Research

Publicly Funded National Labs Important to U.S. Innovation

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Summary

The primary vehicles for energy innovation research in the United States are the Department of Energy's (DOE) 17 National Laboratories. Some argue that government funding for innovation research is unnecessary, as the economic benefits, if they materialize, may not be realized for many years, and the funding itself could displace private funding sources. The Trump Administration has proposed cutting funding for federal innovation research labs. To evaluate this position, this paper compares the Labs' performance with that of the private sector. It finds:

- The National Labs receive approximately $12 billion per year in funding, approximately $5.4 billion of which is dedicated to non-weapons research. With those funds they produce 1,500 inventions per year, and around 700 patents per year.
- For the National Labs, total R&D funding per patent produced by the Labs is around $7.6 million, nearly twice the R&D investment outside the labs of $4 million per patent. However, the Labs spend $16.4 million per revenue-generating license agreement, whereas outside the labs it is nearly four times higher at $63.9 million.
- The National Labs are likely not underperforming compared to alternative innovation investments, but government assessments of the Labs indicate that they could provide even more value if the DOE's bureaucratic oversight is reformed.

Introduction

As the U.S. government is projected to run $1 trillion annual deficits, deficit hawks in the administration are seeking to cut the federal government's funding for innovation research. Specifically, in the crosshairs are Department of Energy's (DOE) National Laboratories (National Labs, or Labs), which receive roughly $12 billion. The President's FY2018 budget proposed cutting energy innovation spending by 30 percent, and the FY2019 proposed budget put forward a $3.3 billion cut (19 percent) to non-defense DOE activities (though an addendum proposed offsetting that cut with $1.5 billion in new spending for sciences). Priorities reflected in the administration's proposed budgets for research conducted by the Labs are on security and early stage science research, rather than energy research. Advocates of cuts contend that the applied research organizations like the Labs could be replaced by the private sector.

These arguments for cutting the Lab's innovation budget often ignore the role the Labs play in matters of national security (particularly with relation to nuclear weapons). Further, the energy innovation mission of the Labs is intended to leverage the national security expertise and technology the Labs possess to create technology that can be delivered to the private sector.

To determine if the private sector could produce equal or greater economic value, this study aims to measure the outputs of the National Labs by examining patents and patent licensing rates relative to global trends. Further, this paper addresses the argument that cutting funding to the Labs would lead to increased innovation research outside the Labs in the private sector and concludes that better opportunities to maximize value lie in reforming the bureaucratic and political approach to overseeing innovation research.

Why Care About Government-Funded Innovation Research?

The United States' fundamental approach to innovation in the energy industry has been for the federal government to fund research organizations known as the National Laboratories. This investment model began in World War II, when the U.S. government fostered war-related research at civilian laboratories. The Labs were borne out of the Manhattan Project, as the U.S. government began directly managing the radiological efforts at laboratories that were part of the Massachusetts Institute of Technology (MIT) and University of California Berkeley, and then established new laboratories dedicated to nuclear weapons research. It was from these government-managed labs, now known as the National Laboratories, that the technology to build a nuclear weapon was developed.

Since World War II, the number of National Labs has swelled to 17, all of which are managed by the Department of Energy (DOE), though are operated by the private sector (not too different than defense contractors). They operate under a "management and operating" model (M&O), which involves the DOE defining research objectives, while the Lab researchers are free to determine the most efficient way to achieve that objective.

The M&O model has been mostly heralded as a success, as the National Labs have delivered numerous economically significant inventions. This includes the clean room (allowing development of microprocessors for computers), lasers, optical media storage, horizontal drilling that finally made oil and gas extraction from shale profitable, a small role in the development of the Internet, and much more. A 2016 report to Congress indicated that the Labs deliver around 1,500 inventions per year.

From an economic perspective, though, the argument that the National Labs provide so many inventions is incomplete. Funding for the Labs is around $12 billion per year, or around 0.02 percent of gross domestic product. The Labs' basic research (as opposed to their applied research) is often supported on the grounds that it is filling a gap in the market. The private sector frequently has little incentive to invest in early-stage research, as its payoffs are too uncertain or too distant—or both. But basic research is only part of what the Labs do. Their work on energy innovation—bringing basic research insights into more usable forms—is a prime example. Of course, this gives rise to the critique that the Labs' budget would provide more economic growth if spent by the private sector, and that government-funded applied research is much worse at identifying profitable opportunities. Taken further, the appropriateness of using taxpayer funds to innovate beyond basic research that may ultimately be made profitable in private hands is a legitimate concern.

While the Labs receive $12.7 billion annually (nearly half the DOE budget), the majority of those funds are spent on weapons-related research and defense activities—something the private sector has weak incentives to pursue, and the government remedies this by funding such activity anyway. Funding applied research from the

Labs leverages the advances of weapons-related technologies for use by the private sector. Prime examples of this transfer dynamic are the civilian uses of nuclear reactors and lasers, which were sought for the purpose of acting as an ignition for nuclear weapons.

Further, many of the market failures present in basic research investment—such as a long lead time before a return on investment, and the potential for competitors to get similar benefits from innovation without bearing the investment costs—are still present to a certain extent in applied research. A study in 2000 found that federally funded applied-research laboratories complemented (and did not necessarily displace) private research, though public R&D investments in applied research *not* in the Labs may be substituting for private sector capital. Simply, even though public support of applied research is worthy of scrutiny, the National Labs are believed to be producing research that would not have been undertaken otherwise.

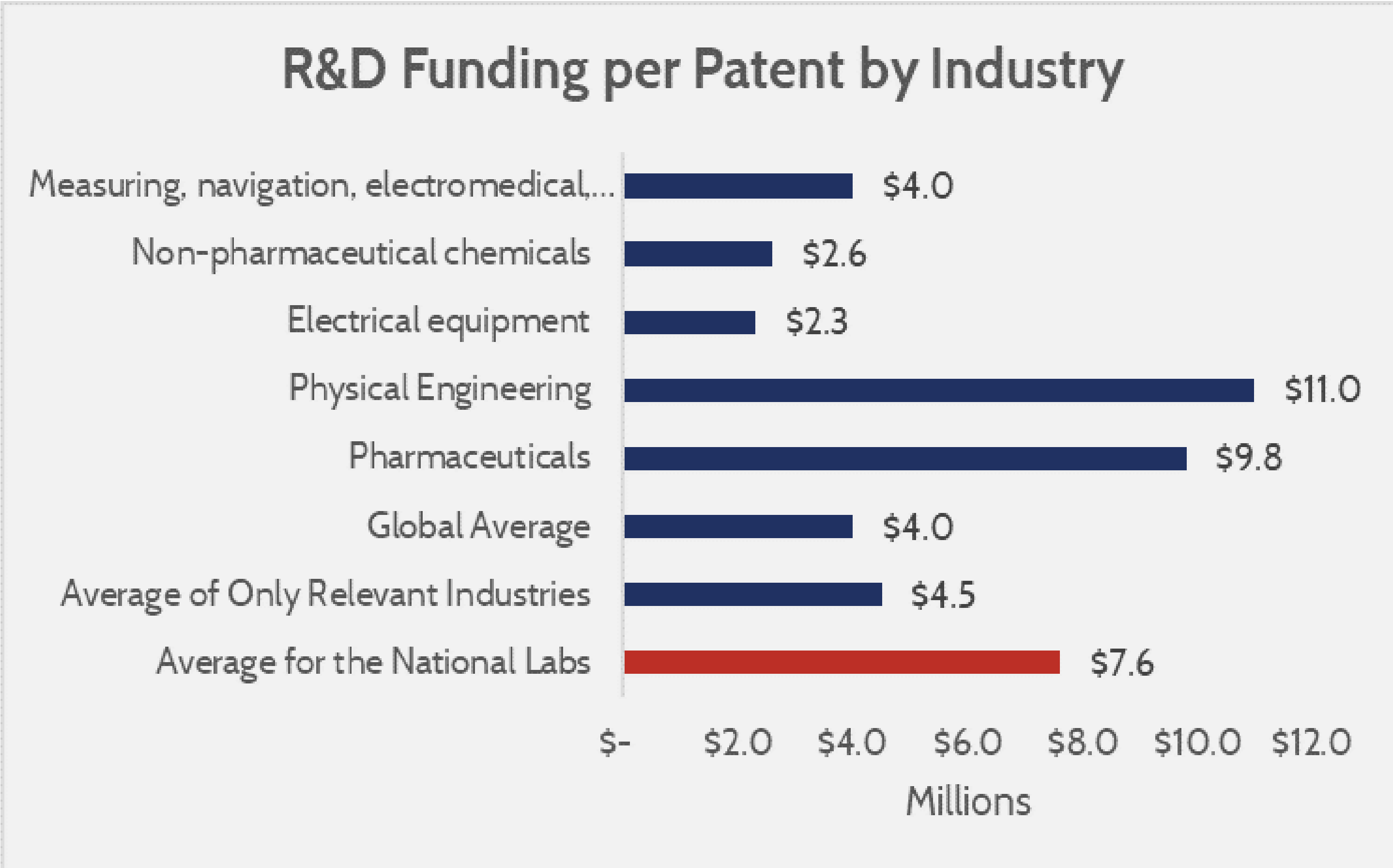
The National Labs provide applied research that is not easy to replace, and their mission is not easily fulfilled by the private sector—meaning capturing those opportunities for innovation requires a continued public investment. These facts do not indicate how much impact the Labs' research actually has, however. How much use does their research get? Are they comparable in their productivity to funded research outside the National Labs?

Current Performance of the National Labs Relative to the Other R&D

Gauging the performance of innovation is a notoriously difficult economic question. The Congressional Budget Office notes that the best way to measure the benefits of innovation is to survey businesses that have benefited from an invention, and to estimate how much profit can be attributed to such an invention—but even that approach is rife with potential errors in methodology. This report aims to gauge performance by answering a simpler, comparative question: Does funding research at the National Labs perform as well as alternative R&D investments?

Measuring outputs of research is challenging, as inventions have an extraordinary range in their potential contribution to the economy. Nobody expects a more reliable cabinet door hinge to provide as much benefit as an HIV-curing drug (something Los Alamos National Lab is working on currently), but both are a single invention. However, in aggregate, a reasonable estimation of performance can be gleaned by observing the outputs of the National Labs in terms of patents relative to their research funding levels, compared to general R&D funding in the affected industries. Further, observing the number of patent licenses relative to their research funding compared to the patent licensing in relevant industries can offer insight as to what degree the inventions are likely to contribute to the economy.

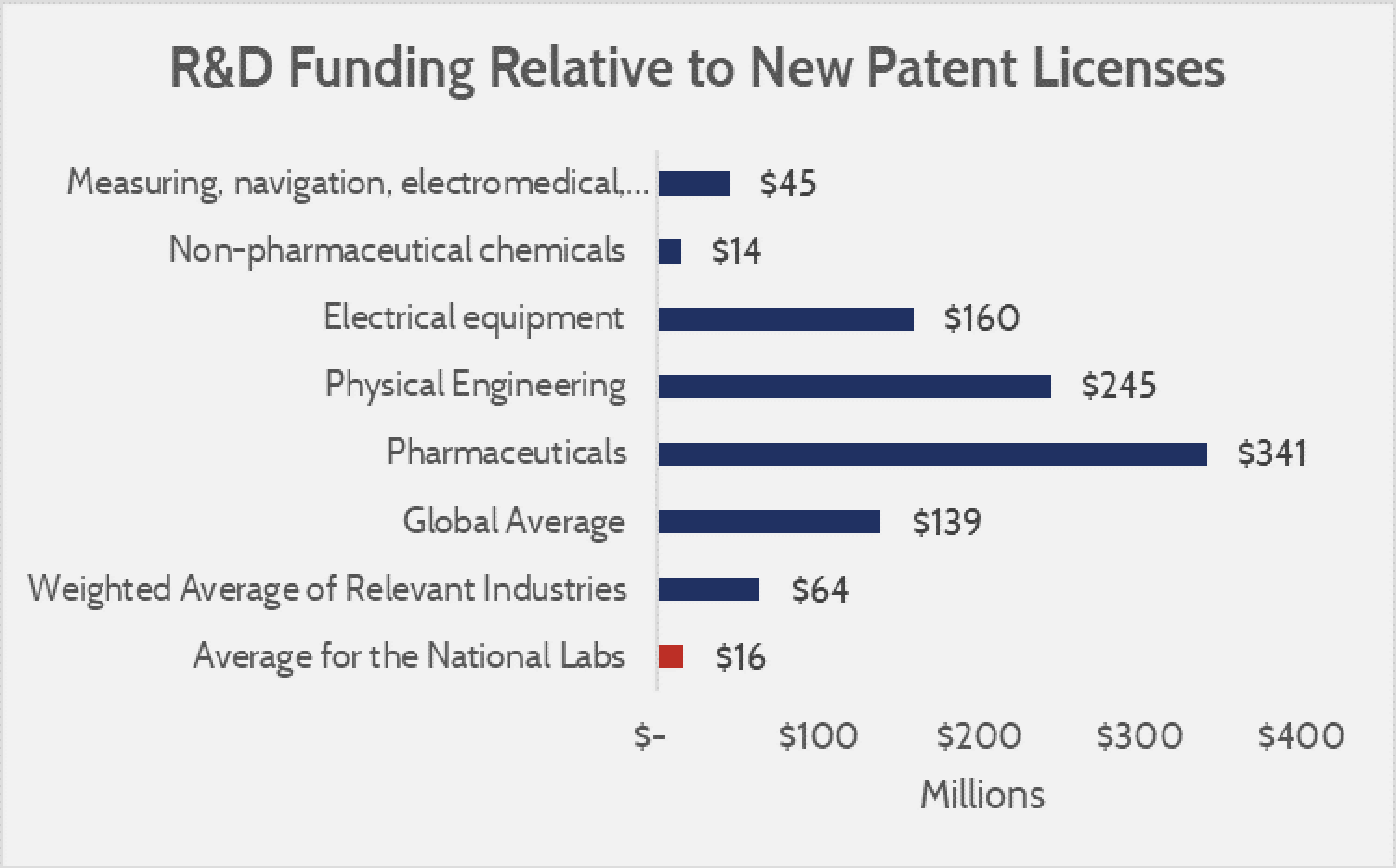
The chart below compares dedicated research spending in the National Labs relative to its 713 patents produced in 2014 to global R&D investments and patents reported in the National Science Foundation's Business Research and Development Innovation Survey, the latest data for which is 2013. The R&D investments outside the labs are broken down by industry, showing industries for which the Labs produced patents in (showing 5 of 11 industries, from most common to least common).



Source: AAF Estimates Using DOE and National Science Foundation data.[1]

The above graph shows that, for the relative amount of money spent on research, the National Labs produce about half as many patents as general research and development investments in related fields. At approximately $5.4 billion of research funding, and producing 713 patents, the Labs cost about $7.6 million per patent, whereas general R&D funding in relevant industries is only $4.5 million for each produced patent. This is not surprising, as government-funded research tends to be directed to early stage research that is less likely to produce a patentable invention. Nevertheless, it does not provide the best defense for the Labs.

The chart below illustrates a different view of the National Labs' relative performance. It compares R&D funding relative to patent-license agreements secured by the Labs and approved license agreements outside the Labs.



Source: AAF Estimates Using DOE and National Science Foundation data.[2]

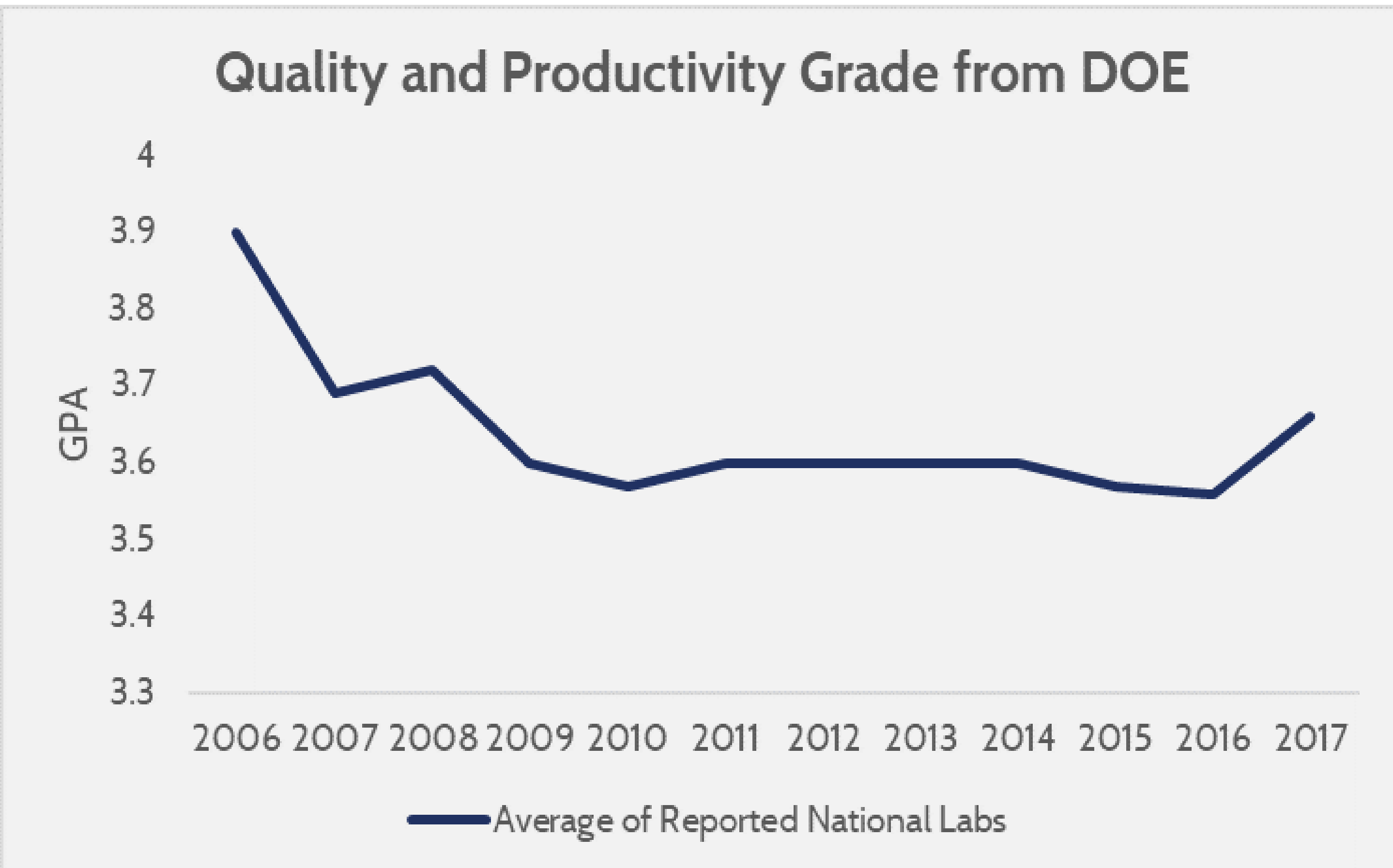
When observing the National Labs' $5.4 billion in funding relative to 330 patent licenses, the Labs cost around $16 million per patent license, whereas the weighted average of relevant industries had funding of $64 million annual funding relative to each new patent license. Relative to general R&D investments, inventions from the National Labs are licensed at a rate nearly nine times higher than the global average, and nearly four times higher than alternative R&D investments in relevant industries. This shows that the deployment of the Labs' technology is high, and is valued by the private sector, which must pay a license fee to make use of the Labs' patents. Patent licenses from the Labs raised $36.07 million in 2013.

As a caveat, it may be easier to acquire licenses from National Labs' patents than competitors, which could explain the Labs' much higher rate of patent licensing. In 2013, the Labs raised $36 million in patent license revenue, and issued 330 new income-bearing patent licenses. Revenue is not directly tied to new license agreements, as past agreements still active are measured in revenue (in total, there were 5,217 active licenses from the Labs in 2013). Total patent income relative to new patent licenses from the Labs is only around $109,000. A geometric mean (a measure of average resistant to outliers) of the comparable industry-wide data shows that total license revenue relative to new patents outside the Labs is much higher, at over $10 million. This discrepancy may be explained largely by patent types (utility patents versus trademarks, designs, copyrights, etc.), and behavior of patent issuers (the technology-transfer mandate of the National Labs versus profit seeking businesses that retain high value licenses). Nevertheless, it does indicate that a reason for so many more patent licenses coming from the National Labs might be because their patents are far cheaper to license.

The upshot of these data points is that the performance of the National Labs in producing economically beneficial inventions is at least comparable to, and perhaps exceeding, the performance of other R&D investments outside the Labs. There is little evidence to show the Labs are underperforming relative to alternative innovation investments. Despite these indicators, definitive assessments as to the net economic value of innovation delivered from the National Labs compared to value from alternative R&D investments remain murky and inconclusive.

Policy Recommendations

The above data does not suggest that there is no room for improvement in the innovation mission of the National Labs, particularly in the energy innovation sphere. The Labs are graded on their performance, and their aggregate grade point average for quality and productivity of research has declined since the earliest kept grades of 2006. The only appreciable boost to productivity came during 2017—mostly due to improvements at the Princeton Plasma Physics Lab.



Source: DOE National Laboratory Report Cards

The National Labs are performing within expectations but are not realizing their full potential. The salient question is not whether the Labs are overfunded, but rather what impediments are there to the Labs operating as efficiently as possible?

The first annual report on the Labs' performance was delivered to Congress last year, and highlighted eroding leadership from the DOE, as well as needless regulatory restrictions, as the biggest impediments to research performance. Reports from the DOE's Office of Technology Transitions (OTT), congressional testimony, and other reports to Congress all converged on the diagnosis that the DOE could improve its ability to define missions while becoming less restrictive in how the Labs fulfill those objectives.

As an example, both the OTT's 2016 Technology Transition Execution Plan (TTEP) and the performance report to Congress last year highlighted unnecessary restrictions on the use of funds for travel for National Labs' employees. While the rules are in place to preserve accountability in the use of public funds, the reality is that these regulations are an impediment to researchers' ability to travel to conferences, confer with peers, and share research. Similarly, any restrictions in how the Labs may use funds to carry out day-to-day tasks are sure to diminish the effectiveness of the M&O model, which at its core is intended to leverage the advantages of the private sector's ability to cut costs and improve administrative efficiency. The Trump Administration would be wise to make identifying unnecessary regulations on the Labs' activity a priority.

While the Trump Administration is seeking to cut the National Labs' funding (a move that is unlikely to survive Congress), it is ignoring the Labs and their mission in other ways. Many positions at the DOE remain unfilled, and the OTT's standing directive from the TTEP is from 2016. The guiding plan for the Labs remains one that prioritizes fulfilling the objectives of President Obama's "Climate Action Plan." The Obama Administration's mission to OTT was, in and of itself, riddled with attempts to direct research efforts to its own preferred technologies—an approach that will not maximize economic benefits.

On the issue of defining missions, DOE Secretary Rick Perry should act as the bridge between the policy sphere and the government's research arm. Recall, the original purpose of the National Labs was to focus government funding around the policy objective of developing a weapon that would allow for swift conclusion to an ongoing war. Since that time, rather than focusing on core strategic or economic concerns of the U.S. government, the Labs are now focused on politically influenced research topics.

As an example of how current policies may be ineffective, a significant focus of the Labs' energy research is on clean energy technology, specifically renewable energy and energy efficiency. However, some of the best environmental benefits from the Labs' research did not come from those programs, but rather from fossil fuel research on horizontal drilling technology, which has since enabled cleaner natural gas to replace coal.

The lesson here is that less prescriptive mandates may be able to deliver more benefits. A better relationship between the DOE and the Labs would be one where the DOE can identify policy issues that are important to national security, public health, or economic growth, and leave the Labs free to discover the best innovation pathways that achieve those objectives. The administration should produce a new TTEP that focuses on allowing the Labs to pursue the most promising avenues to innovation, rather than steering research to the previous administration's political goals.

While expanding freedom of the National Labs to pursue objectives, the DOE could also reconsider its approach to the statutorily required reporting metrics that it produces. Each year, the OTT is supposed to produce data that shows the performance of technology transition programs, with the purpose of offering the Labs insight that allows them to better determine what areas of research are most valued. The data that OTT provides, though, is mostly based on broad metrics of total license agreements, research agreements, patents, and inventions lacks sufficient context to craft a counterfactual. The objective of the Labs is to *complement* research that happens outside of the Labs, not to replace it, and thus the objective of the data is to show not only that the Labs are producing patentable research with commercial value, but also how their performance in specific industry areas compares to alternative efforts that could or would be taking place otherwise. To help the Labs fulfill their objective, the data that identifies R&D areas that have value but are underinvested in would be more useful, and cannot be done with the current narrow scope of data OTT provides.

Conclusion

While there is debate about the appropriate level of government involvement in innovation research and the balance between public and private investment, the evidence suggests that the National Labs are doing economically valuable work that is not easily replaced by the private sector or alternative innovation investments. Scrutiny of the Labs' performance would likely be better placed on the managerial relationship between the DOE and the Labs, rather than focused on the absolute funding levels. Government reports highlight that the stringent regulatory approach of the DOE has inhibited the Labs' productivity. Further, the guidance documents that remain in effect indicate that research efforts are being unduly focused on fulfilling political objectives of an administration no longer in power, rather than on broader policy goals.

The National Laboratories are national assets that have helped produce the incredible technology that has propelled advancement since World War II. In crafting policy that governs the Labs, it is important for policymakers to focus on the unique benefits these institutions are able to provide, and how to restore the relationship between the Labs and the government to a state that once again maximizes the productivity of the Labs.

[1] The above assessment was determined by taking the DOE's budget for the National Labs in the relevant year, subtracting funding specific to defense purposes, and expressing the costs as the remaining value relative to the number of patents reported by the OTT. For a comparison by industry, 40 of the National Labs' 713 patents in the relevant fiscal year were randomly sampled and using the Patent Office's description a determination as to which North American Industry Classification System (NAICS) code was relevant to produce an industry-specific comparison. The classification system for patents is not comparable to the NAICS, so each patent had to be determined individually to allow for comparison to the National Science Foundation's BRDIS data. The charts show the five most common industries that National Labs' patents are relevant to, from the top being most common (25 percent of sampled patents) to least common (3 percent of sampled patents, or 1 of 40). Overall, the 40 sampled patents fell into 11 separate industries.

[2] Ibid.