Russia and the Nanotechnology Revolution

Looking Beyond the Hype

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In April 2007, then Russian president Vladimir Putin extolled nanotechnology research as the key to establishing Russia's competitive advantage in the high-tech world economy and the next round of the arms race. Ever since, the Kremlin has embraced nanotechnology as a strategic linchpin to its long-term global resurgence, asserting state stewardship and pouring billions into boosting the sector. Inside Russia, the prospects for being at the forefront of the unfolding technological revolution are a source of national pride and presumed to augur well for diversifying the economy beyond the energy crutch and for establishing more favorable foreign ties. By contrast, outside commentators typically regard the bravado as a harbinger of more difficult times ahead, emblematic of a statist-nativist turn in the new Russia with neo-imperialist implications for forceful reintegration across Eurasia and mounting geostrategic competition.

Upon closer inspection, there seems to be both less and more to Russia's nanotechnology exuberance. There is "less" in that there are real technological uncertainties surrounding the significance of the nanotechnology revolution, as well as deep-seated institutional constraints on the Russian leadership's capacity to realize its grand visions. Yet, there is "more" in terms of greater potential for stimulating political transparency and decentralization within Russia and for advancing constructive engagement than is commonly appreciated. Accordingly, the next U.S. administration would be well advised to temper reaction to

Moscow's goading while forging rules of the road that encourage mutually beneficial innovation and foreign investment and that avoid precipitating an intense security dilemma.

Russia's Nano-Hubris

Uncertainty surrounds the nanotechnology revolution—the study, creation, and manipulation of matter at the nano-scale, ranging between approximately one and 100 nanometers (1000 times smaller than the next largest unit, the micron). Although in its infancy and with the line between science and fiction blurred by futuristic hyperbole over self-replicating "nano-bots" and "grey goo," an increasing number of nanotechnology-enabled commercial and military applications have begun to appear, ranging from enhanced sunscreen protection to biomedical imaging, novel power sources, artificial intelligence, and smart sensor devices. With scientists already pushing convergence of engineered systems with basic physical, chemical, biological, and human processes, there is growing confidence among researchers, industrialists, and policymakers that nanotechnology represents the "next frontier" of technological advancement. Yet, the enthusiasm for mushrooming opportunities for economic development and defense is matched by concerns for unprecedented environmental, ethical/legal, public health, and security risks unleashed by nanotechology research and development. Uncertainty over technical substance and direction notwithstanding, global sales of nanotechnology-related products are widely expected to climb to one trillion dollars by 2015, with players such as the United States, Japan, China, the European Union, India, and Iran scrambling to implement respective national strategies to spearhead the revolution on commercial and military fronts.

The potential has not been lost on Russia with its long tradition as a leader in basic science, including early research on nanostructures in the 1970s. The current Russian government has seized upon this legacy, as well as the promise of the nascent nanotechnology revolution to project Russia's new self-image as a great power and its visions for strategic opportunism. The Kremlin now frames the leap into nanotechnology as integral to a high stakes global race, with potential for yielding payoffs greater than those in the nuclear and space fields combined for defining Russia's future as a superior "innovative" economy and military. Breakthroughs offer not only to erase the humiliation associated with the protracted post-Soviet transition and Russia's disappointing performance in the computer and biotechnology sectors, but to secure the country's emergence as one of the world's leading economies with conspicuous competitive advantages. Inextricably linked to the restoration of national self-confidence, the nanotechnology revolution has become a beacon for the Kremlin's claims to global leadership for the foreseeable future.

Moscow's visions are backed by action. With its sights set on jumpstarting a

national nanotechnology program that will lay claim to 3-4 percent (over 20 billion dollars) of the market by 2015, the Kremlin has pledged nearly eight billion dollars in state support for related research and production, with annual outlays slated to exceed those in China and on par with the United States. As distinguished from the private sector-driven approach to research and development adopted by others, Russian authorities have again looked to the state to be the locomotive for its national nanotechnology strategy and development. This is embodied by the formation of a government council for nanotechnologies, headed by First Deputy Prime Minister Sergei Ivanov, as well as by the creation of the tax-exempt state corporation Rosnanotekh. The latter, supervised by state appointees with pledged government holdings of six billion dollars for future investment, is authorized to set national priorities, identify and coordinate "promising" research and development, and commercialize specific nanotechnology projects. Intent on spreading the magic of the energy sector to nanotechnology, the government enlisted managerial and financial wizards from the electrical power administration, designated the Kurchatov Institute as a national lab to oversee related scientific research, allocated funds derived from the forced sale of Yukos assets, and identified the fuel and energy complex as the main customer for initial products. By employing financial and administrative incentives to attract private capital, Rosnanotekh is expected to sustain and guide the country's research and industry towards meeting national objectives, while earning profits for the state in the process.

Similarly, Moscow has seemingly staked out a competitive and ambitious trajectory for its strategic nanotechnology pursuits. While other states have generally downplayed prospective military applications (or trumpeted development of "defensive" human sensor and protective gear), Russian scientists and officials have proclaimed that future warfare will be premised on an offensive-dominated, nanotechnology-driven arms race. Putin has struck an especially ominous tone by declaring that Russia will "spare no expense" at developing "super-effective" offensive military applications. This rhetoric took on new meaning in September 2007 with the testing of the "father of all bombs." Notwithstanding the crude nano-link to this fuel air explosive, Russian officials and the high command heralded the device as comparable to a nuclear bomb (without the same environmental impact), marking the onset of the nanotech revolution in military affairs.

At the same time, Moscow actively seeks opportunities to corral international pursuits. Reminiscent of calls for a Russian-dominated "gas OPEC," President Dmitry Medvedev champions the creation of an "integrated nano-industry" of the Commonwealth of Independent States (CIS) to avert unnecessary rivalry, restore valuable regional scientific ties, and reclaim the rightful place of Eurasia atop the global high-tech economy. To date, Russia has inked deals with Astana to jointly sponsor Kazakh nanotechnology projects, and with Ukraine to develop

a joint "seed corporation" to help shepherd Kyiv's long-term nanotech aspirations. Moscow's "nano-pursuits" are not confined to the post-Soviet space, as it openly covets cooperative national ventures with China, South Korea, and Hungary, among others.

Gaps Between Centralization and Control

Notwithstanding the promise for reviving Russian science and industry, the nanotechnology revolution presents fundamental challenges that both render questionable the appropriateness of state centralization and spotlight the government's institutional weakness. Since nanotechnology represents a revolution "at the bottom" of matter that holds out advances for numerous fields, applications, and techniques, its properties inherently assume an intersectoral dimension that places a premium on the cross-fertilization of information and knowledge among a wide range of small, medium, and large-sized research institutions. This poses acute problems for hierarchical systems of innovation, especially in states (such as Russia) with a legacy of imposing self-contained, secretive, risk-averse, and sector-specific R&D silos. Given repeated problems with interdepartmental coordination within the government and preferential designation of the nuclear-centric Kurchatov Institute as the technical gatekeeper to state-sponsored research, it seems that old habits may die hard in the new Russia. This is compounded by the appointment of state administrators with little experience at managing diffuse scientific research, let alone with expertise in nano-science and –engineering.

The retrenchment towards statism also inflates structural disincentives to pushing the frontiers of the nanotechnology revolution. The expressed objectives of Rosnanotekh including facilitating R&D and converting such advances into strategically important production—two hallmark problems with the Soviet system of vertically integrated science and production associations. At this stage, most scientists agree that material behavior that takes place on the nano-scale is more accurately captured by quantum, not classical, mechanics, and the real payoffs rest with invention and molecular manipulation, leaving tremendous uncertainty over specific applications. Accordingly, with the current emphasis placed on commercialization and production, Rosnanotekh risks diverting qualified scientific cadres from making their mark on innovative research. By targeting three times more spending to nanotechnology than to other areas of research, the state is poised to crowd out traditional sponsors of basic research and to exacerbate Russia's brain drain from research to production in this growing field of science. Moreover, as a state corporation, Rosnanotekh has a strong motive to earn profits on government money via successful commercialization of specific nano-based projects and other avenues of financial investment, both of which can come at the expense of cultivating innovative research with unpredictable or indirect profit streams. There is a similar dynamic

in the military sphere, as aggregate shares of expenditures for basic and applied R&D are projected to decline through 2010 relative to the increase in procurement. With rising prices of new weapons, this trend may understate the real constraints on fielding cutting-edge nanotechnology systems in the future, thus hampering the military's role as a prospective steward of the national effort.

By the same token, the nanotechnology revolution threatens to hit Russia's institutions of vertical control where they are weakest. As Russian officials openly acknowledge, the keys to both sustaining nanotechnology and earning state profits will rest with attracting private sector investment. However, the persistence of opaque and selectively enforced property rights is likely to frustrate these objectives. In particular, weak patent laws and the precedents set by the state's discretionary revision of the rules of the game in other sectors not only damage the general business climate, but especially discourage the venture capitalism needed to advance Russia's nanotechnology ambitions. Not surprisingly, and potentially a harbinger of things to come, the first project funded by Rosnanotekh was awarded to a company with Dutch jurisdiction of ownership. Similarly, the pervasive corruption throughout the Russian government has discouraged many scientists, who are highly skeptical that state earmarks and budgetary promises will trickle down to support "true" research and projects. That there are questions about how leaders of Rosnanotekh made their riches and that the state corporation's six billion dollar holdings will be deposited with eight banks seems to feed this anxiety.

Strategic Implications

Russia's grandiose aspirations for nanotechnology present both challenges and opportunities for the United States. On the one hand, the intrinsic scientific and technical uncertainty of the field makes it difficult to predict constructive avenues for competition, cooperation, and/or regulation. This is especially challenging in the military sphere, as we are only at the edge of appreciating the range of prospective applications and with little understanding of how nanotechnology is likely to affect either the distinguishability or the relative advantages of future offensive or defensive systems. Furthermore, this uncertainty creates a situation ripe for states, such as Russia, that are in the course of projecting their self-image on the unfolding landscape and can elevate certain directions of research at the expense of other equally promising directions. By allowing Moscow's rhetoric and ambitions to drive external reaction, Washington risks misperceiving its intentions and prematurely locking in on strategic competition, thus converting the promise of nanotechnology into a new realm of costly commercial rivalry and arms racing.

On the other hand, political enthusiasm and deep-seated constraints on Russia's capacity to embrace the nanotechnology revolution create new openings for reviving the U.S.-Russian strategic partnership. As the fruits of the

nanotechnology revolution are uncertain and diffuse, the risks are global, and each state brings comparative advantages to related research and production, there are both common interests and aversions that impel states to establish international best practices. Russia's commitment to the field will require that it play a constructive role in this process. Yet, as the realization of Moscow's lofty ambitions and future geostrategic identity are constrained by self-imposed structural features, Russia also has a strong stake in making hard choices to decentralize decisionmaking and to strengthen political and economic transparency without active international prodding. As such, the nanotechnology revolution will likely introduce a new playing field for engaging a Russia stripped of the defensiveness and insecurity that imbued the asymmetrical relationship of the early post-Soviet agenda, and ripe for forging mutually beneficial and reciprocal interaction. In this respect, nanotechnology's very nature will likely present new opportunities "at the bottom" for re-grounding the U.S.-Russian strategic partnership.

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