Background Document in preparation for
BEA/NSF R&D Technical Conference
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This document provides an introduction to several research topics that the R&D satellite account team is interested in discussing with academic and other technical experts at the proposed fall R&D Technical Conference. Some of these issues will need to be resolved for the 2007 R&D satellite account, and others are long term research questions.

1) R&D Deflators in the BEA R&D Satellite Account
2) Improved Estimates of Fixed Capital Used for R&D
3) The Scope and Ownership of Capitalized R&D
4) The value of separate estimates of basic research, applied research, and development in the R&D Satellite Account
5) Estimating returns to R&D in a national accounting framework
6) Lag structure of capitalized R&D
7) Depreciation of capitalized R&D Assets
8) Estimating Spillovers from R&D in the Context of the National Accounts; Identifying the Beneficiaries from R&D and the Size of the Benefits Received
9) Measuring R&D Output

1. **R&D Deflators in the BEA R&D Satellite Account**

Because of the inability to measure the value of research and development (R&D) output directly, BEA uses nominal R&D expenditures as the basis for developing the R&D Satellite Account (R&DSA). BEA estimates of real R&D activity in the U.S. should "ideally be based on R&D input costs as specific to the R&D performer as possible" (Frascati Manual, annex 9, paragraph 4). Unfortunately, R&D specific input price deflators are not readily available to deflate the R&D expenditures NSF provides.

For the initial development of the 2006 Preliminary R&DSA framework, BEA will use proxy measures to deflate R&D input costs. For example, in the industry sector, BEA is using input cost deflators generally based on costs in the Scientific Research and Development Services industry (NAICS 5417). BEA and NSF recognize that this simplified approach likely does not accurately reflect the variation in input costs structure for the R&D performed by different industries in different technological areas. Proxy deflators are also used for other R&D performers as well.

BEA believes that further research in the area of R&D price deflators will enhance its ability to estimate real measures of R&D activity. In the short term, BEA will conduct research for the 2007 R&DSA to obtain improved R&D price deflators for the largest input cost: compensation of R&D personnel in industry. The emphasis will be on locating and incorporating prices already developed by sources outside of BEA. In the long term, the goal is to develop improved R&D deflators for compensation and the other input costs with an emphasis on certain key industries such as computers, electronic products, and pharmaceuticals. BEA will perform a more detailed look at the makeup of R&D costs across industries. For example, the

makeup of R&D personnel (scientists, engineers, technicians) or the nature of R&D physical capital investment and its depreciation may vary significantly across industries. An improved understanding of detailed industry input costs and their corresponding prices will further enhance the R&DSA.

What approaches can the conference recommend for creating R&D input deflators?

Lisa Mataloni

2. **Improved Estimates of Fixed Capital Used for R&D**

Fixed capital used to produce R&D includes structures, large equipment, small equipment, and software. Because the value of R&D investment is calculated based on the sum of production costs, the consumption of this fixed capital is a necessary component of cost for the estimates. Data on expenditures for R&D capital are limited in the NSF surveys; accordingly BEA has made broad assumptions for the 2006 R&DSA.

Federal obligations data for R&D are divided into current and capital costs. BEA currently assumes that 85% of capital expenditures are for structures and 15% for large equipment. When no estimate of small equipment is available it is assumed 6% of total non-capital expenditures are for small equipment. Since existing survey data provide no capital expenditures for most industry-performed R&D, this will present a larger challenge when creating industry-level estimates necessary to capitalize R&D in the I-O tables and the NIPAs. For the 2007 R&D satellite account, BEA will seek additional information to improve these estimates of the types and quantities of capital used to create R&D.

Given the absence of complete survey data on the types and quantities of fixed assets used to create R&D, can the conference suggest improvements on these assumptions for estimating these assets?

Carol Robbins

3. The Scope and Ownership of Capitalized R&D

The two prior versions of BEA-produced R&D satellite accounts, Carson, Moylan and Grimm (1994) and Fraumeni and Okubo (2004) developed measures of R&D capital stocks based on the performer of the R&D. Carson, Moylan, and Grimm (1994) also provided tables with annual expenditures by performer based on source of funds and annual expenditure by funder, showing performer. The scope of capitalized R&D in these accounts reflected, with some adjustments, the scope of R&D expenditures as collected by the National Science Foundation based on the Frascati Manual.

The anticipated capitalization of R&D as an intangible asset in the national accounts has raised two related issues. First, what methods will BEA use to determine the ownership of capitalized R&D assets, and second, what is the scope of R&D that should be capitalized? While the source data provide greater detail for performer-based estimates, performer-based capital stocks do not provide an acceptable basis for determining ownership of the assets. Therefore the funder will be assumed to be the owner of R&D for the 2006 satellite account and

funder based estimates will be presented along with the performer-based stocks, despite more limited source data. BEA's 2006 preliminary R&D satellite account will be presented two ways, by performer and by funder. For the 2007 R&D satellite account, BEA will work improve the identification of ownership, exploring the premise that ownership is best assigned to the entity that holds the intellectual property rights to the R&D. This entity may be the funder or the performer or both. **Does the conference view the assignment of intellectual property rights as a reasonable basis for determining ownership of R&D assets in the national accounts? Can the conference suggest other approaches that can be applied to existing data?**

The second, related issue that BEA will consider is how to identify R&D that is freely available. The recent recommendation by the Advisory Expert Group on the type of R&D that should be capitalized in national accounting measures raises the following question. Can we identify freely available R&D and exclude it from capitalization? The Advisory Expert Group (AEG) reviewing proposed changes to the SNA has pointed out that capitalizing freely available R&D would required a change in the SNA's definition of an asset.[1] Since the majority of the AEG was opposed to changing the definition of an asset, they preferred to theoretically exclude capitalization of freely available R&D. The AEG acknowledged the challenges presented by exclusion citing that freely available R&D is 1) likely to be small, 2) difficult to identify, and 3) in practice might not be excluded. BEA would like to develop a working definition and attempt measure of this freely available R&D. The initial premise for this work is that enforcement of intellectual property rights could be used as a standard of R&D that is not freely available. **Can the conference suggest other formulations to identify freely available R&D?**

Carol Robbins

4. **The value of separate estimates of basic research, applied research, and development in the R&D Satellite Account**

The source data used for the R&D satellite accounts do not currently provide all the information necessary to make complete estimates of these three components of R&D without substantial use of analyst's judgment. BEA is interested in whether potential users of the R&D satellite account and R&D capital stock data feel that there is a sufficiently useful analytical distinction between these three forms of R&D to justify BEA making separate estimates of these components of R&D assets.

For the 2006 satellite account, BEA will not create separate estimates of the stocks of basic research, applied research, and development. These will instead be treated as a homogenous stock of R&D. With respect to depreciation, lags, and rates of return, some data users see similarity between applied research and development and others combine basic research with applied research. While BEA's 2006 R&D satellite account will use a 15% annual rate of depreciation for all three types of R&D, other assumptions about depreciation differ by type. The three components may also differ in the extent to which they are freely available, and therefore this distinction may be useful in determining the scope of R&D that should be capitalized. **Does the conference see important analytical uses for separate stocks of basic research, applied research, and development? Can any of these be combined without significant loss of information?**

[1] Ownership rights are enforced by institutional units, either individually or collectively, and economic benefits can be derived by the owners of the asset by holding or using them over a period of time.

Carol Robbins

5. Estimating returns to government and non-profit R&D in a national accounting framework

The BEA R&DSA assumes that the returns to business investment in R&D assets are included in business profits. For the 2006 accounts, the standard version of the satellite account will include only the consumption of fixed capital as the return to government and non-profit R&D. A supplementary version of the satellite account will include an additional return to government and non-profit R&D proxied by a risk free rate from government securities. Over the next year, we will review the economic literature on the returns to academic and non-profit R&D investment to evaluate the reasonability of our original assumptions. **What approach to estimating the returns to government and non-profit R&D does the conference think is most consistent with a national accounting framework?**

Laura Schultz

6. Lag structure of capitalized R&D

The development of capitalized R&D stocks requires a set of working assumptions about the lags between an R&D project's inception and completion. A gestation lag implies two things for the satellite account: expenditure in one year becomes investment in a different year; and an entry for change in R&D-in-progress is required for the R&DSA. While the 1994 R&DSA included a one-year lag, for the 2006 satellite account, a zero-year gestation lag was assumed. While an important motivation for this assumption is consistency with the NIPA framework for other investments, we also believe that firms receive immediate benefits from R&D in progress. On an industry-by-industry basis, this zero-lag assumption may be less appropriate. **As we research the lag structure of R&D expenditures, what approaches seem best from a national accounting perspective? Should we evaluate R&D lags on an industry or technological related basis?**

Laura Schultz

7. Depreciation of capitalized R&D Assets

For the 2006 R&D satellite account, R&D investment is transformed into stocks of R&D capital with a 15% annual rate of depreciation for all performers and types of R&D. BEA has conducted research on rates of returns to private R&D assuming this depreciation rate, which is near the median of the range of empirical estimates. As we refine our estimates for 2007 and work towards industry-level estimates of R&D stocks, we will revisit this depreciation assumption. Empirical evidence suggests that a single depreciation rate may not be accurate for all types of R&D capital. Lev and Sougiannis (1996) find different rates of depreciation for different industries ranging from 12%-20%. It is also commonly assumed that basic, applied and developmental research depreciate at different rates. For instance, when constructing a stock of Federal R&D capital, OMB assumes applied research and development depreciate at a rate of

10% and basic research does not depreciate at all. There are likely differences in the rates of depreciation of government and non-profit R&D capital as well. BEA is considering researching the depreciation of R&D at the sector level. Methodologies being considered are those used by Nadiri and Prucha(1993) and Lev and Sougiannis. **Given the identification problem in estimating both net rates of return and depreciation, what approaches can the conference suggest for estimating depreciation separately from returns? What seems like the best approach at looking at this-- by industry or technological related basis?**

Laura Schultz

8. Estimating Spillovers from R&D in the Context of the National Accounts; Identifying the Beneficiaries from R&D and the Size of the Benefits Received.

The bulk of academic research into R&D spillovers is an extension of the well-known productivity regression, in which tabulated values of Solow's residual are compared to perpetual-inventories of an R&D capital stock. The simplest extension for spillovers received adds measures of *outsiders'* R&D to the regressor list, often mediated by a "technology flow matrix" to keep the number of coefficients manageable. Regressions of this sort that make it to publication usually turn up evidence of external benefits, but results are fragile—disappearing, for example, upon the inclusion of simple time trends. Alongside the productivity literature, but apart from it, stands Mansfield's taxonomy of the gains to R&D's beneficiaries in a simple framework of shifting supply and demand curves. "The firm" here really means its capital owners; benefits such as higher wages are taken to be indirect and not locally caused by the firm's own productivity gains.

At first glance, neither econometric estimates of the rate of return to own and others' R&D nor careful dissection of the benefits and beneficiaries of R&D have much to do with the National Accounts. Capitalizing R&D affects the product/demand side by moving R&D from expense to investment, but measurement of the income side is largely unaffected, at least for for-profit firms: wages, salaries, and benefits are simply tallied up as always, and the various accounting categories of capital earnings continue estimated without change.

This note suggests two arguments for going further, in the direction of integrating the rate-of-return and benefits literatures. The R&D Satellite account has the potential for making statements about multifactor productivity growth. If capital rental values are to be estimated accurately—i.e., as something other than a residual—then careful attention to the returns *as such* to R&D (and to other forms of capital) will be needed, apart from the present accounting classifications. Second, much of the public interest in R&D is policy-driven. As a statistical agency, BEA does not participate in such debates, but our data could be more useful to them. In particular, while the agency is good at producing estimates of how incomes accrue—and becoming good at estimating how productivity grows—it would also be of service to form reliable estimates of how incomes and productivity *would* develop were R&D investment greater than it is, or how they *would have* developed had R&D investment been less than it was. **The first question to put to conference participants is: "Is it appropriate for BEA to pursue 'what-if' accounting?"**

Provided the answer to the first question is "yes," here is a suggestion for how to proceed, following research Laura Schultz is already conducting. First, as the productivity-regression approach is a "short-hand" for a fuller, second-order flexible system of factor demands, find the best fit of a system that includes both a sector's own R&D capital and the R&D stocks of potential upstream technology suppliers, per the work of Bernstein and Nadiri and their collaborators. But second, given a good fit, turn the system inside-out: treat the quantities of even short-run flexible inputs as temporarily fixed, in order to calculate the induced implicit changes in such inputs' prices (as well as in marginal cost) from a small change in own or others' R&D quantities (and from disembodied time trends). This is essentially Mansfield's approach, put to algebra and generalized to include a sector's non-capital inputs. Third, compare the induced price changes year-to-year with such changes as actually occur, to see if there is much of a microeconomic connection between the drivers of productivity growth and its potential beneficiaries. **The second question to put to conference participants is: "Is this research program sensible?"**

Brian K. Sliker

9. Measuring R&D Output

The R&D satellite account is constructed using the sum of input costs as the value of R&D output. **What approach should BEA pursue in the long run to estimate the output of R&D separately from inputs?**
R&D Team