R&D ROI. When Is the Return Enough?

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As CEO, you probably have well-articulated targets for revenue and profitability growth for your company, and you also have a target for the percent of annual revenue you are prepared to spend on R&D to fuel that growth. By setting those business goals, you have implicitly set goals for R&D ROI, and to achieve your business goals, R&D expenditures must realize explicit levels of revenue and profit return. But how can you *calculate* the required revenue and profit return rates? When is the return rate on R&D expenditures "enough" to support the business goals?

It is common industry practice to forecast the time-based revenue and profitability return of R&D projects and, using discounted cash flow (DCF) analysis, calculate the net present value (NPV) and internal rate of return (IRR) of the investment cash flow. A net present value calculated to be greater than zero indicates that the forecasted earnings of the project exceeds the cost, in present dollars, and therefore will be profitable. But this fails to answer a critical question: if all future R&D projects share this same NPV, will future profits be sufficient to meet the business goals? Discounted cash flow analysis only considers the cash flow of a project in isolation. The underlying formulas do not take into account the business context of that investment, specifically, how much the company is prepared to spend on R&D each year, and what revenue and profit growth it expects to achieve. Thus DCF analysis leaves a key question unanswered: when is the NPV and IRR *enough*?

Recognizing the shortcomings of DCF analysis, Analog Devices Inc. set about developing better financial tools to address the problem. The calculation of return rate targets for R&D expenditure must take into account three key business imperatives:

1. Revenue and profit growth targets
2. The percent of annual revenue the company is willing to spend on R&D
3. The anticipated lifecycles of the R&D investment vehicles

Long lifecycle products typically yield lower returns in their early years by comparison to shorter lifecycle products, and so the calculation of return rate targets must comprehend this critical difference. Two new financial measures of R&D project performance were therefore developed that incorporate the key business imperatives.

The first, CRRM, or the Cumulative Required Revenue Multiple, is the value of cumulative revenue any R&D investment must return by the end of its anticipated lifecycle, expressed as a multiple of the cost of the R&D investment, in order to support the target revenue growth and the percent of annual revenue allocated to R&D spending. Expressing the return rate as revenue, rather than profit, is important because most companies have explicit goals to grow revenue at some desired compound annual growth rate (CAGR), recognizing that top-line revenue growth is the primary means to drive bottom-line profit growth.

Therefore,

$$CRRM = \frac{1}{SR} \times \frac{1}{\{f_1/(1+CAGR)^0 + f_2/(1+CAGR)^1 + \ldots f_n/(1+CAGR)^{n-1}\}}$$

where
CRRM = the cumulative revenue return multiple (of the project R&D spend) the project must achieve at the end of the product/project lifecycle
SR = the company's target annual R&D spend rate, expressed as a percent of annual revenue
CAGR = the target compound annual growth rate of revenue to be achieved
f = the shape and duration of the revenue return in time, where
f_1 *= fraction of total lifecycle revenue that is earned in year 1*
f_2 *= fraction of total lifecycle revenue that is earned in year 2, etc. such that* $f_1 + f_2 + f_3 + \ldots + f_n = 100\%$.

Note that the CRRM equation has two primary terms, representing output divided by input. The first term is the reciprocal of the annual R&D spend rate 1/SR. This is the denominator, representing the input and is multiplied by a second term, representing the output that includes the variables *f* and CAGR, where *f* is a representation of both the shape and duration of the product lifecycle. Notice that if the target CAGR is set to zero, the second term of the equation collapses to =1/1 and CRRM is simply equal to 1/SR. This means that if a company is prepared to spend 16% of annual revenue on R&D, then the minimum CRRM it must achieve on *all* R&D projects just to grow revenue at 0% CAGR (maintain flat revenue) is 1/0.16 = 6.25. That is, each project, independent of lifecycle, must achieve a final cumulative revenue multiple of x6.25 times the R&D project spend. If the annual R&D spend rate is halved, to 8%, the minimum return multiple doubles to 1/0.08 = 12.5. Then, as target CAGR is increased to a number greater than zero, and as more *f* terms are added (indicating longer product lifecycles), the second term of the equation increases exponentially, and CRRM becomes increasingly larger.

CRRM is a general equation, in the sense that it calculates the required return rate for *any* R&D project of a given lifecycle, to meet the stated business goals of revenue CAGR for a given annual R&D spend rate. It can be used as an *ex ante* measure of the required ROI, expressed as required cumulative revenue, for any R&D project of a given lifecycle. The CRRM equation can also be used as an *ex post* measure to determine the financial performance of any *specific* R&D project. Did the cumulative revenue of the project exceed or fall short of its CRRM minimum? If the cumulative revenue was greater than the CRRM target, then the project was successful. If less, then it failed to support the business goal of revenue growth. As a figure of merit of the project's performance, the formula can be used to iteratively calculate how much CAGR the project was actually capable of supporting.

A second measure was also developed to determine the required gross profitability of any R&D project. This is called the margin-adjusted CRMM or MACRRM, where

$$MACRRM = CRRM \times \frac{ideal\ gross\ profit\ margin}{expected\ gross\ profit\ margin}$$

If the expected gross profit margin of any R&D project is forecast to be at the company's ideal or target gross profit margin, then achieving the cumulative revenue target also satisfies the gross profit goal. Under such conditions, the ratio on the right of the equation becomes equal to one, and MACRRM = CRRM, i.e., no change is required to the CRRM, and the revenue *and* profit goals will be met if the CRRM is achieved. However, if the gross margin of the project is anticipated to be less than ideal, the ratio on the right becomes greater than one, and it increases the CRRM accordingly. The MACRRM is therefore the required cumulative revenue return multiple that will deliver the same margin *dollars* of return as the target CRRM would have delivered if the expected gross margin was at the ideal/target percentage. MACRRM increases (or decreases) the CRRM to account for expected differences in gross profit margin from ideal.

Both formulae express the return rate as the required cumulative revenue at the end of the project's lifecycle to support the stated business goals of revenue growth (CRRM) and gross profitability (MACRRM). If a proposed R&D project is deemed incapable of meeting this threshold of minimum revenue return, it should be either culled from the portfolio or else other projects with above-minimum return rate must be added, if the business goals are to be realized. This is a considerably better measure of the financial strength of a proposed R&D investment than NPV or IRR, because it provides an answer to the question of how much ROI is enough to meet the business goals.

Notice that the CRRM formula requires the user to predict what *fraction* of the final cumulative revenue is likely to be earned in Year 1, then Year 2, 3 etc. This is the *f* term in the equation, and it represents the likely *shape and duration* of revenue over the anticipated lifecycle of the product. This important parameter in the equation prompts an obvious question. Is it possible to predict what fraction of the final target cumulative revenue is typically achieved when 10%, 20%, or 50% of the anticipated lifecycle has elapsed? In other words, does the shape of cumulative revenue follow some predictable arc, for different products with different lifecycles?

Analog Devices Inc. considered this question and analyzed the cumulative revenue of hundreds of in-house R&D projects released from 1995 onwards, whose lifecycles were deemed complete. The cumulative revenue of all R&D projects in the set was in excess of $9B and included both successful and unsuccessful projects—projects that met the CRRM minimums and projects that didn't. The lifecycles of the R&D projects ranged from one year to 20 years.

The results of this analysis showed that the shape of the cumulative revenue S-curve was essentially the same, independent of product lifecycle. That is, for products with a three year lifecycle or a 15 year lifecycle, after *N* percent of their lifecycle had elapsed, *X* percent of the final cumulative revenue was typically achieved. The relationship between *N* and *X* was the same for products of all different lifecycles and can be expressed in a single equation (See Table 1 below).

Individual R&D projects varied substantially from this S-curve norm, but as additional products of the same lifecycle were combined, the aggregate cumulative revenue reverted to a shape that was common to all product lifecycles. This is an interesting finding since it allows us to predict the likely shape of cumulative revenue over time once the product lifecycle duration is estimated. Adding this to our new-found knowledge of what the required cumulative revenue needs to be at the end of the product lifecycle (from the CRRM equations) allows us to set milestone cumulative revenue targets throughout the life of a product. This is especially useful when measuring the performance of portfolios of products, since the aggregation of multiple projects makes the interim milestones more accurate and meaningful.

Example

A company has a goal to grow revenue at 10% CAGR, while spending 17% of annual revenue on R&D. It is considering a specific project, estimated to have a lifespan of six years (90% of the cumulative revenue is likely to be achieved by year 6, 100% by year 11). Note : "Lifespan" is defined as the time taken from the release date to attainment of 90% of final cumulative revenue, while "lifecycle" is the time taken to reach 100% of final cumulative revenue. The gross margins of the products are forecast to match the company's ideal gross margin. The R&D cost of the project is estimated to be $4M.

Putting these numbers into the CRRM formula, yields a multiple of 7.73, i.e. the final cumulative revenue for any and all projects with 6-year lifespans must be x7.73 times the full cost of the R&D project, in order to support the business goals. This specific project must therefore return 7.73 x $4M = $30.9M by the end of its anticipated lifecycle. From the S-curve of cumulative revenue in Table 1, we can also set targets for what the cumulative revenue ought to be after years 1, 2, 3 etc. (See Table 2 below)

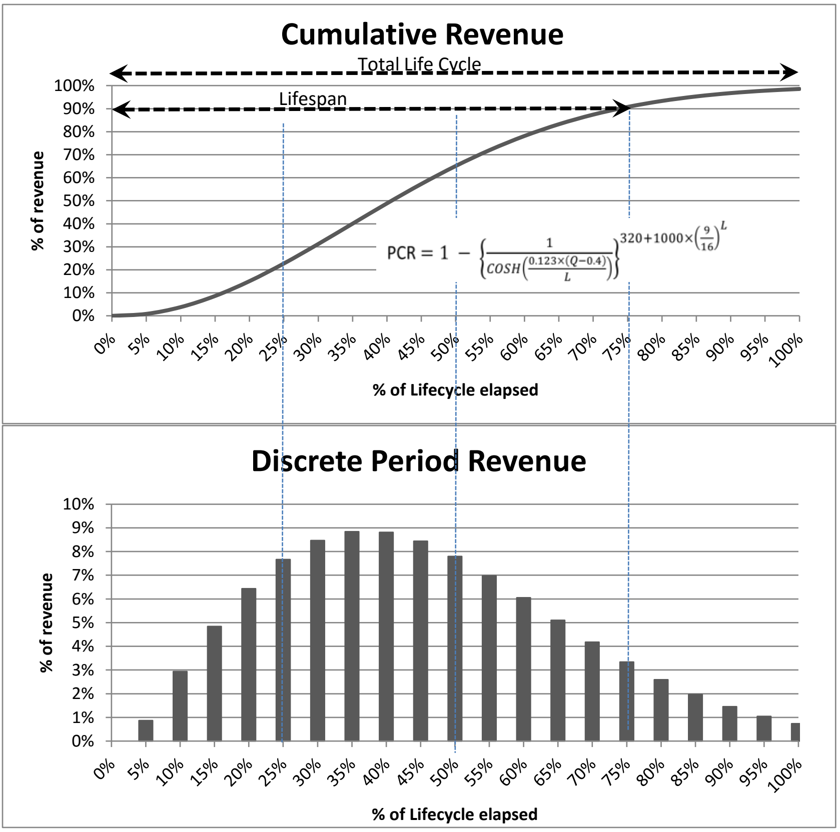

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Table 1. *Showing % of cumulative (and discrete period) revenue likely to be achieved after product release, as a function of product lifecycle. PRC = percent of cumulative revenue. L = estimated project lifespan (Note: not lifecycle). Q = quarters elapsed from release of project.*

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Predicted Cumulative revenue %	5.3%	21.5%	43.2%	64.0%	80.0%	90.3%	95.9%	98.5%	99.5%	99.9%	100%
Cum. Revenue Multiple required	0.41	1.67	3.34	4.95	6.19	6.98	7.41	7.61	7.69	7.72	7.73
R&D Cost of project ($M)	**$4**										
Target Cum revenue by year	$1.64	$6.66	$13.35	$19.79	$24.75	$27.93	$29.65	$30.45	$30.77	$30.88	$30.92

Table 2. *Note the required target cumulative revenue by year, for a project with a 6 year lifespan.*

Modifying the CRRM equation to account for long development cycle times

The CRRM equation as outlined above assumes a relatively short product development cycle time, where monies spent on R&D development projects occur close to the release of the product(s). Under such conditions the first term of the equation, representing the spend rate, can be simply stated as 1/SR, the reciprocal of the target annual R&D spend rate. This is a reasonable approximation for products where development cycle times are typically two years or less.

However, in industries like pharmaceuticals, product development cycle times are often in the range of 8 to 12 years. Under such conditions, even when the percentage of annual revenue spent on R&D is the same each and every year, the "effective" spend rate on R&D, expressed at its current value, is clearly different. It is intuitively obvious that the greater the time separation between R&D expenditures and the commencement of earnings at the release of the product, the higher the CRRM must be to account for the time separation. An adjustments must be made to reflect the fact that project development expenditures have occurred over multiple years and not necessarily in a linear fashion during those years. To make such an adjustment, the first term of the equation must be changed from the simple 1/SR to . . .

$$\{f^1 (1+r)^{y-1} + f^2 (1+r)^{y-2} + \ldots\ldots + f^n (1+r)^{y-n}\} / \mathrm{SR}$$

Where
r = the opportunity cost of capital
y = total product development cycle time in years
f = the shape and duration of the R&D project expenditure in time, where
f_1 = fraction of total R&D project expenditure that is spent in the first Year 1 of the development timeline
f_2 = fraction of total R&D project expenditure that is spent in Year 2 of the development timeline, etc. such that $f_1 + f_2 + f_3 + \ldots + f_n = 100\%$.
SR = the company's target annual R&D spend rate, expressed as a percent of annual revenue

For an R&D project with an 8 year development cycle time, assuming the expenditure is linear over those eight years (one eighth of the total project R&D expenditure is spent each year) with an opportunity cost of capital of 10%, the modified equation yields a value of 1.429/SR, thereby increasing the value of the first term of the equation by 42.9%, and increasing the value of the CRRM accordingly. That is, the required cumulative revenue must be 42.9% higher for an 8 year project development cycle time than it needs be if the development cycle time is only one year. The longer the development cycle time (more *f* terms in the equation) for a given opportunity cost of capital, the more it increases the CRRM. Note that if r = 5% instead of 10%, the equation yields a lower value of 1.194/SR. This modification to the equation makes an essential and appropriate correction, reflecting the time-based value of capital employed during the development process.

For a project with a 2 year development cycle time, where 50% of the expenditure is made in Year 1 and 50% in Year 2, for a 10% opportunity cost of capital, the equation yields a value of 1.05/SR. In other words, a relatively small adjustment of the CRRM, plus +5%, is required to account for a two year development cycle time.

Conclusion

For product-oriented companies, understanding the final cumulative revenue return multiples (CRRMs and MACRRMs) that R&D projects must achieve, as well as the time-based revenue milestones they ought to achieve during their lifecycles, is a fundamental step in connecting R&D expenditure to business goals. It enables the targeting and measurement of R&D ROI/productivity. When companies set goals for revenue growth and annual R&D spending, they are implicitly setting R&D ROI performance goals that must be reached to satisfy the business goals. CRRM and MACRRM quantify the required ROI, making it explicit and measurable.

These return rate targets are poorly understood, or not understood at all, by many product-oriented companies, but they are the logical starting point for any rational business plan.

Why is it important to set "business model compliant" R&D return rate targets and measure performance to those targets?

1. Without such targets, no numerical or logical linkage exists between the top-level business goals and R&D expenditure.
2. When selecting potential R&D projects, unless the minimum cumulative return targets (both revenue and profit) are comprehended, there is a high probability of selecting projects that are the "most" profitable, per NPV/IRR calculations, but which are fundamentally not profitable enough to support the stated business goals.
3. Understanding minimum required revenue return rates correctly focuses the project planning and stage-gate process on a rigorous testing of the assumptions that must prove true to meet those minimal return numbers.
4. Expressing the minimal cumulative revenue goal as a multiple of the project R&D spend enables an easy and automatic recasting of the dollars of minimum cumulative revenue required, should the cost of the project change during the planning and development phase.
5. Expressing the targets as time-based cumulative revenue enables the measurement and reporting of R&D productivity/ROI performance in real-time. It is not necessary to wait until projects have completed their lifecycles to gauge whether projects are meeting their time-based benchmark cumulative return targets.
6. The resulting productivity performance measurement system enables grouping of projects into categories of "successful to date" and "not successful to date" enabling the measurement of real-time project success rates.
7. After-action analysis of "successful to date" versus "not-successful to date" projects facilitates root cause analysis—a critical step to improving project success rates. Do successful projects share characteristics that can be codified and replicated? Do failing projects share characteristics that can be codified and avoided?
8. When R&D productivity trends are measured, analyzed and reported in real time, it is far more likely that adverse trends are quickly recognized and corrected. What gets measured gets improved.

ABOUT THE AUTHOR : During a 30-year career with Analog Devices Inc., Gerald Dundon held several senior management positions including Vice President of Supply Chain & Planning, Vice President of Quality, and Vice President of New Product Productivity. He received a Bachelor of Science degree from the University of Limerick, Ireland and is founder and CEO of Mayorstone Consulting and author of the book *"R&D Productivity. How to target it. How to measure it. Why it matters".* Contact Gerry via email at dundongerry@gmail.com

ABOUT THE BOOK : In an August 2015 review for Electronics Weekly, David Manners wrote "This is a heavyweight book for semiconductor management and it answers one of the most difficult questions the industry has to face: how do you create a business out of R&D." David Manners, Electronics Weekly, Aug 6th 2015

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