

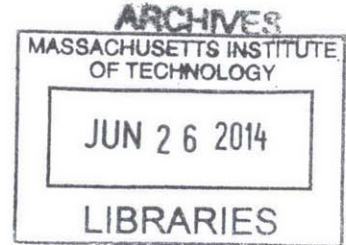
Financial Modeling of New Product Development Economics

By

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Master of Science in Finance

Suffolk University, Boston, 2005



Submitted to System Design and Management Program
In Partial Fulfillment of the Requirements for the Degree of
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Abstract

Product design and development is a complex process that involves extensive engineering considerations as well as management decisions based on the overall vision for the product. Traditionally, most decision making in product development is experienced based and intuitive. With increased scrutiny on cost and a need for greater speed to market, product development processes have been continuously streamlined to become more efficient. Therefore, firms are now required to carefully plan and allocate their resources to effectively respond to market needs. In this thesis, illustrated using a case study of a Nespresso coffee product line, a framework is presented to capture and analyze the financial factors relating to the profitability of a product development project. The methodology can assist product managers better understand the financial aspects of product development and help make more effective and objective project decisions. It can also help companies manage their product portfolio decision making process and prepare for new opportunities.

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Table of Contents

1. MOTIVATION.....	11
1.1 Primary Research Objectives	11
2. INTRODUCTION TO THE PRODUCT DEVELOPMENT PROCESS.....	12
2.1 Definition of Product Development.....	13
2.2 Stakeholders in Product Development.....	13
2.3 Key Processes in Product Development.....	14
3. LITERATURE REVIEW	16
3.1 Goals of the literature review.....	16
3.2 Review of some critical papers in product development.....	16
3.2.1 The New New Product Development Game.....	16
3.2.2. New Product Development: The Performance and Time-to-Market Trade-off	17
3.2.3 New Product Development (NPD) Processes and New Product Profitability: Exploring the Mediating Role of Speed to Market and Product Quality.....	18
3.2.4. Speed to Market and New Product Performance Trade-offs	19
3.2.5 Benchmarking Best New Product Development (NPD) Practices Parts I, II and III	20
3.2.6 Developing Products in Half the Time.....	22
3.2.7 Principles of Corporate Finance	23
3.2.8 Project Interactions Side Benefits and Side Costs.....	24
3.2.9 The Mythical Man-Month	27
3.2.10 A methodology for quantifying the effects of product development on cost and time	27
3.2.11. The Hidden Costs of Accelerated Product Development	29
3.2.12. Product Development Decisions: A Review of Literature.....	30
3.2.13. A Research Agenda for Investigation of Product Innovation in the Financial Services Sector	31
3.2.14. Quality Segmentation in Spatial Markets: When does cannibalization affect product line design?	33
3.2.15. The Profit making allure of Product Reconstruction	34
3.2.16. Cannibalization and New Product Development.....	35
3.2.17. Strategic Issues in Product Recovery Management.....	36
4. RESEARCH METHODOLOGY AND FRAMEWORK	41
4.1 Product Development Trade-off Framework.....	41
4.2 Data Collection Methodology	42

4.3	Research Approach	42
4.4	Software Packages.....	43
4.5	Financial Analysis.....	43
5.	DEFINITION AND FUNDAMENTALS OF PRODUCT DEVELOPMENT ECONOMICS.....	44
5.1	Key Definitions of various analysis techniques	44
5.1.1.	Present Value	44
5.1.2	Net Present Value	45
5.1.3	Payback Analysis	46
5.1.4.	Profitability Index.....	47
5.2	Fundamentals of Product Development Economics.....	47
5.2.1	Cash Inflows/Revenue.....	48
5.2.2	Cash Outflows/Operating Costs	48
5.2.3	Investments.....	48
5.2.4	Operating Profit	49
6	NESPRESSO CASE.....	50
6.1	Background.....	50
6.2	Revenue Estimation	52
6.2.1	Assumptions for Nespresso revenue estimation	53
6.2.2	Nespresso revenue forecasting.....	54
7	PRODUCT DEVELOPMENT MODELS.....	55
7.1	Data Assumptions for the models:	55
7.2	Base Case Model	56
7.3	Base model with Capsule Sales.....	60
7.4	Cannibalization Models.....	64
7.4.1	Cannibalization Model 1	65
7.4.2	Cannibalization Model 2	68
7.4.3	Brief discussion of Cannibalization Models	71
7.5	Recycling	72
7.6	Sensitivity Analysis	78
8	FINDINGS AND NEXT STEPS.....	81
9	APPENDICES	83
9.1	Appendix A: Common Facts about Aluminum Recycling	83

9.2 Appendix B: Definition of Recycling, Refurbishing and Remanufacturing 84

10 Bibliography 85

Table of Figures

Figure 1. Factors influencing New Product Development.....	12
Figure 2: Key Stakeholders in Product Development.....	14
Figure 3: Key Processes in Product Development.....	14
Figure 4: Factors Influencing Product Profitability	19
Figure 5: Trade-offs in Product Development	20
Figure 6: Variables Impacting Product Success	28
Figure 7: Key Steps in Service Development	32
Figure 8: Components of New Product Sales	35
Figure 9: Integrated Supply Chain for Product Recovery.....	38
Figure 10: Key Terminology in Product Recovery.....	40
Figure 11: Product Development Framework.....	41
Figure 12: Product Development Cash Flow.....	49
Figure 13: Typical sales of a product over its lifecycle	52
Figure 14: Cost and Revenue of Base Model	59
Figure 15: Cost and Revenue of Base Model with Capsules.....	63
Figure 16: Cost and Revenue of Cannibalization Model 1	67
Figure 17: Cost and Revenue of Cannibalization Model 2	70
Figure 18: Cost and Revenue compare of Cannibalization Models 1 and 2.....	71
Figure 19: Cost and Revenue of Recycling Model.....	75

Table of Tables

Table 1: Price Per Capsule Computation 54
Table 2: Revenue Estimation for Machines and Capsules 54
Table 3: Net Present Value computation for Base Model..... 57
Table 4: Net Present Value computation for Base Model with Capsules 61
Table 5: Net Present Value computation for Cannibalization Model 1 66
Table 6: Net Present Value computation for Cannibalization Model 2 69
Table 7: Input values for Recycling Model 73
Table 8: Net Present Value computation Recycling Model..... 74
Table 9: Impact of Sales and Recycling on NPV..... 77
Table 10: Sensitivity of revenue and cost on NPV 79
Table 11: Best and worst case scenarios for Nespresso..... 80

1. MOTIVATION

Product development is often the result of a deliberate choice made by organizations in creating and delivering a product. There are often conflicting objectives at play such as reducing the product development cycle time, increasing performance or improving quality. Some objectives may be mutually exclusive and companies that actively manage these may need to consider explicit trade-offs. This thesis will explore the financial modeling of product development and focus on understanding the financial drivers of choices made in new product development.

1.1 Primary Research Objectives

An analysis of the new product development process reveals one challenge facing companies: how do decisions taken in the product development process impact the product's future profitability.

This research will attempt to examine the following:

1. Present financial models for cost and revenue streams for new product development to understand and evaluate the financial impact based on a detailed case study of a Nespresso product.
2. Model the financial impact of cannibalization and its resulting lost sales in related product lines.
3. How can we use quantitative analysis to capture the financial impact of product take-back for recycling? Is recycling always a good choice if decision makers rely purely on financial modeling? Are there other considerations at play here? Could the decision to recycle potentially attract more sales and improve company image? This thesis will also present the financial modeling of recycling costs and monetary benefits.
4. Determine the impact of changes of model parameters on the net present value (NPV) of the product. As certain line items can have more or less impact on the net present value, it is important for companies to identify parameters that are most critical to NPV.
5. Analyze the impact of product development trade-offs to the bottom line.

2. INTRODUCTION TO THE PRODUCT DEVELOPMENT PROCESS

Product development process in firms is often a result of trade-offs between cost, delivery time and product quality. Compressing the product development time may not always be the right choice, as demonstrated by product recalls due to poor design or insufficient product testing. On the other hand, there have also been instances where companies have delayed the introduction of a product into the market in order to ensure higher performance and better product quality. Sometimes, such trade-offs come at a cost such as loss of market share and revenue or loss of reputation and sales when product quality is perceived to be inferior.

Bayus et al stated that there are certain determinants of new product development that in turn determines the speed to market for the product (Bayus, Jain, & Rao, 1997).

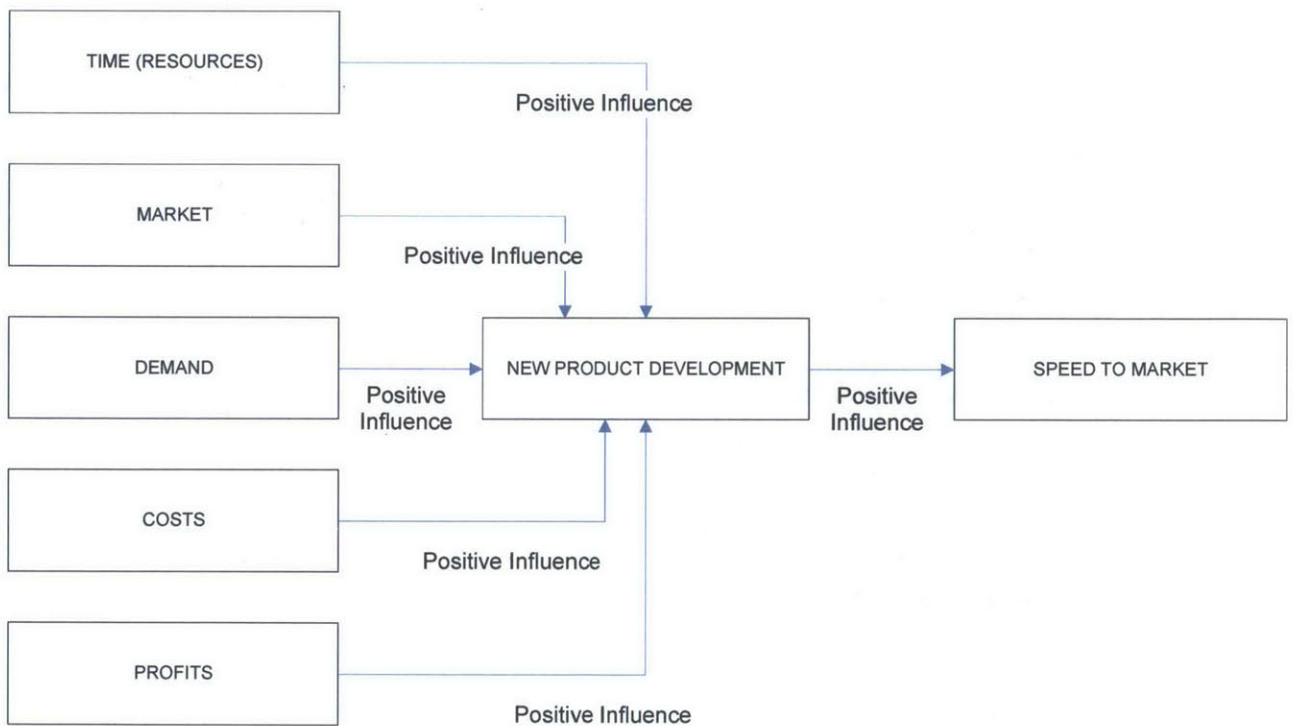


Figure 1. Factors influencing New Product Development

Source: (Bayus, Jain, & Rao, 1997)

New Product Development often focuses on the incremental innovation and the development of evolutionary products. Break-through innovations of discontinuous products or radically innovative products often have larger up-front costs associated with research and development. In the Nespresso case examined here, we will deal with the traditional and more common incremental development of a coffee machine that will displace existing models over time and will eventually be cannibalized by other more recent models.

The impetus for new product development is often the convergence of several endogenous and exogenous factors such as availability of new technologies, regulations, customer expectations, market forces, strength of the Research and Development etc.

2.1 Definition of Product Development

Product development is an innovative, inter-disciplinary process that transforms a market opportunity to a product of value that is capable of fulfilling a need. This is a key activity in an organization as it is often the driver of value and economic success. Product Development can include the creation of new products i.e. the result of disruptive innovation or incremental improvement of existing products which is the result of sustaining innovation, as identified by Clay Christensen in *The Innovator's Dilemma* (Christensen, 1997). Successful product development meets the needs of its customers or creates a new market by catering to the latent needs of its target customers.

(Krishnan & Ulrich, 2001) In their *Product Development Decisions* paper define product development as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale. Product definition plays a key role in the product development process as it balances customer preferences with technical and organizational realities (Krishnan & Kalyanaram, 1997).

2.2 Stakeholders in Product Development

Product development is a cross-functional multi-organizational activity that receives input from strategy, marketing and advertising, engineering design and development, finance and budgeting, suppliers and OEMs amongst others in delivering the product. These stakeholders have an input into the product as

well as the product development process that is responsible for the design and delivery of the product itself. All or a subset of these key stakeholders form the part of the core product development teams. The effectiveness and need for a cross-functional product development team has been well-established in academia (Pinto, Pinto, & Prescott, 1993).

Product Development Stakeholders

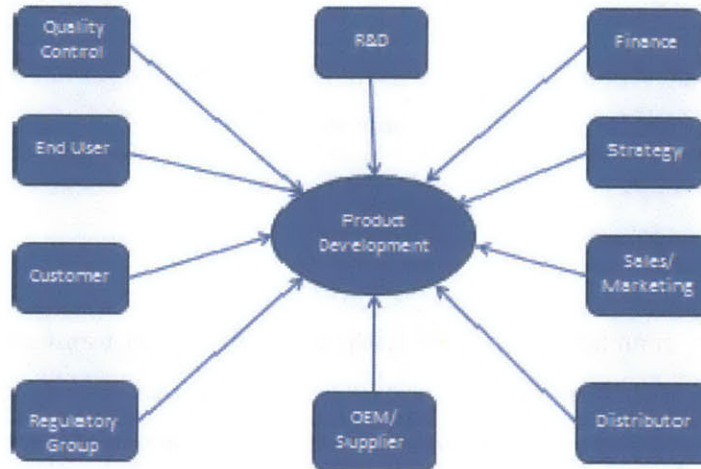


Figure 2: Key Stakeholders in Product Development

2.3 Key Processes in Product Development

In the Product Design and Development book by Ulrich and Eppinger, the authors define the generic product development process as below.



Figure 3: Key Processes in Product Development

Source: (Eppinger & Ulrich, May 2011)

According to Ulrich and Eppinger, the planning phase identifies the opportunity and assesses the technology, market objectives and corporate strategy. During the concept development phase, the market needs are identified and then multiple concepts that would address the need are generated. After further evaluation a concept is chosen as a candidate for further development. In the next phase, the high-level product architecture is defined and its components and dependencies are identified. The functional specification is usually delivered in this phase. In the Detail Design phase, detailed specification such as material selection, production costs and performance details are determined with input from manufacturing engineers. This is followed by the testing and refinement of the prototypes and evaluation of the various prototypes. In the final production ramp-up phase, the actual production process is used to train the workers and the product is brought to the market with the help of logistics and marketing. The production process may be streamlined and improved upon; this is sometimes referred to as Process Innovation, after this phase when the product is launched for large-scale production.

3. LITERATURE REVIEW

This section is an attempt to capture some key thoughts in the various topics that are relevant to this thesis. The main objective is to do a thorough review of past academic and commercial work on product development related topics to assist with gathering sufficient knowledge and understanding in this topic.

3.1 Goals of the literature review

The main goal of the literature review is to capture some critical thinking and research work in areas of product development as it relates to costs and economics. In this section, the following analysis has been conducted:-

- Research the salient theories and concepts in this area
- Identify the key questions that have been addressed to date
- Review different schools of thought and perspectives on the topics of interest
- Recognize key ideas that have contributed significantly to this field

3.2 Review of some critical papers in product development

3.2.1 The New New Product Development Game

Authors: Hirotaka Takeuchi and Ikujiro Nonaka
Source: (Takeuchi & Nonaka, 1986)

The authors argue that the new product development demands speed and flexibility. While traditional attributes such as low cost and high quality are important and relevant, the differentiating factors are the speed and flexibility with which the team performs. In analyzing six leading products developed by multi national companies such as Xerox, Honda and Canon, the authors identified six key characteristics that these companies displayed in their product development process.

Built-in-Instability is triggered. In companies such as Honda and Fuji-Xerox, the top management is responsible for establishing a clear goal with very challenging time or cost pressures. The project team is given a lot of freedom but is also given a set of very challenging problems that it needs to creatively solve. Often times, this leads to a start-up like environment with *self organizing teams*. Such teams

exhibit characteristics such as autonomy, self-transcendence with its own goal setting and cross-fertilization of team members from different functions and of various personalities. This often results in an interesting dynamic where the teams have an *overlapping development process* that does not adhere to traditional division of labor since the interest of the individual is aligned well with the unit as a whole. This also results in teams *Multilearning*, where team members are more in tune with the outside market and develop various skills with a significant breadth of knowledge. This often results in learning from various levels of the organizations that team members may not otherwise interact with in their more traditional roles. Management in such cases adopts a more *subtle control* with an open environment that has rewards based on overall team performance. While the management has check points that help remove ambiguity that can create chaos, successful groups develop a cadence that is geared towards correcting mistakes early and promoting overall group performance. Another important characteristic observed in this study was the *transfer of learning* by the group members to other project team members as well as the community outside the project team. Such as holistic approach has been widely researched in academia and adopted in organizations since this study.

3.2.2. New Product Development: The Performance and Time-to-Market Trade-off

Author(s): Morris A. Cohen, Jehoshua Eliashberg and Teck-Hua Ho
Source: (Cohen, Eliashberg, & Ho, 1996)

This paper examines the trade-off between the objectives of minimizing time to market and maximizing performance of the new product. While significant product performance can help capture a larger market share from competing products, this might also delay the product development process resulting in losing the window of opportunity with the first-movers advantage. These different schools of thought each have business cases that support them as evidenced in research by academic scholars as well as consulting firms such as McKinsey and Booz Allen Hamilton.

The authors present an optimization model that can aid in answering questions relating to optimum performance target, time to spend on design or process and time allocation to various stages of product development using parameters such as cost structure of the firm and market characteristics. Their key assumption is that product improvements are additive during the course of the product development activities. The results of their study confirm a fundamentally intuitive heuristics of product development that it is optimal to spend time on the most productive tasks. They have also empirically shown that products that replace existing products tend to have longer time to market and high performance

targets than brand new first-generation of products. Faster product development might not be advised if the stakes are high; for example, if the market potential is large or the existing product that it would replace has a higher margin. Therefore, their findings suggest product replacement activities should be delayed when existing products have high performance, however if competition is based on product performance it could be a critical factor that needs to be considered. The caveat to this is when the time window to introduce products is short or the firm has quick product development capabilities.

3.2.3 New Product Development (NPD) Processes and New Product Profitability: Exploring the Mediating Role of Speed to Market and Product Quality

Authors: Regina C. McNally, M. Billur Akdeniz, and Roger J. Calantone

Source: (McNally, Akdeniz, & Calantone, 2011)

The motivation for this paper is the tension between product quality and speed to market and their impact on the product profitability. This includes a thorough study of 1,115 different NPD in different firms using Partial Least Squares (PLS) to analyze historical and current data. This study also considers the impact of product development expenses and the cross-functional integration of the project team.

Speed is often perceived to have a negative impact on the product quality. However, speed to market and the innovativeness of the products are considered valuable tools by most leading firms. Their conceptual mediation model is presented in the figure below (captured from the article). This model shows that the impact of development expenses directly on product profitability as well as the indirect impact that it has on profitability through the quality of the product and the lead time. Similarly, the model also tests the hypothesis that the product quality and speed to market mediate the impact of cross-functional integration on product profitability. Their results show that process and development times impact profitability directly and indirectly. The trade-off considerations should include not only the development processes but also the development timing.

The limitations of this study are the firms are of large size only; small and medium size firms have not been included. The research is based on cross-sectional data rather than time-series data to see the evolution of the impact on product profitability.

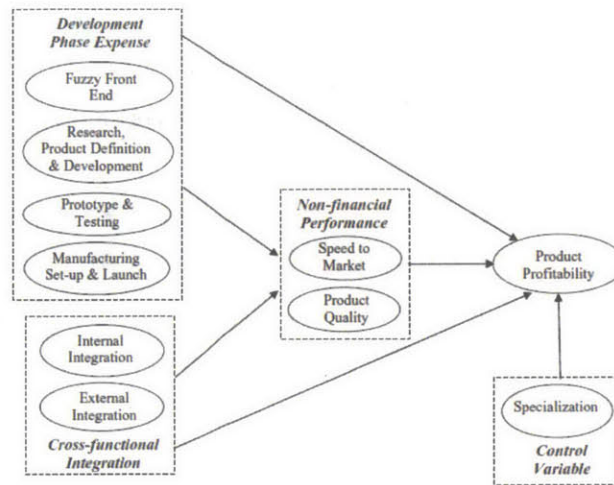


Figure 4: Factors Influencing Product Profitability

3.2.4. Speed to Market and New Product Performance Trade-offs

Authors: Barry L Bayus
 Source: (Bayus, 1997)

In this article, the author analyzes the relationship between product development time and costs. This paper provides a mathematical model that captures product performance and time to market parameters to assist in decision making. This model is then applied to two firms with different business cases to test the robustness of the model. The model would help determine the trade-offs that are necessary to make between product quality, cost and time during the development process. This paper proposes an optimization model to help determine the time to market and product quality decisions that would be in the best interest of the firm.

The two cases examined in the paper have different market forces at play. In the first scenario, a competitor has launched a product in the market place and the choices are based on taking market share from the competitor. In the second scenario the competitor is yet to launch the product and the decision making revolves around the proactive product development effort to beat the competition. Based on the model developed, the authors determine the optimal performance required and development time for each of the scenarios. A key assumption to the model is that higher performance requires higher costs for a given development time. The following diagram from the article summarizes the author's findings on the recommendation based on certain parameters. This study demonstrates

that for products with shorter life cycle, product performance can be low. Similarly, if there is weak competition or lower margins, the product quality does not appear to be a critical factor. However, if there are many competitors or the product life is longer with higher margins, product quality is key.

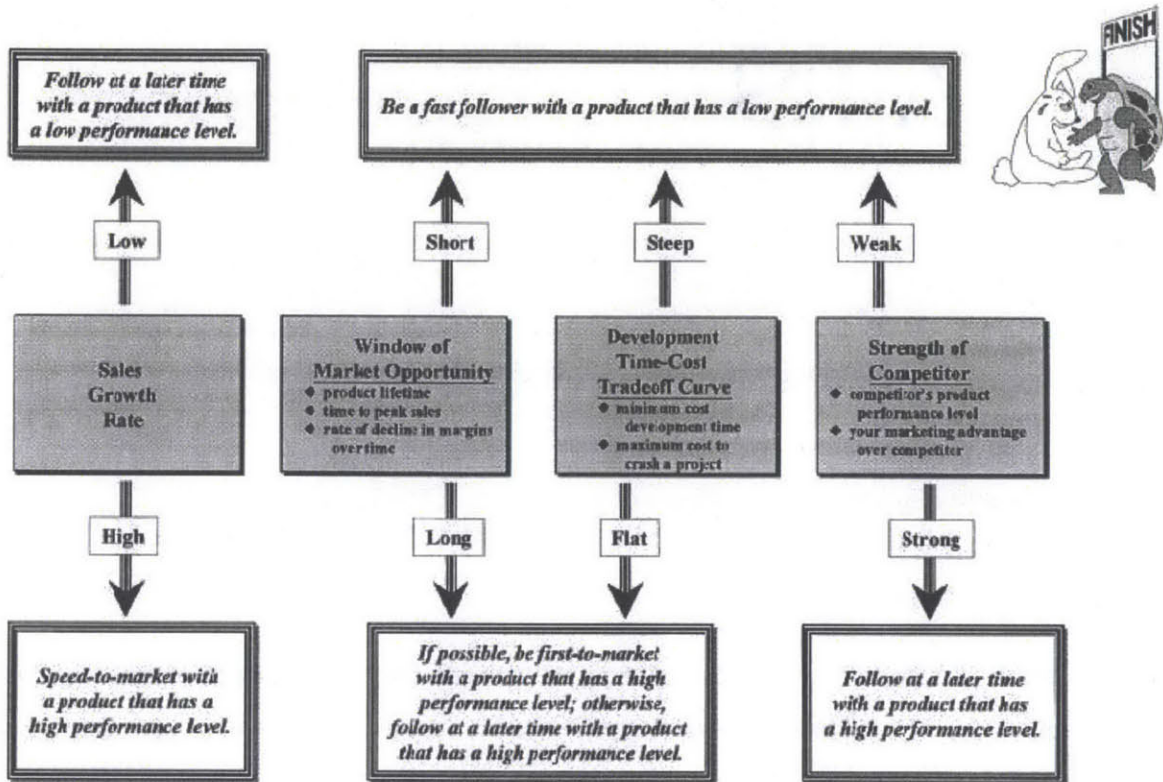


Figure 5: Trade-offs in Product Development

3.2.5 Benchmarking Best New Product Development (NPD) Practices Parts I, II and III

Authors: Robert G Cooper, Scott J. Edgett and Elko J. Kleinschmidt
 Source: (Cooper, Edgett, & Kleinschmidt, 2004)

This research series is based on a comprehensive study of NPD practices at five leading companies. This study involved 113 measures to capture the NPD practices and the effectiveness of the NPD initiatives. The objective of the study was to understand what differentiates firms that successfully develop new products from those that cannot.

Part I: The first part focuses on the people and organization aspect of product development firms. It also summarizes the key findings of the study that the high level of failure rate for development projects with about a half of the projects overrunning cost or having schedule delays.

The aim is to identify the cultural nuances and role played by senior management in these firms and the impact that they have on product delivery. The study has identified key drivers for NPD such as creating an innovative climate and a culture that rewards innovation. A key differentiating factor between top performers and others is also the reward system that recognizes the project leaders as well as the project team as a whole. Other critical factors identified in this part include the low level of risk averseness and the open communication exhibited by top performers. The senior management in the top performing firms also mitigated the fear of failure and encouraged risk taking. An important factor that differentiates the top performers is their attitude and culture that promotes and rewards innovation at the grassroots level. Seeking employees to participate and take ownership of their initiatives, providing them time and resources to pursue projects and supporting their initiatives seem to be key factors that contribute to successful product development.

Part II: The second part of the series focuses on the strategy, especially as it relates to innovation and its link to and impact on new product development. The strategic support is demonstrated through spending activities as well as the management of the portfolio of projects that develop new products. Strategic commitments to the development of new products with resource allocation and the clear communication of the goals have been identified as key strategic drivers of successful new product development. A technology roadmap with a clear technology strategy also aids this process. Often, the strategy should also set tactical short-term goals versus long-term direction so sufficient effort is spent on incremental improvements as well break-through research and development. Dedicated resources that have clear goals are best placed to succeed.

Part III: Several academic literature studies confirm a formal new product development process is a prerequisite for successful product development. The key to this is also in meeting customer needs and expectations, delivering value with quality and customer benefits. The voice-of-the-customer is critical to not losing sight of the end user and target customer during the development process. The authors recommend that offering value that is superior to existing products and ensuring the benefits offered by the product are valuable to the customers are key factors that should be incorporated in decision making for product development dollars. Well-researched market information at the start with continued pulse check on changes in customer perceptions and values during the product development process will help avoid costly mistakes. Another key consideration that can be gathered from market

insights is the product differentiation features that identify how this product is different from all the existing products.

3.2.6 Developing Products in Half the Time

Authors: Preston G. Smith, Donald G. Reinertsen

Source: (Smith & Reinertsen, 1991)

The authors present practical techniques, meant for practitioners in the field that companies can adapt to shorten their product development time significantly from their experience in companies such as Xerox, HP, Black and Decker showing the tasks and timeline from inception to the actual delivery to the customers. Product development time typically includes a significant amount of time spent on the “fuzzy front end” activities defining what the product will and will not do. Although some of the concepts discussed in the book are familiar to practitioners of agile methods in software development, the authors’ present empirical evidence of several companies reducing the product development cycle-time and the rationale behind these successful concepts. The authors recommend an overlapping approach to the phased project planning practices.

The four key product development objectives identified were Development Speed, Project Cost, Product Performance and Development Program Expense. Development time is the total time taken to deliver the product to the market including the concept definition. Authors define product cost as the cost of delivering products to the customers, not just the manufacturing cost since marketing and selling costs can add significantly to the total product cost. Product performance is the measure of the quality of the product and how well it meets the specifications of the target customers. Program Expense includes the one-time product development expenses that will not be incurred during repeated manufacturing of the product. These four objectives define the basis for any trade-offs that might need to be made during the development.

Another key takeaway is the focus on the fuzzy front end processes in product development that significantly increases the overall product cost when this stage is not actively managed. The market clock is a different concept of thinking of time. To quote the book, *it starts ticking when the need for the product first becomes apparent in the marketplace.*

Trade-off is key to any product development. However, it is not often that managers know if the trade-offs they make are aligned with their goals. The results of the analysis become the tools that can create decision rules to help managers make decisions about the product development process including day to day activities. For e.g. increasing a product's development time by three months might decrease its market share by 5%. Managers can then decide if 5% market share is more than the cost of delivering on time. Another typical example of expressing these rules is as impact to the bottom line. If the product cost overruns by 5%, it could result in \$20,000 impact to the profits. It is important for managers to share this information and ensure employees understand this, in order for them to make these decisions by weighing their decisions against these goals.

3.2.7 Principles of Corporate Finance

Authors: Richard A. Brealey; Stewart C. Myers and Franklin Allen

Source: (Brealey, Myers, & Allen, 2006)

In this classic finance textbook, present value is described as the discounted value of a future cash flow. The discount factor, also known as the opportunity cost of capital or hurdle rate, is the rate of return prevailing in the market place for similar risk profile. The rate of return is a function of the risk of the investment. As the risk increases, the rate required by the market to make the investment attractive to investors also increases. The risk free rate is often a very safe investment with guaranteed return of principal and interest such as U.S. Government securities.

The discounting principle is critical to evaluate any investment decisions. Cash flows are typically discounted for two primary reasons; since a dollar today is worth more than a dollar tomorrow and a risky dollar is worth less than a safe dollar. Investors usually have the option of investing in safe or risky assets and should be rewarded for any additional risk they are willing to take. The present value of an investment states what it is worth in today's dollar for the given risk.

Brealey and Myers define Internal Rate of Return (IRR) as the rate of discount that makes the net present value equal to zero.

$$NPV = \sum_{t=0}^N \frac{C_t}{(1+r)^t} = 0$$

Where:

C = Cash flow

T= time

R= IRR

Companies typically evaluate investment options in several ways. Some common techniques are outlined below:

- (i) Pay back: It is defined as the amount of time required to recover the initial investment. Although this method is very popular due to its simplicity, it does not take into account subsequent cash flows or the opportunity cost of capital.
- (ii) Internal Rate of Return (IRR): The internal rate of return described above is another calculation used by some companies. However, it does not consider the differences between short term interest rates and long term interest rates. Another common criticism of IRR is that it does not handle projects that have cash inflows and outflows; when there is more than one change in the sign of the cash flows.
- (iii) Book rate of return: It compares the book income of an investment to the book expenditure. Although this was popular in the past, it is not commonly used anymore.
$$\text{Book rate of return} = \text{Book Income} / \text{Book Assets}$$
- (iv) Net Present Value (NPV): NPV is often used as a tool to make investment decisions. The two key features of NPV are: It is based on forecasted cash flows and is only as accurate as the underlying assumptions; it is additive in nature since the denomination is in current day's worth. If capital is rationed within one period, the profitability index calculated as the NPV per dollar of investment can be used to aid project selection.

3.2.8 Project Interactions Side Benefits and Side Costs

Authors: Aswath Damodaran

Source: (Damodaran, 2001)

Damodaran defines mutually exclusive projects as a set of projects where only one of the set can be accepted by a firm. The aim here is similar to independent projects, where the choice should be based on how much value is added. The simplest and most intuitive way of selecting amongst mutually

exclusive projects is based on Net Present Value. In cases of selecting between projects with equal lives, an alternate method called Differential Cash Flows is available for use. In this approach, managers can compute the difference in cash flows during each period between the two projects compared. The decision rule is provided below:

$NPV_{B-A} > 0$, Project B is better than Project A

$NPV_{B-A} < 0$, Project A is better than Project B

This approach would result in the same decision as calculating and comparing NPV individually for Projects A and B. Another point to consider is that these projects should have the same risk level; hence the same risk premium or discount rate is used.

Projects with Different Lives: Firms often have to make project decisions across projects with different lives. Since NPV of longer projects are typically higher, any decision solely based on that will not consider the reinvestment option available with a shorter project. Two common approaches to evaluate projects with different lives are project replication and equivalent annuities. These approaches tend to extend the timeline to make them equal with various assumptions. In product development, these factors are applicable for products that take shorter development time but might have a shorter product life before it is replaced by a competitor product. Similarly, a product with fewer features at initial release might need to be incrementally upgraded to offer more features that the market demands.

Damodaran defines project replication as an approach that assumes the projects can be replicated until they have the same lives. The project replication is performed until the least common multiple (LCM) of the project lives. For e.g. if A is a 3-year project and B is a 4-year project, then the project replication is done until 12 years for both projects. Apart from being tedious to calculate for large projects with different lives, it may not be realistic to assume the returns that can be expected for these extended time lines.

The alternative is the Equivalent Annuities method that converts the lives by converting their NPV into annuities. Since NPVs are annualized, converting them does not pose any threat to the integrity of the calculation. Damodaran presents the formula below for converting NPV into annuities.

$$\text{Equivalent Annuity} = \text{New Present Value} * [A(PV, r, n)]$$

Where

R = Project discount rate

N= Project lifetime

A (PV, r, n) = Annuity factor, with a discount rate of r and an annuity of n years

This method can also be applied on projects with different lives and discount rates. Although this method will yield the same results as the Replication method, it is less tedious to calculate and can work well with multiple projects that have different lives.

Capital Rationing: Investing is a choice that firms make. Such a choice has consequences since capital is limited. Capital Rationing happens when firms do not have the resources to invest in all its projects that have the potential to earn returns higher than their risk-adjusted discount rate. This is usually the result of higher financing cost or lower credibility of the firm.

Product Cannibalization: Damodaran defines Product Cannibalization as the phenomenon in which a new product introduced by the firm competes with and reduces the sales of the firm's existing products. In most cases, firms do not have a choice of not introducing the new product since that could result in loss of sales to a competitor. A key factor in this decision making process is the ability of the competitor to offer a close substitute.

- a. Competitive Products available with no barriers to entry: If a firm produces competitive products with no significant barriers to entry, product cannibalization is inevitable. If the firm does not introduce the competitive product, then the competitor will and it will result in lost sales for the firm. In such cases, cash flows from product cannibalization are usually not considered since sales will be lost either to itself or to a competitor.
- b. Competitive Products not available due to barriers to entry: If there is any legal restriction or regulation that prevents competitors from introducing a new product, then product cannibalization should be captured in the cash flow analysis for the period when such a protection exists. It is typical for most companies to have some protection that prevents the total erosion of sales due to competitors' products. Often, even brand-image or customer loyalties serve as deterrent to capturing sales.

3.2.9 The Mythical Man-Month

Authors: Frederick Brooks

Source: (Brooks, 1995)

In his seminal work on software development, Brooks asserts “adding manpower to a late software project makes it later”. This assertion is based on fundamental rules of large teams that impact development time. In most projects, it takes time for people to learn and become productive. As the number of people increase, the communication network also becomes large and the overhead related to communication is high. The caveats to this, with respect to the skill level of the people added and the strength of the processes in place are not taken into consideration. In many cases, adding resources before a project falls behind schedule can be preventative.

Although a lot of the input is specific to programming, a key takeaway for product development is that each product is different. Developing a Boeing aircraft would have different set of resource requirements than making pharmaceutical products. However, similar to software, allocation should be made on how much time should be spent on the product conception versus product development and delivery.

3.2.10 A methodology for quantifying the effects of product development on cost and time

Authors: Michael Boer and Rasaratnam Logendran

Source: (Boer & Logendran, 1999)

Boer and Logendran describe product development as a nebulous science where companies are constantly challenged to bring cheaper products into the market at a faster rate. Speed has been identified as a key contributor to the overall project cost. This paper focuses on studying past projects to analyze the results and learn from those experiences. The regression analysis and resulting statistical model may be used as a tool for predicting performance of future projects.

The conceptual model shown by the authors captures two types of variables, those that capture the product development effort and the product success. Product drivers are activities that drive the development process and the product complexity is determined by the complexity of the design and

development. Project cost represents the actual program expense while time represents the time factor throughout the various stages of the product development process.

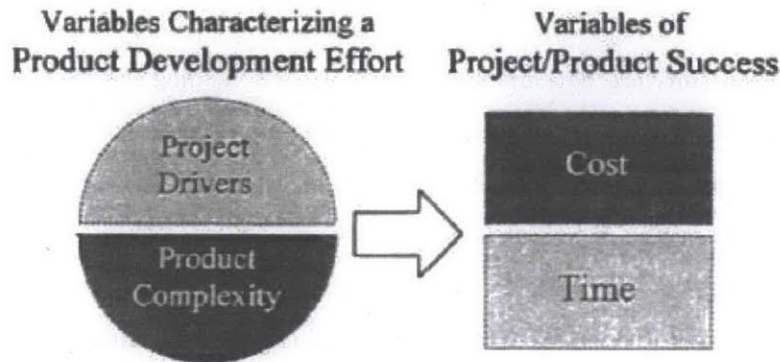


Figure 6: Variables Impacting Product Success

Based on regression analysis and a relationship matrix using these factors, the key findings are presented below:

- a. Product cost increases as number of parts increase: Their findings support other literature that state the number of parts in a product increases its overall cost. The design phase should aim at reducing the total number of parts to keep product cost low.
- b. Product cost and time increases as the number of assembly process increases: Typically, the fewer parts required for product assembly, results in fewer assembly process. Their study shows that this decreases the overall product development cost and time.
- c. Exterior shape of the product is related to product cost: As the shape becomes more complex and unique, it required more specialized parts that increase the overall cost and development time.
- d. Quality/Utility of the product as perceived by the customer: This factor also increases the cost and development time since it typically takes longer to product quality products. The quality of the materials, design aesthetics, attractive packaging etc. adds to the total time and cost.
- e. Product Performance Enabling Specification (PPES): This factor determines how well a product performs and it was found to have the highest impact on product time and cost in their study.

3.2.11. The Hidden Costs of Accelerated Product Development

Author: C. Merle Crawford

Source: (Crawford, 1992)

Accelerated Product Development process, with its focus on innovation, is the mantra of many managers. However, this has a key side effect often comes at the price. In this paper, Prof. Crawford examines some of hidden costs associated with this process. Accelerated product development process works well for organizations when the right expectation and goal are set for the team. The hidden costs identified in this article can be summarized as below:

- a. Low profit trivial innovation: This is described in the paper as Gresham's law that bad money drives out good money, low impact incremental innovation might replace break-through high impact innovation. All the resources allocation to incremental innovation might be eating into any disruptive innovation possible.
- b. Many mistakes happen while skipping steps: Critical steps that collate and assimilate useful information is often skipped when attempting to shrink the product development time. This can sometimes result in misinformed decision making.
- c. People cost can increase in smaller teams: In order to increase the development speed, some firms have smaller, more focused teams that eliminate options and focus on just the delivery. There can be a disruptive side effect to such teams.
- d. Unexpected inefficiencies: In accelerated product development process, inefficiencies may result when the different tasks in the process do not respond well to a shortened time frame including the critical step of Innovation.
- e. Support resources: The shared resources that are not part of the core product development team but offer support, such as scientists, specialists etc. may not adapt well to the speed of such accelerated development teams.

3.2.12. Product Development Decisions: A Review of Literature

Author: V.Krishnan, Karl T. Ulrich
Source: (Krishnan & Ulrich, 2001)

In this important paper on Product Development Decisions within a project, Krishnan and Ulrich review the literature on the various key areas of product development. We will briefly review each section.

Concept Development: This initial phase defines the product specifications, its key features and the post sale supplies and life cycle services. The authors define core product concept as the embodiment of product attributes into some kind of technological approach and includes concept generation and concept selection activities. While the traditional school of thought recommends that concept is frozen before product development begins, more recent studies support the pursuit of several concepts until they can be finalized at the later stage. The lower cost of prototyping and use of computer based simulation makes this possible.

Supply Chain Design: This paper uses a broad purview of supply chain to include the inflow and outflow of material, intellectual property and material. Therefore, supply chain decisions cover supplier selection, production and distribution. Research indicates component design and development designs must be made simultaneously to gain full benefit.

Product Design: The authors define product design as the “detailed design phase, which constitutes the specification of design parameters, the determination of precedence relations in the assembly, and the detail design of the components.” Design decisions, which take place after product concept development, encompass factors that influence product performance while meeting its specification.

Performance Testing and Validation: Prototyping and validating the product design and development is critical. Studies indicate the cost of testing should be balanced against the cost of rework and early and frequent testing might increase the cost of testing but prevent costly mistakes further down the line.

Product Launch and Production Ramp-up: This is one of the key decisions a firm makes since it includes several factors such as how much testing should be completed, launch timing, competitor product features. Production ramp-up is required to serve the target market with the right level of inventory.

The paper also explores decisions in setting up the development project. Companies typically have multiple projects that involve multiple product development initiatives. Insights from the paper on some key areas are given below:

- Product Strategy and Planning: This phase encompasses decisions regarding the target market, the portfolio of products and their priorities.
- Product Development Organization: The authors define this as social system and environment in which a firm's design and development work is carried out. Resource management issues including team hierarchy and set up, performance monitoring and reward system are part of this.
- Project Management: Once the product is selected to be development, then a project initiative is established to develop the product. This activity includes project timing, staffing and monitoring. Tools and techniques such as CPM and PERT are commonly used. Modeling tools such as DSM, enhanced by Eppinger for large-scale product development activities, are also used in complex initiatives by project management professionals.

3.2.13. A Research Agenda for Investigation of Product Innovation in the Financial Services Sector

Author: Raphael K. Akamavi

Source: (Akamavi, 2005)

A literature review in product development will not be complete without reviewing product innovation and development in the services sector known in research as New Services Development (NSD). While product development in manufacturing and software sector has been extensively studied, product development in services, especially financial services has gaps in research coverage. This paper covers the review of existing research in this area.

Development of services tend to have more of an iterative approach, with trial and error and quick course correction as opposed to the more linear product development path for tangible goods. The key steps in service development identified by leading researchers have been summarized in this figure.

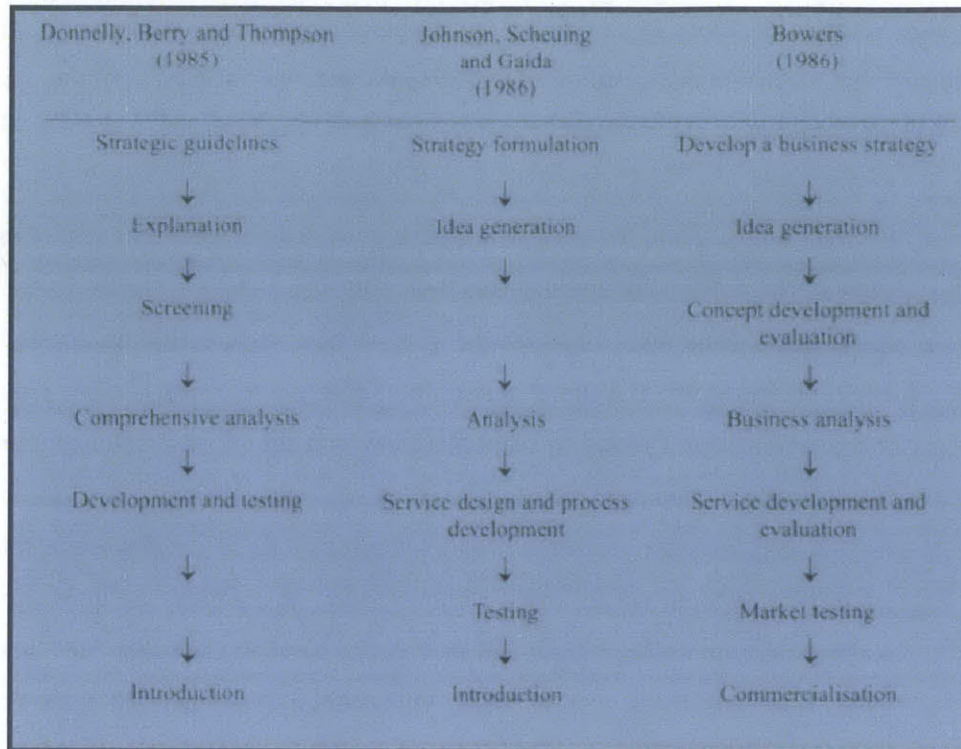


Figure 7: Key Steps in Service Development

Source: Adapted by Raphael Akamavi from Donnelly et al (1985), Johnson et al (1986) and Bowers (1986)

Financial services has been gaining significant interest due to the increased review of its regulation and policies, high costs of new product development and the impact and role of technological innovation in the processes and products offered. While new product development is often the result of rigorous processes and meticulous research, service development appears to have a more informal ad-hoc approach. While attempting to incorporate NPD practices to NSD, special considerations need to be made to distinguish between tangible and intangible products. Other critical aspects to consider are:

- the development time required for services which is shorter as compared to products
- and the simultaneous production and consumption of services; a fundamental difference between physical and intangible products

New product development for financial services has typically resolved around cost savings, error reduction, information security, and customer convenience and minimizing duplication of effort while maximizing overall customer satisfaction. This paper has identified gaps in research areas such as

stakeholder studies in developing products for financial services, empirical studies on customer influence and role in product development in financial services, and most importantly the key of services namely the simultaneous production and consumption.

3.2.14. Quality Segmentation in Spatial Markets: When does cannibalization affect product line design?

Author: Preyas S.Desai

Source: (Desai, 2001)

Multiproduct firms, such as Nestlé's Nespresso products that were studied as part of the present thesis work, should consider product cannibalization in designing their product line. Firms often create products with different price and quality bundles in order to serve the various customer segments. Since customers select the products they want within the product line, value based customers often purchase the cheaper products that are usually also of lower quality. Therefore, lower quality products often cannibalize the higher-end products.

This paper provides interesting perspective on how cannibalization problem impacts quality and price decisions in monopoly and duopoly markets based on models developed by the author. In the case of monopoly, the firm finds it optimal to provide product selection with preferred quality for both the high-end and low-end customers. Here, the impact of cannibalization is not severe. This study also supports the fact that increased competition worsens the cannibalization problem.

In duopoly, the findings take into consideration a key factor called transportation cost which is the taste preference of customers. When the taste preference of the low-end customers becomes weaker, there is more competition in the lower quality product making it attractive for even the high-end customers. This worsens the impact of cannibalization. However, when the taste preference of the high-end customers becomes weaker, the competition for the higher quality market increases and mitigates the cannibalization problem resulting in low-end customers getting their preferred quality in products.

3.2.15. The Profit making allure of Product Reconstruction

Author: John A. Pearce II

Source: (Pearce, 2009)

This article reviews the findings of the quantitative and case based research conducted by the author on product reconstruction. Product reconstruction includes the following:

- Recycling: It involves the break down of the product into parts that can be reused to manufacture same or different new product. Common products that are recycled include aluminum, paper, rubber, glass and plastic.
- Refurbishing: The author defines refurbishing as the process of restoring the product to its original state, without modification so it can be reused for its original purpose. Although these products are sometimes sold for a fraction of the original price, this can be done repeatedly at lower costs when it is profitable.
- Remanufacturing: This is the process of disassembling a product, replacing its worn out parts with newer ones and adding newer components to improve the product where possible.

Companies that recycle must have customers that want to extend that life of the products and care for environmental considerations. However, the article outlines the preconditions to recycle successfully. Firstly, companies need to have a good grasp of the manufacturing process to identify the components that can be converted to scrap that can be reused. Secondly, low barriers to entry increase competition and flood the market with products driving down the profit margin. In such cases, establishing the process to recycle and derive value from that is key to the success of new players. Thirdly, the availability of recycling material might be attractive however the company must be able to collect and process them economically.

3.2.16. Cannibalization and New Product Development

Author: Roger A. Kerin, Michael G Harvey and James T. Rothe
Source: (Kerin, Harvey, & Rothe, 1978)

Although this paper is decades old, the concepts covered are still relevant to establish a basic understanding of the cannibalization effect. A common consequence of extending product line by introducing new products is cannibalization of sales of the existing products. The authors trace the roots of cannibalization to cross elasticity of demand, where the price changes of a product will depend on that of another product but their demands may be independent or substitutable. New product sales can be attributed to three common sources; New customers that just start buying the product, Existing customers of competing firms, Existing customers of the same firm that were buying previous versions of the product line. While the first two types of customers result in incremental revenue, the last category results in the cannibalization of revenue, which is revenue redistributed within the firm from one product to another. The figure below captures the types of revenues for new products.

Components of New Product Sales Volume

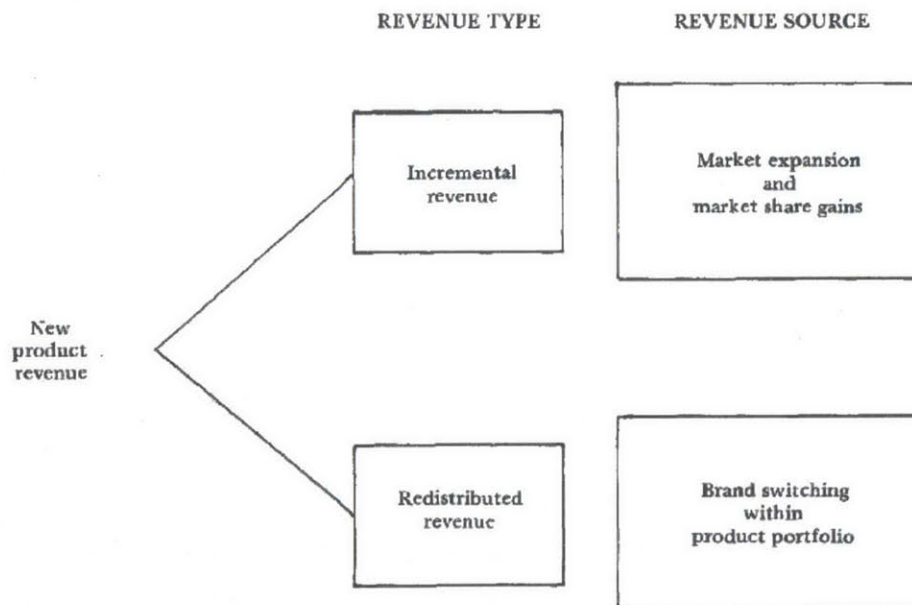


Figure 8: Components of New Product Sales

Cannibalization should be the result of well-thought-of management strategy to fill an existing gap in product portfolio to meet a particular market segment. This might attract new buyers that were previously not interested in the firm's products. Another common reason to cannibalize products is to attract buyers from competing products to maintain market share. In other instances, company might do this as part of their corporate culture to preserve market share.

While introducing new products, a firm should carefully consider the effects of cannibalization in order to report the true benefits of the new product sales and market share as this could distort the performance of new products in terms of profits and volume. Any incremental sales from new customers will truly improve the position of the firm; however any sales from existing customers will have a cannibalization effect on the return on investment of the new product development.

The authors provide the formula below to capture the incremental unit volume necessary to overcome the results of cannibalization.

$$\text{Incremental volume to offset cannibalism effect} = \text{Cannibalized unit volume} \times \text{Ratio of the old and new product margins}$$

3.2.17. Strategic Issues in Product Recovery Management

Authors: Martijn Thierry, Marc Salomon, Jo Van Nunen, Luk Van Wassenhove
 Source: (Thierry, Salomon, Nunen, & Wassenhove, 1995)

The authors define Product Recovery Management (PRM) as "the management of all used and discarded products, components and materials that fall under the responsibility of the manufacturing company". This article states the primary goal of product recovery is to recover the economic value and minimizing waste.

Traditionally the focus for manufacturers has been on keeping costs low for customers. The benefit of making the product more environmentally friendly over the life cycle of the product and providing ability to easily reuse the product were not significant considerations in the past. This has however changed in the present, with customers and Governments demanding these.

The drivers for companies to develop an effective EPM policy include the increase in disposal costs and insurance rates as well as the incentive to retain environmentally conscious customers. Disposed products are sought after as valuable materials and parts can be retrieved and reused by the manufacturers. Companies are beginning to consider these factors and making fundamental changes to their business processes starting from choice of material and sourcing to the distribution to customers, retrieval and disposal of the product at the end of its lifecycle.

Authors assert there are different types of information required to analyze PRM options and make decisions.

1. Product related Information: - Manufacturers require information regarding the material composition of the product, quantities required, design and product recovery. The carbon footprint of the material and product development process should also be known to make effective decisions about the future design and development. Legal and industry standards and requirements are also required to make informed decisions.
2. Magnitude and Uncertainty of Return flows: This article lists several types of return flows as listed below. In each of these cases, the ability to predict the return pattern and number of returns across various geographic locations with different legislative requirements makes it challenge to estimate the returns.
 - a. Legal or Contract based: In some cases there may be legal restrictions requiring the manufacturer to take back the product at the end of its life. There might also be contracts in place to take back entire product or just certain components.
 - b. Rent or Lease based: In the case of lease or rental contracts, manufacturers are required to take the product back at the time of the termination or expiry of the contract.
 - c. Product Failure: If the product does not perform according to specification, manufacturers may be required to take the product back. Manufacturers will need to have good understanding of their product quality and performance and the terms of the contract to estimate these returns.
 - d. Buy-back options: Manufacturers may choose to provide buy-back options on the products they sell. This has several advantages to the customers and manufacturers such as providing low cost components and lowering product disposal cost.

3. Market for reprocessed product and materials: The ease of access and availability of an open market for the reused product, as a whole or its components needs to be determined to access PRM options.
4. Actual Product Recovery and Waste Management Operations: Manufacturers will also need to understand the overall options for product recovery and the various underlying factors. Companies may partner with other organizations for which product recovery and refurbishing or reprocessing as its core competency.

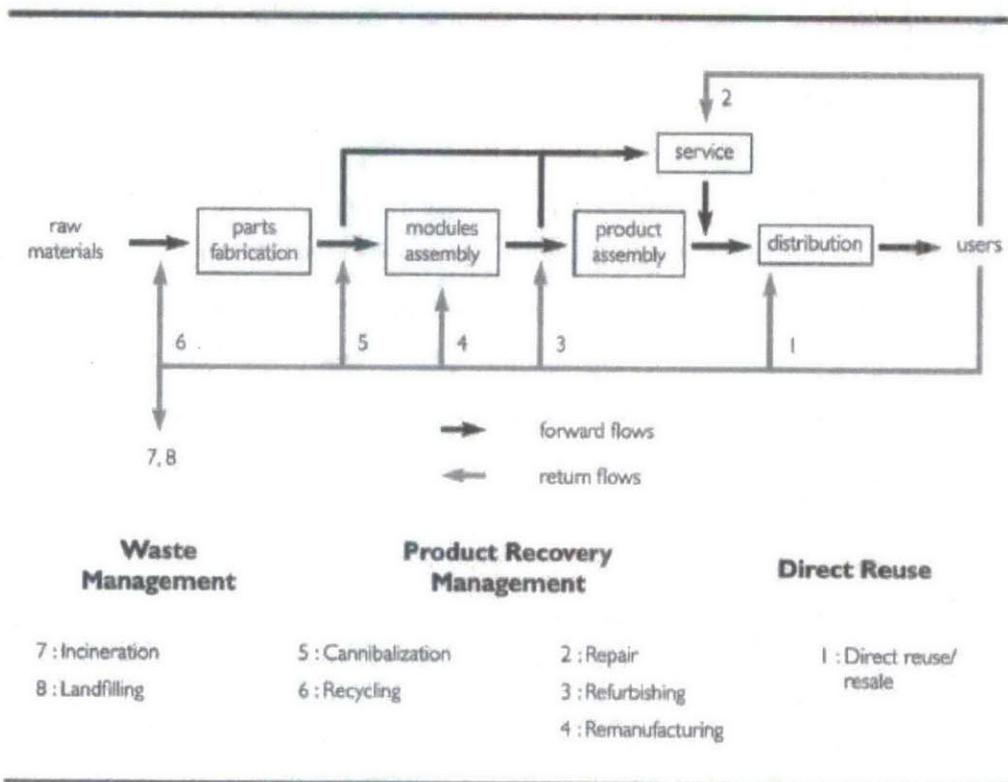


Figure 9: Integrated Supply Chain for Product Recovery

Product Recovery Options

In this article, the authors have identified five product recovery options as listed below. These options vary in the degree of cost and disassembly required to effectively reuse the product or its components.

- a. **Repair:** This is the process of restoring the product back to a working condition. Typically, repairs impact certain parts of the product which are replaced or fixed. Other parts of the product are not impacted; therefore the reassembly of the product is limited.
- b. **Refurbishing:** This is the process of fixing the product and ensuring the overall product meets a predefined quality which is lower than that of new products. All parts of the products may be replaced or inspected to ensure they adhere to the overall product quality. This might also require technology upgrade or replacement of old modules with newer ones.
- c. **Remanufacturing:** This is the process of fixing or replacing the parts of a product to restore the product to its original quality. Products may be disassembled completely and then inspected and tested to ensure the original quality and performance of the product is retained. Similar to refurbishing, this might also be combined with technological upgrades and enhancements that exceed the original product specifications.
- d. **Cannibalization:** In this context, the term cannibalization refers to reusing a few components of the original product in order to repair, refurbish or remanufacture other products. The recovered components from used products are usually in good condition and can be reused in other products to fix them.
- e. **Recycling:** This is the process of reusing as many parts and material of the original product as possible to create or restore a new product. The resulting product may be a new product of the same type or a completely different product. In some cases such as aluminum, the raw material restored from recycle process retains a significant amount of its original property and can be used in the manufacturing of other products.

Here's a summary of the comparison of the various Product Recovery options as presented in the article:

	Level of Disassembly	Quality Requirements	Resulting Product
Repair	To product level	Restore product to working order	Some parts fixed or replaced by spares
Refurbishing	To module level	Inspect all critical modules and upgrade to specified quality level	Some modules repaired/ replaced; potential upgrade
Remanufacturing	To part level	Inspect all modules and parts and upgrade to as new quality	Used and new modules/parts combined into new product; potential upgrade
Cannibalization	Selective retrieval of parts.	Depends on process in which parts are reused	Some parts reused; remaining product recycled/disposed
Recycling	To material level	High for production of original parts; less for other parts	Materials reused to produce new parts

Figure 10: Key Terminology in Product Recovery

4. RESEARCH METHODOLOGY AND FRAMEWORK

In this section, we will look at the framework for the trade-off that was employed during this research and the research approach. We will also review the data gathering methodology.

4.1 Product Development Trade-off Framework

The following framework has been used to create a model that could be used to enable decision making. Managers are forced to make decisions every day about the products they are responsible for delivering, however many a time these decisions are made from gut-feeling and experience. These decisions often resolve around the Cost, Schedule and Product Features, often described as the iron triangle in project management. Some of the key factors that influence these are captured below.

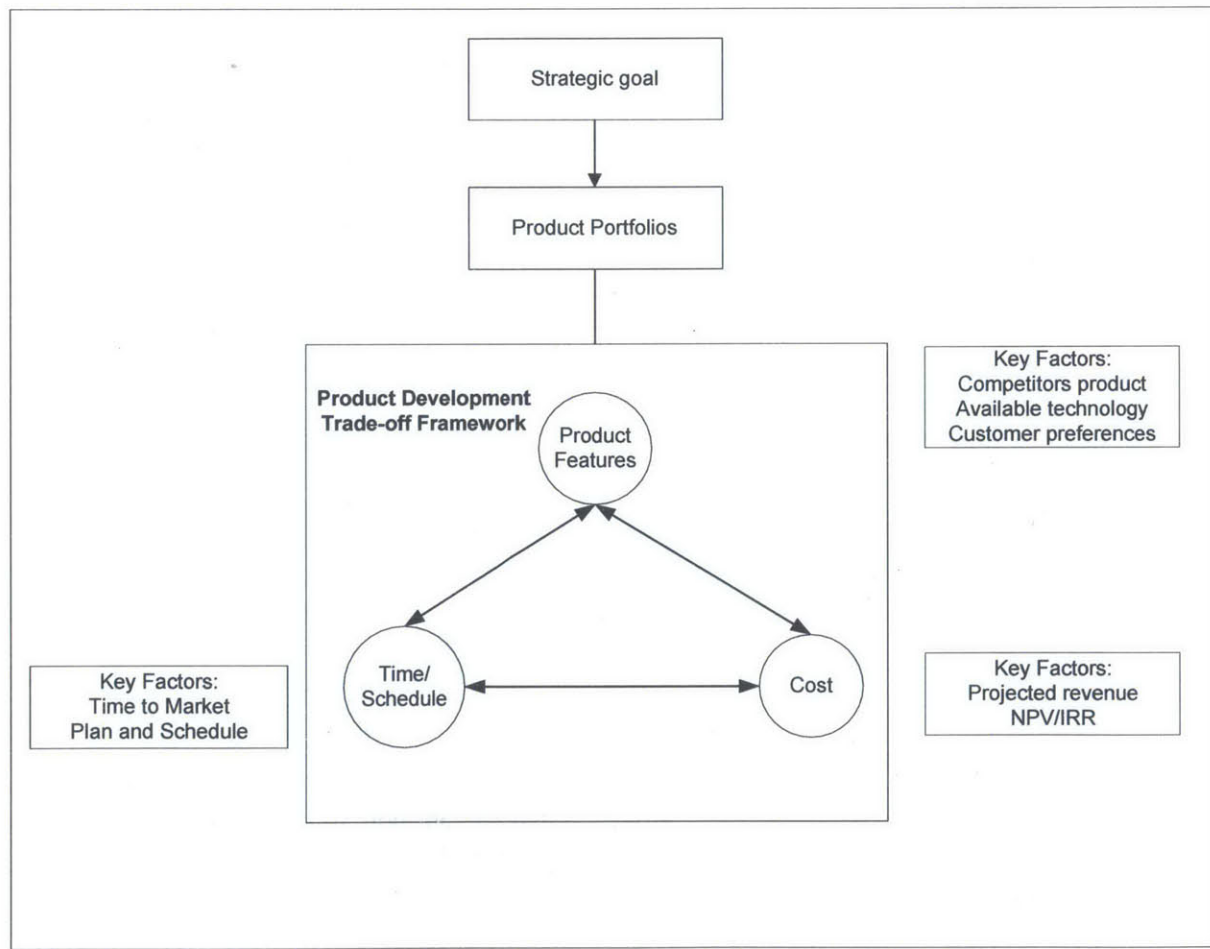


Figure 11: Product Development Framework

4.2 Data Collection Methodology

We employed the following data gathering techniques:

- Company financials
- Industrial surveys and key projections
- Consumer periodicals
- Review of key personnel interviews
- Competitor financials and company research

We used the latest data and research available at the time of this study. Where data was not available, we have made key assumptions based on research that supports the assumptions.

4.3 Research Approach

Based on the analysis, this research focused on building four models relevant to typical product development initiatives. Although these models were built specifically for Nespresso, our case study, the approach is generic and can be adapted to other product development practices. Here are the characteristics of the research approach:

Type	Description
Base Case Model	This base model is built on the product sale in the year the product is introduced and for subsequent years based on the typical lifecycle of the product.
Base Case with recurring revenue Model	In addition to the base model, the recurring sales of coffee capsules associated with each machine sold are captured.
Cannibalization Model	When the next generation of a product is introduced, it often captures part of the sales that would go into a different product of the same manufacturer. In this model we have captured the lost sales of other models.
Recycling Model	With the increase in the number of environmentally conscious consumers, it is critical to have environmentally friendly products and practices in place. In this model, we capture the financial implication of these practices and their impact on the top and bottom line of the product.

4.4 Software Packages

Research data collected from multiple articles and web publications were analyzed and presented using the following:

- Microsoft Excel
- Matlab

4.5 Financial Analysis

The following financial analyses were used in our analysis:

- Revenue analysis
- Cost of Goods sold
- Cash flow projections
- Present Value
- Net Present Value
- Pay back analysis
- Cost Benefit analysis

The analysis was based on the following financial parameters:

- Revenue Projections
- Cost estimates
- Weighted Average Cost of Capital /Opportunity cost
- Research and Development costs
- Marketing costs
- Sales and Distribution costs
- Margin estimates

5. DEFINITION AND FUNDAMENTALS OF PRODUCT DEVELOPMENT ECONOMICS

5.1 Key Definitions of various analysis techniques

5.1.1. Present Value

It is the current value of the future amount of money that has been discounted based on an appropriate interest rate. The objective is to reflect the sum of money from the future in its current value of what it is worth today. Present value of money is typically less than the future value due to a principle called time value of money.

A common quote used to explain time value of money is “a dollar today is worth more than a dollar tomorrow”. This is due to the one day’s worth of interest that can be earned on the dollar. This can be considered in larger denominations to fathom the significance. In his book on Corporate Finance, Aswath Damodaran identifies three critical reasons for this phenomenon:

- Compensation for trading current consumption for future consumption.
- When there is monetary inflation, the value of money decreases in the future.
- Presence of uncertainty risk in future cash flows.

Present value can be computed as below:

$$\text{Present Value} = \frac{CF_t}{(1+r)^t}$$

Where:

CF = Cash flow at time T

t = Future time

r = discount rate

Fundamental Principles:

- Cash flow value will decrease as the discount rate increases.
- As t gets longer, the present value will decrease for a given discount rate.

5.1.2 Net Present Value

Net Present Value is the sum of the present value of individual cash flows. It takes the sum of the present value of the time series or a sequence of cash inflows less cash outflows.

NPV can be computed as below:

$$NPV = \sum_{t=0}^N \frac{C_t}{(1+r)^t} = 0$$

Where:

C = Cash flows

t = Future time

r = discount rate

Application of NPV:

NPV is often used to assess potential external investments such as stock purchases or corporate acquisitions. In corporate environments, companies often use NPV to analyze and evaluate potential investment opportunities in internal projects such as adding a new plant, replacing old machinery, building new software systems.

NPV is most applicable in areas where investment opportunity is immediate. NPV applies in areas where the investment opportunity immediately disappears (Ross 1995). Ross also mentions that in case of investment options that have significant time period, there exists an optionality that should be valued. In evaluating product development scenarios where if a product is not introduced by a company its competitors will capture that share, NPV can be a useful tool in identifying the benefits of investing in product development initiatives.

5.1.3 Payback Analysis

This is a common technique used by firms to make investment decisions. The payback period can be calculated by counting the number of years it takes before the cumulative forecasted cash flow equals the initial investment (Brealey, Myers, & Allen, 2006)

$$\text{Payback Period} = \frac{\text{Amount of Cash Outflow or Cost of Investment}}{\text{Estimated Annual Net Inflow from Investment}}$$

Pay back rule:

The payback method works in many cases, however the following conditions need to be taken into account:

- Payback rule does not consider cash flows after the cut off period: This rule does not consider cash inflows after the cut-off period. Additionally if any expenses or cash outlay for maintenance or upgrade is required, it does not take that into account. This method is useful for identified short term investments with an initial cash outflow and predictable cash inflows.
- All cash flows are considered equal. As the present value of cash flows is not taken into consideration, all cash flows have equal impact on the decision.

Some firms consider discounted pay back period to address some of the issues outlined above.

5.1.4. Profitability Index

During times of heightened capital rationing, another technique used for determining the capital expenditure is called the profitability index. This not only takes into account the net present value of the investment, but also the size of the initial investment required. The higher the profitability index, the better the investment. Theory recommends we take the projects with the highest profitability index based on the available capital.

$$\text{Profitability Index} = \frac{\text{Net Present Value}}{\text{Investment}}$$

5.2 Fundamentals of Product Development Economics

In a typical product development process, there are several key phases as described earlier. Often, these phases have “gates” or milestones that include a checkpoint of the project continuation decision. The go/no go decisions regarding whether to progress with the project is often at these points. Often, these metrics are also used to make design and development decisions. In this chapter, we develop a comprehensive approach for making product development and continuation decisions based on holistic systems thinking. In this section, we will review the key financial terminology in the context of product development.

Product development cash flows

There following is a brief description of key cash flows in the product lifecycle.

5.2.1 Cash Inflows/Revenue

Cash inflows consist of cash coming into the firm through sales of the product. Often, for new products this number is not available at the time of the analysis. Based on competitive market analysis, the revenues are estimated.

Radically innovative products: For products that are the first generation, the first of their kind, revenue forecasts are often little more than educated guesses. Firms employ market researchers to understand consumer needs, develop products based on customer preferences and price the product based on what they think customers will be willing to pay for it. The revenue estimates can often go wrong due to incorrect understanding of market size or incorrect pricing, among other factors.

Incrementally improved products: Estimating the revenue of future generations of a product since its original introduction to the product can be based on the revenue stream of the current product. Even if the product is a new product for the firm, if a competitor has already introduced the first version of it then revenue can be estimated based on market analysis.

5.2.2 Cash Outflows/Operating Costs

This is the cash that a firm spends during a given period of time in various activities associated with product development. Cash outflows typically include operating costs of a firm such as research and development expenses, marketing costs, manufacturing costs, cost of goods sold, administrative costs etc. This often includes costs associated with machinery, depreciation, capital expenditures, coffee, retail outlets, shelf space and advertising costs for a typical coffee maker.

5.2.3 Investments

This is also called as initial cash outlay. It includes capital expenditure and funds used by a company to acquire tangible or intangible assets such as property, machinery, building, equipment, patents, trademarks and facilities required to extend its operations. These investments typically are considered cash outflows at the start of the product development process. Some industries such as telecom or oil tend to be highly capital intensive, while software companies may not require extensive capital at the very beginning. Sometimes, these investments may just be improvements to existing assets to extend their life or provide additional functionality required for the new product.

5.2.4 Operating Profit

This is the profit, revenue less operating costs, earned from a firm's core business activities. It does not include one-time profits from sale of assets or investments. This is the profit a firm can expect to continue to earn in the future based on its current operations.

$$\text{Operating Profit} = \text{Operating Revenue} - \text{Cost of goods sold} - \text{Depreciation and Amortization}$$

The following picture presented in Product Design and Development summarizes the typical product development cash flow for a successful product. As shown below, investments are made during the product development time to create the product. The time to market is shown as the development time. Once the product is available in the market, revenue can be generated from its sales. As ongoing manufacturing of the product is required, there are operating costs associated with it. The difference between sales and this is shown as the operating profit.

The break even time includes the initial development time and the pay back time required to recoup the initial investment. This can extend from a few months to several years depending on the product. It is typical for larger investments to take longer to break even.

Product Development Cash Flow

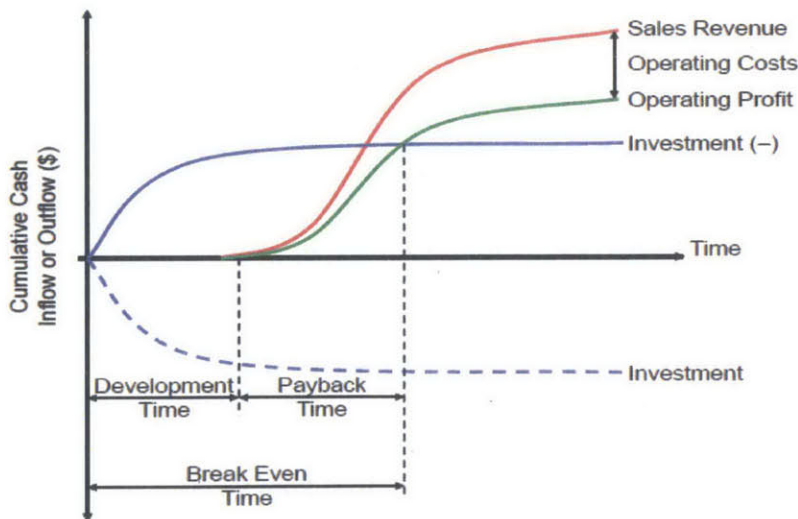


Figure 12: Product Development Cash Flow

Source: (Eppinger & Ulrich, May 2011)

6 NESPRESSO CASE

In this chapter, we will explore the Nespresso case in detail. In the scenario we have studied, Nespresso product development is faced with challenges relating to the product, its cost and delivery time. Although several quantitative and qualitative tools are available for decision making, our analysis will focus on the techniques reviewed in the previous chapter.

The product development team at Nespresso needs a comprehensive quantitative technique to evaluate decisions and weigh them based on their financial merit. While most firms perform quantitative analysis at the start of the product development effort, few revisit it with updated information subsequent to the original analysis. Used properly, this can be a powerful tool in guiding product managers in making design and delivery schedule decisions throughout the product development process.

In this research, the focus will be on the holistic product development practices at a coffee maker called Nespresso. In developing the next generation of coffee makers, the firm must prioritize the changes based on the critical ones that would help it maintain its market share versus the leading cutting edge improvements that would help the firm increase its market presence.

6.1 Background

Nespresso, a luxury brand of Nestle, was created in 1986. It is a leading manufacturer of coffee machines. These machines brew coffee from coffee capsules. Capsules are single serve pre-measured coffee powder mixed with flavors. Nespresso offers different types of coffee machines and unique flavors of coffee that can be brewed in these machines. Capsule pods are hermetically sealed and are made of one gram of aluminum per pod. According to Wikipedia, the retail price of each capsule is approximately sixty to seventy cents. Nespresso has reported annual sales of CHF 3 billion in 2011⁽¹⁾. Its sales have been growing double digits in the last few years⁽²⁾. The profit margins are estimated to be around 30%⁽³⁾ for Nespresso, with capsule profit margin as high as 50%⁽⁴⁾.

Nespresso has several models of machines, for commercial use in office or restaurant settings as well for personal use in home kitchen. The price on these machines can range from \$ 200- \$700⁽⁵⁾. Nespresso recommends the use of its own coffee pods with its machines.

In order to address the growing concerns of the ecological impact, Nespresso set up recycling facilities to increase its green image. The used capsules are collected at select Nespresso centers for recycling.

According to industry reports, Nespresso is building the infrastructure to collect 75%⁽⁶⁾ of its capsules, although the actual collection rate estimate is approximately 25%⁽⁷⁾. The proportion of recycled aluminum in capsules is estimated to be about 30%⁽⁸⁾, although exact amount is not officially published.

A product management team at Nespresso is looking to introduce a newer and better model of a coffee maker. The product team is required to perform economic analysis to understand the financial implications of the product development process.

Foot Notes

⁽¹⁾: Revenue figure is quoted here: <http://www.nestle.com/Media/NewsAndFeatures/Pages/Nespresso-factory-Romont.aspx>

⁽²⁾: Richard Girardot, chief executive of Nespresso commented to Financial Times. <http://www.ft.com/cms/s/0/90d88108-518e-11e0-888e-00144feab49a.html#axzz2DhdaGilR>

⁽³⁾: Profit Margin estimate is mentioned here: <http://www.marketwatch.com/story/nestles-nespresso-reports-11-sales-up-20-2012-03-05>

⁽⁴⁾: Innovation and Renovation: The Nespresso Story by The International Institute for Management Development (IMD), Lausanne, Switzerland. This has been prepared by Research Associate Joyce Miller under the supervision of Professor Kamran Kashani.

⁽⁵⁾: Prices of machines as published in Nespresso's official website: http://www.nespresso-us.com/machines/?utm_source=google&utm_medium=cpc&utm_campaign=NB%20-%20DC%20-%20Exact&utm_term=60914147-VQ6-30441230934-VQ15-1t1-VQ16-c

⁽⁶⁾: Perfecting our Packing Solution: Ecolaboration at Nespresso; Nestle Nespresso S.A., Corporate Communications March 2011

⁽⁷⁾: Under the current system, with minimum incentive the recycling estimate is quoted to be 25 % here: <http://www.zerowasteeurope.eu/2011/05/coffee-capsules-and-zero-waste/>

⁽⁸⁾: The section on Ecological Impact of Nespresso capsule here: <http://en.wikipedia.org/wiki/Nespresso>

6.2 Revenue Estimation

Revenue for new products can be forecasted in several ways, from advanced techniques such as discrete choice models or multivariate customer demand modeling using statistical packages to simple back of the envelope calculations. Depending on the amount of capital required and the risks associated with it, the practices get more sophisticated when the stakes are higher. Other factors that influence the revenue forecasting techniques are industry, product type such as new versus existing and corporate culture.

Growth of sales for consumer goods follow an exponential model initial, where they reach a peak and then stabilize at a point below the peak (Bass, 1969). This stabilization of sales is based on the redirection of sales to other substitute products. This is represented in the figure below (Bass, 1969) The growth model typical of a consumer good such as a coffee maker is expected to follow a similar growth pattern until it is replaced by a newer model or a substitute product that would serve the same need. As Bass describes, long range forecasting is a guessing game, however for a coffee maker, the typical lifecycle is much shorter than products such as cars or refrigerators.

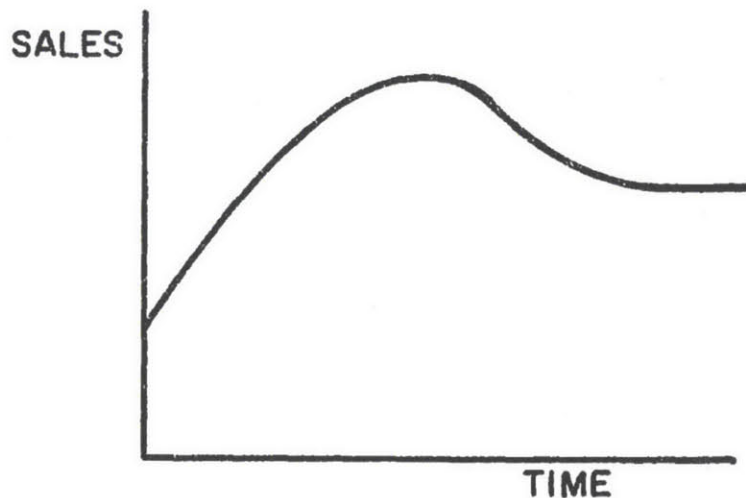


Figure 13: Typical sales of a product over its lifecycle

Source: (Bass, 1969)

Common revenue forecasting techniques for new products include:

- Qualitative techniques: Qualitative approaches are based on observations, interviews, and panel discussions etc. that are subjective and high degree of human judgment. Although this type of forecasting can sometimes be biased, it can absorb relevant information quickly.
 - Delphi Method: Individuals are asked for their opinions which are then compiled and redistributed until a consensus is reached.
 - Consensus Forecasting: Experts gather to discuss their opinion of the future outcome and is usually performed when there is little historical data on a new product.
- Quantitative techniques: These are based on objective historical numerical data that are relevant to the revenue source; however they are often not available for new products.
 - Time Series Method: It is the set of observations taken repeatedly over time in order to identify a pattern in the data that can be used to predict future revenues.
 - Causal Method: These are more sophisticated methods that establish a causal relationship where revenue can be attributed and represented as a function of other factors. They use leading indicators that can predict revenues based on the independent variables that determine the output of the dependent variable such as product revenues.

In forecasting revenue for Nespresso we have used a simple time series approach that includes a growth factor based on qualitative estimates provided by leading industry experts. The revenue component for Nespresso includes cash generated from capsule and machine sales.

6.2.1 Assumptions for Nespresso revenue estimation

1. Revenue is only made up of capsule and machine sales. If further information is available, it can be incorporated here to have a more accurate representation of the revenue breakdown.
2. Revenue grew 30% from 2000-2010 and 20% since (based on data from <http://www.nacsonline.com/NACS/News/Daily/Pages/ND0313123.aspx>).
3. Average sale price per capsule was 0.43 until 2008 and then increased to 0.64
4. Each type of machine contributes equally to total Nespresso revenue. Based on company website, at the time of this analysis, 28 models of machines. Subsequently, Nespresso introduced two additional models that have not been incorporated into this analysis.

6.2.2 Nespresso revenue forecasting

Price per capsule can be calculated as below based on publicly available information.

Description	Amount	Source
Average price per sleeve	\$6.43	Company website
Number of capsules per sleeve	10.00	Company website
Average price of one capsule (2012)	\$0.64	Calculated
Average price of one capsule (2000)	\$0.43	http://en.wikipedia.org/wiki/Nespresso

Table 1: Price Per Capsule Computation

Based on the assumption on the growth rate, the growth factor for sales has been computed. This has been used to determine the estimated sale of capsules in such a way that the total number of capsules sold since the year 2000 sum up to 20 billion capsules.

Revenue from machine sales = Total sales – Revenue from capsule sales

Revenue from each model of machine = Total machine sales/ No. of models

Year	Growth Factor	Estimated number of capsules sold	Revenue from capsule sales	Revenue from machine sales	Total Revenue
2000	1	215,517,269	92,672,425		
2001	1.3	280,172,449	120,474,153		
2002	1.69	364,224,184	156,616,399		
2003	2.197	473,491,439	203,601,319		
2004	2.8561	615,538,871	264,681,714		
2005	3.71293	800,200,532	344,086,229		
2006	4.826809	1,040,260,691	447,312,097		
2007	6.2748517	1,352,338,899	581,505,726		
2008	8.15730721	1,758,040,568	755,957,444		
2009	10.60449937	2,285,452,739	1,470,307,929		
2010	13.78584918	2,971,088,560	1,911,400,307		
2011	16.54301902	3,565,306,273	2,293,680,369	1,526,319,631.3	3,820,000,000.0
2012	19.85162283	4,278,367,527	2,752,416,442	1,831,583,557.6	4,584,000,000.0
Total No. of Capsules sold since the year 2000	20,000,000,000	20,000,000,000			
Capsules Per Machine sales (in 2012)			98,300,587.23		
Per Quarter Total Capsule sales (in 2012)			688,104,110.6	457,895,889.4	1,146,000,000.0
Per Machine Per Quarter sales (in 2012)			24,575,146.8	16,353,424.6	40,928,571.4

Table 2: Revenue Estimation for Machines and Capsules

7 PRODUCT DEVELOPMENT MODELS

In this section, we will delve deeper into the Nespresso case and build models based on the data available. We will start with the basic assumptions that are common to all the models and then build the base case. Once the base case is established, we will build the other models in a step by step fashion by calling out any model specific assumption.

7.1 Data Assumptions for the models:

The following assumptions are based on general Nespresso information available publicly through Nestlé's annual reports, company executive interviews and industry expert opinions.

1. Quarterly sales assumed to be cyclical, Q1= 20%, Q2 = 25%, Q3= 35% or Q4=30% of the total 15% expected overall sales growth. Last year's sale is assumed to be 5% only.
2. Current revenue is only from coffee machine sales; it does not include service contracts or any other Nespresso products.
3. Sale of coffee machines and capsules continue to grow at 15% annually. However, a growth of 5% in the last year of the product's life consistent with market research of lower sales towards the end of the product lifecycle.
4. Based on industry estimates for similar products, development cost assumed to be \$ 3 M, spread equally over 4 quarters and equipment and tooling Costs are \$ 2 million upfront, then half a million a year and scale up with volume of machines sold.
5. Similarly, ramp-up cost assumed at \$ 1 M in quarters prior to and immediately after the product launch.
6. Marketing expense calculation: Nestlé's expense is \$17,395 M CHF. Nespresso contributes 4% to Nestlé's sales. Assuming the same 4% for marketing cost, Nespresso's marketing cost will be $(17,395 \cdot .04) = \$ 695.8$. Per quarter cost is 173.9. Assuming 50% of this is for machines and 50% for capsules, it is 86.9 for each. There are 28 models of machines. Assuming this is equally divided for the 28 models, per model per quarter cost is 3.10 M CHF (~ 2.58 M USD). This has been adjusted by additional 50% based on the industry experience. The rates are assumed to be constant. Nespresso sales are computed as % of Nestle sales (\$3.2 B/\$ 8.63 B).
7. Cost of Goods Sold: Based on the ratio of cost of goods sold to sales ratio of Nestle for Nespresso as well. Nestle has sales of \$ 83.6 B and COGS of \$ 44.1 B. This ratio is 52.7 ~ 53%. Assuming Nespresso has similar COGS to sales ratio, this has been computed based on sales.

8. The units produced are equal to the units sold.
9. Distribution expense calculation: Nestlé's expense is \$7,602 M CHF. Nespresso contributes 4% to Nestlé's sales. Assuming the same 4% for distribution cost, Nespresso's distribution cost will be $(7,609 \cdot .04) = \$ 304.3$ M CHF. Per quarter cost is 76.09. Assuming 50% of this is for machines and 50% for capsules, it is 38.04 for each. There are 28 models of machines. Assuming this is equally divided for the 28 models, per model per quarter cost is 1.35 M CHF (~ 1.13 M USD).
10. Starting in Q2 of Year2, the rates are based on the Distribution cost to sales ratio of Q1, year 2. Nespresso sales are computed as % of Nestle sales (\$3.2 B/\$ 8.63 B).
11. Total product life is expected to be four years with one year of additional development and production ramp-up time.
12. Risk adjusted cost of capital is set at 7%.

7.2 Base Case Model

In the base case, we will analyze the product development cost of a new coffee maker and the revenue generated by its sales. The lifecycle of the product includes the initial product development time as well as the revenue generation time before it can be replaced by newer models.

Coffee machines: Total cash flows, present values, and net present value

	Year 1				Year 2				Year 3				Year 4				Year 5			
(\$ values in millions, except unit price)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sales revenue (coffee machines)					13.0	16.3	16.3	19.6	15.0	18.7	18.7	22.5	17.2	21.6	21.6	25.9	18.1	22.6	22.6	27.2
Sales volume (coffee machines)					52160	65200	65200	78240	59984	74980	74980	89976	86227	107784	107784	129341	90538	113173	113173	135808
Unit price (coffee machines)					250	250	250	250	250	250	250	250	200	200	200	200	200	200	200	200
Total sales revenue					13.0	16.3	16.3	19.6	15.0	18.7	18.7	22.5	17.2	21.6	21.6	25.9	18.1	22.6	22.6	27.2
Development Cost ⁽⁴⁾	-0.75	-0.75	-0.75	-0.75																
Ramp-up Cost ^(5a)				-1.00	-1.00															
Equipment and Tooling Cost ^(5b)			-1.00	-1.00	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.14	-0.14	-0.14	-0.14	-0.14
Marketing and Support Cost ⁽⁶⁾				-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
Production Cost ⁽⁷⁾					-6.91	-8.64	-8.64	-10.37	-7.95	-9.93	-9.93	-11.92	-9.14	-11.43	-11.43	-13.71	-9.60	-12.00	-12.00	-14.40
Production Volume ⁽⁸⁾					52160.00	65200.00	65200.00	78240.00	59984.00	74980.00	74980.00	89976.00	86227.00	107783.75	107783.75	129340.50	90538.35	113172.94	113172.94	135807.53
Unit Production Cost					132.50	132.50	132.50	132.50	132.50	132.50	132.50	132.50	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00
Distribution Cost ⁽⁹⁾					-1.13	-1.41	-1.41	-1.70	-1.30	-1.62	-1.62	-1.95	-1.49	-1.87	-1.87	-2.24	-1.57	-1.96	-1.96	-2.35
Total Costs	-0.8	-0.8	-1.8	-4.0	-10.4	-11.4	-11.4	-13.4	-10.6	-12.9	-12.9	-15.3	-12.0	-14.7	-14.7	-17.3	-12.6	-15.3	-15.3	-18.1
Period Cash Flow	-0.8	-0.8	-1.8	-4.0	2.6	4.9	4.9	6.1	4.4	5.8	5.8	7.2	5.2	6.9	6.9	8.5	5.6	7.3	7.3	9.0
Discounting Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PV Year 1, r = 7%	-0.74	-0.72	-1.66	-3.73	2.41	4.39	4.32	5.33	3.74	4.89	4.80	5.88	4.17	5.40	5.31	6.46	4.14	5.33	5.24	6.37
Net Present Value	71.32																			

Table 3: Net Present Value computation for Base Model

Assumptions

1. Quarterly sales assumed to be cyclical, Q1= 20%, Q2 = 25%, Q3= 35% or Q4=30% of the total 15% expected overall sales growth (Source: <http://www.arabianbusiness.com/richard-girardot-interview-nespresso-coffee-453163.html>). Last year's sale is assumed to be 5% only.

2. Current revenue is only from coffee machine sales; it does not include service contracts or any other Nespresso products.

3. Sale of coffee machines and capsules continue to grow at 15% annually (assuming a growth of 5% in the last year) (Source for overall Nespresso: <http://www.arabianbusiness.com/richard-girardot-interview-nespresso-coffee-453163.html>--This growth is assumed to be for both machine sales and capsule sales associated with the model of machine. Last year's sale is assumed to be 5% only.

4. Development cost assumed to be \$ 3 M spread equally over 4 quarters (based on PDD Chapter 1).

5a. Ramp-up cost assumed at \$ 1 M in quarters prior to and immediately after the product launch (based on PDD Product Economics chapter assumption for the printer).

5b. Equipment and Tooling Costs: 2 million upfront, then 1/2 million a year and scale up with volume of machines sold.

6. Marketing expense calculation: Nestlé's expense is \$17,395 M CHF. Nespresso contributes 4% to Nestlé's sales. Assuming the same 4% for marketing cost, Nespresso's marketing cost will be $(17,395 \cdot 0.04) = \$ 695.8$. Per quarter cost is 173.9. Assuming 50% of this is for machines and 50% for capsules, it is 86.9 for each. There are 28 models of machines. Assuming this is equally divided for the 28 models, per model per quarter cost is 3.10 M CHF (~ 2.58 M USD). This has been adjusted by additional 50% based on the industry experience.

The rates are assumed to be constant (Source: Nestle numbers are from here <http://www.nestle.com/media/newsandfeatures/annual-report-2011>. Nespresso sales are computed as % of Nestle sales (\$3.2 B/\$ 8.63 B).

7. Cost of Goods Sold: Based on the ratio of cost of goods sold to sales ratio of Nestle for Nespresso as well. Nestle has sales of \$ 83.6 B and COGS of \$ 44.1 B. This ratio is 52.7 ~ 53%. Assuming Nespresso has similar COGS to sales ratio, this has been computed based on sales.

8. Assuming the units produced is equal to the units sold.

9. Distribution expense calculation: Nestlé's expense is \$7,602 M CHF. Nespresso contributes 4% to Nestlé's sales. Assuming the same 4% for distribution cost, Nespresso's distribution cost will be $(7,609 \cdot 0.04) = \$ 304.3$ M CHF. Per quarter cost is 76.09. Assuming 50% of this is for machines and 50% for capsules, it is 38.04 for each. There are 28 models of machines. Assuming this is equally divided for

the 28 models, per model per quarter cost is 1.35 M CHF (~ 1.13 M USD).
 Starting in Q2 of Year2, the rates are based on the Distribution cost to sales ratio of Q1, year 2. (Source: Nestle numbers are from here <http://www.nestle.com/media/newsandfeatures/annual-report-2011>. Nespresso sales are computed as % of Nestle sales (\$3.2 B/\$ 8.63 B).

The following is the graphical representation of the major revenue and cost items of the base model.

Key:

X axis: In quarters

Y axis: In Millions (USD)

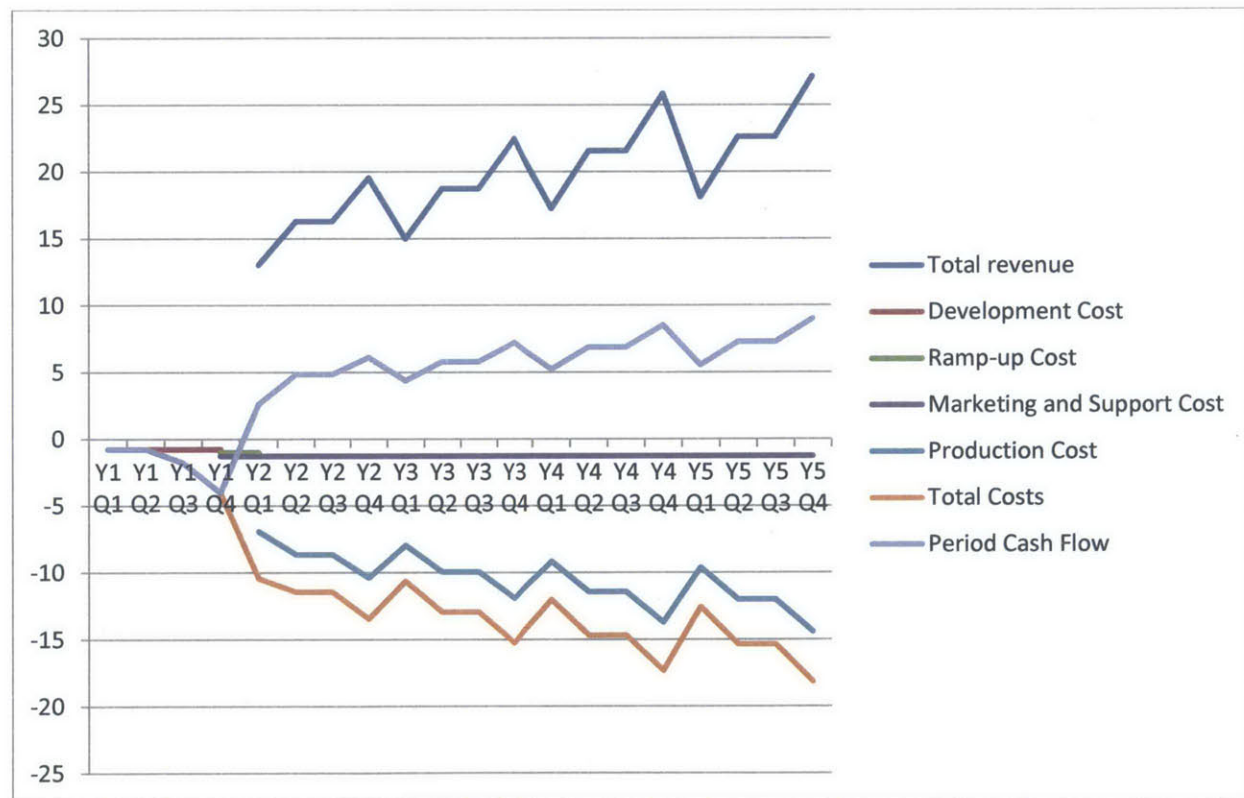


Figure 14: Cost and Revenue of Base Model

7.3 Base model with Capsule Sales

Certain other products are sold as complementary goods where revenue is not only generated from the sales of the product itself but also the sales of the complementary product that is required. A textbook example is the razor and blades model. Each razor generates multiple sales of the blades. Razors are often given away for free, since the manufacturer makes more profit from the sale of the blades. Nespresso has a razor-blade type of bait and hook business model where consumers buy the machine but keep coming back for the coffee.

The recurring revenue portion is the stable portion of the sale that has a high probability of occurrence. In this model, the revenue stream should include the product sale as well as the recurring sales associated with it. In the Nespresso case, the machines generate the base sale. However, the sale of the machine also generates capsule sale. As part of using the machine and actually brewing the coffee, consumers need to buy capsules. Each use of the machine results in capsule sales. Although there are certain other machines that can use Nespresso capsules, the company strongly recommends using the capsules only on Nespresso machines for best results.

Coffee machines and capsules: Total cash flows, present values, and net present value

	Year 1				Year 2				Year 3				Year 4				Year 5			
(\$ values in millions, except unit price)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sales revenue (coffee machines) ^(1a)					13.0	16.3	16.3	19.6	15.0	18.7	18.7	22.5	17.2	21.6	21.6	25.9	18.1	22.6	22.6	27.2
Sales volume (coffee machines)					52160	65200	65200	78240	59984	74980	74980	89976	86227	107784	107784	129341	90538	113173	113173	135808
Unit price (coffee machines)					250	250	250	250	250	250	250	250	200	200	200	200	200	200	200	200
Sales revenue (capsules) ^(1b)					3.3	7.4	11.5	16.4	20.2	24.9	29.7	35.3	37.5	40.2	42.8	46.1	48.0	50.4	52.8	55.7
Sales volume (capsules)					5,216,000	11,736,000	18,256,000	26,080,000	32,078,400	39,576,400	47,074,400	56,072,000	59,478,700	63,737,075	67,995,450	73,105,500	76,160,935	79,980,229	83,799,523	88,382,675
Unit price (capsules)					0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Total sales revenue					16.33	23.69	27.80	35.99	35.21	43.68	48.40	57.82	54.72	61.71	64.39	71.92	66.09	73.02	75.43	82.84
Development Cost ⁽⁴⁾	-0.75	-0.75	-0.75	-0.75																
Ramp-up Cost ^(5a)				-1.00	-1.00															
Equipment and Tooling Cost ^(5b)			-1.00	-1.00	-0.25	-0.25	-0.25	-0.25	-0.26	-0.26	-0.26	-0.26	-0.28	-0.28	-0.28	-0.28	-0.29	-0.29	-0.29	-0.29
Marketing and Support Cost ⁽⁶⁾				-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
Production Cost ⁽⁷⁾					-8.65	-12.56	-14.73	-19.07	-18.66	-23.15	-25.65	-30.64	-29.00	-32.71	-34.13	-38.12	-35.03	-38.70	-39.98	-43.91
Distribution Cost ⁽⁸⁾					-2.26	-3.28	-3.85	-4.98	-4.87	-6.05	-6.70	-8.00	-7.57	-8.54	-8.91	-9.96	-9.15	-10.11	-10.44	-11.47
Total Costs	-0.75	-0.75	-1.75	-5.25	-14.66	-18.59	-21.33	-26.81	-26.29	-31.96	-35.12	-41.41	-39.35	-44.03	-45.82	-50.85	-46.97	-51.60	-53.21	-58.16
Period Cash Flow	-0.75	-0.75	-1.75	-5.25	1.66	5.11	6.47	9.18	8.91	11.72	13.29	16.41	15.37	17.69	18.58	21.07	19.12	21.42	22.22	24.68
Discounting Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PV Year 1, r = 7%	-0.74	-0.72	-1.66	-4.90	1.53	4.60	5.73	7.99	7.62	9.85	10.98	13.32	12.26	13.87	14.32	15.96	14.24	15.68	15.98	17.44
Sum of Present Value	173.37																			

Table 4: Net Present Value computation for Base Model with Capsules

Assumptions

1b. Each coffee machine is assumed to result in a sale of 100 capsules per quarter. This is cumulative as the number of machines in the market increases, the sale of capsules will also increase.

2. Current revenue is only from machine and capsule sales; it does not include service contracts or any other Nespresso products.

4. Development cost assumed to be \$ 3 M, spread equally over 4 quarters (based on PDD Chapter 1). Capsules are already developed.

5a. Ramp-up cost assumed at \$ 1 M in quarters prior to and immediately after the product launch. This does not include ramp-up cost for capsule development.

5b. Equipment and Tooling Costs: 2 million upfront, then 1 million a year and scale up with volume of machines sold.

6. Marketing expense: Nestlé's expense is \$17,395 M CHF. Nespresso contributes 4% to Nestlé's sales. Assuming the same 4% for marketing cost, Nespresso's marketing cost will be $(17,395 * .04) = \$ 695.8$. Per quarter cost is 173.9. Assuming 50% of this is for machines and 50% for capsules, it is 86.9 for each. There are 28 models of machines. Assuming this is equally divided for the 28 models, per model per quarter cost is 3.10 M CHF (~ 2.58 M USD). This has been adjusted by additional 50% based on the industry experience

7. Cost of Goods Sold: Based on the ratio of cost of goods sold to sales ratio of Nestle for Nespresso as well. Nestle has sales of \$ 83.6 B and COGS of \$ 44.1 B. This ratio is 52.7 ~ 53%. Assuming Nespresso has similar COGS to sales ratio, the COGS has been computed based on the sales.

The following is the graphical representation of the major revenue and cost items of the base model with capsules.

Key:

X axis: In quarters

Y axis: In Millions (USD)

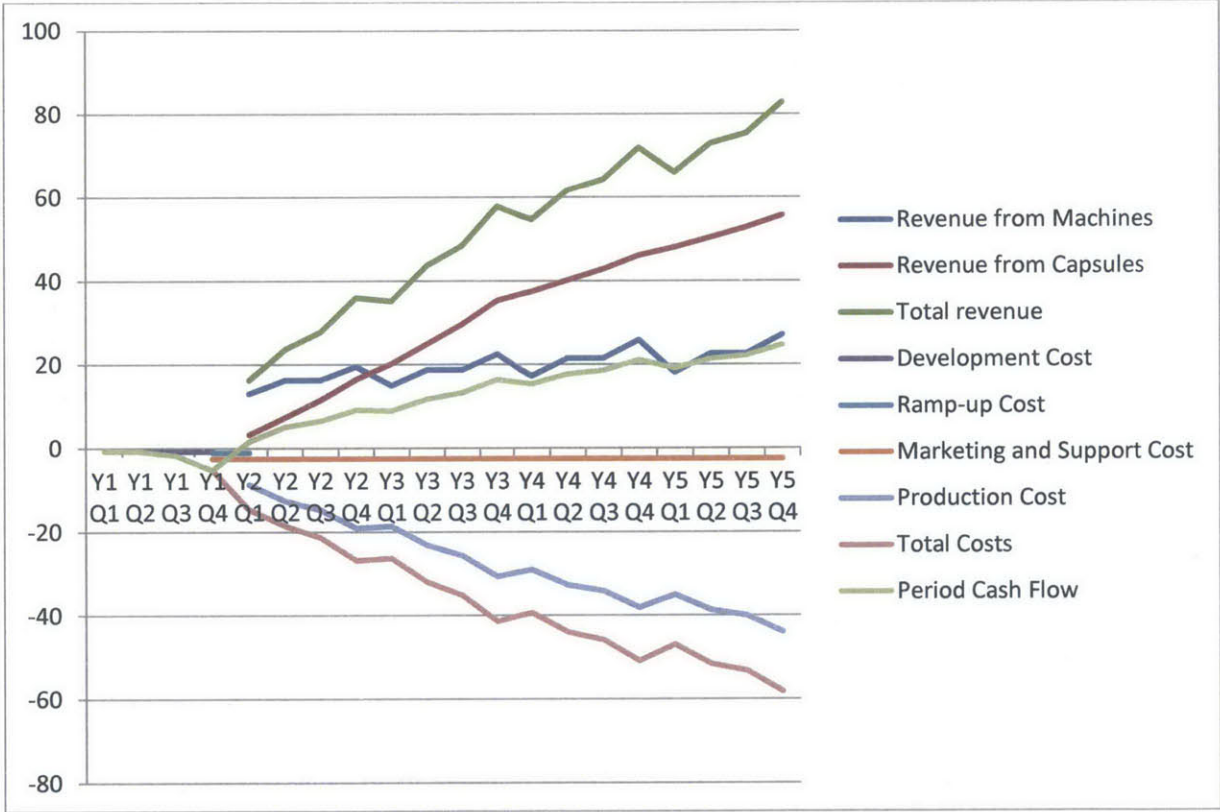


Figure 15: Cost and Revenue of Base Model with Capsules

7.4 Cannibalization Models

These are sales generated by one product, which come at the expense of other products manufactured by the same firm (Damodaran, 2001). Cannibalization impacts the sales and demand of an existing product. The overall impact of cannibalization may be positive or negative. While the product level financial impact may be negative, the new product may bring new sales that might make up for the lost sales. This would result in overall increased sale to the firm, as the market for the existing product shrinks. Certain factors such as price, features and channels attenuate the effects of cannibalization. Typically, there is a distortion in the sales of high priced goods, when a low priced good with lower quality or features is made available in the market place.

The effect of cannibalization is most often seen on the following:-

1. Sales revenue: Overall revenue or market share
2. Sales Volume: Number of units sold of the existing product
3. Sale Price: Sale price of the existing product

University of Pennsylvania Wharton school website provides the following definition: Cannibalization rate: The percentage of New Product Unit Volume that is sales that would have gone to the Old Product had the New Product not been introduced. The cannibalization rate must be less than the contribution or per unit profit margin of the new product sales. However, this approach does not consider the market share that could be lost to competitors if the product is not introduced.

Damodaran asserts lost sales due to product cannibalization can be treated as an expense or cost. However this approach may result in negative net present value. In such cases, the strategic decision to develop the product might be based on pressures from competitors in gaining market share with the launch of a competing product. As the brand loyalty of a firm increases, the chance of losing sales to existing products rather than a competitor's product increases. In such cases, the impact of product cannibalization is higher on the existing product sales.

Below are some common approaches used for taking the effect of cannibalization into product development decision making.

1. Reduce expected lost sales redirected to new product from the existing product sales.
2. Treat as a cost line item in the operating costs of the existing product.

3. Show no impact on product revenue: Some firms choose to ignore this altogether since the existing product would have also caused cannibalized a prior version. They would treat the cannibalization effect on the existing product to cancel out the cannibalization effect it caused at the time of its introduction in the overall accounting of the entire suite of its products.

In the Nespresso case, if the coffee maker introduces a new model, it is expected to impact the sales of other models it closely resembles in terms of price and features. If the newer model is priced lower, it could eat into the sales of cheaper priced models as consumers may upgrade for the better features.

7.4.1 Cannibalization Model 1

Reduce expected lost sales redirected to new product from the existing product sales

One of the most common methods of accounting for cannibalization within the products financial analysis is to reduce the product revenue by the expected sales lost due to cannibalization. The top line of the Income statement with the product revenue is decreased by the sales redirected to the new product.

In the Nespresso case, the number of machines sold in the last two years of the product is reduced to show the impact of cannibalization. Therefore, the product revenue is brought down by about a third in the fourth and fifth year, assuming an average life of five years including the product development time. This in turn impacts the total sales of the capsules associated with those machines and all the revenue and cost items that are tied to the number of products sold. This is analyzed in Cannibalization Model 1 given below.

Coffee machines and capsules: Total cash flows, present values, net present value, and cannibalization

	Year 1				Year 2				Year 3				Year 4				Year 5			
(\$ values in millions, except unit price)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sales revenue (coffee machines) ^(1a)					13.04	16.30	16.30	19.56	15.00	18.75	18.75	22.49	11.55	14.44	14.44	17.33	12.13	15.17	15.17	18.20
Sales volume (coffee machines)					52160	65200	65200	78240	59984	74980	74980	89976	57772	72215	72215	86658	60661	75826	75826	90991
Unit price (coffee machines)					250	250	250	250	250	250	250	250	200	200	200	200	200	200	200	200
Sales revenue (capsules) ^(1b)					3.3	7.4	11.5	16.4	20.2	24.9	29.7	35.3	35.7	36.1	36.6	37.1	37.1	37.2	37.2	37.3
Sales volume (capsules)					5,216,000	11,736,000	18,256,000	26,080,000	32,078,400	39,576,400	47,074,400	56,072,000	56,633,209	57,334,720	58,036,232	58,878,045	58,945,714	59,030,301	59,114,888	59,216,392
Unit price (capsules)					0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Total sales revenue					16.33	23.69	27.80	35.99	35.21	43.68	48.40	57.82	47.23	50.56	51.01	54.42	49.27	52.35	52.41	55.50
Development Cost ⁽⁴⁾	-0.75	-0.75	-0.75	-0.75																
Ramp-up Cost ^(5a)				-1.00	-1.00															
Equipment and Tooling Cost ^(5b)			-1.00	-1.00	-0.25	-0.25	-0.25	-0.25	-0.26	-0.26	-0.26	-0.26	-0.28	-0.28	-0.28	-0.28	-0.29	-0.29	-0.29	-0.29
Marketing and Support Cost ⁽⁶⁾			-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
Production Cost ⁽⁷⁾					-8.65	-12.56	-14.73	-19.07	-18.66	-23.15	-25.65	-30.64	-25.03	-26.80	-27.03	-28.85	-26.11	-27.75	-27.78	-29.42
Distribution Cost ⁽⁸⁾					-2.26	-3.28	-3.85	-4.98	-4.87	-6.05	-6.70	-8.00	-6.54	-7.00	-7.06	-7.53	-6.82	-7.25	-7.25	-7.68
Total Costs	-0.75	-0.75	-1.75	-5.25	-14.66	-18.59	-21.33	-26.81	-26.29	-31.96	-35.12	-41.41	-34.35	-36.57	-36.87	-39.15	-35.72	-37.78	-37.82	-39.89
Period Cash Flow	-0.75	-0.75	-1.75	-5.25	1.66	5.11	6.47	9.18	8.91	11.72	13.29	16.41	12.89	13.99	14.14	15.27	13.55	14.57	14.59	15.61
Discounting Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PV Year 1, r = 7%	-0.74	-0.72	-1.66	-4.90	1.53	4.60	5.73	7.99	7.62	9.85	10.98	13.32	10.28	10.97	10.90	11.57	10.09	10.66	10.49	11.04
Sum of Present Value	139.61																			

Table 5: Net Present Value computation for Cannibalization Model 1

Assumptions

1a. Cannibalization is expected to reduce revenue in the last 2 years of the product by about 33%. This is cumulative as the number of machines in the market increases, the sale of capsules will also increase. For years 4 and 5, capsule sale has been decreased by 33% to adjust for the cannibalization of the machine. This is sales lost to a newer model. As a result of this, other metrics that are dependent or calculated based on revenue will also be reduced in the final two years of the product's life.

The following is the graphical representation of the major revenue and cost items of Cannibalization Model 1.

Key:

X axis: In quarters

Y axis: In Millions (USD)

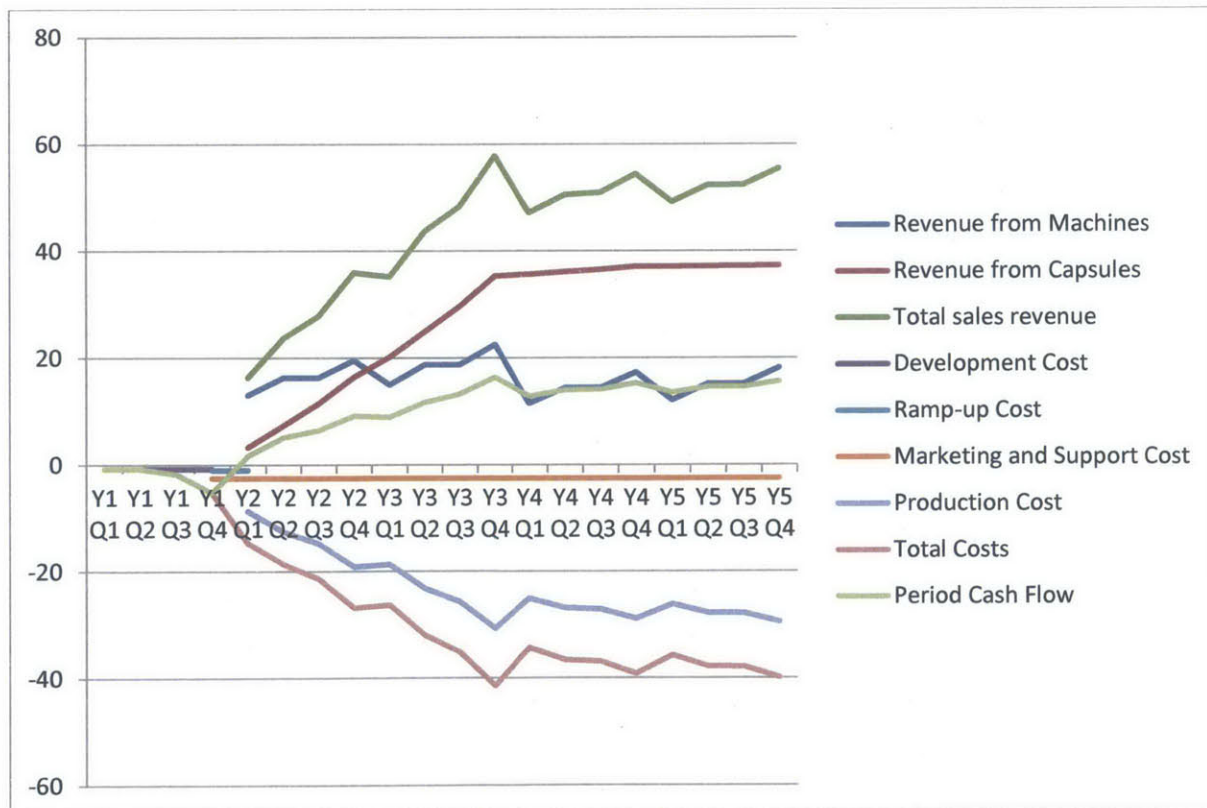


Figure 16: Cost and Revenue of Cannibalization Model 1

7.4.2 Cannibalization Model 2

Treat as a cost line item in the operating costs of the existing product.

The cannibalization effect on the financial statement can also be captured as a cost item. The cost of the sales lost to the new product is captured as a line item. Here the impact of the sale is captured explicitly as a separate item and can be adjusted based on analyses and assumptions.

Applying this to the Nespresso case, the total product revenue does not take into account any effect of cannibalization. Instead, a new cost item that captures the explicit effect of lost sales is added as a notional cost. The final effect on NPV can be similar to deducting the expected reduction in sales due to cannibalization from total revenue since net cash flows from both methods account for cannibalization.

Coffee machines and capsules: Total cash flows, present values, net present value, and cannibalization

	Year 1				Year 2				Year 3				Year 4				Year 5			
(\$ values in millions, except unit price)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sales revenue (coffee machines) ^(1a)					13.04	16.30	16.30	19.56	15.00	18.75	18.75	22.49	17.25	21.56	21.56	25.87	18.11	22.63	22.63	27.16
Sales volume (coffee machines)					52160	65200	65200	78240	59984	74980	74980	89976	86227	107784	107784	129341	90538	113173	113173	135808
Unit price (coffee machines)					250	250	250	250	250	250	250	250	200	200	200	200	200	200	200	200
Sales revenue (capsules) ^(1b)					3.3	7.4	11.5	16.4	20.2	24.9	29.7	35.3	37.5	40.2	42.8	46.1	48.0	50.4	52.8	55.7
Sales volume (capsules)					5,216,000	11,736,000	18,256,000	26,080,000	32,078,400	39,576,400	47,074,400	56,072,000	59,478,700	63,737,075	67,995,450	73,105,500	76,160,935	79,980,229	83,799,523	88,382,675
Unit price (capsules)					0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Total sales revenue					16.33	23.69	27.80	35.99	35.21	43.68	48.40	57.82	54.72	61.71	64.39	71.92	66.09	73.02	75.43	82.84
Development Cost ⁽⁴⁾	-0.75	-0.75	-0.75	-0.75																
Ramp-up Cost ^(5a)				-1.00	-1.00															
Equipment and Tooling Cost ^(5b)			-1.00	-1.00	-0.25	-0.25	-0.25	-0.25	-0.26	-0.26	-0.26	-0.26	-0.28	-0.28	-0.28	-0.28	-0.29	-0.29	-0.29	-0.29
Marketing and Support Cost ⁽⁶⁾				-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
Production Cost ⁽⁷⁾					-8.65	-12.56	-14.73	-19.07	-18.66	-23.15	-25.65	-30.64	-29.00	-32.71	-34.13	-38.12	-35.03	-38.70	-39.98	-43.91
Distribution Cost ⁽⁸⁾					-2.26	-3.28	-3.85	-4.98	-4.87	-6.05	-6.70	-8.00	-7.57	-8.54	-8.91	-9.96	-9.15	-10.11	-10.44	-11.47
Cost of Cannibalization ⁽⁹⁾													-5.47	-6.17	-6.44	-7.19	-6.61	-7.30	-7.54	-8.28
Total Costs	-0.75	-0.75	-1.75	-5.25	-14.66	-18.59	-21.33	-26.81	-26.29	-31.96	-35.12	-41.41	-44.82	-50.20	-52.26	-58.04	-53.57	-58.90	-60.75	-66.45
Period Cash Flow	-0.75	-0.75	-1.75	-5.25	1.66	5.11	6.47	9.18	8.91	11.72	13.29	16.41	9.90	11.51	12.14	13.88	12.51	14.12	14.68	16.39
Discounting Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PV Year 1, r = 7%	-0.74	-0.72	-1.66	-4.90	1.53	4.60	5.73	7.99	7.62	9.85	10.98	13.32	7.90	9.03	9.36	10.52	9.32	10.33	10.56	11.59
Sum of Present Value	132.20																			

Table 6: Net Present Value computation for Cannibalization Model 2

Assumptions

1a. In this model, the impact of cannibalization is not shown on the revenue. Instead the effect of cannibalization is shown as a separate line item in the cost section of the financial analysis.

9. The cost of cannibalization is calculated as 10% of total sales including machines and capsules. This percent can be determined based on estimates from experienced product managers in the industry.

The following is the graphical representation of the major revenue and cost items of Cannibalization Model 2.

Key:

X axis: In quarters

Y axis: In Millions (USD)

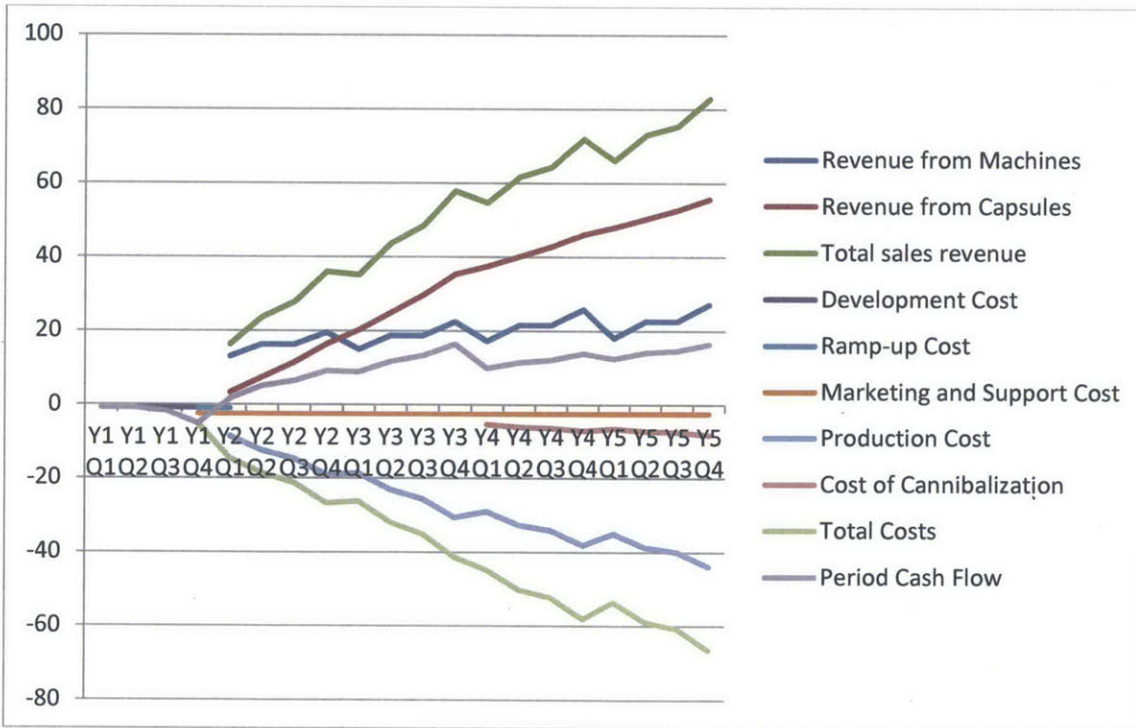


Figure 17: Cost and Revenue of Cannibalization Model 2

7.4.3 Brief discussion of Cannibalization Models

Firms typically employ one of these three approaches to handle cannibalization in product development analysis. At this point, the literature on the benefits and limitations of these methods is limited. Based on the research conducted for this thesis, the approach chosen by firms seems to be based on personal preference of product managers or best practice typically followed at the firm. There are no strong indications of any other rationale for choosing one method over another. A critical factor to consider is the key set of assumptions made and the validity and accuracy of those assumptions.

The following is the graphical representation of the major revenue and cost items of the last two years of the two Cannibalization models.

Key:

X axis: In quarters

Y axis: In Millions (USD)



Figure 18: Cost and Revenue compare of Cannibalization Models 1 and 2

7.5 Recycling

Companies that are looking for new ways to enhance their green image, minimize their expenses on materials and increase their profit margins are looking into recycling and reconstruction as ways of attaining those goals. In *Impact of Corporate Social Responsibility on Buying Behavior* (Mohr et al 2001), the authors conclude it is important for companies to develop trust and engage in socially responsible activities that are meaningful to their customers.

In the seminal work on recycling revenue called *In with the Old*, Dr. Pearce recommends recycling, refurbishing and remanufacturing as ways of increasing revenue and decreasing cost for firms. Over \$300 billion in annual sales is generated by companies that engage in product reconstruction that includes the recycling of materials such as plastic, rubber, aluminum, paper and oil.

When companies choose to recycle there are various costs and benefits associated with it. Initially there is a cash outlay when the company has to set up facilities to collect the used product and then establish a contract with a recycling company to reuse the material.

However, there also are benefits associated with this choice. Consumers, who are becoming increasingly environmentally conscious, avoid products that harm the environment. The ability to recycle the product and the company's commitment to recycling offers some level of comfort to certain consumers. Such a "green" image can help the company increase its sales. Another benefit is the cost. Certain products such as aluminum that can be reused over and over again have high scrap value. Outsourcing the cleaning and processing of scrap material to be able to reuse it can provide additional revenue at a fraction of the cost. Customers often look for signs that the recycling effort does not impact the cost or quality of the product.

Nespresso uses one gram of aluminum in each capsule. It is estimated to set up recycle facilities that can take 75% of the capsules back for recycling. However, based on industry expert opinion the actual recycled quantity is much less about 20-30%. Often, when a company makes a socially responsible decision to decrease its carbon footprint, it is rewarded with additional purchases from environmentally-conscious buyers. In our model, we have captured various scenarios for changes in recycling rates with corresponding changes in sales.

The table below summarizes some of the basic facts gathered about recycling capsules and the aluminum available. Several of the inputs to our models come from these estimates.

Item	Estimate	Source
Estimated % of capsules recycled	2-50%	http://en.wikipedia.org/wiki/Nespresso
Revenue from recycling one ton of aluminum	\$1,000	http://www.aluminum.org/Content/NavigationMenu/NewsStatistics/Sustainability/default.htm#Aluminum Can Recycling
Nespresso will put in place capacity to recycle	75%	http://en.wikipedia.org/wiki/Nespresso
Amount of aluminum per capsule in gram(s)	1	http://en.wikipedia.org/wiki/Nespresso
No. of capsules sold	6,500,000,000	http://www.bloomberg.com/news/2011-10-18/nespresso-customers-cheat-on-clooney-in-coffee-wars-retail.html

Table 7: Input values for Recycling Model

Coffee machines and capsules: Total cash flows, present values, and net present value

	Year 1				Year 2				Year 3				Year 4				Year 5			
(\$ values in millions, except unit price)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sales revenue (coffee machines) ^(1a)					13.0	16.3	16.3	19.6	15.0	18.7	18.7	22.5	17.2	21.6	21.6	25.9	18.1	22.6	22.6	27.2
Sales volume (coffee machines)					52160	65200	65200	78240	59984	74980	74980	89976	86227	107784	107784	129341	90538	113173	113173	135808
Unit price (coffee machines)					250	250	250	250	250	250	250	250	200	200	200	200	200	200	200	200
Sales revenue (capsules) ^(1b)					3.9	8.9	13.8	19.7	24.3	29.9	35.6	42.4	45.0	48.2	51.4	55.3	57.6	60.5	63.4	66.8
Sales volume (capsules)					6,259,200	14,083,200	21,907,200	31,296,000	38,494,080	47,491,680	56,489,280	67,286,400	71,374,440	76,484,490	81,594,540	87,726,600	91,393,122	95,976,275	100,559,427	106,059,210
Unit price (capsules)					0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Recycle revenue ^(1c)					0.0019	0.0042	0.0066	0.0094	0.0115	0.0142	0.0169	0.0202	0.0214	0.0229	0.0245	0.0263	0.0274	0.0288	0.0302	0.0318
Recycle volume (capsules)					3,129,600	7,041,600	10,953,600	15,648,000	19,247,040	23,745,840	28,244,640	33,643,200	35,687,220	38,242,245	40,797,270	43,863,300	45,696,561	47,988,137	50,279,714	53,029,605
Total sales revenue					16.99	25.18	30.11	39.29	39.26	48.68	54.35	64.90	62.23	69.76	72.99	81.16	75.71	83.13	86.02	94.01
Development Cost ⁽⁴⁾	-0.75	-0.75	-0.75	-0.75																
Ramp-up Cost ^(5a)				-1.00	-1.00															
Equipment and Tooling Cost ^(5b)			-1.00	-1.00	-0.25	-0.25	-0.25	-0.25	-0.26	-0.26	-0.26	-0.26	-0.28	-0.28	-0.28	-0.28	-0.29	-0.29	-0.29	-0.29
Marketing and Support Cost ⁽⁶⁾			-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
Production Cost ⁽⁷⁾					-9.00	-13.34	-15.96	-20.82	-20.81	-25.80	-28.81	-34.40	-32.98	-36.98	-38.68	-43.02	-40.13	-44.06	-45.59	-49.83
Distribution Cost ⁽⁸⁾					-2.26	-3.35	-4.01	-5.23	-5.22	-6.48	-7.23	-8.64	-8.28	-9.28	-9.71	-10.80	-10.07	-11.06	-11.45	-12.51
Recycle Cost ⁽⁹⁾ (Collection/transportation/Processing)					-0.50	-1.13	-1.75	-2.50	-3.08	-3.80	-4.52	-5.38	-5.71	-6.12	-6.53	-7.02	-7.31	-7.68	-8.04	-8.48
Recycle Cost (Fixed) ⁽¹⁰⁾					-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Total Costs	-0.75	-0.75	-1.75	-5.25	-15.54	-20.60	-24.49	-31.33	-31.90	-38.87	-43.35	-51.21	-49.78	-55.18	-57.72	-63.64	-60.33	-65.61	-67.90	-73.64
Period Cash Flow	-0.75	-0.75	-1.75	-5.25	1.45	4.58	5.62	7.96	7.36	9.81	11.00	13.70	12.46	14.59	15.26	17.53	15.38	17.52	18.12	20.38
Discounting Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PV Year 1, r = 7%	-0.74	-0.72	-1.66	-4.90	1.33	4.13	4.97	6.93	6.30	8.25	9.09	11.12	9.94	11.44	11.77	13.28	11.45	12.82	13.03	14.40
Sum of Present Value	142.22																			

Table 8: Net Present Value computation Recycling Model

Assumptions
1c. The recycling revenue is from the sale of capsules only. The recycle revenue is calculated assuming 25% of the capsules sold are recycled. Each ton of scrap aluminum is sold for \$ 1000. However, since capsules scrap will need to be cleaned, we are assuming this will only fetch \$ 600 per ton.
9. Assuming 10% of capsules sold can be collected easily for a relatively low cost of 40 cents per capsule and then an additional 15% can be collected for a higher cost of 80 cents per capsule.
10. Recycling fixed cost is \$ 3 M per year. This is distributed across all 28 models of machines available.

The following is the graphical representation of the major revenue and cost items of recycling models.

Key:

X axis: In quarters

Y axis: In Millions (USD)

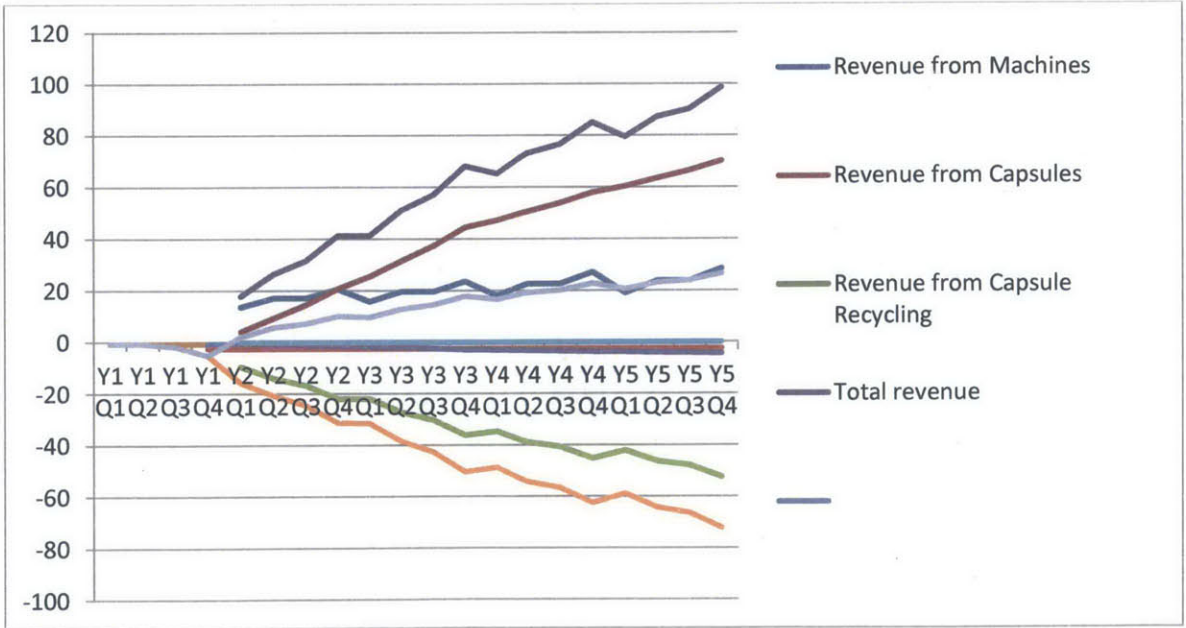


Figure 19: Cost and Revenue of Recycling Model

In the Nespresso case, as is common with other manufacturers, the volume of recycling may not be estimated accurately. Various combinations of recycling volume, cost and price may be used to analyze the impact on the financial analyses. The impact on NPV with various sales and recycling rates is captured in the table below.

Sales Change	Recycling Change	NPV (\$)
0%	0%	203.82
0%	5%	197.66
0%	10%	191.50
0%	15%	185.34
0%	20%	179.18
0%	25%	173.02
0%	30%	166.86
0%	35%	160.70
0%	40%	154.54
0%	45%	148.38
0%	50%	142.22
5%	0%	221.18
5%	5%	214.72
5%	10%	208.25
5%	15%	201.78
5%	20%	195.31
5%	25%	188.84
5%	30%	182.38
5%	35%	175.91
5%	40%	169.44
5%	45%	162.97
5%	50%	156.50
10%	0%	238.54
10%	5%	231.77
10%	10%	224.99
10%	15%	218.21
10%	20%	211.44

Sales Change	Recycling Change	NPV (\$)
10%	25%	204.66
10%	30%	197.89
10%	35%	191.11
10%	40%	184.33
10%	45%	177.56
10%	50%	170.78
15%	0%	255.90
15%	5%	248.82
15%	10%	241.73
15%	15%	234.65
15%	20%	227.57
15%	25%	220.48
15%	30%	213.40
15%	35%	206.31
15%	40%	199.23
15%	45%	192.15
15%	50%	185.06
20%	0%	273.26
20%	5%	265.87
20%	10%	258.48
20%	15%	251.08
20%	20%	243.69
20%	25%	236.30
20%	30%	228.91
20%	35%	221.52
20%	40%	214.13
20%	45%	206.73
20%	50%	199.34

Table 9: Impact of Sales and Recycling on NPV

7.6 Sensitivity Analysis

A critical component of the performing economic analysis on product development is to understand the various scenarios and perform analysis for best and worst case to set the right expectation on risk profile. In Nespresso's case, we use this to determine the net present value in the best and worst case scenarios. Sensitivity analysis is most widely used for risk measurement and risk management.

In most cases, these numbers are gleaned from industry experts and product managers that are familiar with the process. If there is uncertainty about them or if there is no consensus, a more sophisticated weighted average or Monte Carlo simulation can be used.

In their book on product design and development, Otto and Wood assert the boundaries on the design variables will define the solutions to the model. In the product design and development process, we should consider what changes in certain parameters will have on the model and determine which constraints can be relaxed in order to improve the overall development of the product (Otto & Wood, 2000).

In their book on Sensitivity Analysis, Saltelli, Chan and Scott (Saltelli, Chan, & Scott, 2009) describe the use of this as follows: *Sensitivity analysis can be used to explore how the impacts of the options you are analyzing would change in response to variations in key parameters and how they interact.*

In case of Nespresso, the sensitivity analysis is based on several changing each key parameter to see the impact of that on the NPV. This is critical in answering questions relating to the impact of changes in expected costs, volume or product development schedule.

	Change in %	Volume	Change in Volume	Change in NPV %	NPV \$	Change in NPV \$
Sales Volume	50	2,166,820	-722273	0.69	120.31	48.98
	20	1,733,456	-288909	0.27	90.92	19.59
	10	1,589,001	-144455	0.14	81.12	9.80
	base	1,444,547	0	0.00	71.32	0
	-10	1,300,092	144455	-0.14	61.52	-9.80
	-20	1,155,637	288909	-0.27	51.73	-19.59
	-50	722,273	722273	-0.69	22.34	-48.98
Sales Price	50	375.00	-125.00	0.69	120.31	48.98
	20	300.00	-50.00	0.27	90.92	19.59
	10	275.00	-25.00	0.14	81.12	9.80
	base	250.00	0.00	0.00	71.32	0
	-10	225.00	25.00	-0.14	61.52	-9.80
	-20	200.00	50.00	-0.27	51.73	-19.59
	-50	125.00	125.00	-0.69	22.34	-48.98
	Change in %	Cost in \$	Change in Cost \$	Change in NPV %	NPV \$	Change in NPV \$
Production Cost	50	251.97	83.99	-0.94	4.31	-67.01
	20	201.58	33.60	-0.38	44.52	-26.80
	10	184.78	16.80	-0.19	57.92	-13.40
	base	167.98	base	0	71.32	0
	-10	151.18	-16.80	0.19	84.72	13.40
	-20	134.38	-33.60	0.38	98.12	26.80
	-50	83.99	-83.99	0.94	138.33	67.01
Equipment Cost	50	6.14	-2.05	-0.03	69.54	-1.78
	20	4.92	-0.82	-0.01	70.61	-0.71
	10	4.51	-0.41	-0.01	70.96	-0.36
	base	4.10	0.00	0.00	71.32	0
	-10	3.69	0.41	0.01	71.68	0.36
	-20	3.28	0.82	0.01	72.04	0.71
	-50	2.05	2.05	0.03	73.11	1.78
Marketing Cost	50	31.88	-10.63	-0.12	62.66	-8.66
	20	25.50	-4.25	-0.05	67.86	-3.46
	10	23.38	-2.13	-0.02	69.59	-1.73
	base	21.25	0.00	0.00	71.32	0
	-10	19.13	2.13	0.02	73.05	1.73
	-20	17.00	4.25	0.05	74.79	3.46
	-50	10.63	10.63	0.12	79.98	8.66
Ramp-up Cost	50	3.00	-1.00	-0.01	70.40	-0.92
	20	2.40	-0.40	-0.01	70.95	-0.37
	10	2.20	-0.20	0.00	71.14	-0.18
	base	2.00	0.00	0.00	71.32	0
	-10	1.80	0.20	0.00	71.51	0.18
	-20	1.60	0.40	0.01	71.69	0.37
	-50	1.00	1.00	0.01	72.25	0.92
Development Cost	50	4.50	-1.50	-0.02	69.88	-1.44
	20	3.60	-0.60	-0.01	70.75	-0.57
	10	3.30	-0.30	0.00	71.03	-0.29
	base	3.00	0.00	0.00	71.32	0
	-10	2.70	0.30	0.00	71.61	0.29
	-20	2.40	0.60	0.01	71.90	0.58
	-50	1.50	1.50	0.02	72.76	1.44

Table 10: Sensitivity of revenue and cost on NPV

In the case of Nespresso, the best case and worst case scenarios have been computed based on the upper threshold of the various parameters if the market factors are in favor. In determining each parameter, the best possible case under normal circumstances has been taken into account. Similarly, for the worse case performance, the lower threshold that would negatively impact the financial metrics is taken into account. It is common for the parameters to be different across different industries, product groups, demographics, geographic regions and other considerations.

The following table summarizes the best and worst case parameters used in Nespresso case. These numbers can be adjusted based on updated information to reflect the NPV in the best and worst cases. This helps us in understanding the impact on NPV and bottom line if our base-line assumptions are not correct.

Parameters	Base Case	Best Case	Worst Case
Revenue			
Revenue	1	1.2	0.8
Costs			
Production	1	0.85	1.2
Equipment	1	0.75	1.1
Marketing	1	0.8	1.2
Ramp-up	1	0.7	1.25
Development	1	0.8	1.1
NPV	1	2.62	0.06

The information above is presented in dollar terms in the table below.

Parameters	Base Case	Best Case	Worst Case
Revenue			
Revenue	316.95	522.95	181.38
Costs			
Production	167.98	235.59	115.35
Equipment	4.10	2.72	4.74
Marketing	21.25	17	25.5
Ramp-up	2	1.4	2.5
Development	3	2.4	3.3
NPV(in million \$)	71.32	186.79	4.11

Table 11: Best and worst case scenarios for Nespresso

8 FINDINGS AND NEXT STEPS

Project decisions have significant impact on the future of the company as well as the market place. These decisions do not only impact the financial performance of firms but also set the competitive landscape for companies to create, develop and compete. Therefore decisions regarding the development of products must be carefully weighed. Factors within the firm, outside in firm in its market place as well as macroeconomic factors influence product development activities and determine the success of a product.

This research has analyzed and validated the various methods used to model product development costs. It has also shown the link between assumptions and results, thereby demonstrating the importance of carefully selecting and validating assumptions made in the models since results can be significantly impacted by them.

Key Findings

1. Economic analysis is a strong tool used by managers to support decision making in product development. This can be used for calculating the financial impact from resources spent on new product development or incremental product changes.
2. There are several popular techniques such as Pay back method or Net Present Value is used by real-world product managers. The most common method is Net Present Value. These techniques primary reduce any inherent biases in decision making. Decisions can then be just logical deductions from the results of the analysis.
3. Quantitative techniques are not free from subjective biases. Although these biases are reduced they are not entirely eliminated. These quantitative methods strongly rely on estimates from managerial experience and subject matter expertise that are inherently biased.
4. Several models can be built to incorporate various aspects of product development. These models can also be used to perform sensitivity analysis to understand the most influential factors in product development. This can help the team prioritize to ensure those factors are as

accurate as possible. This will also help in developing a critical path for product development that ensures these important tasks do not slip.

Next Steps

It would be interesting to conduct in-depth study and analysis of the following areas when more data points and additional research data are available:

1. Cannibalization techniques used in product development analysis
2. Estimation techniques for product recycling and buy-back

9 APPENDICES

9.1 Appendix A: Common Facts about Aluminum Recycling

Below are some common facts about Aluminum recycling. Please refer to source at this link for additional details: <http://www.recycling-revolution.com/recycling-facts.html>)

1. Aluminum cans can be recycled completely and put back on grocery shelf in 60 days.
2. Common household items that are recycled are soda cans. However other items such as siding, lawn furniture, widow frames can also be recycled.
3. Aluminum can be repeatedly reused. It does not lose its basic properties to prevent reuse.
4. Aluminum contributes to less than one percent of the waste stream in the US since it is often recycled.
5. Recycling aluminum saves 95% of the energy required to produce it from ore.

9.2 Appendix B: Definition of Recycling, Refurbishing and Remanufacturing

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Source: Techniques in Reverse Engineering and New Product Development and Product design book by Kevin N Otto and Kristin L Wood ; Pearson Education 2003

The paper provides the following distinction in the terminology (Otto & Wood, 2000):

The Three R's			
An overview of the kinds of opportunities available in product reconstruction			
	RECYCLING	REFURBISHING	REMANUFACTURING
What It Involves	Breaking down a used product into constituent parts that are converted into different products or used as raw material.	Restoring a product to "like new" condition for the same use, with no changes to the original design.	Making a used capital or consumer durable good "better than new" through complete refurbishing plus an upgrading of parts and features.
Required Expertise With Initial Product	Usually low	Medium	High
Barriers to Entry	Usually low	Moderate	High
Example	Used plastic soda bottles are melted down and used for park benches, fleece clothing, lifeguard chairs and plastic lumber.	A used commercial battery is restored to its original condition.	A 20-year-old passenger jet is made "like new" and retrofitted with updated electronics.

Source: John A. Pearce II

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