the labs of closed institutes, private firms, joint ventures, or in their own companies, though scientists who simultaneous hold positions in research institutes or university departments and these other types

[12]As a condition of access to the closed biological research institutes, we were required to hire employees of the institutes rather than trained interviewers to conduct the interviews. In all likelihood, therefore, the interviewers personally knew some or all of the respondents, which would violate the anonymity and confidentiality of the data collection process. Also, we could not implement all of the standard quality control measures, though we were able to implement some. For the record, we did conduct analyses of the data from the closed biological institutes parallel to those we report below, and we found overwhelming similarity.

of institutions could have been included.[13] It also omits scientists who work in institutes with other specializations (e.g. geology or botany), those that have not received ISTC funding, and those in remote regions of the country. These restrictions undoubtedly limit the generalizability of our findings. Strictly speaking, they apply to scientists working in state-sector institutes that have traditionally undertaken both civilian and military research. We have no way of knowing for sure, but it seems likely that most such institutes would have received some funding from the ISTC by the time of our survey and that the vast majority are located in the major cities where we conducted the study. But we cannot rule out the possibility that scientists in institutes with different profiles and/or that have not received ISTC have systematically different views towards the new science institutions that have taken root in Russia. We revisit the issue of how our sample design might have affected our findings in the conclusion. Caveats notwithstanding, our survey gives unprecedented empirical insight into the orientations of a wide swathe of currently practicing Russian scientists, which can serve as a benchmark for future studies of the same populations and for comparisons with data on scientists in other institutional settings.

Although the study was funded by the US State Department, not the ISTC, the ISTC offered us several forms of crucial assistance. First, it provided us with a letter to the directors of the institutes we wished to survey describing the nature of the study and requesting that they not only allow ROMIR's interviewers onto their premises to in order to conduct interviews, but also assist them in identifying a random set of respondents who had not received ISTC funding. Undoubtedly, we would not have been able to obtain access to the institutes without these letters. Secondly, the ISTC provided us with lists of specific scientists from each institute who had applied for funding and who had received funding. Using these list, we were to able to fulfill our

[13] For an analysis of the development of commercial ventures involving scientists in contemporary Russia, see Schweitzer (2000).

task of evaluating the ISTC by over-sampling ISTC program participants and scientists who had applied for ISTC funding but had not received any funding. In order to avoid possible biases due to the over-sampling of these groups, we computed post-stratification weights, which reproduce the population's joint distribution (as best as we can estimate them from published sources and ISTC's data) by specialty and ISTC funding. We apply these weights in all the analyses that we report below. We randomly sampled in advance from the lists of these two strata (funded and unfunded ISTC applicants), so interviewers were assigned lists of scientists in these two categories to be interviewed prior to entering the institutes.

Once they gained access to the institutes, the interviewers then were responsible for developing a random sample of institute researchers who had never applied for ISTC funding based on institute personnel records, thus rounding out the sample. ROMIR used only experienced interviewers for this project. They underwent a standard training session, which we observed, in which the sampling technique was carefully described to them and the entire questionnaire was reviewed one question at a time to identify potential complications. The trainer emphasized the need to assure the respondents of confidentiality and complete discretion.

Fieldwork began on November 2, 2002, and ended on January 23, 2003. Generally fieldwork went smoothly, with one exception: the survey had to be cut short abruptly in one institute, when the institute leadership became suspicious and ordered the interviewers to leave. The institute's remaining sample volume was reallocated to other institutes of similar profile.[14] Potential respondents were informed that the purpose of the study was to evaluate Western programs that support Russian science, examine ways to improve their effectiveness, and assess the outlook of Russian scientists on a range of professional issues. In order to attain a good

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[14] Only one of the twenty initially chosen institutes refused to participate in advance. We replaced it with a similar institute from the backup list.

response rate and to compensate respondents for their time, we paid them an honorarium of $10. A total of 602 interviews were completed. According to the detailed logs of interviewers, 230 scientists who were initially sampled had to be replaced because they no longer worked at the particular institute (83), were currently working abroad or at a distant location (130), were away due to illness or leave (8), or did not meet quota requirements (9). Among sampled scientists actually contacted, 52 refused to participate, for an overall refusal rate of 7.4%. Among those who refused, 70% said they were too busy, 15% said they feared violating the institute's non-disclosure policies, 12% said they had no interest in the study, and 3% gave some other reason. After the completion of fieldwork, ROMIR staff called back a randomly chosen 15% of the respondents to verify that the interview had taken place. All these interviews were verified. In sum, we have good reason to believe our survey in the open institutes followed accepted survey research procedures to the greatest extent possible in a study of this nature.

Methods of Analysis

Our survey contained 25 questions measuring respondents' attitudes toward the changes in Russia's science institutions and their views on scientists' social responsibility.[15] We analyze the responses to these two questions in three steps. First, we examine the univariate distributions across the categories of each question. This provides us with a general sense of the distribution of attitudes among scientists. However, any individual question may be a poor or problematic measure of underlying views, and when we have as many questions at hand as we do, it can be difficult to make broad conclusions about the overall cast of opinions. Therefore, in the second step of our analysis we combine subsets of the original questions into four composite scales measuring the underlying attitudes of interest. We use exploratory factor analysis (principal components factors with oblique rotation) to identify which of the individual survey items

[15] The first author will gladly provide an English-language translation of the complete questionnaire upon request.

belongs with which scale. Then we compute the mean score for each respondent on the set of items constituting each scale.[16] We examine histograms of the four scales to see how the underlying orientations that shape the answers to specific questions are distributed in our sample.

In order to determine how individual and contextual factors shape the attitudes of scientists, we then proceed, in the third step of our analysis, to estimate four sets of linear regression models, one for each scale. Because our sample is highly clustered (drawn from 20 institutes), ordinary least squares (OLS) regression is not appropriate: we would expect some correlation of the error terms among respondents sampled from the same institute, which violates the OLS assumption that errors are independent across observations. Therefore, we use a survey-corrected estimator that takes the clustering of respondents within institutes (our primary sampling units) into account in the estimation of the standard errors of the coefficients. The estimator also adjusts standard errors for heteroskedasticity.[17] This estimation approach does not affect the estimation or interpretation of the coefficients, but it makes the standard error (and hence the statistical inferences) more robust. We also apply our post-stratification weights in all the analyses, in order to adjust for the over-sampling of ISTC grantees, which was part of our sampling design.

In addition to variables derived from our hypotheses – measuring age, current and prospective success, work context, and ethnicity – and regular institute salary, we include

[16] To facilitate the factor analysis and additive scale construction, we treat the ordinal response categories on the 18 variables measuring attitudes as if they were interval scales. That means we treat the response categories as if they are equally spaced, even though there is no a priori reason to assume this is the case. Our justification for doing so is that we have a large number of items to analyze and it is much easier to "reduce" the data and combine subsets of items into scales if we can treat them as interval measures. Scaling methods such as latent class analysis that treat the response categories as discrete are difficult to implement with a large number of items. Moreover, it is unlikely that the results would differ substantively were we to use such methods, as our ordinal measures do incorporate the ordering of response categories.

[17] For technical details on the implementation of survey-corrected estimation, see StataCorp (2005).

standard demographic control variables in our models: sex, education (post-graduate degree vs. bachelor's or less), and residence (Moscow city vs. elsewhere).[18] Also, even though we have fewer concrete hypotheses regarding social responsibility norms, for the sake of consistency and completeness we incorporate the same set of independent variables in our models for the scales measuring these outcomes as we do in our models for the scales measuring subjective adaptation.

Descriptive Statistics

Descriptive statistics for all the independent variables we use in our analyses, based on both unweighted and weighted samples, are presented in Table 1.[19] We achieved a balanced sample with respect to these variables. The skewed age distribution does not reflect sampling bias: it actually provides a reasonably representative picture of the age distribution of currently working Russian scientific researchers. The small proportions of scientists in their twenties, thirties, and forties reflects the crisis that befell Russian science during the 1990s: few young people chose science as a career during that period, and working scientists of the younger generation were more likely to abandon science altogether or move abroad. Our weighted sample is about two-thirds male, which is about right considering the fields we are studying (women predominate in biology, which explains why their weighted proportion is notably higher than their unweighted proportion). Ethnic Russians constitute 83% of the weighted sample. Here again, we have little reason to suspect this figure, though it is noteworthy that about 6% of respondents declined to indicate their ethnicity.

[Table 1 about here]

[18] We follow standard practice by taking the natural logarithm of institute salary, in order to adjust for skew in the salary distribution. For the 12 respondents with missing data on salary, we substituted the sample mean. We also include a dummy variable denoting these substitutions so that they do not affect our estimate of the effect of income. In preliminary analyses, we also tested for effects of wage arrears during the last year. In no case did we find significant effects of wage arrears, so for the sake of simplicity we omit this variable from the models we report.

[19] The most dramatic effect of the weights is to correct for the over-representation of physicists (which reflects their predominance among recipients of ISTC funding) and recipients of foreign grants (whom we over-sampled by design, since ISTC grants are type of foreign grant).

Note that the Russian system offers two post-graduate degrees – a *kandidat* degree (equivalent to a PhD in an American university) and a *doktor* degree (which requires a second dissertation). As we would expect, most of our respondents have one or other of these degrees, but some have only a university diploma (or, in a few cases, even less). A broad spectrum of job titles is represented in our sample, ranging from institute directors to entry-level research positions ("junior scientific researchers"). Although 62% our sample works in institutes located in Moscow, this also reflects (more or less) the actual situation in Russian science: since pre-Soviet times Russian researchers have been concentrated largely in Moscow.

To classify scientists according to their access to foreign and domestic grants, we rely on questions that asked respondents to indicate the number of each type of grant they applied for and received, as both principal investigator (PI) and non-PI, in the last decade. We classified respondents into one of four categories with respect to each type of grant: those who have never applied, those who have applied but have never been funded, those who have received grants but never as principal investigator, and those who have received at least one grant as a principle investigator. We make these distinctions rather than relying on a simple dummy variable to indicate whether the respondent received any grants of the particular type for two reasons. First, those who apply for grants but have no success in obtaining them may have especially negative views of grant-based financing (due to "sour grapes"), or they may have more positive views than those who never applied at all due to a "selection effect" (the fact they applied implies they are more oriented toward the grant system than those who never applied). Second, those who receive grants as principal investigators personally reap the most financial and professional benefits from the grant system, so they might have more positive views of that system than scientists who only receive grants as project team members.

The important role that foreign and domestic grants have come to play in the financing of scientific research is evident in the large proportions of our sample – even correcting for the over-sampling of ISTC grantees – who have received grants, though most have received them as participants on projects rather than as principal investigators. Even after applying our weights to correct for the over-representation of ISTC grantees, about 40% of the sample received at least one foreign grant and more than three-quarters received at least one Russian grant in the decade preceding the survey. It is difficult, though evidently not impossible, to remain employed as a scientist in Russian state-funded institutions without receiving grants.[20]

The rise of other new sources of financing is also evident in our data: 22% of the weighted sample worked on at least one contract with a foreign firm and 28% on at least one contract with a Russian firm in the last ten years. Nearly half had worked on at least one contract from the Russian government (which, although it is a form of government financing, differs from the block-grant budgetary financing typical of the Soviet period because such contracts are allocated, at least in principle, on the basis of competition). About one in ten of our respondents had at some point participated in the formation of a scientific or technical business. Finally, we obtained data on the number of publications in both international and Russian journals and number of foreign conferences attended by respondents in the last five years, as well as the number patents received.

Results

Subjective Adaptation

[20] As further evidence of the importance of grants to the survival of scientists, 31% of the weighted sample indicated that "supplementary salary from grants and special contracts" was the largest source of income for them in the previous month (compared to 50% who said this of their regular salary). Another 34% cited grants and contracts as the second largest source.

Our analysis of subjective adaptation examines two sets of questions: one pertaining to how respondents view the recent changes in Russia's science institutions and one regarding their views on the merits of grant-based financing. Attitudes toward grants are a good specific measure of Russian scientists' subjective adaptation to new science institutions because hostility toward grant-based financing was a distinctive Soviet-era characteristic. Few would deny that in the last decade grants have come to play a very significant role in Russian science; but Russian scientists themselves might well disagree over the nature of that role. Those who embrace the new institutions that Russian science has had to adopt should embrace grants and view their impact on Russian science as largely positive. On the other hand, Russian scientists who remain committed to Soviet-era institutions should take a more critical view of grants.

In the battery pertaining to views on new institutions, respondents were asked to indicate what effect each of five specific changes in Russian science had on their scientific field (Table 2).[21] The five possible responses ranged from "very negative" to "very positive," with a neutral category in the middle. The distributions of responses show widespread positive assessments of four of these changes: more access to foreign grants and contracts, greater freedom to attend foreign conferences, enhanced cooperation between Russian and foreign scientists, and improved access to grants and contracts in general. In each case, a sizable majority (84% or more) of respondents indicated the effect has been positive or very positive. Very few (5% or less) indicated that any of these changes had negative effects. A more modest majority sees the new possibility to start a scientific business (55%) as positive, while 14% see it as negative. By these five measures, it appears that most Russian scientists view greater access to grants, greater exchanges with foreign scientists, and the opportunity to combine science and business as having salutary effects on their fields.

[21] The items are ordered in table 2 based on the results of the factor analysis, not their order in the survey instrument.

[Table 2 about here]

The second set of questions pertaining to subjective adaptation consists of five questions regarding the relative advantages and disadvantages of grant-based and budgetary financing (Table 2, Panel B). The distributions of responses to these questions suggest a greater diversity of views on the merits of grants than on the effects of the recent institutional changes. Still, the broad tendency is to view grants positively. Nearly half agree that grants are more efficient (47%) and over two-thirds agree that they bring together effective research teams (69%), while about one-third and one-fifth, respectively, disagree with these claims. As to whether budgetary financing allocates funds more fairly, opinion is about equally divided among those who agree, those who disagree, and those who neither agree nor disagree. About half agree that budgetary financing decreases the incentive to do work with commercial applications, while 30% disagree. Also, our respondents tend to see grant-based financing as more based on scientific merit: nearly half (45%) believe that scientific quality matters more for obtaining grants, while only 5% say quality matters more for obtaining budgetary financing.

The remaining half of the sample sees neither grants nor budgetary financing as relying more than the other on scientific quality. Together with the finding that about one third agrees that budgetary financing allocates funds more fairly, this points to considerable skepticism within the Russian scientific community that grant-based financing is more merit-based than budgetary financing. We cannot tell from the survey data what lies behind this skepticism, but it could well reflect the fact that many Western grant programs explicitly target current and former weapons researchers: this is a clear example of a funding criterion other than scientific merit. In addition, scientists may believe, based on experience or impressions, that such non-scientific factors as personal connections, ability to communicate in English, and skill at crafting proposals or promoting commercial interests figure centrally in deciding which Russian scientists receive grants. We heard some of these grounds for skepticism about grants in the focus groups we conducted with physicists in 2001 (Gerber and Ball, 2002; see also Kneen [1995] and Weiner [2002] for allegations of favoritism and criticism of the privileging of weapons researchers). In any case, although the survey data clearly reveal substantial ambivalence as to whether grants are allocated on the basis of scientific merit, they also suggest that by and large Russian scientists view grant financing in positive terms and they do not see budgetary financing as more merit-based.

The individual questions are broadly consistent, but any one of them may give an idiosyncratic impression of how Russian scientists have adapted subjectively to the changes they have experienced in their science institutions. We can obtain more reliable measures of adaptation by creating composite scales out of the individual measures. To find out how best to combine our ten measures of subjective adaptation into a smaller number of scales, we assigned integer scores from 1 to 5 to the response categories for all the variables and performed a principal components factor analysis. The preferred solution, using the conventional criteria that factors with an eigenvalue greater than 1.0 should be retained, yielded two factors. The pattern of factor loadings in the rotated solution clearly shows that the individual questions from each battery pertain to two separate factors.[22] Accordingly, we created two scales by first recoding the variables as necessary so they all are coded in a consistent direction and then taking the mean values on the five variables corresponding to each scale. The label the scale based on the

[22] Factor loadings are the correlations between the factors and the original variables. Here we are using factor analysis to identify which variable relates to which factor: the greater a loading in absolute value, the stronger the relationship between the corresponding factor variable.

variables in Panel A the "pro-change" scale and the scale based on the variables in Panel B the "pro-grant" scale.

The "pro-change" scale has a mean of 4.08 on a scale of 1 to 5, with higher values denoting more positive views of the institutional changes (standard deviation = .56).[23] Thus, the mean orientation toward the institutional changes is quite positive. The histogram of the scale (Figure 3) shows that the distribution is concentrated in the upper end, indicating that support for the institutional changes in Russian science is clearly the norm in our sample. Very few respondents fall in the range of neutral (3 on the scale) and even fewer fall below. Based on this measure, the predominant tendency among Russian scientists has been adaptation to the institutional changes that have taken place in Russian science since the collapse of the Soviet Union.

[Figure 3 about here]

The "pro-grant" scale has a mean of 3.37, only slightly more positive than the "neutral" midpoint of 3.00 (standard deviation = .71). The histogram for the pro-grant scale (Figure 4) indicates a roughly symmetric distribution declining concentrations of respondents as one proceeds further from the mean in either direction (in the manner of a normal curve centered on the mean). Based on our composite measure, we conclude that opinions remain rather evenly divided as to the merits of grant-based financing, with a moderate tendency to view grants positively and a more pronounced tendency to hold moderate (close to the mean) views.

[Figure 4 about here]

Our two composite measures paint somewhat different pictures as to the level of subjective adaptation to new science institutions among Russian scientists. The pro-change scale

[23] We report the descriptive statistics, reliability coefficients (Cronbach's alpha), and inter-scale correlation matrix for all four scales we construct in the Appendix Table A1.

suggests more widespread adaptation, while the pro-grant scale implies weaker overall adaptation and more evenly divided distribution of views. These results are not contradictory: the two scales measure different (though related) dimensions of adaptation. The pro-grant scale pertains specifically to grant-based financing, while the pro-change scale is broader, as it incorporates views on the opening of Russia to international science and the right to open scientific businesses, in addition to views on grants. The correlation between the two scales is .36, which shows that they are, in fact, consistent. The clear implication of the comparison of the two scales is that scientists feel more ambivalent (in aggregate) about grant-based financing than they do about greater openness and commercial opportunities. On the other hand, even with respect to grants, the main tendency is on the positive rather than the negative side of the divide. Our data suggest Russian scientists have generally adapted to the changes in their science institutions that they have experienced since the collapse of the Soviet, they have done so less than wholeheartedly (particularly with respect to grant-based financing) and some have adopted more thoroughly than others.

Social Responsibility

We have eight questions from two batteries that relate to views on scientists' social responsibility (Table 3). Four deal with whether scientists have a sense of duty to serve Russia's national interests (Panel A). Half or more of the responses to each of these questions take a position consistent with this ethic of national service. Asked directly, a solid majority (71%) agrees that scientists have a duty to serve Russia's interests, and only 13% disagree. A very narrow majority (51%) disagree that scientists have the right to work on military projects for any country of their choosing. This statement that implicitly values scientists' autonomy over national security considerations, which may be why one-third agree with it. Most respondents agree that scientists doing military work abroad harm Russia and that the Russian government should control which scientists are permitted to work abroad (62% in each case). Still, more than one in five disagree with both of these statements. Altogether, while most scientists in our sample appear to espouse a sense of national duty, there is considerable variation of views on this topic.

[Table 3 about here]

The next four questions deal with scientists' broader moral responsibility for how their work is used (Table 3, Panel B). As for the previous battery it appears that about half or slightly more agree that scientists bear such a responsibility (65% when asked directly, fewer otherwise), while a substantial number disagree (20% when asked directly, more otherwise). Opinion is most divided as to whether it is unrealistic to expect scientists to worry about how clients use their results "in today's society where money rules everything": half agree but 37% disagree. While 62% say a scientist should never do work that could harm society if it fell in the wrong hands, 20% disagree. Finally, half oppose the statement that a scientist's first duty is to feed his family, not ethical concerns, but 26% agree.

Once again, the factor analysis results clearly show that the two respective batteries each load on their own factor. We recoded the items in Panel A so that higher values indicate greater commitment to the national service ethic and took the mean across these items to produce a "duty" scale. The mean score on the duty scale is 3.58 (standard deviation=.89), suggesting that on average Russian scientists tend to adhere to this sense of duty, but only weakly. The duty scale has the highest standard deviation of any of our scales (all of which run from 1 to 5), which shows that there is most variation of opinion with respect to this issue. This is confirmed by the histogram for the duty scale (Figure 5), which reveals noteworthy concentrations around the value of 4, but also around the values of 3 (consistent neutrality) and 5 (consistent agreement). Some respondents can be found at all of the lower values.

[Figure 5 about here]

We combined the remaining four items in Table 3 into a "responsibility" scale, with higher values denoting stronger agreement that scientists bear responsibility for how their work is used. The mean on this scale is 3.36 (standard deviation = .79). As in the case of the duty scale, the prevailing tendency is to agree slightly with the notion that scientists should answer for how their work is used but there is considerable variation of views on the issue. The histogram shows that the division of opinion follows a nearly normal distribution about the mean (Figure 6).

[Figure 6 about here]

In descriptive terms, both the univariate distributions and the analysis of the duty and responsibility scales point to the same basic conclusion: Russian scientists widely adhere to the norms of national service and social responsibility, but in both cases the commitment to these norms is far from universal and there are substantial numbers of dissenters. That, of course, raises the question: what variables are systematically related to the variation in views on these ethical issues, as well as to the diverse levels of subjective adaptation we identified in the previous section?

The correlation between the duty and responsibility scales, which we would expect to be positive, is .25. Thus, the two separate dimensions of ethical views we have specified are clearly related (as we would expect) but also distinct – as are the two separate dimensions of subjective adaptation. Also, there is only one correlation of note between either of the scales measuring adaptation and either of the scales measuring social responsibility: the correlation between the pro-change and duty scales is -.19. This indicates that scientists who adhere to the traditional national service ethic tend to be less supportive of the recent institutional changes, and vice versa. Otherwise, adaptation and social responsibility norms are unrelated (the other three relevant correlations are less than .10 in absolute value).

Correlates of Adaptation and Social Responsibility

We present two sets of model results for each dependent variable: a full model (including all covariates) and a preferred model (including only statistically significant effects). We arrive at preferred specifications by removing non-significant variables from the complete model and applying equality constraints to certain coefficients where substantively and empirically justifiable. To save space, we focus our analysis on the preferred models.

Our models for the pro-change and the pro-grant scales provide some evidence for the hypothesized effects of age, current and prospect success, work context, and ethnicity (Table 4). Controlling for other variables, scientists over 40 have lower values on the pro-change scale, while those over 50 have lower values on the pro-grant scale.[24] Current success at obtaining foreign grants (either as PI or non-PI) has the anticipated positive effects on the pro-change scale.[25] Success at receiving a Russian grant increases the expected value on the pro-grant scale, though the effect is only marginally significant. This is especially noteworthy because Ball and

[24] In both cases we identified the suitable age cut point based on the complete model and constrained the effects of the dummy variables corresponding to ages past that cut point to be equal. This yielded statistically significant age effects even when none of the initial set of dummy variables (contrasting the corresponding ages to the baseline of "30 and under") were significant in the complete model. The reason for this is that by increasing the number of observations in the baseline and the contrast group(s) we lower the standard error around the estimate of the contrast (effect).

[25] We combine the PI and non-PI categories in our preferred model because the difference in their coefficients in the complete model is not statistically significant and it seems implausible that there would be a significant effect non-PI status but not PI status. The non-significance of PI status in the complete model most likely reflects the small number of weighted observations in the category, which tends to increase the standard error of the corresponding coefficient.

Gerber (2005) found that Russian grants had no effect on the propensity of Russian scientists to engage in weapons proliferation activities, but foreign grants did reduce that propensity. The effect of foreign grants on the pro-grant scale is twofold: those who applied but never received funding score lower on the scale than the baseline (those who never applied and those funded only as non-PIs), while PIs score significantly higher. Thus, we have evidence of "sour grapes" on the part of unsuccessful applicants and also evidence that success in the new system increases normative approval of it.[26] Obtaining contracts from the Russian government has the expected positive effect on the pro-change scale, while contracts from foreign firms increases support for grant-based financing. The other effects of our measures of current success are not significant.

[Table 4 about here]

The productivity measures (prospective success) have only modest effects: publication record and starting a business have none, foreign conference attendance is associated with higher scores on the pro-change scale, and scientists who have received a patent tend to score higher on the pro-grant scale. Work context has no effects on the pro-grant scale, but scientists working as physicists are less supportive of the institutional changes and those working in universities are more supportive, as hypothesized. Also consistent with expectations, ethnic Russians have lower expected values on the pro-change scale, net of the other variables in the model.[27] Logged institute salary is negatively associated with the pro-change scale, implying that salary is less a measure of success at negotiating the new institutions than a measure of standing within the old

[26] Of course, those who applied for but did not receive funding may have legitimate grievances against the process which denied them funding. We characterize these complaints as "sour grapes" for the sake of simplicity, since we are not in any position to assess the validity of principled complaints about grant-based financing based on personal difficulties securing grants.

[27] We keep the dummy variable for "missing ethnicity" in the model even though it is not significant because it is needed to preserve the interpretation of the "zero" category on the "ethnic Russian" dummy variable as pertaining to non-ethnic Russians. Without the "missing ethnicity" dummy, the effect of the "ethnic Russian" dummy would contrast ethnic Russians to "non-ethnic Russians or missing," and some of those with missing ethnicity may well be ethnic Russians. The same logic applies to the dummy variable for missing salary.

institutions. Overall, our preferred models account for, respectively, 12.4% and 13.2% of the variance in the two scales using R-squared as the criterion. While much of the variance in subjective adaptation cannot be attributed to the variables in our models, they perform rather well be social science standards. While not all the effects anticipated by our hypotheses obtain, we do find at least some evidence in favor of each.

Our models for the two scales measuring social responsibility show pronounced effects of age: younger Russian scientists are significantly less likely to adhere to the national service ethic associated with the Soviet era, and they are also less likely to agree that scientists bear moral responsibility for how their work is used (Table 5). As we hypothesized, ethnic Russians are more likely to feel a sense of duty to serve Russia's national interests, which probably reflects nationalist or patriotic considerations. We also hypothesized that indicators of "commercial orientation" would be negatively associated with social responsibility. Our findings are contradictory in this regard: scientists who do contract work for Russian firms and those who have started businesses have lower expected scores on the duty scale, but so do scientists who do contract work for the Russian government. Also, Russian scientists who have received patents have higher expected scores. Scientist-businessmen tend to score higher on the responsibility scale, while recipients of Russian government contracts score lower. Clearly, commercial orientation has no straightforward relationship with views on the social responsibility of scientists.

[Table 5 about here]

Several other statistically significant effects are worthy of note. Although we should treat these with caution because we did not anticipate them on theoretical grounds, in some cases plausible explanations suggest themselves. Scientists who have never applied for foreign grants are substantially more likely to espouse the national service ethnic than those who have applied – whether or not the latter actually received foreign funding. This is a strong effect: the point estimate of .466 is slightly larger than half a standard deviation of the scale. The most likely explanation for this finding is that a sense of commitment to serving Russia's national interests deters some Russians scientists from seeking foreign grants. Some scientists may be so devoted to Russia that they perceive the pursuit of foreign grants as a (mild) form of treason. Thus, the positive association between non-applicant status and the duty scale reflects a causal effect from the latter to the former rather than vice versa. Alternatively, scientists who do not apply for foreign grants because they lack the qualifications, ambition, or ideas necessary to be competitive may well resort to nationalistic ideas in order to justify their inactivity in foreign grant seeking. In either case, this finding may lend insight into why some scientists have not sought foreign grants even though they offer more substantial support than domestic Russian grants do.

Another similar finding is that publications in Russian journals are associated with a greater sense of duty. Most likely, Russian publication output reflects an orientation toward Russian science at the expense of a more international orientation. The same, in fact, probably could be said about the positive effect of having received a patent on expected duty scale score. Most of the patents received by respondents are Russian patents, so this variable may capture an orientation to Russian science rather than commercial orientation (as we originally construed it).[28]

The effects of grant status and foreign conference participation on the responsibility scale are somewhat inconsistent and difficult to interpret. The positive effect of administrative status,

[28] Less than 1% of the sample received international patents but not Russian patents, while 16% received Russian patents only and 3% received both types of patents.

however, suggests that Russian scientists who occupy positions of authority and responsibility are more likely to endorse the notion that scientists in general are morally accountable for how their work is used. Perhaps their duties as managers require them to think beyond their narrow research interests and doing so is linked with broader moral concerns. Finally, we note that women score substantially higher on the responsibility scale net of other variables: perhaps Russian women scientists are more altruistic and less egocentric in their professional orientations than their male counterparts.

Our preferred models perform quite well by social science standards, accounting for 18.4% and 17.3% of the variance, respectively, in the duty and responsibility scales. Thus, although there are relatively few statistically significant effects – and, among them, only age and ethnicity correspond to theoretically derived hypotheses – these effects are relatively predictive of orientations toward social responsibility.

Conclusion

Our data indicate that, in broad terms, many Russian scientists have subjectively adapted to the changed institutional conditions that shape their professional lives, in the sense that they view the new institutions in general and grant-based financing in particular in normatively positive terms. However, the process of adaptation is uneven and diversity of opinions remains. Age and current success within the new system – especially at getting grants – are systematically linked to subjective adaptation: younger scientists and those who have obtained grants are more likely to approve of the institutional changes in Russian science. Prospective success, work context, and ethnicity are also associated with subjective adaptation, but less consistently so.

To what extent might these findings reflect the nature of our sample? Recall that all of our respondents – whether or not they themselves are ISTC grantees – work for organizations that have received at least some financing from the ISTC, and all are physicists, chemists, or biologists. We used weights to correct for the over-sampling of individual ISTC recipients, but we have no way to determine whether a similar distribution of views about new institutions and grant-based financing prevails in institutes where nobody has received ISTC funding or in other scientific fields (such as geology or botany.) It certainly could be the case that scientists in such institutes are more skeptical about the increasing role of grants and the changes that have taken place in Russian since the collapse of the USSR, because neither they nor their colleagues have benefited from ISTC grants. On the other hand, they may well have benefited from other sources of grant and contract funding. Moreover, our sample also excludes scientists who do R&D work for private companies (unless they also hold positions in state-based research institutes), and such scientists might be expected to take a more positive view of the institutional changes. Thus, only additional empirical research that incorporates scientists in other institutional settings can provide a firm basis for assessing whether our findings are biased by our sample. And while we should certainly hesitate to generalize our findings to Russian scientists in all disciplines or all institutional settings, our data nonetheless provide valuable quantitative benchmarks that both supplement the substantial qualitative literature on changes in Russian science and offer empirical grounds for comparative analyses in future studies based on different samples.

One drawback of conducting a benchmark survey is that by definition one lacks prior studies to serve as bases for assessing dynamics. For this reason, we cannot say whether Russian scientists' views toward the new science institutions in general and grant-based financing in particular have changed over time. However, whether or not a substantial change has taken place over time, our results stand in contrast to claims made in earlier studies regarding the orientations of Russian scientists. Interviews conducted with 40 Russian scientists in 1993 suggested that the predominant outlook toward grant-based financing in particular was negative (Gerber, 2001). Accounts of obstacles to reform within science often cite the "mentality" (Ben Ouagrham, 2000: 48) or "culture" (Kneen, 1995: 298) of scientists as persistent barriers. Our findings paint a different picture: by 2003 Russian scientists tended to view grants and other new institutions in much more positive light.

Three different mechanisms could explain why most Russian scientists now embrace the new institutions: the attrition from science of those who supported the old system (who, due to their hostility, never applied for grants and thus would find it very difficult to continue working in science), changes in the views of scientists as they attained success and became accustomed to the grant-based system, and cohort replacement (whereby younger scientists with no experience of budgetary financing gradually have taken the place of older scientists.) These potential mechanisms are not mutually exclusive, and all three mechanisms could have operated together.

We also found evidence that norms of social responsibility are common among Russian scientists, but hardly universal. The strong, positive effects of age on such norms imply that as new cohorts enter the ranks of Russian scientists, the community's aggregate level of commitment to serve Russia's interest and their sense of moral responsibility for how their work is used will probably decline further. We would attribute the effects of age to differences in Soviet-era and post-Soviet professional socialization. The Soviet Union inculcated a sense of national duty among the scientists it trained through its propaganda and its state-provided education. No institutions we know of in contemporary Russia serve the same function. Instead, younger Russian scientists today have had to struggle to make it professionally and economically, and messages of larger altruistic duty probably have less resonance for them. On the other hand, recent years have witnessed an upsurge of nationalist sentiment in Russia, and this may encourage younger scientists to embrace the national service ethic that still holds sway among their older colleagues.

Altogether, our findings provide some grounds for optimism regarding the long-term future of Russian scientists in that Russian scientists are evidently adapting to the institutional transformations they have experienced. We would expect that if the economic and political factors that have contributed to the institutional changes continue to transform the way that science is organized and financed in Russia, scientists will continue to adapt apace. On the other hand, our findings are less optimistic with respect to concerns about the potential for Russian scientists to contribute – purposefully or inadvertently – to the proliferation of weapons of mass destruction. During the Cold War, scientists' commitment to serve the national interests of Russia gave them a normative motive to participate in weapons related research. In the post-Cold War world, however, a commitment to serve Russia's interests has the potential to curtail any temptations of scientists to peddle their weapons-related expertise to terrorist organizations or pariah states, because such entities could easily attack Russia. The same goes for an individual sense of moral responsibility on the part of scientists for how their work is used: scientists who embrace such a norm would seem unlikely candidates to provide weapons know-how to terrorists. The evident decline of these two norms of social responsibility of Russian scientists therefore does not bode well on the proliferation score. At the same time, it may be that a more narrow professional commitment to scientific work – which disavows any larger ethical concerns – might actually enhance the productivity of Russian scientists and help keep them working in Russia.

While cross-national studies identify connections between different national science institutions and the norms and practices of scientists (e.g. Traweek, 1988), our study is the first we know of to empirically examine whether and how the scientists subjectively adapt to dramatic changes within a single country in the institutions that shape their professional lives. The end of the Cold War has brought a similar, though much less dramatic, set of changes to American science institutions (Solingen, 1993). It would be interesting to how extensively American scientists have adapted to these changes and whether similar similar cleavages to those we have found in Russia obtain in the United States and in other countries. We hope our study might offer some guidance as to how this topic might be approached, as well as a useful benchmark for comparative analyses of adaptation and norms among scientists in response to institutional change.

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TABLE 1
Descriptive Statistics for Control Variables, Survey of Russian Scientists

Categorical Variables:

	Unweighted	Weighted		Unweighted	Weighted
Age			**Position/Job title**		
19-30	8%	12%	Institute administrator	3%	2%
31-40	13%	13%	Head of laboratory	19%	17%
41-50	26%	25%	Professor	3%	2%
51-60	30%	28%	Lead scientist/docent	23%	22%
61-78	23%	21%	Senior scientist/teacher	31%	34%
Gender			Scientist	12%	14%
Male	74%	64%	Junior scientist	7%	8%
Female	26%	36%	Other	2%	1%
Ethnicity			**Moscow city**	62%	62%
Russian	84%	83%	**Russian grants,last 10 years**		
Ukrainian	4%	3%	Never applied	16%	15%
Jewish	3%	3%	Never funded	8%	7%
Other	4%	4%	Funded, non-PI only	40%	46%
Declined to state	5%	6%	Funded as PI	37%	31%
Highest degree			**Foreign grants, last 10 years**		
Some university	1%	1%	Never applied	19%	39%
Higher education	18%	17%	Never funded	13%	20%
Kandidat	53%	58%	Funded, non-PI only	46%	28%
Doktorat	28%	24%	Funded as PI	22%	13%
Scientific specialty			**Any contracts, last 10 years, with...**		
Physics	63%	45%	...foreign firms	26%	22%
Chemistry	19%	15%	...Russian firms	23%	28%
Biology	18%	40%	...Russian government	42%	47%
			Ever Started Scientific Business	9%	11%

Continuous Variables

	Means		*Standard deviations*	
Russian articles published, last 5 years	7.95	7.54	11.43	12.10
Intenational articles, last 5 years	4.87	3.75	7.50	7.03
Foreign conferences attended	2.39	1.88	4.57	4.11
Patents received	0.06	0.47	1.56	1.31

TABLE 2. Variables and Factor Analysis: Views on new science institutions and grants

A. Views on Impact of Changes in Russian Science on Respondent's Field

	Very negative	Somewhat negative	Neutral or no effect	Somewhat positive	Very positive	**Rotated Factor Loadings**	
New possibility to start a scientific or technical business	3%	11%	30%	45%	10%	**.410**	.108
Greater accessibility of competitive grants and contracts	0%	5%	11%	49%	35%	**.509**	.345
More cooperation between Russian and foreign scientists	1%	1%	11%	55%	32%	**.800**	-.108
More freedom to attend foreign conferences	0%	1%	9%	48%	42%	**.845**	-.143
More access to foreign grants and contracts	0%	1%	8%	46%	44%	**.824**	.059

B. Views on Grant-Based and Budgetary Financing

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	**Rotated Factor Loadings**	
Grant financing allocates funds more efficiently than budgetary financing	13%	34%	21%	22%	10%	.047	**-.848**
Grant financing often brings together effective research teams	17%	52%	12%	13%	6%	-.131	**-.502**
Budgetary financing allocates funds more fairly than grant financing	8%	23%	34%	29%	6%	-.090	**.786**
Budgetary financing decreases the incentive to do work with commercial applications	11%	40%	18%	23%	7%	.103	**-.516**
Scientific quality matters more for grant-based than for budgetary financing	45%		50%		5%	-.064	**-.457**

TABLE 3. Scientists on How Their Work is Used: Duty, Controls, Moral Responsibility

A. Sense of Duty to Serve Russia

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Rotated Factor Loadings	
Russian scientists have an obligation to serve Russia's national interests	37%	34%	15%	8%	5%	-.105	**.621**
A scientist should have the right to work on a project of military importance in whatever country he wants to	10%	23%	16%	31%	20%	-.021	**-.728**
Russian scientists who work abroad on military-related projects hurt Russia	25%	37%	16%	16%	6%	.101	**.832**
The Russian government should carefully control which scientists can work abroad on military projects and which cannot	23%	39%	14%	13%	10%	.009	**.650**

B. Sense of moral responsibility for how work is used

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Rotated Factor Loadings	
A scientist bears moral responsibility for how his work is used by those who hire him	20%	45%	15%	16%	4%	**-.718**	.068
In today's conditions where money rules, it is unrealistic to expect scientists to worry about how clients use their results	7%	43%	13%	30%	7%	**.673**	.098
A scientist should never do work that could harm society if it fell into the wrong hands	32%	30%	17%	13%	7%	**-.441**	.214
A scientist's first responsibility is to feed his family, not moral or ethical concerns about how his work is used	8%	18%	24%	37%	13%	**.766**	.114

TABLE 4
Regressions for subjective adaptation measures, with "survey corrected" standard errors

Dependent variable:	*Pro-change Scale*				*Pro-grant Scale*			
	B	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
Cohort (30 and under)								
31 to 40	-.011	.093			.016	.112		
41 to 50	-.090	.070	-.089 **	.032	-.033	.139		
51 to 60	-.108 *	.062	-.089 **	.032	-.222	.137	-.175 *	.101
61 and over	-.133	.089	-.089 **	.032	-.048	.147	-.175 *	.101
Russian grant status								
Never aplied								
Never funded	-.167	.111			-.037	.161		
Funded, non-PI only	-.078	.083			.156	.116	.201 *	.101
Funded as PI	-.148 *	.083			.177	.138	.201 *	.101
Foreign grant status								
Never applied								
Never funded	.002	.101			-.182	.116	-.243 **	.066
Funded, non-PI only	.185 **	.072	.153 **	.059	.012	.126		
Funded as PI	.027	.152	.153 **	.059	.195	.154	.241 **	.100
Contract, foreign firm	-.050	.052			.123	.097	.187 **	.084
Contract, Russian firm	.037	.090			.168 **	.073		
Contract, Russian gov't	.165 **	.061	.154 *	.075	.050	.125		
Ln(Russian articles)	.015	.059			-.027	.044		
Ln(International articles)	.037	.037			.044	.046		
Ln(foreign conferences)	.128 **	.043	.115 **	.042	.087	.060		
Any patent received	.015	.082			-.135 **	.046	-.115 **	.050
Started a business	.020	.067			-.042	.115		
Physicist	-.207 *	.107	-.196 **	.063	-.136	.086		
University	.132 *	.065	.140 *	.067	.095	.063		
Administrative Position	.011	.109			-.030	.108		
Ethnic Russian	-.123 *	.070			.029	.093		
Missing Ethnicity	-.086	.140			.063	.160		
Woman	-.046	.093			-.036	.072		
Graduate Degree	.032	.069			-.299 **	.069	-.288 **	.101
Moscow city	.011	.100			.126	.113	.245 **	.074
Regular salary(logged)	-.161 *	.078	-.157 **	.070	-.172	.115		
Missing salary	-.083	.096	-.058	.075	.001	.114		
Constant	5.417 **	.614	5.254 **	.504	4.647 **	.870	3.237 **	.125
R-square	.147		.124		.178		.132	

****p < .05, two-tailed** ***p < .05, one-tailed**

TABLE 5
Regressions for social responsibility measures, with "survey corrected" standard errors

Dependent variable:	*Duty Scale*						*Responsibility Scale*					
	B		**SE**	**B**		**SE**	**B**		**SE**	**B**		**SE**
Cohort (30 and under)												
31 to 40	.302	**	.091	.315	**	.100	.551	**	.085	.500	**	.096
41 to 50	.411	**	.090	.440	**	.090	.723	**	.114	.689	**	.113
51 to 60	.447	**	.083	.475	**	.096	.598	**	.119	.591	**	.097
61 and over	.783	**	.093	.791	**	.130	.852	**	.133	.787	**	.123
Russian grant status												
Never aplied												
Never funded	-.244		.212				-.061		.122			
Funded, non-PI only	.018		.215				.136		.094			
Funded as PI	-.102		.117				-.102		.120	-.196	*	.103
Foreign grant status												
Never applied				.466	**	.073						
Never funded	-.350	**	.122				-.442	**	.201	-.371	**	.148
Funded, non-PI only	-.422	**	.068				-.093		.119			
Funded as PI	-.332	**	.114				-.350	**	.121	-.303	**	.088
Contract, foreign firm	-.183		.122	-.276	**	.100	-.051		.129			
Contract, Russian firm	-.285	**	.111	-.190	**	.089	.043		.115			
Contract, Russian gov't	-.191	**	.065	.071	*	.039	-.113		.068	-.085	*	.048
Ln(Russian articles)	.048		.042				-.035		.035			
Ln(International articles)	-.074		.056				.031		.052			
Ln(foreign conferences)	.094		.065				.078		.054	.094	*	.049
Any patent received	.449	**	.141	.451	**	.158	.164		.138			
Started a business	-.243	**	.098	-.257	**	.122	.249	**	.107	.234	**	.106
Physicist	-.067		.107				.141		.121			
University	.172		.115				-.037		.064			
Administrative Position	.049		.114				.264	**	.101	.241	**	.101
Ethnic Russian	.237	**	.102	.217	*	.115	.112		.120			
Missing Ethnicity	.297	**	.132	.207		.158	.098		.238			
Woman	.055		.136				.313	**	.104	.269	**	.095
Graduate Degree	-.286	**	.105	-.330	**	.107	-.018		.079			
Moscow city	-.161		.098				.009		.103			
Regular salary(logged)	.056		.069				.009		.066			
Missing salary	.103		.118				.433	**	.204			
Constant	3.168	**	.621	3.010	**	.134	2.470	**	.597	2.773	**	.110
R-square	.213			.184			.196			.173		

****p < .05, two-tailed** ***p < .05, one-tailed**

APPENDIX TABLE A1. Constructed Scales: Descriptive Statistics and Correlations

A. Descriptive Statistics*

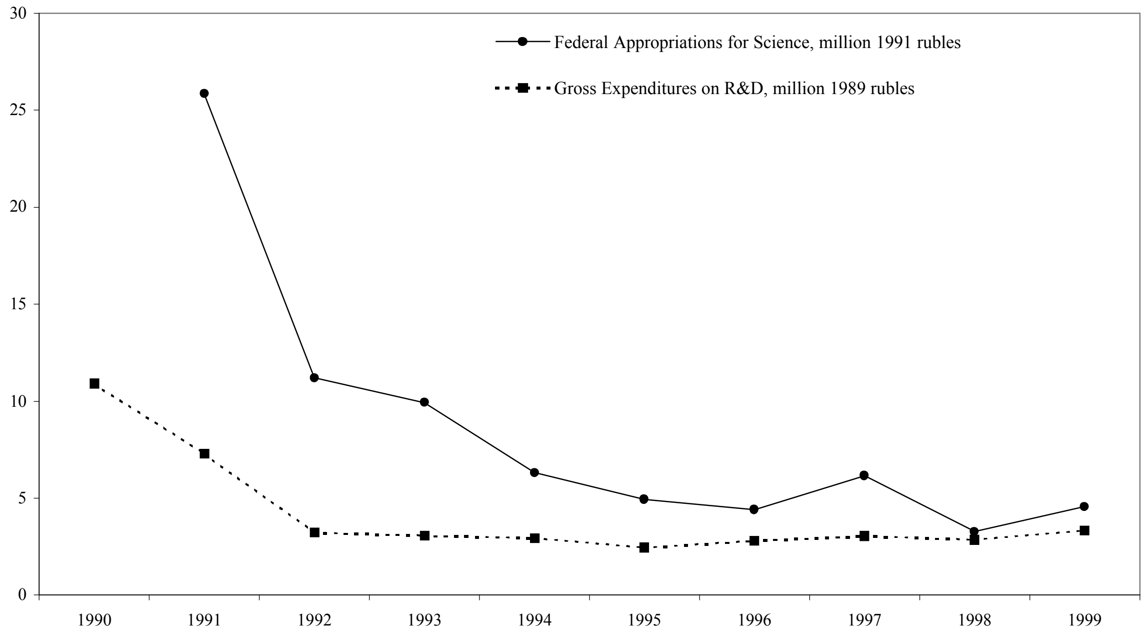
	Mean	Standard Deviation	Cronbach's Alpha
Pro-change: Support for post-Soviet changes in science	4.08	.56	.74
Pro-grant: Support for grant-based financing	3.37	.71	.63
Duty: Sense of duty to serve Russia	3.58	.89	.68
Responsibility: Sense of responsibility for how results are used	3.36	.79	.57

B. Correlations

	Pro-change	Pro-grant	Duty	Responsi-bility
Pro-change	1.00			
Pro-grant	.36	1.00		
Duty	-.19	-.08	1.00	
Responsibility	.09	-.01	.25	1.00

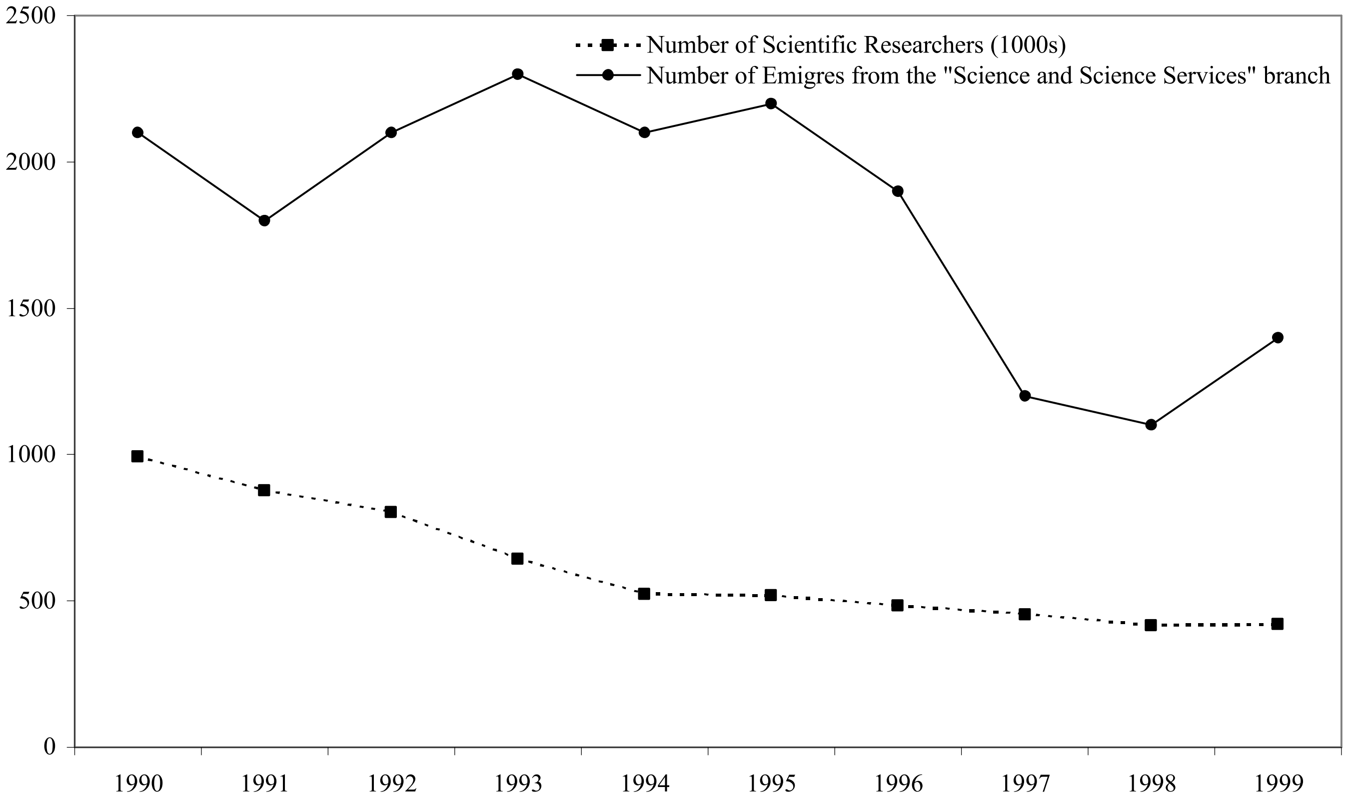
*All scales run from 1 to 5.

Figure 1: Financing of Russian Science During the 1990s



Sources: Mindeli and Gokhberg, eds. 1999, pp. 42, 44; Mindeli and Gokhberg, eds., 2001, pp.42, 44.

FIGURE 2: Personnel and Emigration, 1990-1999



Sources : Ushkalov and Malakha 1999, p. 51; Mindeli and Gokhberg 1999, p.28; Mindeli and Gokhberg 2001, pp.28, 40

Figure 3: Histogram, Pro-change scale

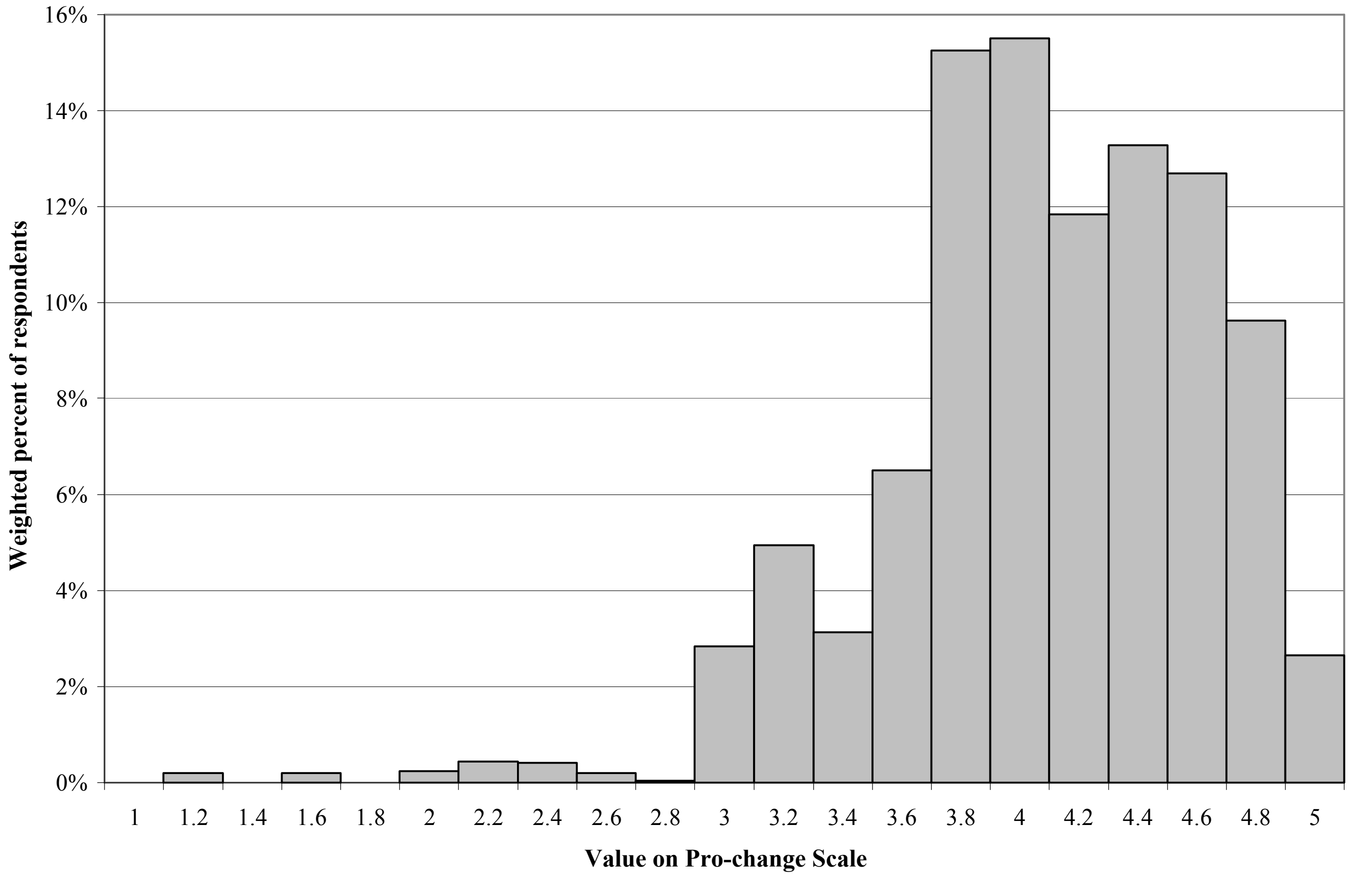


Figure 4: Histogram, Pro-grant scale

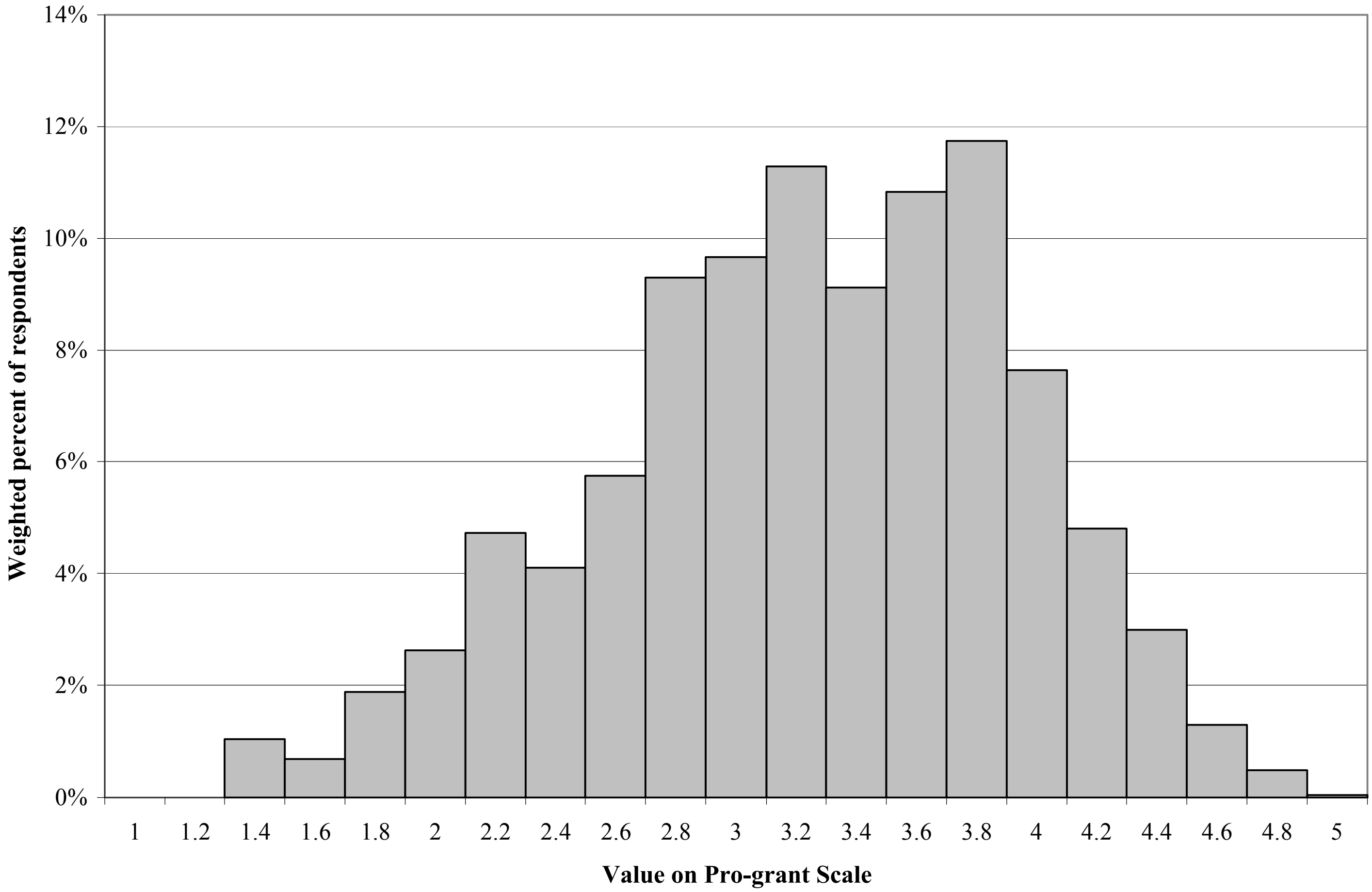


Figure 5: Histogram, Duty scale

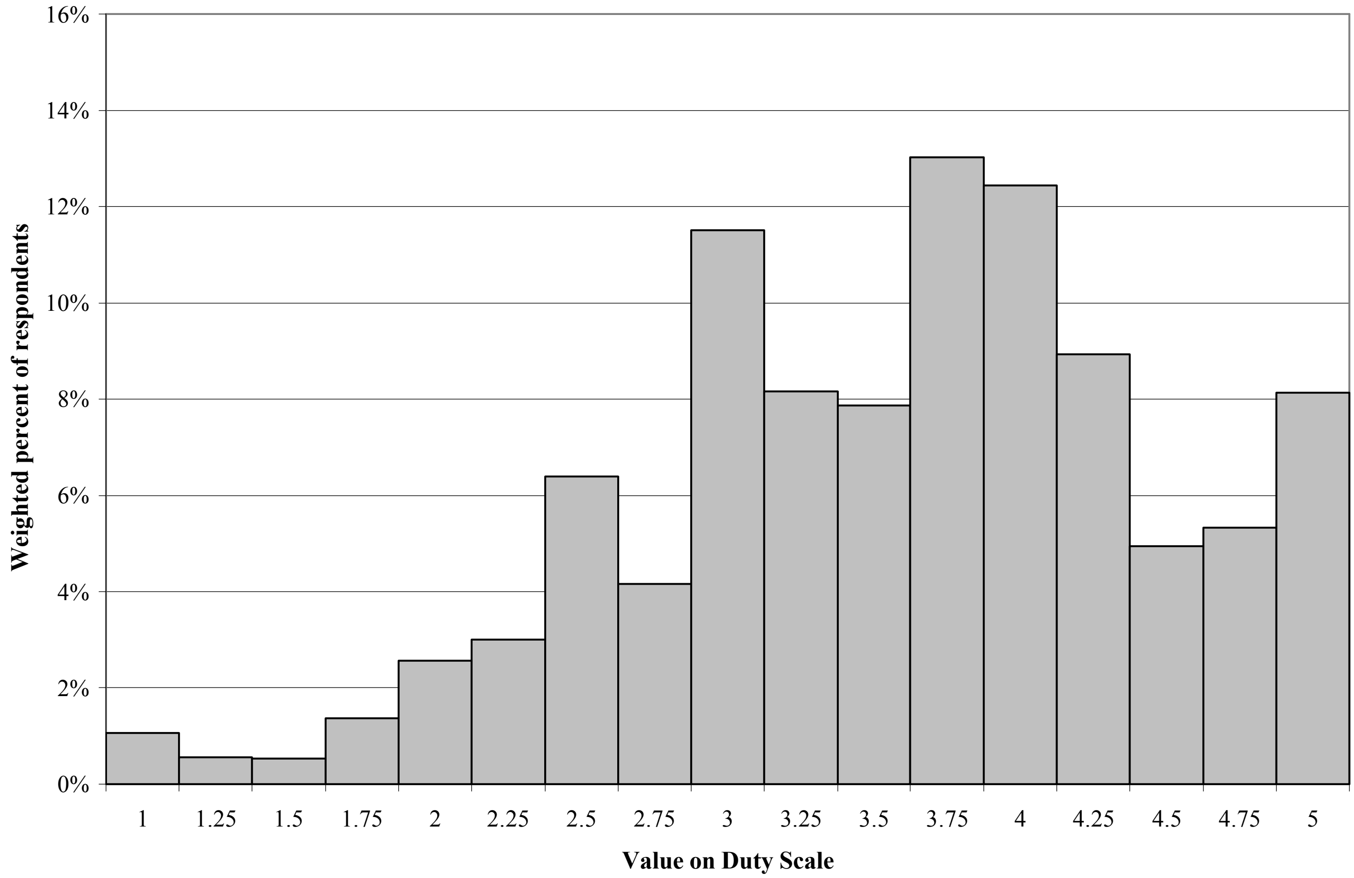


Figure 6: Histogram, Responsibility scale