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Developing a Producer Price Index for Scientific Research and Development
NAICS 5417 Scientific Research and Development Services
ISIC 7310 Research and Experimental Development on Natural Sciences and Engineering (NSE)

Producer Price Index Program
US Bureau of Labor Statistics

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I. Introduction and Background

According to the National Science Foundation (NSF), U.S. expenditures on research and development (R&D) grew from $288.3 billion in 2003 to $397.6 billion in 2008. In that time period, R&D spending growth, in current dollars, averaged 6.6% per year compared to 5.4% GDP growth. In 2008, these expenditures accounted for 2.79% of GDP as estimated by NSF.[1]

In September 2006, the Bureau of Economic Analysis (BEA) released an R&D satellite account, developed in partnership with NSF. A satellite account refers to a set of accounts that BEA uses for experimental measurement in a framework consistent with GDP but separate from the official accounts. The purpose of the R&D satellite account is to examine how treating R&D as an investment, rather than as an expense, impacts final demand. Note that treatment of R&D as investment is consistent with the recommendations in the 2008 System of National Accounts. The new satellite account shows that the new treatment of R&D has a substantial impact on GDP. As investment, R&D would increase GDP, in current dollars, by an average of 2.5 percent per year between 1959 and 2002.[2]

Earlier this summer, BEA released initial information from the 2010 R&D Satellite Account, which updates and extends BEA's estimates of the effect of R&D on economic growth through 2007, including coverage of the most recent business cycle expansion. The updated results show that GDP would have been, on average, 2.7 percent, or $301.5 billion, higher between 1998 and 2007 if R&D spending would have been treated as investment in the U.S. national income and product accounts. R&D accounted for about 6.3 percent of average annual growth in real GDP between 1998 and 2007 and 6.6 percent between 2002 and 2007. To put that contribution into perspective, the business sector's investment in commercial and other types of structures accounted for just over 1.3 percent of average annual growth in real GDP between 1998 and 2007.[3] The satellite account also breaks R&D down into private and government categories and several sub-categories within each broad category – see the table on the next page. From 1998 to 2007, the share of the business sector's private business investment accounted for by biotechnology-related industries grew from 14% to 29%, while the share accounted for by ICT industries increased slightly from 29% to 32%. The share accounted for by Transportation Equipment industries remained virtually unchanged, declining 1% to 13% in 2007, while All Other Industries' share declined from 43% in 1998 to 27% in 2007.[4]

[1] Boroush, Mark
[2] Okubo, et al. The national economic accounts in the US currently treat R&D expenditures as intermediate inputs and thus for businesses, including government enterprises, R&D expenditures are not included in GDP.
[3] BEA News Release, June 30, 2010
[4] BEA News Release, June 30, 2010; ICT stands for Information-Communications-Technology-Producing Industries.

Real Domestic R&D Output by Performer, 1998-2007
[Millions of chained (2005) dollars]

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total R&D performance	**225,077**	**251,509**	**277,777**	**296,402**	**299,492**	**315,237**	**329,628**	**347,818**	**370,440**	**402,508**
Private	**190,225**	**213,444**	**235,080**	**248,007**	**245,971**	**257,096**	**269,612**	**285,578**	**306,858**	**336,793**
Business	169,372	190,677	209,555	219,228	214,123	222,607	233,309	248,032	269,023	297,750
Universities and colleges	7,669	8,442	9,266	10,354	11,466	12,733	13,807	14,333	14,700	15,245
Other nonprofit institutions serving households	7,375	8,011	9,384	10,954	12,285	13,105	13,366	13,904	13,713	13,842
Federally funded R&D centers:										
Business	1,971	1,921	1,957	2,076	2,333	2,569	2,658	2,670	2,667	2,789
Universities and colleges	2,768	2,848	2,949	3,227	3,440	3,565	3,800	3,819	3,843	4,019
Other nonprofit institutions serving households	1,069	1,546	1,969	2,168	2,323	2,517	2,671	2,821	2,913	3,148
Public	**34,852**	**38,065**	**42,697**	**48,395**	**53,522**	**58,141**	**60,016**	**62,240**	**63,581**	**65,714**
Federal Government	15,545	16,577	18,857	21,455	23,384	25,418	25,473	26,493	26,744	27,486
State and local governments[1]	496	506	516	543	547	592	629	601	609	624
Universities and colleges	16,322	18,320	20,550	23,226	25,785	28,140	29,834	31,016	32,162	33,635
Federally funded R&D centers:										
Universities and colleges	2,489	2,661	2,773	3,171	3,806	3,990	4,081	4,129	4,066	3,969

R&D Research and development
1. Excludes universities and colleges.
NOTE. Implemented using the aggregate output price index.
SOURCE: NEWS RELEASE, BUREAU OF ECONOMIC ANALYSIS, June 30,2010

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BEA intends to complete the necessary research to incorporate R&D investment into core GDP accounts in 2013. A primary methodological issue that still remains is how to construct a deflator for use in creating estimates of real investment in R&D. Ideally, BEA would like to have a producer price index that directly measures actual market transactions for R&D output, focusing on purchased output as opposed to internal production for a firm's own use.[5] Since such measures are not available, the satellite account currently uses two different price indexes for deflation purposes. The first is a cost-based index that is an aggregation of detailed price indexes for the inputs used to perform R&D, used for deflating spending by government and other nonmarket entities. This method assumes that there is no productivity growth as real output is growing at the same rate as real inputs and thus, while useful for estimating the impact of inflation on R&D inputs, is less appropriate for R&D output. The second measure is a weighted combination of gross output prices of industries investing in R&D.[6] A significant portion of the indexes used for this measure are industry-based Producer Price Indexes (PPIs). Thus, output prices for these industries are used as the next best alternative in lieu of actual R&D output prices. Use of such an aggregate output price index does assume that there are common factors in R&D production across industries and tends to average out effects of rapidly changing output prices for particular products.

Until recently, the U.S. PPI view was that R&D output was not measureable because we could not identify marketable output or recurring transactions. Over the course of the past 20 years, the PPI's successful experience with services industries with conceptual and operational challenges has given us the tools to at least reconsider this position for R&D industries. This paper will examine how the U.S. PPI program, if funding became available, would approach the development of a pricing and sampling methodology for R&D industries as well as the issues that would need to be researched in this development process.

II. Developing a U.S. Producer Price Index for R&D

When surveying an industry for inclusion in the U.S. Producer Price Index, there are four major criteria to consider in developing an output price index:

1. Industry output definition
2. Obtaining net transaction prices
3. Maintaining a constant quality index
4. Sampling

Industry Output Definition

To determine the output of many service industries, a two-step process generally needs to be followed. First, a conceptual definition of output must be agreed upon. Second, the conceptual definition must be operationalized. This is the process of identifying actual products of the

[5] Copeland, Medeiros, and Robbins
[6] Robbins and Moylan

industry that truly represent the output and whose price is measured in a manner consistent with the output concept.

BEA's satellite account makes a distinction between two types of R&D: business purchases of R&D and own-account investment.[7] Most R&D is conducted by companies for their own use. Currently, the PPI indirectly includes own-account R&D in the mining and manufacturing indexes. This type of R&D is captured in the transaction prices of the products included in these indexes. The PPI excludes non-market output; therefore, efforts in developing a price index would be concentrated on business purchases of R&D, which accounted for approximately 34% of R&D expenditures of all for-profit industries in 2007[8]. Given the probable focus of the PPI's development, the BEA will need to determine whether or not an index (or set of indices) that represents at best only 34% of total R&D expenditures is useful for deflating all R&D including own-account. Preliminary discussions with BEA suggest that indexes for industry group NAICS 5417, Scientific Research and Development Services, might adequately serve as a proxy for price movement for all research and development from all other industries because the Input Output data indicates the output of these industries is used by a large portion of the industries known to be very R&D intensive. Information from NSF in 2008 indicates that pharmaceutical/medicines, communications equipment, and the semiconductor/other electronic component industries among manufacturing industries and software publishers, computer system design and related services, and scientific R&D services among services-providing industries are the most R&D intense, using employment as a size measure for R&D intensity:

Worldwide R&D employment intensity for activities in selected industries: 2008

Industry	Percent
All industries	7.1
Manufacturing industries	6.9
Pharmaceuticals/medicines	14.1
Computers/peripheral equipment	11.9
Communications equipment	26.7
Semiconductor/other electronic components	19.3
Navigational/measuring/electromedical/control instruments	10.2
Motor vehicles/trailers/parts	5.8
Aerospace products/parts	8.7
Nonmanufacturing industries	7.3
Software publishers	17.8
Computer systems design/related services	24.8
Scientific R&D services	30.7

NOTE: R&D employment intensity is R&D employment divided by total employment.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Business R&D and Innovation Survey: 2008

[7] Robbins and Moylan
[8] BEA News Release, June 30, 2010 , accompanying tables.

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The industries listed in the table on the previous page are similar to the 13 industries identified by BEA as R&D intensive as part of its update on the 2007 R&D satellite account, using the ratio of R&D investment to overall industry receipts as a size measure.[9]

According to the North American Industry Classification System (NAICS), industry group NAICS 5417 comprises establishments engaged in conducting original investigation undertaken on a systematic basis to gain new knowledge (research) and/or the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes (experimental development). The industries within this industry group are defined on the basis of the domain of research; that is, on the scientific expertise of the establishment. The 2007 NAICS structure is comprised as follows:

5417 Scientific Research and Development Services
54171 Research and Development in the Physical, Engineering and Life Sciences
541711 Research and Development in Biotechnology
541712 Research and Development in the Physical, Engineering, and Life Sciences Except Biotechnology
54172 Research and Development in the Social Sciences and Humanities

Note that we may not be able to produce indexes for all of the industries in this group. NAICS 5417 is comparable with ISIC, Rev. 4, Division 72, Scientific Research and Development.

What is the output of this industry? The 2008 System of National Accounts defines R&D output as "creative work undertaken on a systematic basis to increase the stock of knowledge" and use of this knowledge "for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production." Using this definition, these are the questions we would need to address in this area:

- What is the actual service to be measured?
- Is it R&D for a specific product or improvement?
- Is it R&D for a general class of product?
- Is it R&D for a specific industry?
- Does output consist of the research services provided, the sale of licensing rights or patents, or some combination of both?

In summary, the ability to develop a methodology for capturing prices and maintaining constant quality will influence the output definition.

[9] Robbins and Moylan. The three additional industries identified by BEA are residuals – Other computer and electronic products manufacturing; other transportation equipment; and chemical minus pharmaceutical and medicine manufacturing.

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Net Transaction Prices

The price index should reflect the price of representative actual transactions occurring monthly in the marketplace. A primary concern for pricing R&D on a monthly basis is that services are unique and non-recurring. For the other Sector 54 professional services that are included in the PPI, model prices are collected. These industries, such as accounting and management consulting, require a specific contract to be collected and set as a baseline transaction. The PPI then collects labor descriptions, labor costs, labor hours, expenses, reimbursables, multipliers, or other negotiated mechanisms for setting the price. These inputs are fixed according to this baseline transaction. Although companies may never encounter the exact transaction again, they report the amount of revenue they would hypothetically receive if the same contract were negotiated using the same inputs. Thus, in looking at pricing methodology for R&D, we would focus at least on answering the following questions:

- Is the model pricing methodology appropriate for R&D?
- Does it matter if the R&D contract results in a patent or license?
- Would it be appropriate for the PPI to measure licenses and patents separate from the R&D contracts?
- Do similar transactions occur often enough for this type of sale to be repriceable for a monthly index?

BEA measures the value of purchased R&D as the margin between the provider's receipts and costs.[10] Thus, would margin pricing be appropriate for the R&D PPI? Currently, margin pricing is used exclusively in the U.S. PPI for the wholesale and retail trade industries. Like R&D, output of the trade industries is not directly quantifiable. However, to use margin prices in a monthly index for trade, transactions must be recurring or have close substitutes. Again, R&D services are typically non-recurring and, depending on the level at which the service is defined, there may be no close substitutes. Thus, our research would likely focus on the viability of model pricing first.

Constant Quality

The PPI is calculated as a modified Laspeyres Index designed to estimate a fixed-input output price index model. This assumes that output is fixed. In most industries, this would involve quality adjustment as goods are periodically modified to adjust for technological or style changes. The adjustment process involves factoring out the cost for any changes made to the product or service.

Model pricing allows the service delivery process, type of buyer, and contract terms to be held constant in most cases. Technological improvements to inputs may enable the same exact service priced in a prior period to be produced more quickly (requires less labor-hours) in the current period, thereby reducing costs that may lead to lower fees. In this case, input

[10] Robbins and Moylan. The authors point out that when information on receipts and costs is not available, BEA estimates the margin by using the ratio of net operating surplus to gross output for miscellaneous professional, scientific, and technical services (5412OP) from BEA's GDP-by-industry data.

requirements have changed, but the service provided has not. Therefore, the price reduction is valid and an explicit quality adjustment would be unnecessary.

However, the outputs of the R&D industry may evolve due to introduction of new technologies or new types of services leading to potential new item bias. To address this bias, using a process called directed substitution, the industry analyst would periodically contact each company to review the sampled services and determine whether new types of services have been introduced. If new services are identified, probability techniques would be employed to give these new services a chance of selection. Assuming R&D changes at a rapid pace, we would need to research how often directed substitution would have to be performed. We would be concerned with determining how often is too often such that the price index is no longer meaningful.

Sampling

Since revenue data are used as weights in the PPI, sampling by revenue is the ideal, implying that the ideal frame for sampling establishments would be the U.S. Census Bureau's Business Register, which provides information on total revenues by establishment (also referred to as value of shipments or turnover). However, due to confidentiality limitations, the Census Business Register is not available for use by the PPI program. Thus, the PPI program is faced with a continual challenge of finding alternative sources of frame data for sampling of service industries. Often alternative frames that are used do not have revenue data as a basis for sampling. In these industries, an alternative size measure data in the frame is selected that closely relates to the output of the industry.

To find an appropriate frame, we first need to determine who should be represented in the frame. Which types of companies are classified in NAICS 5417? The NAICS definition does not provide clear direction as to the specific types of establishments included, though the product list using the breakdown for the North American Product Classification System would assist in that determination. The latter distinguishes between basic and applied research, development services, licensing of rights to use intellectual property, and intellectual property works. Ultimately, we will need to answer the following questions:

- Who provides R&D?
- Are they stand-alone companies?
- Are they subsidiaries or divisions of manufacturing companies who also invest in own-account R&D? How would these units be represented in the frame?
- Would the revenue derived from own-account R&D be included when determining the relative weights of each frame unit? Or, would we include own-account R&D in the total revenue of the unit and assume that prices to be measured accurately reflect price change in the own-account portion of the unit?

There are many companies that market directories based on NAICS industries. If companies that perform own-account R&D are also classified in NAICS 5417, it would be difficult to discern which establishments are in-scope for the PPI using these types of directories or other NAICS-based frames such as the BLS Quarterly Census of Employment and Wages (QCEW). The QCEW, which provides employment counts as a size measure, is often used as a fallback when

no alternative frame is available. In fact, this frame source is the primary source for the majority of the U.S. PPI.

We must have a frame as well as a sample that is representative of the industry size. The frame size should approximate the correct number of establishments According to preliminary figures for the 2007 Economic Census, there are 16,654 establishments classified in NAICS 5417.[11] Again, what types of establishments are included? Given the size of the industry and diversity of R&D performed, how many sample units and price quotes should be selected?

Conclusion

BEA plans to officially introduce R&D as an investment component in the GDP accounts in 2013. The current price indexes used by BEA to deflate R&D are based on more general imputations or cost driven input indexes which hold productivity measures static. If progress is to be made on developing a PPI for R&D outputs, a major effort will be required to better understand the production transformation processes for R&D that is sold in the marketplace rather than produced for own-account. In a best case outcome, a PPI for marketed R&D may also provide a useful proxy for own-account R&D if for no other reason than the alternatives for national income accountants, at this point, are exceedingly limited. As mentioned in previous sections, many outstanding questions from a PPI perspective remain. Perhaps the most important is determining (with help from the industry) just exactly what can be priced periodically and how best to ensure measures of pure price change are captured. Whatever methodology is developed must be robust and flexible enough to apply to R&D outputs from a range of industries.

[11] 2007 Economic Census, Sector 54: Professional, Scientific, and Technical Services, Industry Series – Preliminary Summary Statistics for the US, December 9, 2009. Detailed Statistics from American Fact Finder.

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