A Note on the Cost Allocation Problem for R&D Investments

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1. Introduction

Examples of expenditures on intangible assets are *advertising and marketing expenses* and *research and development expenditures*. Both of these categories of expenditures have the character that the present period outlays will create incremental revenues in the future for the firm that undertakes them.[1] These current period expenditures on intangible assets have a different character than expenditures on tangible durable inputs, which can be used for a number of periods and then sold to other users.[2] The problem is how to *allocate* the cost outlays on intangible investments over future periods. Thus these accounting problems in have a different character than in the treatment of reproducible capital, where a straightforward opportunity cost approach can be taken. In the present note, the approach taken is one of *matching* current costs with future expected revenues.[3]

In section 2, we present a reasonably general cost allocation model that assumes a constant structure of real and nominal interest rates. We relate this model to the usual models of depreciation for reproducible capital.[4] In sections 3 and 4, we relax this simplifying assumption.

In section 3, we present the details involved in making various cost imputations for a simple 4 period model, while in section 4, we present the algebra of the general model, along with a discussion of the data requirements for implementation of the model.

Section 5 concludes with a discussion of some of the difficult conceptual and practical issues that are involved in capitalizing R&D expenditures.

2. The Basic Cost Matching Methodology

[1] I am taking more or less the same point of view on the nature of R&D inputs as that expressed in Pitzer (2004). The present paper is complementary to that of Pitzer in that I look in more detail at some of the algebraic complications that capitalizing R&D might entail.
[2] In many cases, the stream of future revenues created by an intangible investment can be sold on the marketplace (e.g., patents, trademarks and franchises), but if it is not sold, we still have the problem of how to distribute the intangible investment costs over future periods. If it is sold, then the purchaser has the problem of allocating the purchase cost to future periods.
[3] Paton and Littleton (1940; 123) argued that the primary purpose of accounting is to match costs and revenues. For an excellent early discussion on the importance of matching costs to future revenues, see Church (1917; 193).
[4] This section can be skipped by readers who are not particularly interested in the relationships with the reproducible capital model.

To fix ideas, suppose that in period t, a firm has made expenditures on creating an intangible asset, which are equal to C^t:[5]

$$(1)\ C^t \equiv \sum_{m=1}^{M} P_m^t Q_m^t$$

where P_m^t is the period t price for the mth type of input that is used to create the intangible asset and Q_m^t is the corresponding quantity purchased. These expenditures in period t are expected to generate a future stream of incremental revenues for the firm. Let R_0^t denote the immediate period t incremental revenues (which could be zero) and let R_n^t denote the incremental revenues that the period t expenditures C^t are expected to generate n periods from the present period t, for n = 1,2,… Let r^t be the (nominal) period t opportunity cost of financial capital. Then the discounted value of these expected incremental revenues is:[6]

$$(2)\ R^t \equiv R_0^t + R_1^t/(1+r^t) + R_2^t/(1+r^t)^2 + R_3^t/(1+r^t)^3 + \ldots$$

The problem is to allocate the current period cost C^t over future periods. Thus let C_n^t be the allocation of C^t to the accounting period that is n periods after period t for n = 0,1,2,… At first sight, it seems reasonable that these future cost allocations C_n^t should sum to C^t. However, this turns out *not* to be so reasonable: costs that are postponed to future periods must be escalated by the (nominal) interest rate r^t, so that the present value of discounted future costs is equal to the actual period t costs C^t. Thus the intertemporal cost allocations C_n^t should satisfy the following equation:

$$(3)\ C^t = C_0^t + C_1^t/(1+r^t) + C_2^t/(1+r^t)^2 + C_3^t/(1+r^t)^3 + \ldots$$

To see why discounting is necessary, consider the following simple example where we invest C^t during the present period and we anticipate the revenue R_2^t two periods from now. The expected discounted profits that this investment will generate are:

$$(4)\ \Pi \equiv -C^t + R_2^t/(1+r^t)^2.$$

The period by period cash flows for this project are $-C^t$, 0, R_2^t. We want to *match* the period t cost C^t with the period t+2 revenue flows. Thus we want to convert the cash flow stream $-C^t$, 0, R_2^t into an equivalent cash flow stream 0, 0, $-C_2^t + R_2^t$. If we choose

$$(5)\ C_2^t \equiv C^t(1+r^t)^2,$$

then it can be seen that these two cash flow streams have the same present value and C_2^t is the "right" period t+2 cost allocation. Put another way, if we simply carried forward

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[5] The material in this section is taken from Diewert (2004). C^t could represent the cumulated costs over a number of periods that it has taken to develop a useful product or process.

[6] Thus R^t is the expected asset value of the R&D project at the beginning of period t. At the beginning of period t+1, the expected asset value will decline (if expectations do not change) to $R_2^t/(1+r^t) + R_3^t/(1+r^t)^2 + \ldots$ and so on. Thus as the revenues are realized, the asset value will decline.

the period t costs C^t and set C_2^t equal to C^t, we would be neglecting the fact that the costs took place in period t while the return on the investment was deferred until period t+2 and hence, we need to charge the opportunity cost of financial capital for two periods on the initial investment (for two periods) until it is expensed in period t+2.

How should the intertemporal cost allocations C_n^t be chosen? It is natural to make these cost allocations proportional to the corresponding period anticipated revenues. Thus choose the number $\square$ so that the following equation is satisfied:

(6) $C^t = \square R^t$.

Thus we set the observed period t cost associated with the intangible investment C^t equal to the constant $\square$ times the discounted value of the anticipated incremental revenue stream R^t that the investment is expected to yield.[7]

Typically, $\square$ will be equal to or less than one, since otherwise, the period t intangible investment expenditures C^t should not be undertaken. If $\square$ is less than one, then there will be an expected profit above the opportunity cost of capital, which could be some form of monopoly profit or a reward for risk taking.

Once $\square$ has been determined by solving (6), then the intertemporal cost allocations C_n^t can be defined to be proportional to the corresponding anticipated incremental revenues R_n^t for future periods:

(7) $C_n^t \equiv \square R_n^t$; $\qquad n = 0,1,2,\ldots$

We can convert the nominal cost allocation factors C_n^t into constant (period t) dollar cost allocations f_n^t as follows:

(8) $f_n^t \equiv C_n^t/(1+\square^t)^n$; $\qquad n = 0,1,2,\ldots$
$\qquad = \square R_n^t/(1+\square^t)^n$

where $\square^t$ is the period t consumer price inflation rate, which is expected to persist into the future.[8] The f_n^t defined by (8) are the constant (beginning of period t) dollar counterparts to the period t nominal cost allocation factors C_n^t that occurred in (3). We can define the period t real interest rate r^{t*} in terms of the period t nominal rate r^t and the period t general inflation rate $\square^t$ as follows:

(9) $1+r^{t*} \equiv (1+r^t)/(1+\square^t)$.

[7] Of course, the practical problem that the national income accountant will face is: how can the future stream of incremental revenues be estimated?
[8] This expectational assumption could be relaxed at the cost of more notational complexity; see section 4 below.

Substituting (8) and (9) into (3) shows that the constant dollar cost allocations f_n^t satisfy the following equation:

$$(10)\ C^t = f_0^t + f_1^t/(1+r^{t*}) + f_2^t/(1+r^{t*})^2 + f_3^t/(1+r^{t*})^3 + \ldots$$

Once these intertemporal constant dollar cost allocation factors f_n^t have been defined by (8), we can see that the constant dollar "asset" value of these deferred costs at the beginning of period t is C^t defined by the right hand side of (10), which we will denote by V_0^t. However, at the beginning of period t+1, the constant dollar "asset" value of the deferred costs will decline to V_1^t defined by the second line in (11) below if expectations do not change, at the beginning of period t+2, the constant dollar "asset" value of the deferred costs will decline to V_2^t defined by the third line in (11) below if expectations do not change, and so on:[9]

$$\begin{aligned}(11)\ C^t = V_0^t &= f_0^t + f_1^t/(1+r^{t*}) + f_2^t/(1+r^{t*})]^2 + f_3^t/(1+r^{t*})]^3 + \ldots \\ V_1^t &= f_1^t + f_2^t/(1+r^{t*}) + f_3^t/(1+r^{t*})]^2 + f_4^t/(1+r^{t*})]^3 + \ldots \\ V_2^t &= f_2^t + f_3^t/(1+r^{t*}) + f_4^t/(1+r^{t*})]^2 + f_5^t/(1+r^{t*})]^3 + \ldots\end{aligned}$$

The sequence of constant dollar "asset" values V_0^t, V_1^t, V_2^t, … shows how the period t intangible investment can be written down over time in constant period t dollars. Then these constant dollar "asset" values can be used to form a sequence of "asset" depreciation rates $\square_n^t$.[10] These depreciation rates $\square_n^t$ can also be applied to the investment components Q_m^t to form estimated constant dollar input stocks for the intangible investments.[11] Thus the assumptions made about the shape of the anticipated future period incremental revenues generated by the intangible investment, along with the matching of costs to revenues methodology, determine the pattern of depreciation that can be used to write down these costs associated with the intangible investment over time.

The period t beginning of the period and end of period user cost charges, f_0^t and u_0^t respectively, for the intangible investment have the following forms, where period t cross section depreciation charge D_0^t is defined as $V_0^t - V_1^t$:

$$\begin{aligned}(12)\ f_0^t &\equiv V_0^t - [(1+\square^t)/(1+r^t)]V_1^t \\ &= V_0^t - V_1^t/(1+r^{*t}) \\ &= [V_0^t r^{*t} + D_0^t]/(1+r^{*t});\end{aligned}$$

[9] The V_n^t are counterparts to the sequence of reproducible capital cross section asset prices at time t for assets of age n. Thus much of the algebra associated with reproducible capital can be adapted to the present intangible capital situation.

[10] If the assumptions on the anticipated (real) incremental revenues are such that the f_n^t decline at the geometric depreciation rate $\square$, then this rate will carry over to V_n^t; i.e., we will have $V_n^t = (1-\square)^n C^t$ for n = 0,1,2,… if $f_n^t = (1-\square)^n f_0^t$ for n = 1,2,…

[11] It is not necessary for the statistical agency to do this but some users will be interested in the resulting M asset stocks that form capital stock aggregates of the Q_m^t. Normal index number theory can be used to aggregate these M stock components into an overall capital stock aggregate using the period t flow prices P_m^t as price weights.

$$\text{(13) } u_0^{\,t} \equiv V_0^{\,t}(1+r^t) - (1+\rho^t)V_1^{\,t}$$
$$= (1+\rho^t)[\, V_0^{\,t} r^{*t} + D_0^{\,t}]$$

The above two formulae show that the period t "user cost" for the intangible investment does not consist solely of a depreciation charge, $D_0^{\,t}$: there are also real interest rate charges that must be added to the depreciation term.

It should be noted that the cost allocation model outlined above can be applied to other forms of "assets"; namely, deferred charges, prepaid expenses[12] and transfer fees when a reproducible asset is acquired. The one hoss shay form of revenue matching is probably the preferred method for dealing with this type of transfer fee "asset".

Of course, the practical problem with all of the above algebra is that it is entirely driven by the pattern and magnitudes of expected future incremental revenues but the statistician will not have very good information on these expected revenues. Moreover, it is not clear what would be a "good" rough approximation to these expected revenues.[13]

There are some additional complications in dealing with intangible assets in a national income accounting framework that can be best illustrated by a "concrete" example. Thus we consider a simple example in the following section and look at the various accounting transactions that will be necessary to implement the cost matching model outlined in this section.

3. A Simple Example

We consider a special case of the model outlined in the previous section where the current period t is set equal to 0, R&D costs equal to C^0 are incurred at the end of period 0 and this project has no further nonfinancial costs in future periods but it is expected to yield nominal revenues of R^2 and R^3 in periods 2 and 3. All costs and revenues are transacted at the end of each period. The one period nominal (bond) expected interest rate (or cost of capital) at the beginning of period 1 is r_1, at the beginning of period 2 is r_2 and at the beginning of period 3 is r_3, with all expectations being formed at the end of period 0 or the beginning of period 1.[14] We assume that the project is funded by one period bonds and no dividends are paid out so that as the firm gathers revenues, bond debt is retired at the end of periods 2 and 3. From the perspective of the beginning of period 1, the firm's *expected discounted profits* are:

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[12] Hatfield (1927; 16) gives several examples of this type of asset, including insurance payments which apply to multiple accounting periods, the stripping away of surface rock for a strip mine and prepaid expenses. Hatfield (1927; 18) notes that this type of asset is different from the usual sort of tangible asset since this type of asset cannot readily be converted into cash; i.e., it has no opportunity cost value.

[13] Thus the practical measurement problems are much harder in the intangible context compared to the case of reproducible capital where a straightforward capital expenditures survey that includes information on the age of retired capital assets (or their age and sale price if the reproducible assets are sold before they are worthless) will enable the statistician to construct somewhat accurate depreciation rates and user costs.

[14] Thus our model is slightly more general than in the previous section in that we are no longer assuming that the term structure of interest rates is constant.

(14) $\Pi^0 \equiv -C^0 + R^2/(1+r_1)(1+r_2) + R^3/(1+r_1)(1+r_2)(1+r_3) \geq 0$.

From the perspective of the end of period 3, the firm's expected profits are:

(15) $\Pi^0(1+r_1)(1+r_2)(1+r_3) = -C^0(1+r_1)(1+r_2)(1+r_3) + R^2(1+r_3) + R^3 \equiv A^3$

where A^3 is the firm's net asset value at the end of period 3.

The counterpart to equation (3) in the previous section is the following equation:

(16) $C^0 = C_0^{\,0} + C_1^{\,0}/(1+r_1) + C_2^{\,0}/(1+r_1)(1+r_2) + C_3^{\,0}/(1+r_1)(1+r_2)(1+r_3)$

where the $C_n^{\,0}$ are the cost allocations of the actual period 0 cost, C^0, to periods n = 0,1,2,3.[15] Since there are no expected revenues in periods 0 and 1, it is natural to set the period 0 and 1 cost allocations, $C_0^{\,0}$ and $C_1^{\,0}$, equal to 0. We shall also impose inequalities on the period 2 and 3 cost allocations so that the allocated costs do not exceed the corresponding revenues for those periods. Thus we assume that the 4 cost allocations $C_n^{\,0}$ satisfy (16) and the following equations and inequalities:

(17) $C_0^{\,0} = 0$; $C_1^{\,0} = 0$; $0 < C_2^{\,0} \leq R^2$; $0 < C_3^{\,0} \leq R^3$.

This is all of the information that we need to set up a set of (expected) accounts for the firm for the 4 periods under consideration. Table 1 below does this. Note that ($-$) means that the corresponding item is a current period cost to the firm. D^t denotes the net debt of the firm at the end of period t. D^0 is equal to C^0 and so the end of period 0 net asset value, counting just debt (negatively) and cash flow (positively) is $A^0 \equiv -D^0 = -C^0$.

Table 1: **Abbreviated Income and Balance Sheet Accounts for the R&D Firm**

Line 0: Period t	0	1	2	3
Line 1: Revenues R^t	0	0	R^2	R^3
Line 2: Nonfinancial costs C^t ($-$)	$-C^0$	0	0	0
Line 3: Interest paid ($-$)	0	$-r^1D^0$	$-r^2D^1$	$-r^3D^2$
Line 4: Deferred nonfinancial costs	C^0	0	0	0
Line 5: Deferred interest	0	r^1D^0	r^2D^1	r^3D^2
Line 6: Allocated costs $C_n^{\,0}$ ($-$)	0	0	$-C_2^{\,0}$	$-C_3^{\,0}$
Line 7: Period t income Π^t	0	0	$R^2 - C_2^{\,0}$	$R^3 - C_3^{\,0}$
Line 8: End of period debt D^t	$D^0 = C^0$	D^1	D^2	0
Line 9: End of period net asset value A^t	$A^0 = -D^0$	A^1	A^2	A^3

[15] Think of C^0 as being the market and own account (for profit) segments of GERD for the firm or industry under consideration. For now, we exclude the non market component of GERD from our simple model because there are no identifiable revenue streams that are associated with non market R&D, which is given away freely to all who want to use it. Thus there are no future revenues that current costs can be matched to.

The end of period 0 debt level, D^0, is equal to the end of period 0 expenditures on R&D, C^0. In this example, there are no further real expenditures on R&D in periods 1 to 3. If there were, we would have to set up tables similar to Table 1 and combine the resulting tables by summing up expenditures in the various categories.[16]

The end of period 1 and 2 debt levels are given by:

$$(18)\ D^1 \equiv (1+r_1)D^0 \qquad = (1+r_1)C^0 ;$$
$$D^2 \equiv (1+r_2)D^1 - R^2 = (1+r_1)(1+r_2)C^0 - R^2.$$

The *end of period net realizable asset values* A^t, counting only beginning of the period debt (negatively) and cash flows (positive for revenues, negative for costs), turn out to equal the negative of the end of period debt levels:

$$(19)\ A^1 \equiv -(1+r_1)D^0 \qquad = -(1+r_1)C^0 ;$$
$$A^2 \equiv R^2 - (1+r_2)D^1 \qquad = R^2 - (1+r_1)(1+r_2)C^0 ;$$
$$A^3 \equiv R^3 - (1+r_3)D^2 \qquad = R^3 + (1+r_3)R^2 - (1+r_1)(1+r_2)(1+r_3)C^0.$$

Lines 1-3 and 8-9 in Table 1 correspond to real transactions whereas lines 4-6 represent the imputations that are necessary to get the sum of the first 6 lines to equal an appropriate *matched income* $\square^t$ for each period t, line 7, which matches costs with revenues in each period. Note that since there are no project revenues in periods 0 and 1, the corresponding matched incomes, $\square^0$ and $\square^1$, are set equal to zero by our imputation scheme.

Note that the *net present value of the matched incomes*, $\square^2$ and $\square^3$, *equals the discounted present value of the revenues generated by the R&D investment in period 0*, $\square^0$, defined by (14); i.e., we have:[17]

$$(20)\ \square^0 = \square^2/(1+r_1)(1+r_2) + \square^3/(1+r_1)(1+r_2)(1+r_3).$$

We now work through the lines in Table 1 for period 0. The firm undertakes R&D expenditures in period 0 that sum to the value C^0. These expenditures show up as a negative entry in line 2.[18] Since there are no period 0 revenues associated with these R&D expenditures, the expenditures C^0 are capitalized at the end of period 0 and these capitalized expenditures show up in line 4. These capitalized expenditures are formally identical to an investment, and thus are an imputed output of the firm for period 0. At the end of period 0, the firm borrows financial capital of the amount D^0 equal to C^0 (in order

[16] However, Table 1 sets out the basic accounting framework for capitalizing the costs pertaining to a single period, period 0. A similar Table can be constructed if there are additional R&D expenditures in period 1 that generate identifiable incremental future revenues.
[17] We need to use the matched income entries in Table 1 and (14) and (16) to establish this result.
[18] This input value aggregate can be decomposed into a price and quantity component if prices for R&D employees, R&D intermediate input purchases and R&D capital service inputs are available; see de Haan and van Rooijen-Horsten (2004; 19) for an outline of the methodology for setting up an R&D input price index.

to finance the payments associated with the R&D expenditures) and this shows up in the firm's balance sheet at the end of period 0 as debt;[19] see line 8. There is no deferred or capitalized interest for period 0 because the borrowing took place at the end of the period. Also, there are no allocated costs to set against revenue in period 0, because the R&D project has yet to generate any revenues, and so line 6 has a 0 entry for period 0. The sum of the first 6 lines gives us the firm's income for period 0, Π^0, and it turns out to be 0 (as desired using our matching principle).

Turning now to period 1 and the entries in the period 1 column, there are still no project revenues in period 1, so the entry in line 1 is 0. We assume that there are no additional nonfinancial costs in period 1,[20] so that the entry in line 2 is also 0. However, the firm has period 1 interest expenses equal to r^1D^0, and these interest expenses appear as a negative entry in line 3. These interest costs are also associated with the project and since we still have no project revenues to offset these costs, our matching principle forces us to capitalize these interest expenses as well; see the offsetting entry in line 5 of the period 1 column. Since there are no project revenues in period 1, we still do not allocate any costs to this period, so that line 6 has a 0 entry for period 1. The sum of the first 6 lines for the period 1 entries gives us the firm's income for period 1, Π^1, and it also sums to 0. Line 8 gives us the total (net) debt of the firm at the end of each period, assuming that any revenues received during the period are used to reduce debt at the end of the period. These net end of period t debts, D^t, are also equal to the end of period capitalized expenditures. The negative of D^t is equal to A^t, which is the realizable net asset value of the firm; i.e., it is an asset value that recognizes all costs (with a negative sign) but it recognizes revenues only when they occur; i.e., when they are realized.

Turning now to the entries in the period 2 column, there are project revenues in period 2, so the entry in line 1 is R^2. Again, we assume that there are no additional nonfinancial costs in period 1, so that the entry in line 2 is 0. However, the firm has period 2 interest expenses equal to r^2D^1, and these interest expenses appear as a negative entry in line 3. It turns out that our matching principle forces us to capitalize these interest expenses as well;[21] see the offsetting entry in line 5 of the period 2 column. Since there are project revenues in period 2, we allocate the cost C_2^0 to this period, so that line 6 has the entry $-C_2^0$ for period 2. The sum of the first 6 lines for the period 2 entries gives us the firm's income for period 2, Π^2, and it sums to the period 2 revenues, R^2, less the allocated cost C_2^0. The entries in the period 3 column are analogous to the period 2 columns.

4. A Summary of the Information Needed to Implement the Capitalization Procedure

Examining the example in the previous section, it can be seen that R&D cost capitalization procedure (in nominal terms) has the following informational requirements:

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[19] For the sake of simplicity, we have only a single interest rate to measure the opportunity cost of capital in each period; i.e., we have not dealt with the complications due to a mixture of debt and equity financing.
[20] If there were additional R&D research expenditures, we would set up another table similar to Table 1, which would distribute these costs over future periods.
[21] This capitalization of interest is required in order to ensure that the present value equation (20) will hold.

- Information on current period 0 R&D costs in nominal terms, C^0 say.
- Information on the expected future stream of incremental revenues generated by the R&D investment in period 0 in nominal terms, say R_0^0, R_1^0, R_2^0,…
- Information on the one period nominal interest rates r_1^0, r_2^0, r_3^0, that are expected to prevail in future periods 1, 2, 3, …

Given the above information, first find the parameter α by solving the following equation:

$$(21)\ C^0 = \alpha[R_0^0 + R_1^0/(1+r_1^0) + R_2^0/(1+r_1^0)(1+r_2^0) + R_3^0/(1+r_1^0)(1+r_2^0)(1+r_3^0) + \ldots].$$

The *matched cost* C_n^0 that should be allocated to period n for the period 0 R&D project can now be defined as follows, once we have determined α:

$$(22)\ C_n^0 \equiv \alpha R_n^0 ; \qquad n = 0,1,2,\ldots .$$

This gives us enough information to fill out all of the real and imputed transactions that correspond to the transactions in the Table 1 example. Thus the entire cost matching procedure is driven by our assumptions about the future nominal anticipated incremental revenues, the R_n^0, and our assumptions about future nominal one period interest rates (or opportunity costs of capital), the r_n^0.

In order to get constant dollar cost allocations f_n^0 as in section 1 above, we need some additional information on expected future rates of general inflation. Thus to the above information set, add:

- Information on expected future rates of CPI inflation for periods 1,2,3, …, say, ρ_1^0, ρ_2^0, ρ_3^0, … .

The *constant period 0 dollar matched cost* f_n^0 that should be allocated to period n for the period 0 R&D project can now be defined in terms of the corresponding nominal dollar allocations C_n^0 as follows:

$$(23)\ f_0^0 \equiv C_0^0 ;$$
$$f_n^0 \equiv C_n^0/(1+\rho_1^0)(1+\rho_2^0) \ldots (1+\rho_n^0) \qquad n = 1,2,\ldots .$$

Finally, if we want to construct measures of real R&D (flow) input, we need information on the prices and quantities of the inputs that are used to create the R&D asset. Thus, add to the above information set:

- Information on the prices and quantities of the flow inputs that comprise the period 0 cost, C^0; i.e., these are the P_m^t and Q_m^t that appeared in equation (1) above.

Thus there are 5 separate informational components that are required in order to do a complete accounting for R&D investments.

Note that we agree with Pitzer (2004) that R&D investments are *fundamentally different* from investments in reproducible capital. Pitzer (2004; 2) regards R&D investments as producing "recipes" but a recipe is not the usual type of "productive" input. Pitzer defines "productive" inputs as follows:

"Fundamental to production is the notion that inputs are proportional in some sense to outputs. Outputs are created by combining a particular collection of inputs in a particular manner. … If more outputs are desired, then more inputs are necessary, and usually, more of all inputs. It may not be necessary to double the inputs to double the outputs, but more inputs are necessary to produce more outputs." John Pitzer (2004; 2).

We also agree with Pitzer that the asset value of a marketable R&D investment is a discounted monetary flow of payments that will usually have some form of monopoly element to it:

"A patented entity is an asset that permits the owner to levy an assessment, much like a tax, on other units for the use of a recipe. In some cases, the assessment is paid by another producing unit to acquire the right to produce outputs based on the recipe. In other cases, the owner will produce the outputs and levy the assessments on its customers by charging a monopoly price. The market value of the asset is the present value of the future assessments that are expected to be collected by the asset's owner." John Pitzer (2004; 5).

Thus the treatment of R&D assets will necessarily be quite different in some respects from the treatment of reproducible capital assets. In particular, the treatment of R&D assets involves *two* separate deflation problems:

- The deflation of expenditures on R&D inputs at a point in time into price and quantity components. This requires information on the price and quantity components of the inputs into the creation of the R&D asset.
- The deflation of the nominal intertemporal cost allocation of the current R&D flow expenditures into constant dollar cost allocations. The deflator to be used here is a general purchasing power deflator.

5. Discussion of Some Difficult Issues

Pitzer (2004) and de Haan and van Rooijen-Horsten (2004) raise a number of difficult issues that arise if we attempt to capitalize R&D expenditures in the National Accounts. In this section, we look at some of these difficulties in the light of the algebra presented in the previous sections.

- How exactly do the various imputations outlined in section 2 fit into standard national accounting categories?

At least some new lines to the system of input output framework will have to be created to accommodate some of the imputations. The details need to be worked out.

- What is the "best" set of "standard" assumptions that we can make about the pattern of future expected revenues for market R&D?

There is some review of the empirical literature on R&D depreciation rates in De Haan and van Rooijen-Horsten (2004; 20-24) but it would seem that a more extensive discussion of these issues is required before the Canberra Group can make concrete recommendations to the National Accounts community. Although life is simplest if we assume geometric rates of revenue decay, there may well be more realistic "standard" models for the pattern of future incremental revenues that are quite different from our usual set of assumptions about depreciation for reproducible capital.

- What is the "best" deflator for converting current dollar values into constant dollar values?

De Haan and van Rooijen-Horsten (2004; 20) mention that the Frascati Manual recommends the use of the GDP deflator for constant price comparisons, but Kohli (1982; 211) (1983; 142) and Diewert (2002; 556) argue against this choice, since the GDP deflator has negative weights for imports and this can cause the deflator to *decrease* if the price of imports *increases* enough.[22] Hill (1996; 94-97) and Diewert (2002; 557) discuss some alternative choices to the GDP deflator.

- What is the "best" set of assumptions to make about interest rates and future inflation rates?

Should we work with the assumption of a constant real interest rate as is convenient in studies of depreciation for reproducible capital? If so, how should we choose this real rate?

- Should Non Market R&D be capitalized?

Aspden (2003) argues that all research potentially provides benefits to society that can accrue over long periods of time. Hence, he advocates capitalizing both private and public R&D. There is no doubt that publicly funded research that is made freely available provides benefits to society. However, there are no "straightforward" market *transactions* that can provide us with guidance on the future distribution of these benefits. The problem is that the freely given benefits may show up in the form of lower output prices, higher input prices or higher profits. To work out the exact nature of the improvements due to the freely available R&D would require some complicated general equilibrium modeling along with many assumptions. Moreover, the cost matching methodology explained above will not work in this context because there will be no easily identifiable revenues that the deferred costs can be matched to. These

[22] Diewert (2002; 556) gave a recent US example of perverse behavior of the GDP deflator, where the chain type price indexes for C, I, X and M for the third quarter of 2001 decreased over the previous quarter (at annual rates) by 0.4%, 0.2%, 1.4% and 17.4% respectively, but yet the overall US GDP deflator increased by 2.1%.

considerations suggest that it would be simpler to *not* capitalize publicly available R&D expenditures. This is the position taken by de Haan and van Rooijen-Horsten (2004; 18) and provisionally by Pitzer (2004; 9). However, current National Accounts conventions simply put the non market R&D expenditures into government consumption (i.e., an artificial output is created out of these input expenditures and added to GDP). This is essentially the same treatment that is done for other difficult to measure general government "outputs" but I am not sure that it is completely satisfactory. However, given that these non market R&D expenditures have been shunted over to the government sector, there is nothing to prevent us from inventing a method that would essentially spread this government "output" over future periods.[23] The exact details of how this should be done need to be worked out.

- Should unsuccessful R&D ventures be capitalized?

De Haan and van Rooijen-Horsten (2004; 24) discuss this issue. They note that some experts argue that unsuccessful ventures should be immediately expensed or "written off", while other experts argue that all R&D activities, whether successful or not, contribute to acquiring a commercially valuable knowledge stock.[24] Both points of view are justifiable but it seems to me that the first point of view is more in line with market realities. This issue requires further discussion.

- Is the proposed method of R&D capitalization consistent with the national accounts treatment of other intangible assets, such as mineral exploration, advertising and franchising?

This is an issue for national accounting experts to discuss. However, in my opinion, all (market sector) current period expenditures on any of the above intangible assets have the same character as (market sector) current expenditures on R&D: expenditures are made now in the hope of "creating" future period incremental revenues. Hence, essentially the same matching of costs to future revenues methodology used above could be applied to these activities and overall consistency could be achieved.[25]

- How should taxes and subsidies and subsidies be treated?

[23] This possibility was noted by Pitzer (2004; 9): "If unpatented entities were to be treated as assets, then an accounting treatment needs to be created for them. At first glance, it would appear that unpatented entities should be given the same accounting treatment as patented entities because both affect future income in the same way. The lack of assessments for unpatented entities prevents use of any of the treatments discussed in the previous section, which means that either different treatments should be accorded patented and unpatented entities or a new methodology applicable to both should be developed."

[24] De Haan and van Rooijen-Horsten(2004; 24) also note the analogy of unsuccessful R&D ventures to unsuccessful oil wells: "For mineral exploration, the SNA 1993 recommends that all mineral exploration should be treated as gross fixed capital formation (#166) since both successful and unsuccessful exploration efforts are needed to acquire new reserves. In a similar way, one may conclude that the value of the knowledge capital stock should include both the costs of successful and unsuccessful R&D."

[25] The same matching methodology will work for transfer costs (i.e., transactions costs of whatever form) as well.

Again, de Haan and van Rooijen-Horsten (2004; 12) discuss this issue. They point out that in the Netherlands, subsidies for R&D are quite substantial. In Canada, there is a favorable business income tax treatment for R&D investments of an approved type. It is not completely clear how to deal with these tax and subsidy complications.

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