2007 R&D Satellite Account Methodologies:
R&D Capital Stocks and Net Rates of Return

Bureau of Economic Analysis/National Science Foundation R&D Satellite Account Background Paper

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December 2007 www.bea.gov

Preface

This paper discusses the methodologies used in constructing current- and constant-cost R&D net stocks and depreciation flows in the 2007 R&D Satellite Account. It also constructs net rates of return on private assets inclusive of R&D in a manner consistent with recent issues of the *Survey of Current Business*, and it discusses how such net rates might be constructed to be consistent with the user-cost of production economics.

Acknowledgements

Thanks to Carol Moylan for posing the questions behind this work, Justin Monaldo for many tabulations, Dennis Fixler and Rosemary Marcuss for review and direction, and James Kim for editorial assistance. Errors remain mine.

R&D Capital Stocks and Net Rates of Return

The R&D Satellite Account initiative at the Bureau of Economic Analysis (BEA) aims to measure research and development (R&D) activity and its economic effects. The effort requires a clear view of how much R&D capital exists in the economy, and how productive it is. This paper describes how the Bureau of Economic Analysis estimated net R&D capital stocks in the 2007 R&D Satellite Account, and it gives rates of return consistent with the rates of return on non-R&D assets that BEA has published elsewhere.

These rates are the so-called *ex post* net own rates of return to capital owned by nonfinancial corporations and by various industries. The *ex post* net own rate is just the ratio of a sector's net operating surplus to its nonfinancial assets, properly construed. Both numerator and denominator are valued in current dollars, so the ratio is a rough gauge of a sector's profitability through time, with some immunity to inflation.[1]

The focus of this paper is the R&D capital stock and net own rates of return of the business sector. A follow-up paper is planned to discuss returns to government and nonprofit capital.

This paper includes two main sections.

The first details the tabulation of R&D capital from current-cost investment through net stocks and depreciation, with special attention to the construction of bench-mark stocks when the time is short between the first *recorded* investment and the first net stock reported out. This is a solved problem in the productivity literature for constant depreciation rates and short investment series; here the solution is extended to cases where neither depreciation nor the growth of investment is roughly constant.

The second section describes the calculation of net own rates of return in the framework of BEA's previously published returns for non-R&D assets. The outcome of the exercise is counterintuitive, raising questions about data and specification. For comprehensive business and industrial aggregates and the few R&D-intensive sectors considered, the effect on *ex post* net own rates of return of capitalizing R&D spending is negative: the contributions of R&D investment to net operating surplus do not keep pace with contributions to the capital stock. The only exception is the computer and electronic products manufacturing industry. In terms of the mechanics of the calculation, this is the same as saying that for most sectors treated, the growth rate of constant-cost R&D capital does not match the net own rate of return when R&D is not capitalized. The effects are small for the main aggregates, where R&D capital's share in the total is still slight.

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[1] By contrast, an *ex post* net nominal rate equals the own rate plus a weighted average of the inflation rates of the sector's assets. With inflation "back in," the net nominal rate is like a simple bond yield or a loan rate, and the profitability at any given time of sectors with different asset mixes may be compared. An *ex post* net real rate, equal to the nominal rate less a general inflation rate, would extend cross-sectoral comparability over time. All *ex post* rates exhaust net operating surplus by construction, leaving behind no pure economic profits or losses. *Ex ante* rates—own, nominal, or real—forgo the ex-post residual approach altogether in favor of an observed interest rate or well-chosen constant to represent the opportunity cost of capital. Calculating the net rate as a residual implies all assets in a sector earn the same rate, but *ex ante* rates might differ across assets or the projects to which assets are deployed.

I. Computing R&D Stocks

The geometric perpetual-inventory equation, by which BEA calculates nearly all its other capital stocks, can be used to calculate the capital stock of R&D as well. At the "deflation level"—i.e., where all investment spending is assumed to be priced by the same deflator—the equation that BEA uses is:

$$\begin{aligned} K_t &= K_{t-1} - D_t + I_t \\ &= (1-\delta)K_{t-1} + (1 - \tfrac{1}{2}\,\delta)I_t \end{aligned} \tag{1}$$

where K_{t-1} and K_t are successive annual constant-cost end-of-year net stocks, and I_t and $D_t = \delta(K_{t-1} + \tfrac{1}{2}I_t)$ are real flows during the year of investment and depreciation, respectively. The question of timing—when do investment flows congeal to stocks—is settled by compromise: BEA's "mid-year convention" applies the depreciation rate ($\delta>0$) to half the current year's investment, rather than to all of it or none of it. Though the rate is treated as a constant across time for most BEA assets and for the highlighted variant of the 2007 Satellite Account,[2] an alternative variant presented here treats δ as a smoothly changing time-series, to be applied to all R&D capital, even that "installed" long ago. One may rationalize an across-the-board depreciation time-series, as opposed to different time-invariant rates on investments made in different years, by appeal to the prevalence of obsolescence: a rising tide swamps all boats.

The main computational problem with (1) is determining the initial capital stock. For non-R&D assets, BEA has unpublished investment series that run long before the first reported net stocks, so it is simple enough to set the benchmark value of capital to zero as of the end of the year preceding the first recorded investment. If no investment actually occurred before the first record of it, then this is exactly right; but it's more likely that bookkeeping, especially by statistical agencies, lags behind real activity, so that a zero seed-value must be below the unknown true value. However, with a high enough depreciation rate or a long enough running start before the first publishable net stock, the downward bias melts away.

Unfortunately, R&D tabulations from the National Science Foundation, on which BEA's work relies, begin in 1956, only three years before the first year-end stocks in the Satellite Account. As a zero initial value would be inappropriate, BEA estimated a benchmark value, adapting the technique of Griliches, who showed that under reasonable conditions the unobserved growth rate of the net stock is well approximated by the observed growth rate of constant-cost investment.[3] To see this, restate (1) as:

$$g_K = (1-\tfrac{1}{2}\delta)I_t/K_{t-1} - \delta \tag{2}$$

[2] Depreciation rates differ among non-R&D assets and industries and also for R&D capital across industries. However, in the 2007 Satellite Account, R&D capital is treated as homogeneous at any level of industrial aggregation—i.e., no splits yet for basic or applied research or development. See Charles Ian Mead, "R&D Depreciation Rates in the 2007 R&D Satellite Account," BEA/NSF R&D Satellite Account Background Paper" (November 2007), on the selection of depreciation rates for individual industries.

[3] Z. Griliches, "Returns to Research and Development Expenditures in the Private Sector," in John W. Kendrick and Beatrice Vaccara, eds., *New Developments in Productivity Measurement*, National Bureau of Economic Research *Studies in Income and Wealth*, Vol. 44 (1980), pp. 419-54, especially note 5 on p. 427.

where $g_K = K_t/K_{t-1} - 1$ is the discrete growth rate of capital, then rearrange once more:

$$K_{t-1} = I_t\,(1-½\delta)/(g_K + \delta) \qquad (3)$$

so the benchmark K_{t-1} depends on g_K. If g_K and δ are both constant, then unobserved K and observed I will have the same growth rate, estimated as the transform $g_K = e^m - 1$ of the slope coefficient m of a linear regression of $ln\,I_t$ on calendar time t:

$$ln\,I_t = b + m\,t + \varepsilon_t\,. \qquad (\varepsilon_t \text{ an error term}) \qquad (4)$$

For very short series such as those Griliches had, a regression using the whole available time-series on $ln\,I_t$ offered the best estimate of the growth rate and so the benchmark. However, casual inspection of the growth of real R&D investment over the half century since 1956 shows it has not been approximately constant but rather exhibits pronounced swings, so a full-sample regression could mislead. As a result a "suitable subsample" of the investment data is sought. Beginning from the earliest recorded observation and then pushing out to later and later years, the best subsample is defined as the one that maximizes the *linearity* of the relationship between $ln\,I_t$ and calendar time, given statistical variability—i.e., the search is across successive subsamples for the largest absolute correlation between $ln\,I_t$ and calendar time, which amounts to an R^2 test of the regression (4). If the growth rate of real investment is plausibly constant, then the sequence of regression R^2's should, after an initial plunge from a two-observation default of 100 percent, steadily increase, implying that the full sample is appropriate. But if the growth rate undergoes a sizeable change, then the R^2 sequence should fall again before resuming an upward path: in that case, a good sample begins at the earliest observed investment and stops at the first peak of the post-plunge R^2.

For the featured "R&D Output" investment deflator, no growth-rate regressions used the whole 1956-2004 sample; one (for "Transportation Equipment") used only nine observations. Regression results using (4) and implied growth-rate estimates are:

	Chemical Products Mfg	Transportation Equipment Mfg	Computer and Electronics Mfg	All Other Nonfinancial Corporate Business
Estimated m:	.086936	.06326	.092167	.066046
Std. Error:	(.002713)	(.002452)	(.002012)	(.001088)
R^2	.992271	.989592	.993846	.989521
Subsample	1956-65	1956-64	1956-70	1956-96
Implied g_K:	.090826	.065304	.096548	.068276
Est. Std. Error:	(.002959)	(.002612)	(.002206)	(.001163)

When the depreciation rate is not fixed but is an assigned time-series[4], the growth-rate method needs further modification. Maintain g_K constant, but differentiate K, I, *and* δ in (2) with respect to (continuous) time, to write:

$$(1-½\delta)(g_I - g_K)\,I/K = \dot{\delta}(1 + ½\,I/K) \qquad (5)$$

[4] Again see Charles Ian Mead, "R&D Depreciation Rates in the 2007 R&D Satellite Account," BEA/NSF R&D Satellite Account Background Paper" (November 2007).

where $\dot{\delta} = d\delta/dt$ and g_I is the growth rate of real investment, which may now differ from the growth rate of capital g_K. It is apparent that g_K exceeds or falls short of g_I as $\dot{\delta}$ is negative or positive, respectively. Now using (3) to replace I/K, rewrite (5) as:

$$(g_K + \delta)(g_I - g_K) = \dot{\delta}\,[1 + \tfrac{1}{2}(g_K + \delta)/(1 - \tfrac{1}{2}\delta)] \qquad (6)$$

then collect terms to find a quadratic equation in g_K:

$$g_K^{\,2} \;+\; [\delta - g_I + \dot{\delta}/(2\text{–}\delta)]\,g_K \;+\; [2\dot{\delta}/(2\text{–}\delta) - \delta g_I] \;=\; 0 \qquad (7)$$

where the positive-branch solution:

$$g_K = \tfrac{1}{2}[(g_I - \delta_{1956}) - \dot{\delta}/(2-\delta_{1956})] + \{\tfrac{1}{4}[(g_I - \delta_{1956}) - \dot{\delta}/(2-\delta_{1956})]^2 + \delta_{1956}\,g_I - 2\dot{\delta}/(2-\delta_{1956})\}^{1/2} \quad (8)$$

is continuous with the usual case of a time-invariant depreciation rate when $\dot{\delta}$=0. Note g_K still depends on the estimate of $g_I = e^m$–1, where m is still from regression equation (4); but it also depends on δ_{1956} — i.e., the depreciation rate that prevails during the year of the first recorded investment — and on $\dot{\delta}$, estimated as the slope coefficient n of the linear regression of δ_t on calendar-time t:

$$\delta_t = c + n\,t + \zeta_t . \qquad (\zeta_t \text{ an error term}) \qquad (9)$$

The same issue of a proper sample comes up here as in (4), and another regression R^2 test resolves it; the two regressions' sample lengths might be different. Results for (9) are:

	Chemical Products Mfg	Transportation Equipment Mfg	Computer and Electronics Mfg	All Other Nonfinancial Corporate Business
Estimated n:	5.93×10^{-4}	9.70×10^{-4}	8.890×10^{-4}	8.809×10^{-4}
Std. Error:	(1.93×10^{-5})	(3.15×10^{-5})	(2.89×10^{-5})	(2.63×10^{-5})
R^2 (same for all)	.96833	.96833	.96833	.96833
Subsample (also)	1956-88	1956-88	1956-88	1956-88

Finally, using fitted g_I, δ_{1956}, and fitted $\dot{\delta}$, evaluate (8) for g_K:

	Chemical Products Mfg	Transportation Equipment Mfg	Computer and Electronics Mfg	All Other Nonfinancial Corporate Business
Implied g_K:	.087448	.060628	.092529	.063962

then feed g_K and δ_{1956} into (3). The resulting benchmark K's are good starting-points for perpetual-inventory accumulations when depreciation rates are not constant.[5]

Regardless of whether δ is fixed or time-varying, year-to-year constant-cost depreciation flows at the deflation level were already given as D_t in (1), and current-cost depreciation is D_t times the year-t R&D investment deflator. However, the current-cost

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[5] Note that (8) imposes an upper bound on $\dot{\delta}$, for $\tfrac{1}{4}[(g_I - \delta_{1956}) - \dot{\delta}/(2-\delta_{1956})]^2 + \delta_{1956}\,g_I - 2\dot{\delta}/(2-\delta_{1956})$—i.e., the terms inside the radical—must be nonnegative. The bound, $\dot{\delta} \leq (2\text{–}\delta_{1956})[4 + g_I - \delta_{1956} - 2(2+g_I)^{1/2}(2\text{–}\delta_{1956})^{1/2}]$, is over a dozen times as large as what the Satellite Account actually used.

net stock is not end-of-year K_t times the year-t investment deflator, but rather K_t times the average of the year-t and year-$(t+1)$ investment deflators, with the average assumed to represent the end-of-year-t stock-price, in order to approximate capital's end-of-year replacement value. Forming higher-level aggregates—e.g., combining industry-by-industry stocks and flows to the "business" level—is a solved problem: current-cost aggregates, which represent values, are just the sums of their constituents; while constant-cost aggregates, which represent quantities, are in general constructed as superlative (e.g., Fisher) aggregates of the constant-cost volumes and investment deflators prevailing at the constituent level. When the constituent deflators move in strict proportion (as here, where they are the same across sectors), then Fisher aggregates reduce to simple sums.

Tables 2.1 through 2.6 of the October 2007 *Survey of Current Business* article presenting the 2007 Satellite Account give the results of the computations described here, for the featured "R&D Output" investment deflator and fixed industry-specific R&D depreciation rates. Tables 2.3X through 2.6X, below, present corresponding results (for private industries only) when industry-specific R&D depreciation rates are constrained to accelerate (in lockstep) over time.

II. User-Costs and Net Rates of Return for R&D Capital

BEA has not explicitly included a detailed decomposition of returns to capital as part of its core accounts. Consumption of Fixed Capital (*CFC*)—depreciation of assets owned—was deducted from a sector's gross operating surplus (*GOS*), and the remainder, "net operating surplus" (*NOS*), was parsed as payments to different institutional recipients. Two methods are discussed: one based on the user-cost, the other as implemented in recent issues of the *Survey of Current Business*.

User-cost approach to computing rates of return

One approach to a net rate of return applicable to at least some capital is to rephrase nominal gross operating surplus as the sum of the implicit rental values of capital types owned by a sector:

$$GOS = \sum_{i=1}^{n} U_i K_i \tag{10}$$

where the implicit rental price of capital type i is its user-cost U_i, which plays a key role in modern production economics.[6] Apart from modifications for taxes, this is written:

$$U = P(\delta + r - \mathbb{E}\hat{P}) \tag{11}$$

where P is the nominal purchase price of a new asset, δ is the depreciation rate of that price as the asset begins to age — the *same* rate as in the perpetual-inventory equation, under the geometric model — $\mathbb{E}\hat{P}$ is the expected rate of inflation (or "capital gain") on new assets of that type, and r is a nominal net rate of return on asset(s). Now, U is a price just as P is, though with a different focus: U evaluates capital's contribution to *current*

[6] C.f. D. Jorgenson and Z. Griliches, "The Explanation of Productivity Change," *The Review of Economic Studies*, Vol. 34, No. 99 (1967), pp. 249-283, especially equation (7) on p. 256, the top of p. 257, and tax effects at equation (11) on p. 267. The article was reprinted in the May 1972 *Survey of Current Business*.

production, but P represents the present discounted value of current and all future contributions. Both prices are nominal, and both may be made "real" by normalizing by a common current general deflator π. This should not be confused with the net rate of return: r is still a nominal rate, comparable in principle to some observed interest rate, whether or not U and its leading P are to be normalized; but $r - \mathbb{E}\hat{P}$ is the asset's "own" rate, which beats its "real" rate as $\mathbb{E}(\hat{P} - \hat{\pi}) < 0$. Alternatively, $r - \mathbb{E}\hat{\pi}$ is the real net rate of return while $\mathbb{E}(\hat{P} - \hat{\pi})$ is the real rate of capital gain. Note that dropping $\mathbb{E}\hat{P}$ from (11) when expected nominal capital-gains are not zero amounts to treating r as an own rate. Finally, if new-asset purchase prices are available only in "real" form (i.e., if some upstream office provides the downstream analyst only P/π in ratio form rather than separately and wrongly calls the ratio "P": not the case here), then not only is U real, but so also are $\mathbb{E}\hat{P}$ and r; but dropping $\mathbb{E}P/\pi$ when expected real capital gains are not zero again makes r an own rate—the *same* own rate, for a given $\mathbb{E}\hat{\pi}$, as when prices had been in nominal terms. A schematic chart of the various *ex post* net rate concepts follows:

Concept:	Write:	Estimate *Ex Post* Net Rates as (*see below*):	(12)
own	$r - \mathbb{E}\hat{P}$	$NOS_t \Big/ \sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$	
nominal	r	$[NOS_t + \sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})\mathbb{E}_t \hat{P}_{i,t:t+1}] \Big/ \sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$	
real	$r - \mathbb{E}\hat{\pi}$	$[NOS_t + \sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})\mathbb{E}_t(\hat{P}_{i,t:t+1} - \hat{\pi}_{t:t+1})] \Big/ \sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$	

The formulas in the rightmost column of (12) are now described. Observe first that the national accounts already fill out some of (10) and (11): for asset i in year t, nominal $CFC_{i,t} = P_{i,t}\,\delta_{i,t}\,(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$ by the mid-year convention, where δ_i might change from one year to the next. Treating r and $\mathbb{E}\hat{P}$ like δ offers an appealing way to apply an *ex post* user-cost in the same framework:

$$GOS_t = \sum_{i=1}^{n} P_{i,t}(\delta_{i,t} + r_{i,t} - \mathbb{E}_t \hat{P}_{i,t:t+1})(K_{i,t-1} + \tfrac{1}{2} I_{i,t}) \tag{13}$$

Read $\mathbb{E}_t \hat{P}_{i,t:t+1}$ as: "the expected rate of change of new prices for asset i from year t to year t+1, given information available as of t." The deflation-level constant-cost capital notion for the user-cost, $K_{t-1} + \tfrac{1}{2} I_t$, which was already implicit as the basis for CFC flows, lies between the constant-cost net stocks available at the start (K_{t-1}) and end (K_t) of year t; the current-cost concept, $P_t(K_{t-1} + \tfrac{1}{2} I_t)$, is comparable to BEA's current-cost net stocks at the start of the year, $\tfrac{1}{2}(P_{t-1} + P_t)K_{t-1}$, and the end, $\tfrac{1}{2}(P_t + P_{t+1})K_t$.

Next, remove nominal CFC from (13):

$$NOS_t = \sum_{i=1}^{n}(r_{i,t} - \mathbb{E}_t \hat{P}_{i,t:t+1})P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t}) \tag{14}$$

Normalizing both sides by $\sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$ brings us almost to the "own" line of (12). However, equation (14) has one observed value to the left of the equal-sign but as many as $2n$ unobserved values (i.e., $r_{1,t}$, …, $r_{n,t}$; and n different capital-gain terms) to the right.

Standard production economics sets all $r_{i,t}$ to the (same) best alternative return on tied-up funds, r_t^*, but like the capital-gains terms, this is an expected rate. Further, firms within a sector deploy assets across projects of varying risk, among them risky research and development programs, so the "best alternatives" might differ from one asset to the next. Many analysts have settled on the *ex post* method, whereby a single r_t is selected to satisfy (14), given assumptions on the capital gains terms, and that is the approach taken here, which appears in the "own" line of (12).

But assumptions on capital gains are themselves controversial. On one hand are Jorgenson and Griliches[5], who use after-the-fact observed investment-deflator growth rates (pp. 278-79): a perfect-foresight solution that is perhaps too bumpy, inducing, to the extent asset-specific capital-gains do not offset each other, countervailing bumps in the solved-for r_t series. On the other hand are Hall and Jorgenson, who set $\mathbb{E}_t \hat{P} = 0$ on grounds that expected capital gains must be transitory, and so impose an *own* rate.[7] Between these two views are efforts to smooth capital gains (and the time series of implicit nominal rates of return) by replacing each $\mathbb{E}_t \hat{P}_{i,t:t+1}$ with a moving average of investment-price growth rates (e.g., $\mathbb{E}_t \hat{P}_{i,t:t+1} \approx \sum_{\ell=1} w_\ell \hat{P}_{i,t-\ell:t-\ell+1}$). The Office of Productivity and Technology at the U.S. Bureau of Labor Statistics has adopted this approach.[8]

Rates of return compatible with recent BEA calculations

While there remain unresolved issues in the compilation of suitable net rates of return, it would be helpful if any returns that included R&D were easy to compare with other rates of return previously calculated in BEA's history. Accordingly, net rates of return on assets (among them R&D) in the 2007 Satellite Account are calculated using methods compatible with recent issues of the *Survey of Current Business*.[9] The net

[7] C.f. R.E. Hall and D. Jorgenson, "Tax Policy and Investment Behavior," *American Economic Review*, Vol. 57, No. 3 (1967), pp. 391-414. They used an *ex ante* pre-tax discount rate of 14 percent (p. 400). It is worth pointing out that for high-tech goods such as computers (and BEA's R&D price index leans heavily on the computer deflator), rapid declines in quality-adjusted new-investment prices must take a heavy toll on the resale value of used assets: properly including such obsolescence in δ might leave few capital losses.

[8] A good discussion and empirical comparison of the three approaches laid out here, and also of *ex ante* methods, is found in M. Harper, E. Berndt, and D. Wood, "Rates of Return and Capital Aggregation Using Alternative Rental Prices," Chapter 8 of D. Jorgenson and R. Landau, eds., *Technology and Capital Formation* (MIT Press, 1989), pp. 331-372. That chapter examined capital gains with a view toward stable, positive, nominal net rates of return. Its working assumption of a single net rate common to all assets in an industry—i.e., simple static efficiency—is strong (though any *ex post* approach must accede to it), and one could ask why nominal net rates are persistently different across industries with the same large corporate players. One might then ask what capital-gains solution would minimize cross-industry variations in nominal rates of return, and how well such a solution would predict subsequent actual asset-price inflation.

[9] C.f. P. Lally, "Note on the Returns for Domestic Nonfinancial Corporations," *Survey of Current Business* (May 2006), pp. 6-10; and P. Lally, G. Smith, A. Hodge, and R. Corea, "Returns for Domestic Nonfinancial Business," *Survey of Current Business* (May 2007), pp. 6-10. The first term in the numerator of equation (15) below, matches the first columns of Table 2 in both articles, and the first two terms in the denominator sum to what the two articles call (averaged) "Produced Assets," apart from slight variations in the timing of how inventories are averaged. By contrast, "Produced Assets" in *NIPA* Table 5.9 are strictly end-of-year. Earlier expressions of "net returns," using somewhat different conventions, have appeared from time to time in the *Survey*, running back at least as far as pp. 8-9 of the April 1989 article, "The Business Situation." The reports were never part of the National Accounts and never connected with the user-cost.

returns are *ex post* own rates—i.e., expected capital-gains are ignored, and so absorbed into r—computed as ratios of net operating surplus to consecutive-year averages of "Produced Assets," which sum current-cost net stocks and inventories. Capitalizing R&D increases *NOS* by the current value of nominal R&D investment less the current value of nominal R&D depreciation; but the denominator of the ratio can only increase by the average current-cost R&D net stock. Whether the ratio as a whole increases or decreases depends on whether the R&D investment-to-stock ratio, less the R&D depreciation rate, exceeds or falls short of the net rate of return as calculated without R&D capitalized. While R&D investment might be expected to exhibit some payoff in R&D-intensive industries, the gains could be obscured by unresolved measurement problems in current data.

At the national level, then, BEA currently computes the pre-tax *ex post* net own rate of return in year t on Produced Assets owned by Nonfinancial Corporate Business as:

$$\frac{\text{(Non-R\&D } NOS \text{ of Non-financial Corporate Business[10]})_t + \text{(Private Business Current-Cost R\&D Investment[11]})_t - \text{(Private Business Current-Cost R\&D Depreciation[12]})_t}{\text{(}\textit{Average}\text{ Current-Cost Net Stocks of Non-R\&D Capital Owned by Nonfinancial Corporate Business[13]})_t + \text{(}\textit{Average}\text{ Current-Cost Inventory Stocks Held by Nonfinancial Corporate Business[14]})_t + \text{(}\textit{Average}\text{ Current-Cost Net Stocks of R\&D Capital Owned by Private Business[15]})_t} \qquad (15)$$

The shaded terms give net own rates of return on nonfinancial corporate capital with R&D spending treated as intermediate input instead of investment; the two unshaded terms in the numerator give the net effects of capitalizing R&D on net operating surplus, and the unshaded term in the denominator gives the R&D increment to average Produced Assets. To restate (15) in terms compatible with the user-cost and mid-year convention (albeit still as an own rate), replace the consecutive-year averages of current-cost net stocks in the denominator by $\sum_{i=1}^{n} P_{i,t}(K_{i,t-1} + \tfrac{1}{2} I_{i,t})$.[16]

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[10] *NIPA* Table 1.14, line 24.

[11] http://www.bea.gov/rd/xls/1959_2004_rd_data.xls, Table 2.1, line 6. N.B.: Dividing this by the "R&D Output" deflator (Table 4.2, line 4) gives constant-cost R&D investment (Table 2.2, line 6). An alternative measure of constant-cost R&D investment would divide the current-cost figure by the "R&D Input" deflator (Table 4.2, line 5). An estimate of the rate of multifactor productivity growth in R&D conduct is found by subtracting the growth rate of the R&D Output deflator from that of the R&D Input deflator.

[12] http://www.bea.gov/rd/xls/1959_2004_rd_data.xls, Table 2.5, line 6. This is *constant-cost* consumption of private-business fixed R&D capital (Table 2.6, line 6), times the "R&D Output" deflator (Table 4.2, line 4).

[13] *Fixed Assets and Consumer Durables*, Table 6.1, line 4. *FACD* gives end-of-year-*t* "spot" values; the year-*t* "average" cited in equation (15) is the simple average of consecutive years' *FACD* spot values.

[14] *NIPA* Table 5.7.5A, line 3 and Table 5.7.5B, line 19, give seasonally-adjusted end-of-quarter estimates of private nonfarm inventories, which are all attributed to nonfinancial corporations. (BEA assigns financial corporations and governments no inventories.) These are worked up from unpublished monthly figures. The year-*t* "average" in equation (15) is the average of the 13 end-of-month values (December 31, *t*–1… …through December 31, *t*) that bracket year *t*, plus the average of 13 corresponding end-of-month values of unpublished *corporate* farm inventories.

[15] http://www.bea.gov/rd/xls/1959_2004_rd_data.xls, Table 2.3, line 6 gives end-of-year-*t* "spot" values; the year-*t* "average" cited in equation (15) is the simple average of consecutive years' spot values.

[16] This paper does not examine production-theoretic accounting for inventories.

Data limitations, however, require certain assumptions (and would even in a user-cost approach): First, difficulties in separating proprietors' income into capital and labor components, and in uncovering assets to support financial corporations' substantial earnings, encourage a focus on nonfinancial corporate business. Second, NSF's surveys of businesses' R&D spending do not categorize companies by legal form of organization, so all "private business" R&D investment, and resulting stocks and depreciation, are for now assigned to nonfinancial corporations.[17] Third, the NSF surveys treat outsourced and intramural investment asymmetrically: R&D purchased "from outside" necessarily includes a return to performers' employed capital, while in-house R&D costs, per accounting conventions, do not; the shortfall would lead to an underestimate of R&D investment, stocks, and depreciation.[18] But for these, private business R&D investments are assumed "clean," having already been disentangled from investments in software.[19]

The 2007 Satellite Account began the work of disaggregating nationwide R&D tallies among industries. This paper extends the account by computing net rates of return for Private Nonfarm Nonfinancial Industry and three manufacturing sectors—Chemical Products (NAICS 325), Computer and Electronic Products (NAICS 334), and Transportation Equipment (NAICS 336)—using the approach given in equation (15), with a few changes. First, as the sectoral concept is now the industry not the corporation, pre-R&D -basis *NOS* in the numerator includes (all of) nonfarm proprietors' income, but no farm income (whether corporate or noncorporate). Second, financial *industries*—NAICS sectors "Finance and Insurance" and "Real Estate and Rental and Leasing" since 1997, but SIC "Finance, Insurance, and Real Estate" (converted to a NAICS basis) before—are excluded, but financial *corporations*, as such, are not. Analogous adjustments were made to current-cost net stocks and inventories. Note the conversion from SIC to NAICS industries, already carried out by BEA in conformance with Bayard and Klimek[20] for data back through 1987, is much rougher before 1987, depending on fixed weights largely determined by regressions.[21] Note also that NSF's industry classification of business-owned R&D investment is actually on a company basis, which BEA has not adjusted.

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[17] We're not completely in the dark: a special NSF tabulation for 2001 found 98.8 percent of "Gross Expenditure on R&D" by business *performers* was spent by nonfinancial corporations, 1.2 percent by financial corporations, and zero (!) by unincorporated businesses.

[18] See http://www.bea.gov/rd/xls/1959_2004_rd_data.xls, Table 5.1, where own-account R&D investment by "All For-Profit Industries" runs from 3¼ (1987) to 2¼ (2004) times the value of purchased R&D. BEA already makes a partial adjustment, estimating the depreciation (only) on assets used for intramural R&D (C.f. Table 8, line 4). Steps toward imputing the remaining investment shortfall might begin by assuming the same net rate of return on assets used for intramural R&D as on assets used to produce sold output. The solution would be a sequence of year-at-a-time simultaneous values of: enhanced investment, R&D net stock, depreciation volumes, and net rates of return. Contrast the usual perpetual-inventory method, where investment data are assumed complete, net stock and depreciation series follow, and net rates finish. Some experiments within BEA, using generous assumptions, did not finish greatly different from the usual method. The same issue comes up in BEA's capitalization of software expenses, where a zero net rate on in-house development is also assumed.

[19] See Lisa Mataloni and Carol E. Moylan, "2007 R&D Satellite Account Methodologies: Current-dollar Aggregate Sector Estimates," BEA/NSF R&D Satellite Account Background Paper" (December 2007).

[20] C.f. Kimberly N. Bayard and Shawn D. Klimek, "Creating a Historical Bridge for Manufacturing Between the Standard Industrial Classification System and the North American Classification System," presented at the Joint Statistical Meetings in San Francisco, August 2003.

[21] SIC-NAICS recoding of *GOS* and inventories are on background spreadsheets, available upon request.

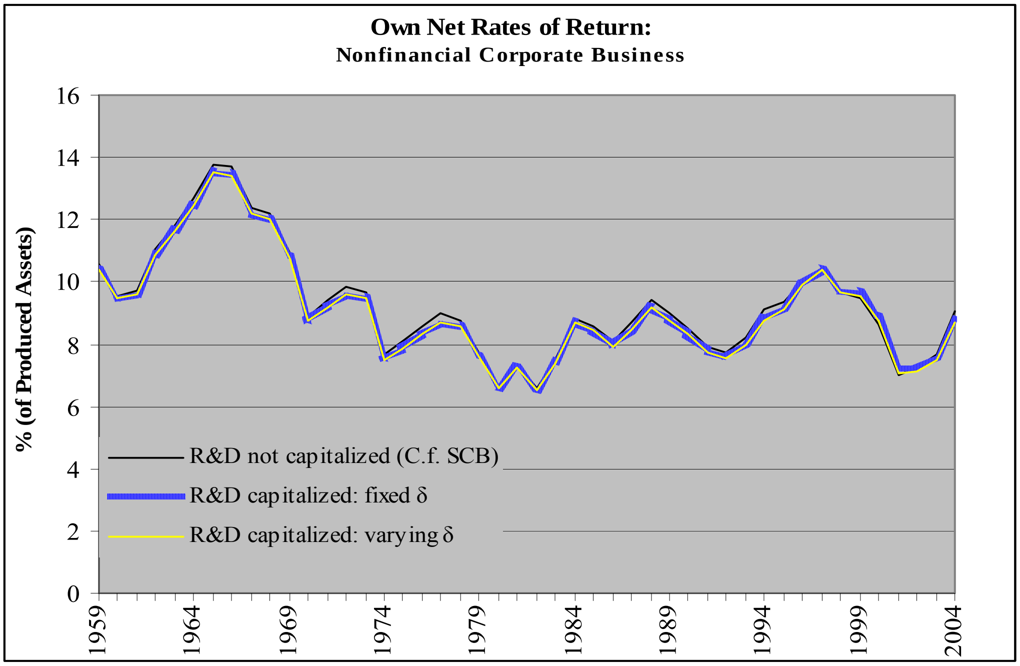
Tables A, B, and C, below, carry out the computations described here. Table A does not capitalize R&D spending and so is directly comparable to BEA's previous work. Apart from data revisions, entries in the "Nonfinancial Corporate Business" rows agree with column (1) of Table 1 of the May 2006 *Survey of Current Business* article, "Note on the Returns for Domestic Nonfinancial Corporations in 1960-2005" (p. 7). And apart from the exclusion of farms, entries in the "Private Nonfarm Nonfinancial Industry" rows would correspond to the "Total" column of Table 1 of the May 2007 *Survey* article, "Returns for Domestic Nonfinancial Business" (p. 6). BEA has not previously reported net rates of return for the chemical, transportation equipment, or computer and electronic equipment manufacturing industries.

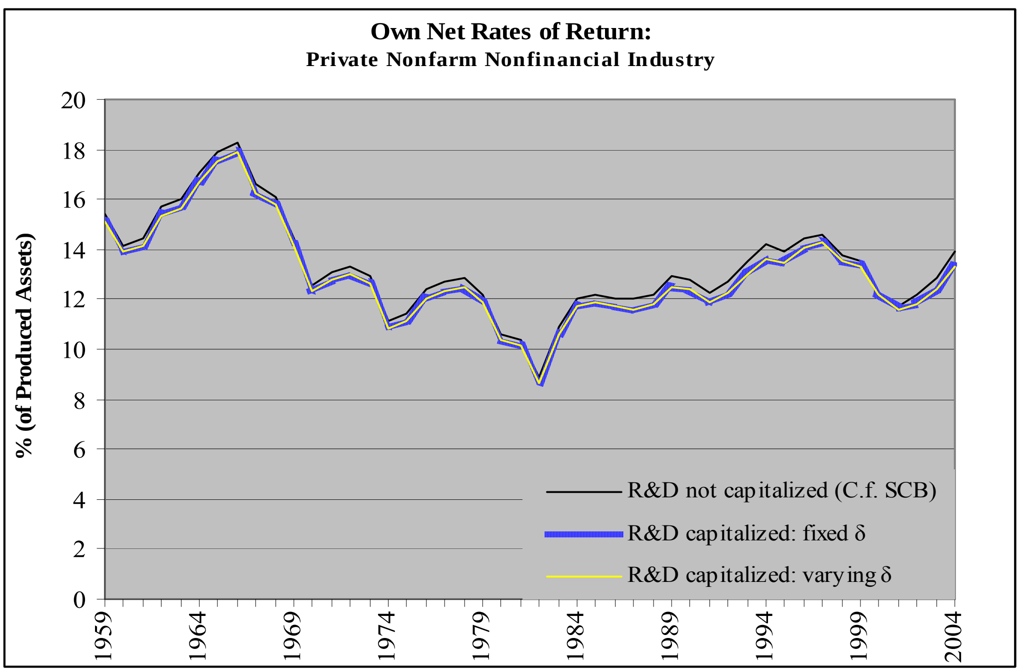
Table B calculates net rates of return when R&D is capitalized subject to fixed, unchanging R&D depreciation rates, so its figures are direct extensions of the October 2007 Satellite Account. Table C calculates rates of return when R&D is capitalized, but industry-specific R&D depreciation rates are constrained to accelerate (together). It uses the R&D investment, stock, and depreciation tallies given in Tables 2.3X through 2.6X.

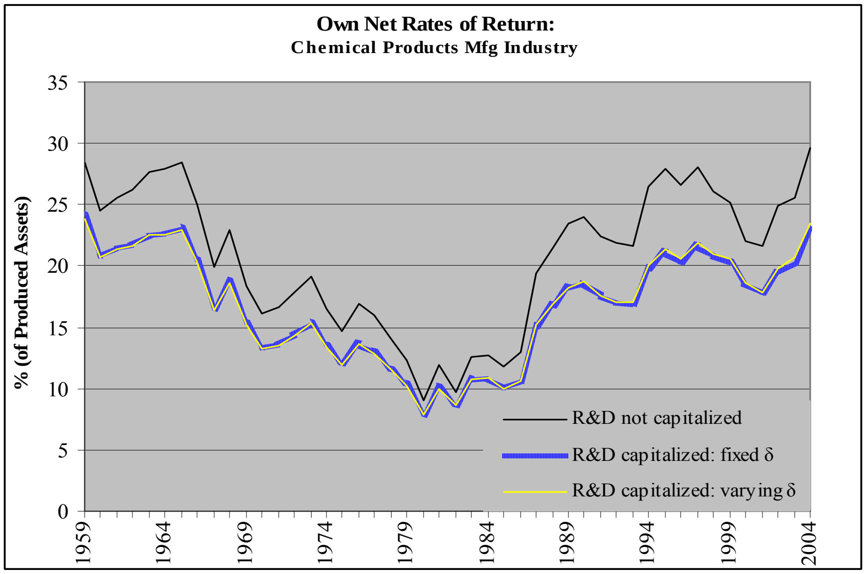
Charts of the time-paths of net own rates of return are presented below, a sector at a time, comparing the different treatments of R&D. In each chart, the solid black line traces the net own rate of return when R&D spending is not capitalized, the rough blue line when R&D is capitalized under the assumption of unchanging depreciation rates (which differ across sectors), and the thin yellow line when R&D is capitalized under the assumption of time-varying depreciation rates. As can be seen in the first two charts, capitalizing R&D does little to net rates in aggregate, under either depreciation regime, because R&D capital is still a small share of the total.

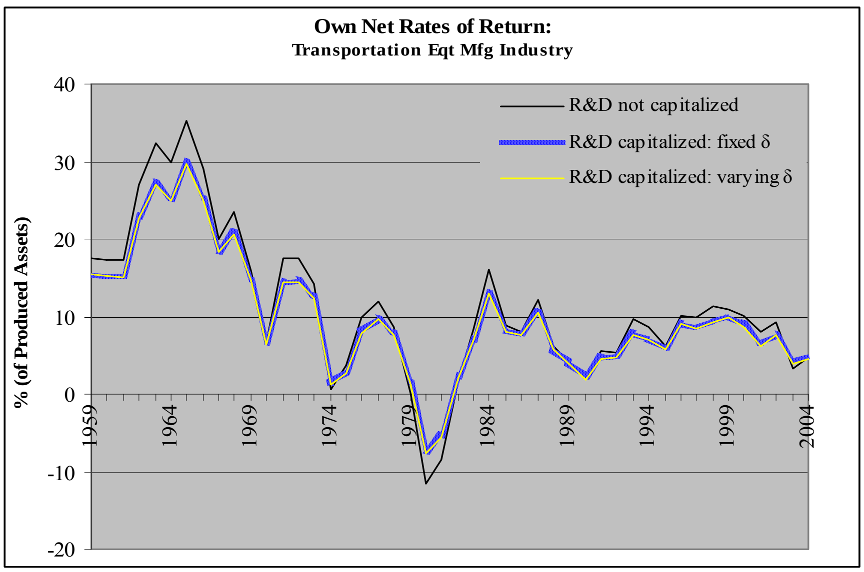
In the charts for three R&D-intensive manufacturing industries—Chemicals, Transportation Equipment, and Computers & Electronics—the capitalization of R&D plainly does affect levels of net rates of return, but not rates of growth; again, whether the depreciation rate is a constant or an accelerating time-series hardly matters, as differences across the two depreciation treatments in net operating surplus and current-cost stocks largely offset each other. The Chemical and Transportation Equipment industries are shown to be persistently less profitable when R&D is treated as capital than when it is not, a counterintuitive result as net operating surpluses increase less than net stocks. Only Computer and Electronic Equipment manufacturing appears more profitable with R&D capitalized: dot-com losses are halved. Comparisons of profitability across sectors must await the computation of *ex post* nominal net rates of return to filter disparate capital gains on industries' different asset mixes.

To sum up, this paper has constructed R&D capital stocks under fixed and time-varying depreciation rates with very little lead time between the first recorded investment and the first net stock reported. It has also mapped out a user-cost strategy consistent with how BEA accounts for depreciation in the NIPAs, and presented net rates of return to capital inclusive of R&D in a way that is consistent with BEA's recent practice.


Own Net Rates of Return:
Nonfinancial Corporate Business
% (of Produced Assets)
16
14
12
10
8
6
4
2
0
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
R&D not capitalized (C.f. SCB)
R&D capitalized: fixed δ
R&D capitalized: varying δ


Own Net Rates of Return:
Private Nonfarm Nonfinancial Industry
% (of Produced Assets)
20
18
16
14
12
10
8
6
4
2
0
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
R&D not capitalized (C.f. SCB)
R&D capitalized: fixed δ
R&D capitalized: varying δ


Own Net Rates of Return:
Chemical Products Mfg Industry
% (of Produced Assets)
R&D not capitalized
R&D capitalized: fixed δ
R&D capitalized: varying δ
0
5
10
15
20
25
30
35
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004


Own Net Rates of Return:
Transportation Eqt Mfg Industry
% (of Produced Assets)
R&D not capitalized
R&D capitalized: fixed δ
R&D capitalized: varying δ
-20
-10
0
10
20
30
40
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004

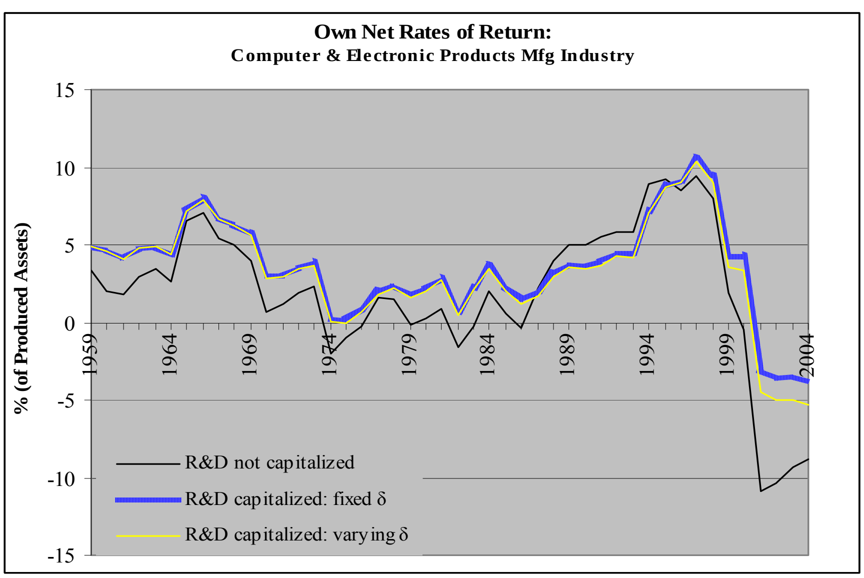

Own Net Rates of Return:
Computer & Electronic Products Mfg Industry
% (of Produced Assets)
R&D not capitalized
R&D capitalized: fixed δ
R&D capitalized: varying δ
-15
-10
-5
0
5
10
15
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004

Table 2.3X. Current-Cost Net Stock of Private-Business R&D by Type of Funder, 1959-2003
[Millions of dollars]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business	19,672	20,936	22,236	23,680	25,315	27,262	29,633	32,629	36,094	39,849	44,360
Chemical (NAICS 325)	3,950	4,301	4,683	5,076	5,509	6,017	6,589	7,227	7,857	8,578	9,401
Transportation (NAICS 336)	4,214	4,434	4,679	4,945	5,256	5,584	6,079	6,750	7,696	8,594	9,661
Computer and electronic (NAICS 334)	3,634	4,011	4,365	4,739	5,135	5,592	6,125	6,859	7,708	8,627	9,741
All Other	7,873	8,191	8,509	8,919	9,416	10,069	10,839	11,793	12,833	14,050	15,557

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business	49,077	53,099	57,053	65,356	77,996	87,607	95,229	104,426	117,111	135,653	159,762
Chemical (NAICS 325)	10,271	11,031	11,733	13,227	15,734	17,834	19,479	21,284	23,675	27,082	31,416
Transportation (NAICS 336)	10,609	11,297	11,972	13,760	16,253	17,776	19,021	20,804	23,444	27,227	31,923
Computer and electronic (NAICS 334)	10,917	11,977	13,063	15,050	17,945	20,070	21,739	23,647	26,524	31,004	36,950
All Other	17,281	18,794	20,284	23,319	28,064	31,926	34,990	38,690	43,468	50,339	59,474

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Nonfinancial Corporate Business	183,740	204,046	224,396	247,213	269,867	291,142	309,909	330,023	350,246	370,351	392,819
Chemical (NAICS 325)	35,684	39,833	43,861	48,198	52,206	55,987	60,005	64,674	69,086	74,112	79,313
Transportation (NAICS 336)	36,068	39,530	42,423	45,906	49,973	54,625	58,819	62,308	64,913	66,275	67,380
Computer and electronic (NAICS 334)	43,302	48,024	53,549	59,096	63,769	68,081	69,734	71,244	71,776	71,915	71,656
All Other	68,686	76,659	84,562	94,013	103,920	112,448	121,351	131,797	144,471	158,049	174,470

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nonfinancial Corporate Business	411,902	427,410	436,309	444,059	456,971	475,554	500,131	539,526	587,270	625,291	655,208	685,943
Chemical (NAICS 325)	83,971	89,349	92,879	94,802	96,020	97,787	101,813	108,814	118,142	126,999	137,637	153,760
Transportation (NAICS 336)	69,317	70,634	71,436	71,860	72,783	72,355	71,026	73,562	74,597	73,147	73,465	77,937
Computer and electronic (NAICS 334)	71,716	71,555	72,096	74,569	78,895	85,618	92,536	97,971	110,440	122,936	132,055	138,251
All Other	186,897	195,872	199,897	202,828	209,274	219,794	234,755	259,179	284,090	302,208	312,050	315,995

R&D Research and development
NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that accelerate together through time.
See equations (5) through (9) in the accompanying text for derivations of the end-of-1955 real net stock benchmarks.

Table 2.4X. Real Net Stock of Private-Business R&D by Type of Funder, 1959-2004
[Millions of chained (2000) dollars]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business	49,227	52,722	56,331	60,427	64,846	69,670	75,244	81,666	88,539	95,883	103,916
Chemical (NAICS 325)	9,886	10,830	11,864	12,954	14,110	15,378	16,732	18,087	19,272	20,640	22,023
Transportation (NAICS 336)	10,546	11,165	11,854	12,618	13,464	14,271	15,437	16,895	18,879	20,679	22,631
Computer and electronic (NAICS 334)	9,094	10,100	11,058	12,094	13,153	14,290	15,552	17,168	18,908	20,758	22,818
All Other	19,701	20,627	21,555	22,760	24,118	25,732	27,523	29,517	31,480	33,806	36,444

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business	110,835	116,551	122,689	130,465	136,688	139,914	143,997	148,614	154,638	162,321	170,831
Chemical (NAICS 325)	23,195	24,213	25,232	26,403	27,573	28,482	29,454	30,291	31,262	32,406	33,592
Transportation (NAICS 336)	23,958	24,796	25,746	27,469	28,483	28,390	28,762	29,607	30,956	32,579	34,134
Computer and electronic (NAICS 334)	24,655	26,290	28,091	30,043	31,449	32,054	32,872	33,654	35,023	37,100	39,510
All Other	39,027	41,253	43,620	46,549	49,182	50,989	52,909	55,062	57,396	60,235	63,595

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business	179,445	188,699	199,066	211,666	225,327	238,118	248,971	261,315	275,871	290,216	307,221	323,941
Chemical (NAICS 325)	34,850	36,837	38,910	41,268	43,590	45,790	48,206	51,209	54,415	58,076	62,030	66,039
Transportation (NAICS 336)	35,225	36,557	37,634	39,305	41,725	44,677	47,253	49,336	51,129	51,935	52,698	54,514
Computer and electronic (NAICS 334)	42,290	44,412	47,505	50,598	53,244	55,682	56,022	56,412	56,534	56,354	56,041	56,402
All Other	67,080	70,893	75,017	80,495	86,768	91,969	97,490	104,358	113,792	123,851	136,452	146,986

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business	337,509	350,157	370,635	400,707	438,864	482,857	534,762	596,252	648,427	685,466	719,680	751,893
Chemical (NAICS 325)	70,556	74,540	79,127	84,197	90,243	98,297	107,853	119,949	131,698	143,993	161,323	182,451
Transportation (NAICS 336)	55,777	57,331	59,978	63,821	66,773	68,573	72,913	75,738	75,854	76,858	81,770	85,260
Computer and electronic (NAICS 334)	56,504	57,861	62,239	69,181	79,012	89,340	97,106	112,129	127,485	138,154	145,050	148,248
All Other	154,673	160,426	169,291	183,507	202,837	226,647	256,891	288,436	313,389	326,461	331,537	335,935

R&D Research and development
NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that accelerate together through time. See equations (5) through (9) in the accompanying text for derivations of the end-of-1955 real net stock benchmarks.

Table 2.5X. Current-Cost Depreciation of Private-Business R&D by Type of Funder, 1959-2004
[Millions of dollars]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business	3,070	3,247	3,443	3,636	3,866	4,172	4,534	5,006	5,610	6,258	6,962
Chemical (NAICS 325)	431	469	510	551	596	653	718	793	877	963	1,055
Transportation (NAICS 336)	793	835	878	922	975	1,043	1,128	1,251	1,428	1,622	1,821
Computer and electronic (NAICS 334)	615	671	734	793	858	939	1,030	1,151	1,309	1,479	1,665
All Other	1,231	1,272	1,320	1,370	1,437	1,538	1,658	1,810	1,996	2,194	2,421

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business	7,811	8,628	9,304	10,141	12,231	14,636	15,956	17,412	19,547	22,266	26,244
Chemical (NAICS 325)	1,166	1,274	1,362	1,463	1,747	2,099	2,307	2,520	2,810	3,165	3,676
Transportation (NAICS 336)	2,042	2,229	2,368	2,567	3,083	3,626	3,876	4,194	4,714	5,385	6,334
Computer and electronic (NAICS 334)	1,892	2,117	2,316	2,548	3,079	3,679	4,002	4,344	4,856	5,554	6,609
All Other	2,711	3,008	3,258	3,563	4,321	5,231	5,771	6,354	7,166	8,162	9,625

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business	30,979	34,912	38,405	42,871	47,355	51,876	56,098	60,223	64,880	69,148	74,665	79,295
Chemical (NAICS 325)	4,277	4,804	5,305	5,920	6,505	7,074	7,653	8,304	9,045	9,766	10,701	11,498
Transportation (NAICS 336)	7,389	8,202	8,861	9,692	10,602	11,675	12,785	13,786	14,708	15,308	15,959	16,490
Computer and electronic (NAICS 334)	7,917	9,000	9,973	11,226	12,341	13,368	14,108	14,572	15,014	15,222	15,561	15,695
All Other	11,396	12,906	14,265	16,033	17,907	19,759	21,552	23,561	26,114	28,852	32,444	35,612

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business	84,173	88,334	90,974	93,777	100,014	107,620	118,596	132,071	145,187	151,407	159,937	170,189
Chemical (NAICS 325)	12,447	13,370	13,922	14,243	14,884	15,756	17,197	19,051	21,035	22,485	25,041	28,770
Transportation (NAICS 336)	17,232	17,885	18,248	18,548	19,168	19,492	20,377	21,486	21,938	21,547	22,522	24,227
Computer and electronic (NAICS 334)	16,007	16,406	16,946	17,858	19,722	21,975	24,327	27,393	31,396	33,941	36,407	38,508
All Other	38,487	40,673	41,858	43,126	46,240	50,396	56,695	64,141	70,818	73,433	75,967	78,683

R&D Research and development
NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that accelerate together through time. See equations (5) through (9) in the accompanying text for derivations of the end-of-1955 real net stock benchmarks.

Table 2.6X. Real Depreciation of Private-Business R&D by Type of Funder, 1959-2004
[Millions of chained (2000) dollars]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business	7,656	8,154	8,694	9,241	9,905	10,683	11,564	12,654	13,902	15,196	16,600
Chemical (NAICS 325)	1,074	1,178	1,288	1,400	1,527	1,673	1,831	2,005	2,174	2,338	2,515
Transportation (NAICS 336)	1,978	2,096	2,218	2,343	2,498	2,671	2,877	3,163	3,538	3,939	4,341
Computer and electronic (NAICS 334)	1,534	1,685	1,854	2,016	2,199	2,403	2,628	2,911	3,244	3,591	3,971
All Other	3,070	3,194	3,334	3,481	3,682	3,937	4,229	4,576	4,946	5,329	5,772

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business	17,982	19,121	20,227	21,574	22,998	24,016	24,820	25,614	26,940	28,218	29,744
Chemical (NAICS 325)	2,683	2,824	2,960	3,113	3,285	3,444	3,588	3,707	3,874	4,012	4,166
Transportation (NAICS 336)	4,702	4,940	5,148	5,460	5,797	5,950	6,030	6,170	6,497	6,824	7,179
Computer and electronic (NAICS 334)	4,355	4,692	5,035	5,421	5,790	6,038	6,225	6,390	6,693	7,038	7,490
All Other	6,242	6,666	7,084	7,580	8,125	8,584	8,977	9,347	9,877	10,344	10,909

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business	31,352	32,943	34,822	37,227	39,987	42,835	45,450	47,977	51,062	54,509	58,165	62,263
Chemical (NAICS 325)	4,328	4,533	4,810	5,141	5,493	5,841	6,201	6,616	7,118	7,699	8,336	9,028
Transportation (NAICS 336)	7,478	7,739	8,034	8,416	8,952	9,640	10,358	10,983	11,576	12,068	12,433	12,948
Computer and electronic (NAICS 334)	8,012	8,493	9,043	9,748	10,420	11,038	11,430	11,609	11,816	11,999	12,122	12,324
All Other	11,534	12,178	12,934	13,922	15,121	16,315	17,461	18,770	20,552	22,744	25,274	27,963

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business	66,304	69,928	74,032	80,333	89,822	102,132	116,520	132,071	149,697	157,918	167,835	178,526
Chemical (NAICS 325)	9,804	10,584	11,329	12,201	13,367	14,953	16,896	19,051	21,688	23,452	26,277	30,179
Transportation (NAICS 336)	13,574	14,159	14,849	15,889	17,215	18,498	20,020	21,486	22,620	22,474	23,635	25,414
Computer and electronic (NAICS 334)	12,608	12,987	13,790	15,298	17,712	20,854	23,901	27,393	32,372	35,401	38,205	40,395
All Other	30,317	32,198	34,062	36,944	41,528	47,827	55,703	64,141	73,018	76,591	79,718	82,538

R&D Research and development
NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that accelerate together through time. See equations (5) through (9) in the accompanying text for derivations of the end-of-1955 real net stock benchmarks.

Table A. Net Own Rates of Return on Private-Business Capital by Type of Funder (R&D Not Capitalized), 1959-2004
[Percent of Consecutive-Year Average Produced Assets]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business (*versus* ...)	**10.55**	**9.57**	**9.73**	**11.06**	**11.85**	**12.66**	**13.78**	**13.68**	**12.39**	**12.22**	**10.92**
Private Nonfarm Nonfinancial Industry	**15.41**	**14.16**	**14.43**	**15.69**	**16.01**	**17.05**	**17.89**	**18.28**	**16.60**	**16.09**	**14.43**
Chemical (NAICS 325)	28.47	24.51	25.59	26.21	27.69	27.90	28.48	25.03	19.99	22.89	18.30
Transportation (NAICS 336)	17.49	17.41	17.39	26.97	32.37	29.98	35.35	29.09	20.07	23.45	15.96
Computer and electronic (NAICS 334)	3.35	2.00	1.81	2.94	3.41	2.59	6.50	7.08	5.44	4.98	3.95
All Other Private Nonfarm Nonfinancial Industry	15.20	14.00	14.27	15.28	15.40	16.61	17.23	17.95	16.63	15.86	14.51

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business (*versus* ...)	**8.87**	**9.42**	**9.82**	**9.67**	**7.65**	**8.09**	**8.59**	**8.99**	**8.78**	**7.75**	**6.66**
Private Nonfarm Nonfinancial Industry	**12.58**	**13.12**	**13.32**	**12.90**	**11.12**	**11.47**	**12.39**	**12.71**	**12.83**	**12.20**	**10.59**
Chemical (NAICS 325)	16.10	16.70	17.83	19.18	16.51	14.68	16.85	15.99	13.97	12.29	9.07
Transportation (NAICS 336)	6.60	17.45	17.61	14.32	0.52	3.63	9.95	11.87	8.74	0.00	-11.55
Computer and electronic (NAICS 334)	0.68	1.23	1.91	2.30	-2.00	-1.03	-0.21	1.59	1.47	-0.20	0.22
All Other Private Nonfarm Nonfinancial Industry	12.99	13.13	13.30	12.91	11.60	11.88	12.60	12.89	13.17	12.85	11.55

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business (*versus* ...)	**7.34**	**6.57**	**7.51**	**8.82**	**8.60**	**8.07**	**8.70**	**9.45**	**9.01**	**8.53**	**7.88**	**7.73**
Private Nonfarm Nonfinancial Industry	**10.36**	**8.84**	**10.88**	**12.02**	**12.16**	**12.05**	**12.02**	**12.21**	**12.91**	**12.81**	**12.27**	**12.71**
Chemical (NAICS 325)	11.91	9.68	12.54	12.67	11.76	12.93	19.42	21.50	23.49	24.03	22.36	21.85
Transportation (NAICS 336)	-8.39	1.55	8.52	16.06	8.87	8.01	12.27	6.22	4.09	2.01	5.56	5.28
Computer and electronic (NAICS 334)	0.88	-1.56	-0.22	2.04	0.56	-0.41	2.24	4.02	5.00	5.03	5.46	5.79
All Other Private Nonfarm Nonfinancial Industry	11.11	9.28	11.18	12.15	12.61	12.51	12.09	12.37	13.11	13.06	12.38	12.85

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business (*versus* ...)	**8.23**	**9.10**	**9.37**	**10.03**	**10.44**	**9.66**	**9.51**	**8.60**	**6.99**	**7.24**	**7.68**	**9.03**
Private Nonfarm Nonfinancial Industry	**13.54**	**14.19**	**13.88**	**14.42**	**14.57**	**13.75**	**13.52**	**12.25**	**11.75**	**12.17**	**12.86**	**13.88**
Chemical (NAICS 325)	21.60	26.50	27.96	26.59	28.01	26.07	25.13	21.96	21.57	24.91	25.51	29.68
Transportation (NAICS 336)	9.78	8.62	6.13	10.09	9.83	11.31	10.96	10.11	7.98	9.34	3.28	4.73
Computer and electronic (NAICS 334)	5.82	8.88	9.27	8.49	9.40	7.99	1.86	-0.51	-10.85	-10.32	-9.36	-8.79
All Other Private Nonfarm Nonfinancial Industry	13.61	14.12	13.79	14.34	14.45	13.63	13.62	12.44	12.33	12.62	13.43	14.34

R&D Research and development
NOTE. These ex post net own rates are compatible with those presented in the May 2006 and May 2007 issues of the *Survey of Current Business.*

Table B. Net Own Rates of Return on Private-Business Capital by Type of Funder (R&D Capitalized, constant depreciation rates), 1959-2004
[Percent of Consecutive-Year Average Produced Assets]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business (*versus*...)	**10.38**	**9.47**	**9.61**	**10.90**	**11.65**	**12.42**	**13.51**	**13.44**	**12.21**	**12.04**	**10.80**
Private Nonfarm Nonfinancial Industry	**15.11**	**13.93**	**14.17**	**15.38**	**15.68**	**16.68**	**17.51**	**17.90**	**16.28**	**15.78**	**14.19**
Chemical (NAICS 325)	24.08	20.82	21.48	21.70	22.58	22.68	23.07	20.48	16.48	18.77	15.31
Transportation (NAICS 336)	15.56	15.36	15.24	22.88	27.20	25.13	29.88	25.18	18.44	20.76	14.65
Computer and electronic (NAICS 334)	4.93	4.67	4.14	4.77	4.93	4.41	7.16	8.00	6.78	6.38	5.71
All Other Private Nonfarm Nonfinancial Industry	15.03	13.87	14.13	15.14	15.25	16.46	17.07	17.78	16.47	15.73	14.41

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business (*versus*...)	**8.77**	**9.22**	**9.61**	**9.51**	**7.52**	**7.84**	**8.33**	**8.72**	**8.58**	**7.63**	**6.60**
Private Nonfarm Nonfinancial Industry	**12.34**	**12.80**	**13.00**	**12.62**	**10.87**	**11.11**	**12.01**	**12.33**	**12.48**	**11.91**	**10.37**
Chemical (NAICS 325)	13.36	13.61	14.39	15.40	13.50	12.01	13.68	12.94	11.55	10.34	7.87
Transportation (NAICS 336)	6.51	14.43	14.56	12.53	1.39	2.84	7.97	9.76	7.82	1.35	-7.43
Computer and electronic (NAICS 334)	2.99	3.04	3.59	3.84	0.29	0.16	0.91	2.01	2.46	1.79	2.22
All Other Private Nonfarm Nonfinancial Industry	12.90	13.01	13.18	12.81	11.51	11.75	12.46	12.74	13.03	12.72	11.45

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business (*versus*...)	**7.24**	**6.51**	**7.40**	**8.68**	**8.47**	**7.94**	**8.45**	**9.17**	**8.80**	**8.34**	**7.78**	**7.62**
Private Nonfarm Nonfinancial Industry	**10.14**	**8.68**	**10.62**	**11.74**	**11.87**	**11.71**	**11.62**	**11.81**	**12.50**	**12.39**	**11.92**	**12.29**
Chemical (NAICS 325)	10.04	8.71	10.71	10.86	10.04	10.64	15.13	16.79	18.19	18.66	17.52	17.01
Transportation (NAICS 336)	-5.37	2.20	7.10	12.97	8.18	7.79	10.48	5.87	4.20	2.21	4.73	5.03
Computer and electronic (NAICS 334)	2.89	0.70	2.25	3.65	2.29	1.48	1.99	3.20	3.76	3.67	3.92	4.51
All Other Private Nonfarm Nonfinancial Industry	11.01	9.22	11.07	12.05	12.50	12.36	11.95	12.24	13.00	12.94	12.32	12.71

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business (*versus*...)	**8.00**	**8.78**	**9.17**	**9.92**	**10.40**	**9.73**	**9.65**	**8.87**	**7.24**	**7.24**	**7.58**	**8.78**
Private Nonfarm Nonfinancial Industry	**12.99**	**13.59**	**13.42**	**14.05**	**14.28**	**13.56**	**13.39**	**12.24**	**11.64**	**11.82**	**12.39**	**13.31**
Chemical (NAICS 325)	16.93	19.84	21.06	20.30	21.63	20.83	20.37	18.55	17.80	19.46	20.31	22.89
Transportation (NAICS 336)	7.87	7.23	5.96	9.17	8.70	9.52	10.13	9.00	6.67	7.65	4.27	4.96
Computer and electronic (NAICS 334)	4.45	7.20	8.82	9.13	10.58	9.47	4.31	4.24	-3.03	-3.58	-3.48	-3.74
All Other Private Nonfarm Nonfinancial Industry	13.37	13.82	13.56	14.16	14.33	13.58	13.62	12.46	12.26	12.37	13.06	13.93

R&D Research and development
NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that stay constant through time.
These ex post net own rates are compatible with the R&D capital calculations of Tables 2.1 through 2.6 of the 2007 R&D Satellite Account.

Table C. Net Own Rates of Return on Private-Business Capital by Type of Funder (R&D Capitalized, accelerating depreciation rates), 1959-2004
[Percent of Consecutive-Year Average Produced Assets]

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Nonfinancial Corporate Business (*versus*...)	**10.36**	**9.46**	**9.60**	**10.89**	**11.64**	**12.41**	**13.50**	**13.43**	**12.19**	**12.02**	**10.78**
Private Nonfarm Nonfinancial Industry	**15.09**	**13.91**	**14.15**	**15.37**	**15.67**	**16.67**	**17.49**	**17.88**	**16.26**	**15.76**	**14.17**
Chemical (NAICS 325)	23.91	20.69	21.36	21.61	22.49	22.57	22.96	20.37	16.37	18.66	15.21
Transportation (NAICS 336)	15.42	15.24	15.14	22.77	27.08	25.00	29.72	25.04	18.32	20.64	14.55
Computer and electronic (NAICS 334)	4.86	4.62	4.12	4.79	4.94	4.41	7.12	7.92	6.67	6.27	5.60
All Other Private Nonfarm Nonfinancial Industry	15.02	13.86	14.12	15.13	15.25	16.45	17.06	17.77	16.47	15.72	14.40

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Nonfinancial Corporate Business (*versus*...)	**8.75**	**9.20**	**9.59**	**9.49**	**7.50**	**7.82**	**8.31**	**8.71**	**8.55**	**7.62**	**6.58**
Private Nonfarm Nonfinancial Industry	**12.33**	**12.78**	**12.98**	**12.61**	**10.85**	**11.09**	**12.00**	**12.32**	**12.47**	**11.90**	**10.36**
Chemical (NAICS 325)	13.27	13.52	14.31	15.32	13.42	11.92	13.60	12.88	11.48	10.28	7.81
Transportation (NAICS 336)	6.41	14.34	14.47	12.45	1.25	2.68	7.85	9.69	7.70	1.19	-7.69
Computer and electronic (NAICS 334)	2.87	2.92	3.46	3.70	0.10	-0.06	0.69	1.83	2.24	1.59	2.04
All Other Private Nonfarm Nonfinancial Industry	12.89	13.00	13.18	12.80	11.50	11.75	12.45	12.74	13.02	12.72	11.45

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nonfinancial Corporate Business (*versus*...)	**7.22**	**6.49**	**7.39**	**8.67**	**8.46**	**7.92**	**8.43**	**9.15**	**8.78**	**8.31**	**7.74**	**7.57**
Private Nonfarm Nonfinancial Industry	**10.14**	**8.67**	**10.62**	**11.74**	**11.86**	**11.70**	**11.61**	**11.81**	**12.50**	**12.39**	**11.90**	**12.28**
Chemical (NAICS 325)	10.01	8.68	10.71	10.84	10.00	10.60	15.16	16.86	18.28	18.76	17.59	17.07
Transportation (NAICS 336)	-5.60	2.09	7.07	13.01	8.12	7.69	10.41	5.69	3.95	1.89	4.47	4.76
Computer and electronic (NAICS 334)	2.73	0.51	2.08	3.47	2.04	1.19	1.71	2.95	3.53	3.42	3.67	4.27
All Other Private Nonfarm Nonfinancial Industry	11.01	9.22	11.07	12.05	12.49	12.36	11.94	12.24	13.00	12.94	12.31	12.69

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nonfinancial Corporate Business (*versus*...)	**7.95**	**8.74**	**9.13**	**9.89**	**10.36**	**9.65**	**9.55**	**8.75**	**7.08**	**7.13**	**7.49**	**8.72**
Private Nonfarm Nonfinancial Industry	**12.98**	**13.59**	**13.43**	**14.06**	**14.28**	**13.53**	**13.34**	**12.18**	**11.55**	**11.79**	**12.39**	**13.33**
Chemical (NAICS 325)	16.98	20.01	21.31	20.56	21.91	21.03	20.52	18.62	17.80	19.78	20.73	23.49
Transportation (NAICS 336)	7.68	7.01	5.70	9.07	8.50	9.29	9.88	8.70	6.23	7.57	3.93	4.61
Computer and electronic (NAICS 334)	4.19	7.06	8.76	9.02	10.39	9.07	3.53	3.38	-4.50	-5.02	-4.99	-5.36
All Other Private Nonfarm Nonfinancial Industry	13.36	13.81	13.56	14.16	14.33	13.56	13.58	12.42	12.21	12.35	13.07	13.95

R&D Research and development

NOTE. Implemented using the aggregate output price index, and industry-specific R&D depreciation rates that accelerate together through time. These ex post net own rates are compatible with the R&D capital calculations of Tables 2.3X through 2.6X.