ECONOMIC / FINANCIAL ANALYSIS OF PRODUCT DEVELOPMENT

Reference:

Ulrich, K.T. & Eppinger, Steven D., Product Design and Development, McGraw Hill 1995

In 1990, Polaroid Corporation was in the midst of developing a new product, the CI-700 Digital PhotoPrinter . . . The CI-700 produces instant full-color photographs from digital images stored in a computer. The primary markets for the product are the graphic arts, insurance, and real estate industries. During the CI-700's development, the Polaroid product development team was faced with several decisions which it knew could have a significant impact on the product's profitability:

- Should the team take more time for development in order to make the product available on multiple computer "platforms," or would a delay in bringing the CI-700 to market be too costly?
- Should the product use print media (instant film) from Polaroid's consumer camera business or new and specialized premium-quality print media?
- Should the team increase development spending in order to increase the reliability of the CI-700?

The product development team needed tools to help it make these and other development decisions. This chapter presents an economic analysis methodology for supporting the decisions of product development teams. The methodology consists of two types of analysis, *quantitative* and *qualitative*. The emphasis in this chapter is on quick, approximate methods for supporting decision making within the project team.

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ELEMENTS OF ECONOMIC ANALYSIS

Quantitative Analysis

There are several basic cash inflows (revenues) and cash outflows (costs) in the life cycle of a successful new product. Cash inflows come from product sales. Cash outflows include spending on product and process development; costs of production ramp-up such as equipment purchases and tooling; costs of marketing and supporting the product; and ongoing production costs such as raw materials, components, and labor. The cumulative cash inflows and outflows over the life cycle of a typical successful product are presented schematically in Exhibit 2.

Economically successful products are profitable, that is, they generate more cumulative inflows than cumulative outflows. A measure of the degree to which inflows are greater than outflows is the *net present value* (NPV) of the project, or the value in today's dollars of all of the expected future cash flows. The quantitative part of our economic analysis methodology estimates the NPV of a project's expected cash flows. Our methodology uses NPV techniques because they are easily understood and used widely in business. (The appendix to this chapter is a brief tutorial on NPV.) The value of quantitative analysis is not only in providing objective evaluations of projects and alternatives but also in bringing a measure of structure and discipline to the product development process.

Qualitative Analysis

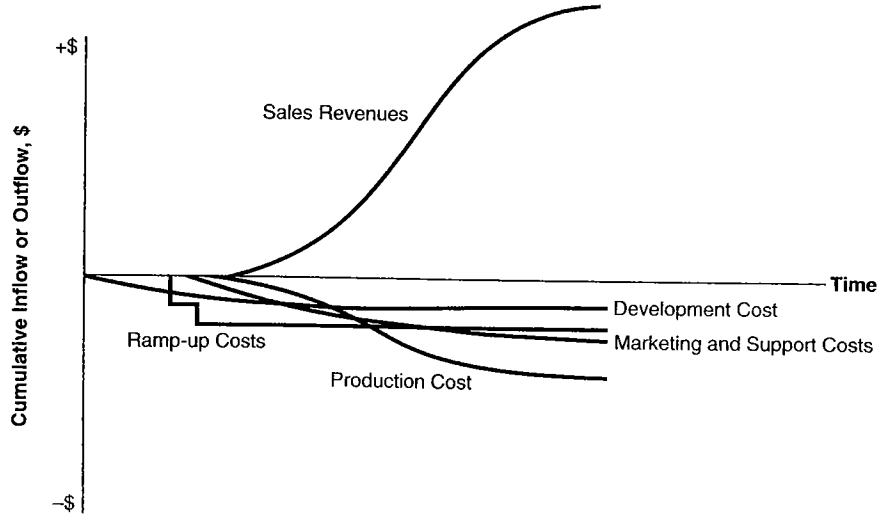
Quantitative analysis can capture only those factors that are measurable, yet projects often have both positive and negative implications that are difficult to quantify. Also, quantitative analysis rarely captures the characteristics of a dynamic and competitive environment. The chief executive of a major American corporation underscores this point: "I've had MBAs argue with me that a capital expenditure is wrong because it doesn't have a payback within two or three years; they ignore the fact that if we don't make the move, we'll fall behind the rest of our industry in four or five years" (Linder and Smith, 1992). Our methodology uses qualitative analysis to capture some of these issues. Our approach to qualitative analysis is to consider specifically the interactions between the project and (1) the firm, (2) the market, and (3) the macroeconomic environment.

When Should Economic Analysis Be Performed?

Economic analysis, which includes both quantitative and qualitative approaches, is useful in at least two different circumstances:

- ***Go/no-go milestones:*** For example, should we try to develop a product to meet this market need? Should we proceed with the implementation of a selected concept? Should we launch the product we have developed? These decisions typically arise at the end of each phase of development.
- ***Operational design and development decisions:*** Typical operational decisions involve questions such as: Should we spend $100,000 to hire an outside firm to develop this component in order to save two months of development

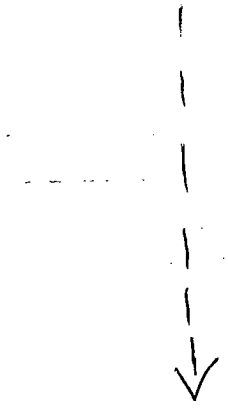
EXHIBIT 2 Typical cash flows for a successful new product.



time? Should we launch the product in four months at a unit cost of $450 or wait until six months when we can reduce the cost to $400?

The analysis done at the beginning of a project can usually be updated with current information so that it does not have to be created in its entirety each time. Used in this way, the analysis becomes one of the information systems the team uses to manage the development project.

Economic analysis can be carried out by any member of the development team. In small companies, the project leader or one of the members of the core project team will implement the details of the analysis. In larger companies, a representative from a finance group may be appointed to assist the development team in performing this analysis. We emphasize that even when someone with formal training in financial modeling takes responsibility for this analysis, the entire team should fully understand the analysis and be involved in its formulation and use.



BUILD A BASE-CASE FINANCIAL MODEL

Constructing the base-case model consists of estimating the timing and magnitude of future cash flows and then computing the NPV of those cash flows.

Estimate the Timing and Magnitude of Future Cash Inflows and Outflows

The timing and magnitude of the cash flows is estimated by merging the project schedule with the project budget, sales volume forecasts, and estimated production costs. The level of detail of cash flows should be coarse enough to be convenient to work with, yet it should contain enough resolution to facilitate effective decision making. The most basic categories of cash flow for a typical new product development project are:

- Development cost (all remaining design, testing, and refinement costs up to production ramp-up)
- Ramp-up cost

- Marketing and support cost
- Production cost
- Sales revenues

Depending on the types of decisions the model will support, greater levels of detail for one or more areas may be required. More detailed modeling may consider these same five cash flows in greater detail, or it may consider other flows. Typical refinements include:

- Breakdown of production costs into direct costs and indirect costs (i.e., overhead).
- Breakdown of marketing and support costs into launch costs, promotion costs, direct sales costs, and service costs.
- Inclusion of tax effects, including the depreciation tax shield and investment tax credits. (Tax effects are typically considered in even simple financial modeling. For the sake of clarity, however, we omit the tax effects in our examples.)
- Inclusion of such miscellaneous inflows and outflows as working capital requirements, cannibalization (the impact of the new product on existing product sales), salvage costs, and opportunity costs.

The financial model we use in this chapter is simplified to include only the major cash flows that are typically considered in practice, but conceptually it is identical to more complex models. For a good discussion of most of the cash flows that a firm would ever consider in analyzing a product development project, see the discussion of financial analysis in Crawford (1994).

The numerical values of the cash flows come from budgets and other estimates obtained from the development team, the manufacturing organization, and the marketing organization. Exhibit 3 shows the relevant financial estimates for the CI-700. (These data have been disguised to protect Polaroid's proprietary financial information.) For a more detailed discussion of manufacturing costs, see the chapter "Design for Manufacturing." Note that all revenues and expenses to date are *sunk costs* and are irrelevant to NPV calculations. (The concept of sunk costs is reviewed in the appendix.)

EXHIBIT 3 CI-700 project budgets, sales volume forecasts, and production costs.

1. Development cost	$5 million
2. Ramp-up cost	$2 million
3. Marketing and support cost	$1 million/year
4. Unit production cost	$400/unit
5. Sales and production volume	20,000 units/year
6. Unit price	$800/unit

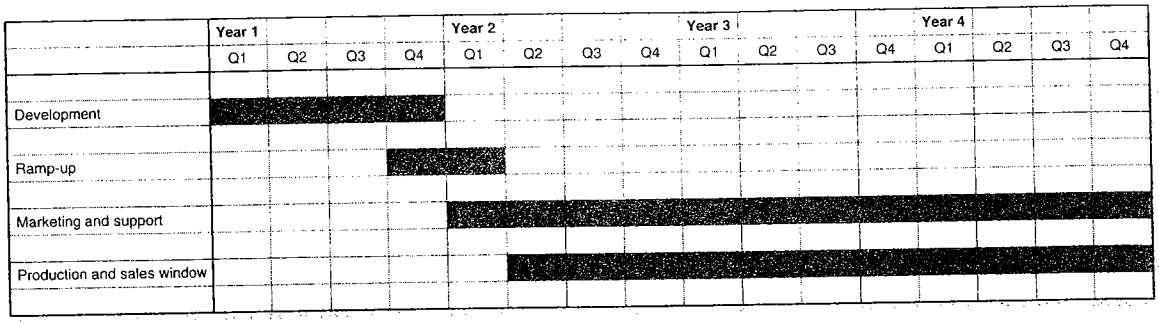


EXHIBIT 4 CI-700 project schedule from inception through market withdrawal.

In order to complete the model, the financial estimates must be merged with timing information. This can be done by considering the project schedule and sales plan. Exhibit 4 shows the project timing information in Gantt chart form for the CI-700. (For most projects, a time increment of months or quarters is most appropriate.) The remaining time to market is estimated to be five quarters, and product sales are anticipated to last 11 quarters.

A common method of representing project cash flow is a table. The rows of the table are the different cash flow categories, while the columns represent successive time periods. Usually this table is encoded in a computer spreadsheet to facilitate further analysis. For this example, we assume that the rate of cash flow for any category is constant across any time period (e.g., total development spending of $5 million over one year is allocated equally to each of the four quarters); however, the values can be arranged in any way that best represents the team's forecast of the cash flows. We multiply unit sales quantity by unit price to find the total product revenues in each period. We also multiply unit production quantity by unit production cost to find the total production cost in each period. Exhibit 5 illustrates the resulting table.

EXHIBIT 5 Merging the project financials and schedule into a cash flow table (all dollar values are in thousands in this and subsequent tables).

	Year 1				Year 2				Year 3				Year 4			
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Development cost	−1,250	−1,250	−1,250	−1,250												
Ramp-up cost				−1,000	−1,000											
Marketing & support cost					−250	−250	−250	−250	−250	−250	−250	−250	−250	−250	−250	−250
Production cost						−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000
Production volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit production cost						−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4
Sales revenue						4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sales volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit price						0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Compute the Net Present Value of the Cash Flows

Computing the NPV requires that the net cash flow for each period be determined, and then that this cash flow be converted to its present value (its value in today's dollars). Consider, for example, the calculations for year 3, first quarter:

1 The period cash flow is the sum of inflows and outflows:

Marketing cost	$\$-250{,}000$
Product revenues	4,000,000
Production cost	$-2{,}000{,}000$
Period cash flow	$\$1{,}750{,}000$

2 The present value of this period cash flow discounted at 10 percent per year (2.5 percent per quarter) back to the first quarter of year 1 (a total of eight quarters) is $1,436,306. (The concepts of *present value* and *net present value* are reviewed in the appendix.)

$$\frac{\$1{,}750{,}000}{1.025^8} = \$1{,}436{,}306$$

3 Project NPV is the simple sum of the discounted cash flows for each of the periods, or $8,203,000. (Here and in the rest of the chapter we round financial figures to the nearest one thousand dollars.)

The Base-Case Financial Model Can Support Go/No-Go Decisions and Major Investment Decisions

The NPV of this project, according to the base-case model, is positive, so the model supports and is consistent with the decision to proceed with development. Such modeling can also be used to support major investment decisions.

EXHIBIT 6 Total cash flows, present values, and net present value.

	Year 1				Year 2				Year 3				Year 4			
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Development cost	−1,250	−1,250	−1,250	−1,250												
Ramp-up cost				−1,000	−1,000											
Marketing & support cost					−250	−250	−250	−250	−250	−250	−250	−250	−250	−250	−250	−250
Production cost						−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000	−2,000
Production volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit production cost						−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4	−0.4
Sales revenue						4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sales volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit price						0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Period Cash Flow	−1,250	−1,250	−1,250	−2,250	−1,250	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
PV Year 1, r = 10%	−1,250	−1,220	−1,190	−2,089	−1,132	1,547	1,509	1,472	1,436	1,401	1,367	1,334	1,301	1,269	1,239	1,208
Project NPV	8,203															