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Understanding U.S. S&T Competitiveness: Rethinking NSF's *S&E Indicators* Report

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While the NSF report contains valuable information, its analysis of U.S. technology-based economic competitiveness is seriously flawed and misleading.

For 42 years the U.S. National Science Foundation (NSF) has been producing its biennial *Science and Engineering Indicators* report, and since 1998 it has included a chapter "Industry, Technology and the Global Marketplace." The NSF report is seen by many in the media and policy making community as an unbiased source for understanding the U.S. position in global technology-based competitiveness. So when the report concludes that, "The strong competitive position of the U.S. economy overall is tied to continued U.S. global leadership in many KTI [knowledge- and technology-intensive] industries," it is not unreasonable for official Washington to take this as a good housekeeping seal of approval that all is well and to view any calls of alarm regarding the state of U.S. tech-based competitiveness as the "boy crying wolf."[1]

But while the NSF report contains valuable information, its analysis of U.S. technology-based economic competitiveness is seriously flawed and misleading. There are a number of problems. First, the report relies on an overly broad definition of KTI industries, most of which are neither in global competition or technology-based. For example, the fact that the health care and financial services industries have grown much faster in the United States than in our competitor nations is seen by the NSF as evidence of U.S. economic competitiveness, when in fact it is just the opposite. Second, the report conflates the absolute size of sectors with U.S. national competitiveness. Third, the report measures output using dollar denominated exchange rates which makes accurate international comparisons difficult. And fourth, the report fails to provide sufficient transparency for much of its key data, preventing outside analysts from knowing exactly what is included and excluded in the NSF analysis.

When these first three limitations are controlled for the result is actually quite different than the official NSF findings. In fact, U.S. science and technology-based (S&T)

competitiveness has declined significantly as other nations have put in place policies to make gains while the United States has not.[2]

If the NSF is going to provide accurate and useful analyses of science and technology data related to U.S. competitiveness, it would be well served to significantly restructure the makeup and structure of the analysis in this key chapter to focus solely on science and technology-based, globally traded sectors. Doing so will provide policymakers with a more accurate assessment of the true competitive position of the U.S. S&T-based economy.

OVERLY BROAD DEFINITION OF TECHNOLOGY INDUSTRIES

Chapter 6 seeks to analyze the competitive position of U.S. technology industries internationally. However, most of the industries that the NSF includes have little or no bearing on U.S. competitiveness. The NSF mostly analyzes what they term knowledge- and technology-intensive industries (KTI), a definition they borrow from the OECD. While KTI includes industries one would normally think of as globally traded technology-based, such as computer software, aircraft and spacecraft, pharmaceuticals, computers and office machinery, semiconductors and communications equipment, and scientific instruments, it also includes non-traded, and in some cases non-technology-based industries, including financial, business, communications, education and health services.[3]

There are two problems with the KTI industry definition. First, many of these industries are not traded in global markets. Traded sectors are ones where there is significant potential competition from foreign providers, while non-traded sectors are largely provided only in the United States. In other words, while our computers or airplanes might be made in another nation, our health care and banking services will by and large be provided domestically.

While all industries affect a country's productivity and thus living standards, traded sectors are the only ones that face competition from establishments in other nations. Tradable sectors typically pay high wages and have large positive spillovers within their countries and local areas, so they are particularly important to a healthy economy.[4] But they only flourish in countries that provide them with a competitive business environment, because they face increasingly stiff international competition. Non-tradable sectors, on the other hand, are not in danger of disappearing due to international competition because they cannot compete across borders.

A rough calculation suggests that over three-quarters of the output of U.S. KTI industries is in sectors that are not principally traded, such as K-12 educational services, hospitals, and telecommunications services. Collectively, output in these non-traded sectors grew 20 percent faster than overall GDP growth from 1997 to 2012 in nominal terms.[5] In contrast, traded KTI sectors grew 24 percent slower than overall GDP growth.

The second problem with the NSF definition of KTI industries is that many of these industries, such as business consulting, legal services, and K-12 education, have little to do with science and technology. The primary qualification to be a KTI industry is the education level of the workers employed. But ranking countries based on the size of industries with larger numbers of educated workers with is misleading if what we really care about is the state of U.S. technology industries relative to other countries.

For example, NSF includes in their KTI definition the financial service industry. And it is no surprise the United States has a large financial services industry relative to other nations. But this growth has more to do with the rise of the financial services industry, not as a provider of needed capital to business, but as a "casino" that diverts needed capital from wealth-creating enterprises to itself.[6] It also includes health care as a KTI industry, where the United States has the dubious distinction of ranking number one in the world in share of GDP devoted to health care. But having a large health care sector is certainly not an indicator of innovation (although manufacturing output in the life sciences industry is an indicator).[7] Rather it is a cost that is imposed on companies in the United States that are competing in global markets. Likewise, why include K-12 education? Teacher salaries and administrative overhead costs are hardly indicative of educational quality, and the size of the sector is clearly an upstream indicator, not a downstream one.

Ranking countries based on the size of their industries with larger numbers of educated workers is misleading if what we really care about is the state of U.S. technology industries relative to other countries.

It is not that the growth of these sectors is necessarily bad (although in cases like financial services and health care, it can be). The point is that the chapter does not serve its intended purpose: to provide a useful measure of the "downstream effects" of "research and development and other activities that advance science and technology" in the United States.[8] Instead, the report misleads readers into thinking all is well because "the U.S. has the largest KTI share of any large developed economy," when in fact the size is mostly due to the inclusion of industries that do not compete internationally and/or are technology-based.[9] Going forward, instead of including any industry that employs a higher share of educated workers, NSF should limit its focus to S&T-based industries.

While NSF's measure of KTI is too broad, its measure of high-tech (HT) manufacturing is too narrow. NSF does not include "medium-high" technology industries, such as chemical manufacturing and automobile manufacturing, that are very R&D intensive. This matters because according to the OECD, relative to other competitor nations, especially Germany, Japan and Korea, the United States does poorly in these industries (See Figure 1).[10] Not including medium-high tech industries artificially enhances the U.S. competitive standing

In short, NSF should stick to S&E industries—software, R&D labs, and medium and high-tech manufacturing. NSF is not an economic analysis organization like the Bureau of Economic Analysis, and by including so many other industries that have nothing to do with innovation-based competitiveness, they lull the reader into a false sense of complacency about the U.S. position.

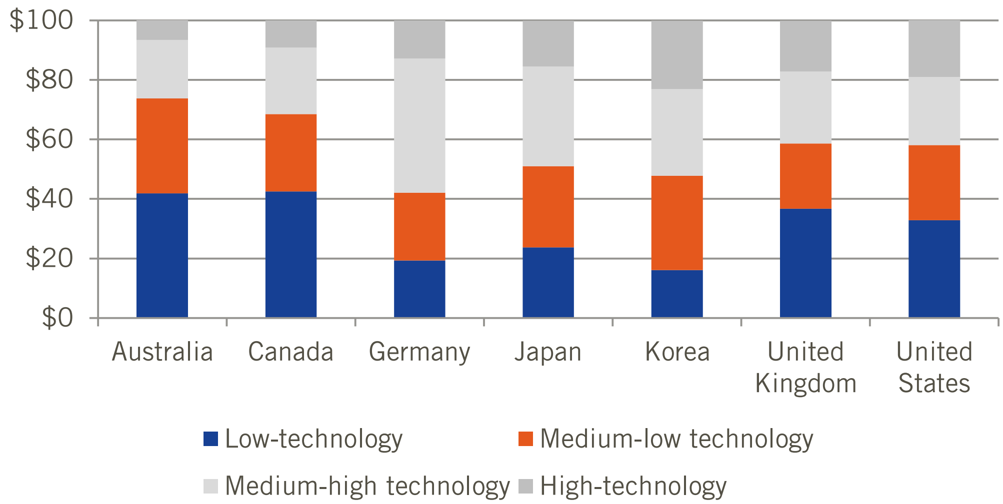

Figure 1: Composition of Manufacturing Sector by Technology Intensity[11]

USE OF ABSOLUTE RATHER THAN PER-GDP MEASURES

The second problem with Chapter 6 is that it presents an overly optimistic interpretation of the data by relying on misleading indicators. For example, the report focuses on the absolute size of U.S. output instead of more accurate assessments like size as a share of GDP or trends over time. For example, the highlights section states in bold that "The United States is the largest global provider of commercial KI services and HT manufactured goods."[12] Likewise, NSF's Figure 6-16 compares overall output of HT manufacturers, where the United States looks like a clear winner.

But the United States is also the largest economy in the world, so these kinds of statistics are largely meaningless. It would in fact be surprising if the United States was anything other than the largest in the world on KTI industries. Any accurate comparison of technology-based output between nations has to adjust for the size of the economy. Otherwise, it leads to the illogical result that were the United States to split into two nations, then the inherent technology strengths of the two economies would be half that of the unified United States. Moreover, by the logic of the NSF report, the United States could lose 1 percent of its KTI share a year for ten years and NSF would still be able to report that all is well because the U.S. would still be larger on absolute terms than nations such as Germany, Japan, and South Korea.

Moreover, the NSF report too often provides only decontextualized snapshots that ignore important trends over time. For example, the U.S. share of high-tech world output fell between 2003 and 2012. Chapter 6 mentions this in the text of the report yet leaves it out of the highlights section. But even here, simply looking at trends in share are not enough, since they do not control for changes in the size of nations. The United States has more workers (and population) than it did in 2003, in contrast to Japan, for example, which, due to an aging society and limited immigration, has fewer workers. But comparing trends in overall U.S. high-tech output growth to a country like Japan is misleading because it does not control for the size of the economy.

In another example of the NSF report's overly optimistic interpretation of the data is a box on U.S. manufacturing and employment, which states, "Several signs point to an increase in U.S. manufacturing activity after years of decline." The box lists a small rebound in employment (after an unprecedented deep decline in the 2000s) and cites some media stories that claim that some U.S. firms are building new manufacturing facilities in the United States again.[13] It mentions that "some analysts and researchers point to resurgence," and asserts that the debate is not about whether there is a resurgence but whether the resurgence will lead to significant growth in manufacturing jobs.[14] In fact, there is a serious debate about whether there is a resurgence, with organizations like the International Monetary Fund arguing that it is "unlikely for manufacturing to become a main engine of growth in the United States."[15] Had the authors looked carefully at the data from the Department of Commerce, they would have seen that real U.S. manufacturing output in 2012 remains below 2007 levels (See Figure 2). And this does not account for systemic measurement errors that overstate U.S. manufacturing output.[16]

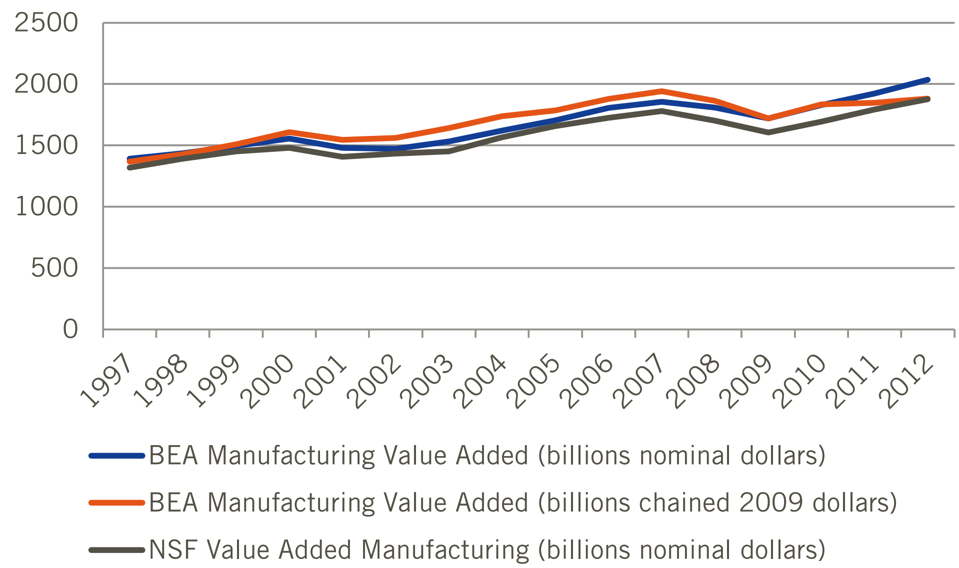

Figure 2: Estimates of U.S. Manufacturing Value Added[17]

In addition, the report's discussion is sometimes at odds with its own data. For example, following conventional wisdom, it is dismissive of the high-tech strength of Europe—but NSF's Table 6-4 shows that the EU has a large positive balance on computer and information services, while the trade balance for the United States is negative. The report also ignores the relative sizes of the U.S. and EU trade deficits in HT goods more broadly; the EU trade deficit in HT goods is only 11 percent of the U.S. deficit.[18] Developing nations, meanwhile, increased their share of HT exports from 29 to 40 percent, a fact which, again, makes it into the body of the report but not the highlights section. Likewise, the data in the report show that the U.S. trade surplus in R&D services in 2010 fell to just 28 percent of its 2006 level, but this trend is not reflected in NSF's analysis.[19]

EXCHANGE-RATE COMPARISONS

A third problem with the chapter is that it compares output across nations using dollar-denominate figures. To assess nation's technology industry capabilities, it correctly measures value-added output. However, it does so in dollars based on current exchange rates, which the chapter admits is an "imperfect measure" because of the link between exchange rates and the fact that "some countries' currencies are not market determined."[20] They are indeed an imperfect measure, and it would be preferable if the report used purchasing power parity measures for more accurate, apples-to-apples comparisons.

LACK OF TRANSPARENCY

One final problem is that much of the industry data used by NSF are provided by a private firm—IHS Global Insight—and are proprietary, so readers are unable to see the underlying data or methodology. For example, there is no way to tell from the report how IHS converts nominal dollars into constant dollars. Nor does NSF provide a detailed list of the industry code IHS uses to construct its technology industry composite. Any economic methodology used in public government reports should be fully replicable, as it is otherwise impossible to know whether or not the calculations accurately reflect the intent of the analysis.

The NSF needs to fundamentally restructure Chapter 6 to more accurately assess U.S. technology-based competitiveness.

CONCLUSION

In short, National Science Foundation's biennial *Science &Engineering Indicators* report is a valuable and helpful resource. But if the NSF wants to supplement its analysis of science inputs (e.g., R&D spending and STEM degrees) and outputs (eg. patents) with an examination of how the United States fares in global S&T-based competition, it needs to fundamentally restructure Chapter 6 to more accurately assess U.S. technology-based competitiveness.

ENDNOTES

1 National Science Board, *Science & Engineering Indicators 2014*. (Arlington, VA: National Science Foundation) 14-01, p. 6-55.

2 Robert D. Atkinson and Scott Andes, *The Atlantic Century II*, (ITIF, July 2011), http://www.itif.org/files/2011-atlantic-century.pdf.

3. National Science Board, *Science & Engineering Indicators 2014*, p. 6-7.

4. Robert D. Atkinson and Stephen J. Ezell, *Innovation Economics: The Race for Global Advantage* (New Haven: Yale University Press, 2012), http://globalinnovationrace.com/, 92-94. See also, Enrico Moretti, *The New Geography of Jobs* (Boston, Mariner Books, 2012).

5. Because the NSF report does not identify precisely the NAICS codes it uses, these numbers are only an estimate. GDP grew by 89 percent from 1997 to 2012 in nominal terms, while the non-traded KTI sectors grew 109 percent. Source: U.S. Bureau of Economic Analysis.

6. Susan Berger, "How Finance Gutted Manufacturing," (*Boston Review*, March 10, 2014) http://www.bostonreview.net/forum/how-finance-gutted-manufacturing/mike-rose-response-finance-and-manufacturing.

7. Jason Kane, "Health Costs: How the U.S. Compares With Other Countries," *PBS NewsHour: The Rundown* (October 22, 2012), http://www.pbs.org/newshour/rundown/health-costs-how-the-us-compares-with-other-countries/.

8. National Science Board, *Science & Engineering Indicators 2014*, p. 6-7.

9. National Science Board, *Science & Engineering Indicators 2014*, p. 6-13.

10. OECD, STAN Industry 2008 (value added, volumes; number of persons engaged; accessed February 27, 2012), http://www.oecd.org/sti/stan/, in Robert D. Atkinson, Luke A. Stewart, Scott M. Andes, and Stephen Ezell, "Worse Than the Great Depression: What Experts Are Missing About American Manufacturing Decline" (Information Technology and Innovation Foundation, March 2012), http://www.itif.org/publications/worse-great-depression-what-experts-are-missing-about-american-manufacturing-decline, 46.

11. OECD, STAN Industry 2008.

12. National Science Board, *Science & Engineering Indicators 2014*, p. 6-5.

13. See Atkinson, "Worse Than the Great Depression."14. National Science Board, *Science & Engineering Indicators 2014*, 6-28.

15. Oya Celasun, Gabriel Di Bella, Tim Mahedy and Chris Papageorgiou, "The U.S. Manufacturing Recover: Uptick or Renaissaince?" (IMF Working Paper, 2014) http://www.imf.org/external/pubs/ft/wp/2014/wp1428.pdf. Also see the Reshoring Initiative, http://www.reshorenow.org.

16. Atkinson, "Worse Than the Great Depression." Susan N. Houseman, Timothy J. Bartik, and Timothy J. Sturgeon, *Measuring Manufacturing: How the Computer and Semiconductor Industries Affect the Numbers and Perceptions*, Working Paper, 14-209 (Upjohn Institute, 2014), http://research.upjohn.org/up_workingpapers/209/.

17. National Science Board, *Science & Engineering Indicators 2014*, Appendix Table 6-14; Bureau of Economic Analysis, Value Added by Industry (Manufacturing), http://www.bea.gov/iTable/iTableHtml.cfm?reqid=51&step=2&isuri=1.

18. National Science Board, *Science & Engineering Indicators 2014*, Appendix Table 6-21.

19. National Science Board, *Science & Engineering Indicators 2014*, Appendix Table 6-23.

20. National Science Board, *Science & Engineering Indicators 2014*, p. 6-13.

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