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Design of a Methodology to Support Software Release Decisions

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6   RELEASE DEFINITION

"Management by objective works if you know the objectives.
Ninety percent of the time you don't."
-- Peter F. Drucker --

6.1   Introduction

Applying the concept of maximizing behaviour to decision-making assumes that the decision-maker's objectives can be translated into a preference function, representing, in quantitative terms, the value, or utility, of a given set of alternatives. Making a choice consists of selecting the alternative with the highest positive utility for the decision-maker (Allison 1971). Two axioms are applicable here (Edwards 1954). In the first place, given two alternatives A and B, the *closure axiom* requires that it must be possible to determine which alternative is preferable, or if there is no particular preference. The *transitivity axiom* requires that if alternative A is preferred to B, and alternative B is preferred to C, then alternative A is preferred to alternative C.

This concept is followed when answering the first secondary research question: 'How to model the market entry trade-off for a software product? The conditions for a purely economic approach, assuming maximizing behaviour, are taken; with no cognitive limitations, no time and cost constraints, a closed environment, and perfect information [complete and reliable].

In Section 6.2 an overview is given of existing capital budgeting methods. In Section 6.3, different market life-cycle models, from the semiconductor industry, are introduced, demonstrating the effects of delayed market entry on revenues. In combination with one of the capital budgeting methods, these are used for defining an extended model to evaluate different release alternatives in Section 6.4, thus answering the first secondary research question raised. Based on the elaboration of aspects of maximizing behaviour, practices for the *'Release Definition'* process area are derived in Section 6.5. This Chapter ends with a summary and conclusions in Section 6.6.

6.2   Capital Budgeting Methods

When developing products, manufacturers should have an understanding of the expected product lifetime, the expected cash inflows, the pre-release cash outflows [development cost] and post-release cash outflows [operational costs], and the resulting net asset value; information that is specific to the external environment and internal characteristics of an organization. The first orientation of this information takes place when the proposal for a product development investment is appraised.

Renkema and Berghout (1997) investigate and compare available methods: [54]
   ❖ *Financial Approach*. Methods from the financial approach, traditionally used for the evaluation and selection of corporate investment proposals, focus on incoming and outgoing cash flows as a result of the investment made. Examples of such methods are: Net Present Value [including *Sensitivity Analysis* and Simulation, Decision Tree Analysis], Profitability Index, Internal Rate of Return and Payback Method, discussed later.

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[54] The focus of their study is on methodologies to evaluate information systems.

❖ *Multi-criteria Approach*. This approach incorporates non-financial consequences as a result of the investment, which are difficult to express in monetary terms. Comparing financial and non-financial consequences is difficult, as they lack a common denominator, but multi-criteria decision analysis methods can overcome this by creating one single measure for an investment. The methods require the design of decision criteria, and the relative importance for all criteria, by assigning weights and finally assigning scores to the criteria. The multiplication of each score with its corresponding weight, and calculation of the overall score gives the final score for an investment. An example of this approach is the *Information Economics Method* (Parker *et al.* 1989), which distinguishes three different categories of evaluation criteria: Enhanced ROI, Business Domain and Technology Domain.

❖ *Ratio Approach*. These methods assist in IT evaluations through ratios, like IT related expenditures against total turnover. An example is the *Return on Management* or ROM method, comparing the value of management to the cost of management (Strassman 1990).

❖ *Portfolio Approach*. These methods evaluate IT investments by plotting them against various criteria, in fact a special case of a multi-criteria approach with a graphical representation of evaluation results. Examples are *Bedell's method* (Bedell 1985), *Investment Portfolio* (Berghout and Meertens 1992) and *Investment Mapping* (Peters 1989).

Well-known methods for a financial approach are:

❖ *Net Present Value (NPV)*.[55] [56] The Net Present Value of an investment is calculated as the present value of forecasted future cash flows plus the initial investment. The initial investment will be in most cases negative as it is a cash outflow. It calculates the return on the initial cash outflow I by correcting the annual cash inflows C_t after the development T for the discounted value of money, using the risk-based discount rate r. In formula terms:

$$NPV \quad = \quad -I + \Sigma \, C_t \, / \, (1+r)^{\,T} \qquad\qquad\qquad (6.1)$$

Erdogmus (1999), for example, describes a comparative evaluation method for software development strategies based on NPV.

❖ *Profitability Index (PI)*. The Profitability Index, also called benefit-cost ratio, is the present value of forecast future cash flows divided by the initial investment. The rule is to accept a project if the index is greater than one, meaning the project will have a positive NPV. The problem with this method is that the ratio is used, instead of the NPV value itself. If two projects are mutually exclusive, the rule applied might lead to the wrong choice.

❖ *Internal Rate of Return (IRR)*. This method, also called Discounted-Cash-Flow Rate of Return, looks at the discount rate, which makes NPV equal zero. The rule is to accept a project if the opportunity cost of capital is less than the internal rate of return. In this

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[55] Basic NPV can be extended with an analysis of how sensitive the NPV is when variables are changed (Brealey and Myers 1991, pp.215-217). This *Sensitivity Analysis* begins with the creation of the most likely expected values for each of the relevant variables: the base scenario. The sensitivity analysis is conducted by changing each relevant variable to a best and worse value, holding the other variables constant at their base values. When this exercise is completed for all variables, it can be concluded which variables have the greatest impact on the NPV. This analysis can also be used to investigate the break-even point of the investment for different combinations of variable values. The sensitivity analysis is limited in the sense that only variations in one variable at a time are studied. The possible inter-dependency between variables is also discarded, as is the situation where a variable is serially dependent over time [i.e. the variable influences itself]. These limitations can be the reason to consider a *Monte Carlo simulation* as an alternative approach (Brealey and Myers, p.223).

[56] Basic NPV as well as the related Sensitivity Analysis and simulation approaches assume that the investment to consider is a 'now or never' decision (irreversible). They do not take into account the flexibility of stopping an investment prematurely. As the total investment is normally subdivided into a sequence of smaller investments, a different approach is to incorporate the possibility of deciding at each next investment moment whether to continue investing. This is called *Decision Tree Analysis* (Brealey and Myers, p.229).

case, the project will have a positive NPV. The same problem might occur when two projects are mutually exclusive. It is not the difference between the opportunity cost of capital and discount rate that makes the real difference, but rather the difference between the NPV values.

❖ *Payback Method*. This method investigates how rapidly a project pays back its initial investment. The method gives equal weight to all cash flows before the payback date and no weight to subsequent flows. If the same cut-off period is used to differentiate between projects and is too short, the method will tend to only accept short-lived projects. If the cut-off is too long, projects may be accepted with a negative NPV, because the discount rate is not taken into account.

In recent years, there is a tendency to apply option-pricing theory to development investments, referred to as the *real options approach* (Balasubramanian *et al.* 2000), as in the software industry (Benaroch and Kaufmann 1999; Sullivan *et al.* 1999; Boehm and Sullivan 2000; Cottrell 2000; Erdogmus 2002; Tallon *et al.* 2002).[57] [58] Reasons for this approach are that the traditional NPV-method is regarded as static; not offering the possibility of handling uncertainty, no incorporation of management flexibility to stop a project, called staged investment or time-to-build option, and not including the possibility of starting second-stage projects, called the build option (Dixit and Pindyck 1994). A real options approach applied to software development investments means the investment is not only in financial assets but also in physical and human assets. A *real option* is defined by an investment decision characterized by:

1. Uncertainty; the reason why a real option has value.
2. Discretion; to correspond to discrete points of go/no-go decisions.
3. Irreversibility; signifying the change in future possibilities due to a decision taken today.
                                                                    (Kogut and Kulatilaka 2001, p.8)

However, there is also criticism of the real options approach. Erdogmus (2002) investigates some major differences between financial options and real options, as in Figure 6-1. Applying a real options approach is complex and still leaves management with the difficult task of estimating input parameters (Ribbers *et al.* 1997). Alternatives for the traditional NPV approach have been developed; trying to reduce, or eliminate, the disadvantages of the traditional approach. Kallberg and Laurin (1997) describe, for example, the possibility of extending NPV with time-to-build and growth options, as in Figure 6-2. Ribbers *et al.* (1997) give an example of how NPV can be extended with *Decision Tree Analysis*, offering the possibility of incorporating the time-to-build option. More research is needed to explore approaches, which are favourable and practically applicable, under which conditions.

The studies discussed concern the interest of manufacturers operating in a market with pricing issues and competition. This is not a situation applicable to all different software manufacturer types. Other situations are, for example, (see also Butler 1990):

❖ Where a custom system is written on contract the schedule is normally fixed. In this case however, the trade-off to be made is between operational cost and the penalty for late delivery.

❖ Where a custom system is written in-house, the revenue from released software is not generated by the number of items sold, and can, for example, be measured in terms of efficiency and/or effectiveness improvements [productivity improvement]. In this situation however it is still possible to speak of a market window. Releasing the software later will delay these improvements.

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[57] A general comparison between the traditional Discounted Cash Flow (DCF) methods and the real options approach can be found in Mandron (2000).
[58] A comprehensive list of possible options can be found in (Dixit *et al.*1995; Trigeorgis 1996; Benaroch 2002).

❖ There may be situations where it is difficult to apply a financial justification for individual projects. Possible reasons are:
  - The project only delivers a sub-system as part of the overall product.
  - The project delivers a platform or an IT infrastructure, to be used by other systems.
  - The project's budget is allocated on an annual basis.

In these cases the allotment of overall revenues to a single project is difficult.

Financial Options	Real Options
Complete markets. A replicating portfolio can emulate any payoff structure.	*Incomplete markets.* A replicating portfolio that emulates a particular payoff structure may not exist.
Traded asset. The underlying asset is traded in the financial markets.	*Twin security.* The underlying asset is not traded; instead, the existence of a proxy, or twin security whose value is correlated with the underlying asset must be assumed.
Observed current price. The current price of the underlying asset is observed.	*Hypothetical asset.* The current price of the underlying asset is not observed. It must be estimated in present value terms.
No discount rate. A discount rate is not needed to value the option because of the existence of an observed price and the replication and no-arbitrage [law of one price] assumptions.	*Discount rate needed.* A discount rate is often needed to calculate the present value of future payoffs.
No interaction. Financial options are self-contained, fixed-structure contracts. They don't interact.	*Extensive interaction.* Real options within a project or across different projects often have complex interactions. The behaviour of one option may affect the value of the other.
Limited sources of uncertainty. Financial options involve one or two uncertain underlying assets.	*Multiple sources of uncertainty.* Real options frequently involve multiple underlying assets or assets with multiple sources of uncertainty.
Single ownership. Financial options have defined ownership.	*Shared ownership.* Real options are often shared among competitors. A company's exercise of a real option may kill or significantly undermine a similar real option for a competitor, and vice versa.
Value leakage. The holder of a financial option may be subject to loss of benefits, such as dividends, that are available to the holders of the underlying asset, but not to the holders of an option. This behaviour can be modelled using historical data or industry conventions.	*Value leakage or amplification.* The holder of a real option may experience a reduction or an increase in benefits as a result of random actions by other market players. However such actions often do not necessarily follow defined patterns, and as such, are difficult to model.

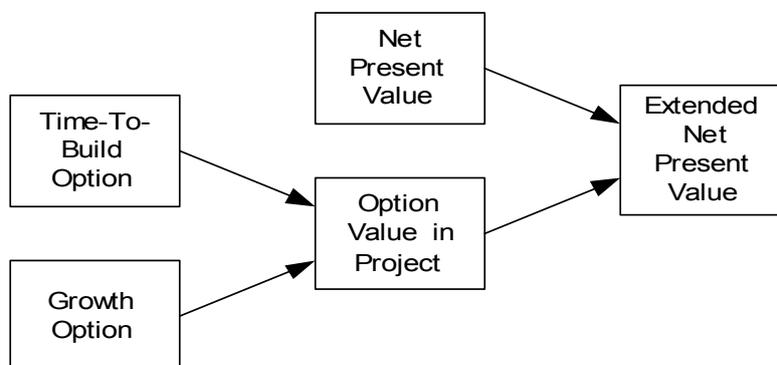**Figure 6-1: Financial Options versus Real Options**
(Erdogmus 2002)

Figure 6-2: Extended Net Present Value
(Kallberg and Laurin 1997, p.71)

In practice it might be difficult to uniquely classify an investment in software product development, and the resulting product may contain many aspects (Berghout 1997, p.78).

The capital budgeting methods discussed are normally applied when a proposal for a product development investment is appraised. A valid question is whether they can be of further use once a proposal has been accepted and product development has started. Motivation could be that, as product development progresses, uncertainties regarding the external environment, and project performance, are gradually reduced, enabling an organization to review the original business case. One could go further and possibly use a capital budgeting method to model the market entry trade-off by comparing the two alternatives. Before addressing this further, some market entry models are presented.

6.3   *Modelling the Market Entry Trade-off*

Assuming the concept of maximizing behaviour or the *theory of the firm*, the primary objective of an organization is to maximize its profit (Hirschey 2003, p.5). Profit maximization means that marginal revenue [asset value generated from cash inflows] equals marginal costs [cash outflows] and thus, marginal profit equals zero. Total profit is equal to total revenue minus total costs. A breakeven point is reached when revenues equal costs and thus, profit is zero. In manufacturing environments, costs normally comprise of pre-release development costs and post-release operational, or maintenance, costs.

To demonstrate the effects of a delayed market entry on profit, information should be available about the market life-cycle model, defining the market, or demand, window. Two cases are considered here: a triangular time-to-market cost model and an extended model with a saturation period.

6.3.1   Triangular Time-to-Market Model

In this Section, a simple product life-cycle, frequently used in the semiconductor industry, is presented, as described by, for example, Liu (1995). The product life-cycle is approximated to a triangle with duration *2W*, partitioning the market into two stages:

❖ Market growth window with duration *W*. The product begins to gain market acceptance and sales tend to grow rapidly as the product reaches the mass market.

❖ Market decline window with duration *W*. As technology advances, and superior products are launched, product sales will begin to decline. This downward trend in sales continues as the market declines, forcing managers to phase out the product.

It is assumed that the peak of the market is in the middle of the product life-cycle and that, to maximize revenues or asset value, the product should be on the market by the start of the market [demand] window,[59] as illustrated in Figure 6-3. This model can be used to compare delivering a software product on time and delivering it with a delay.

For an on-time market entry, the resulting asset value *C* will be equal to:

$$C \quad = \quad \tfrac{1}{2} \cdot 2W \cdot C_{max} \qquad\qquad\qquad (6.2)$$

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[59] These models are described in terms of 'revenues'. For consistency with the text the term 'asset value' is used instead.
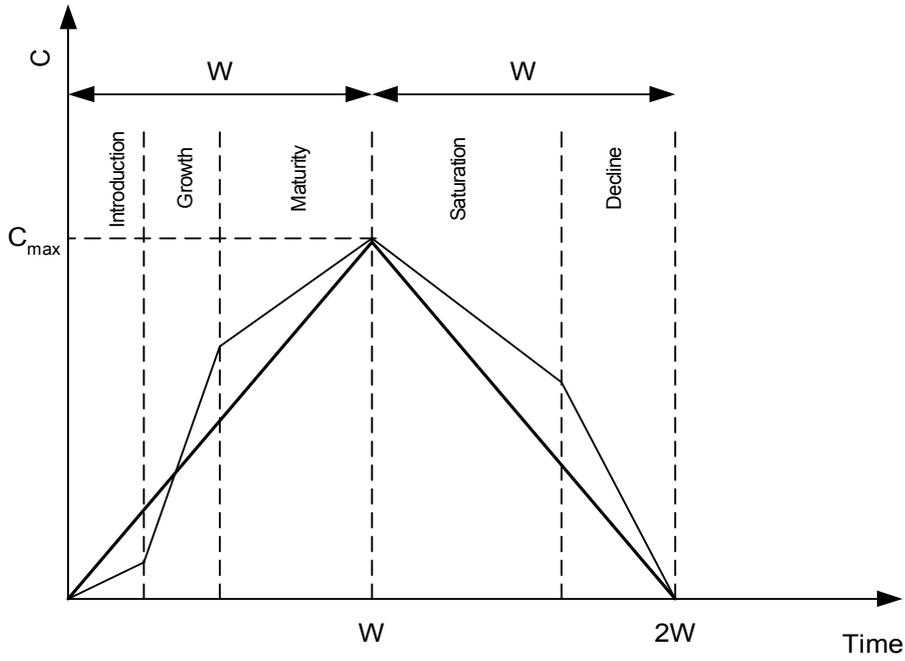
**Figure 6-3: Approximation of Product Life-cycle to a Triangle**
(Liu 1995)

For a product launch not meeting its initially planned release date T_r [start of market window] but with a delay D, and assuming the peak of the market is in the middle of the product life-cycle, the asset value C' will now be equal to:

$$C' \quad = \quad \tfrac{1}{2} \cdot (W\text{-}D\text{+}W) \cdot [\,(W\text{ - }D)/W\,] \cdot C_{max} \tag{6.3}$$

The loss in asset value C_{loss} is:

$$
\begin{aligned}
C_{loss} \quad &= \quad C - C' \\
&= \quad C \cdot D\,(3W - D) / 2W^{\,2}
\end{aligned}
\tag{6.4}
$$

In Figure 6-4, Asset value in a delayed market entry is illustrated.
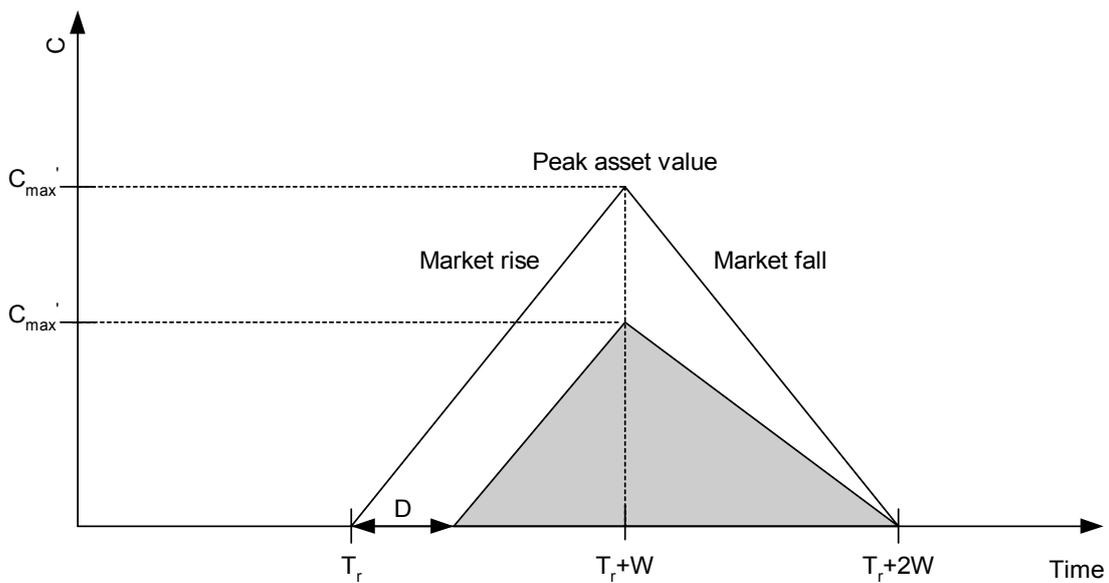
6-4: Asset Value ~ Delayed Market Entry
(Liu 1995)

6.3.2   Triangular Time-to-Market Model with Saturation

Another product life-cycle, frequently used in the semiconductor industry, is a triangular time-to-market model with a saturation period, as in Figure 6-5; described, for example, by Levitt (1992) and Wu and Wei (1997). In this case, the market is partitioned into three stages:

❖   Market growth window with duration W_1. See previous Section.
❖   Period of no growth [saturation] with duration S. As the product matures, sales are largely limited to repeat customers, as the majority of potential customers have already made their first choices. During this phase, there is no growth in the market.
❖   Market decline window with duration W_2. See previous Section.
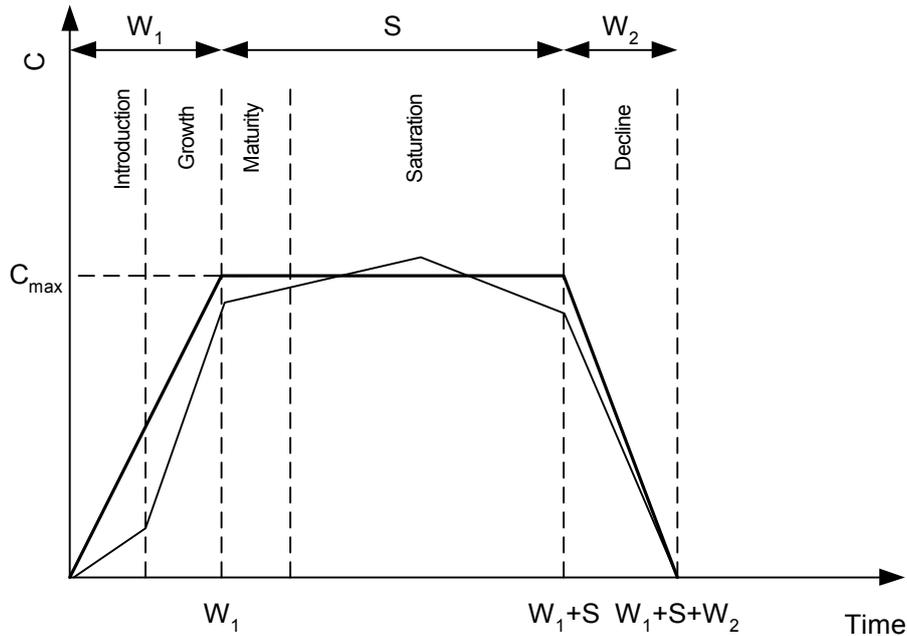

Figure 6-5: Approximation of Product Life-cycle to a Triangle with a Saturation Period
(Levitt 1992)

This model can also be used to make a comparison between delivering a software product on time and delivering it with a delay.

For an on-time market entry, the resulting asset value C is equal to:

$$ C \quad = \quad \tfrac{1}{2} \cdot W_1 \cdot C_{max} + S \cdot C_{max} + \tfrac{1}{2} \cdot W_1 \cdot C_{max} \qquad (6.5) $$

Where a product launch is not meeting its initially planned release date T_r [start of market window] but has a delay D, and assuming that the peak of the market is in the middle of the product life-cycle, the asset value C' will now be equal to:

$$ C' \quad = \quad [\, S + \tfrac{1}{2} \cdot (W_1 - D + W_2) \,] \cdot [\, (W_1 - D)/W_1 \,] \cdot C_{max} \qquad (6.6) $$

The loss in asset value, as in Figure 6-6, is:

$$ C_{loss} \quad = \quad C - C' $$
$$ \quad = \quad C \cdot [\, D \cdot (2W_1 - D + 2S + W_2) \,/\, (W_1 \cdot (W_1 + W_2 + 2S)) \,] \qquad (6.7) $$
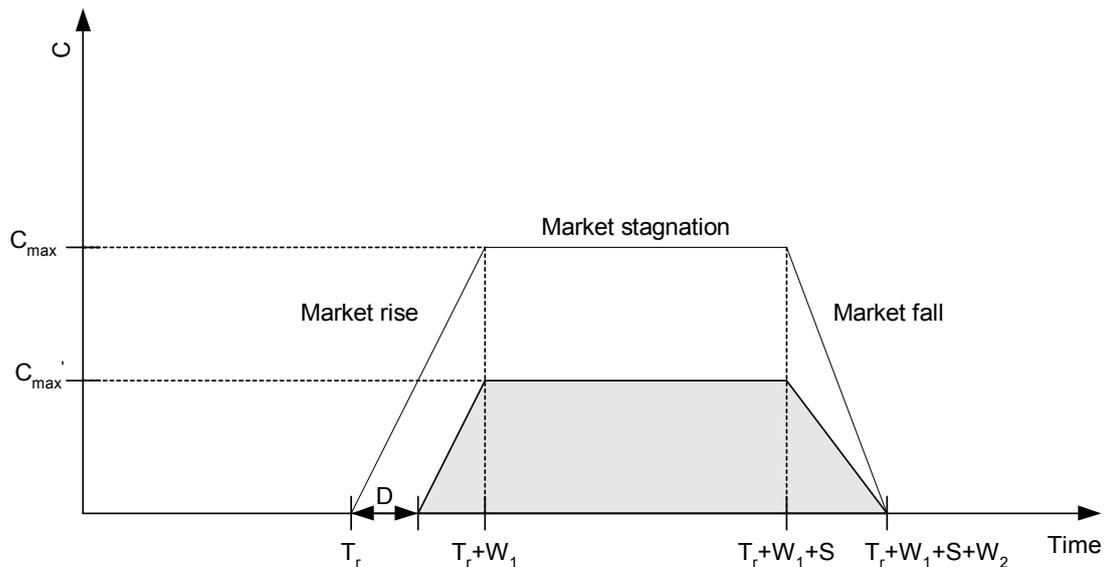
Figure 6-6: Asset Value for a Delayed Market Entry
(Levitt 1992)

6.3.3   Extended Model with Cost Functions

The models presented are simplifications of the real world and have their origin in the semiconductor industry, which is characterized by small market windows and high sales volumes. The principle of demonstrating lost asset value due to delayed market entry can however be applied to any industry, and also to the software industry. The important issues are the overall asset value curve, related to the market window, and the resulting revenue curve for a delayed market entry. Manufacturer organizations capable of defining these curves obtain valuable input for decision-making, especially for cost-benefit analyses. This requires additional cost information, and the model is extended to include cost functions, describing pre-release investment costs and post-release operational costs. This is only used for the triangular time-to-market model to demonstrate the principle (see also Sassenburg 2004).

For the 'on-time' delivery of a product, three functions are defined:
- ❖ Asset value C [Figure 6-3]:
    - Product lifetime is equal to $2.W$ with peak C_{max} at $T_r + W$.
    - Time of market entry defines a triangle, representing market penetration.
    - Triangle area equals total asset value.
- ❖ Development cost I [Figure 6-7]:
    - Product development time is equal to T_r with peak I_{max} at $T_r/2$.
    - Start of project at $T=0$ defines a triangle, representing development cost distribution.
    - Triangle area equals total development cost.
- ❖ Operational cost M [Figure 6-7]:
    - Peak M_{max} at $T_r + W$.
    - Time of market entry defines a triangle, representing operational cost distribution.
    - Triangle area equals total operational cost.

This leads to the following equations:

$$C \qquad = \qquad \tfrac{1}{2} . 2W . C_{max} \qquad\qquad\qquad\qquad (6.8)$$

$$I \qquad = \qquad \tfrac{1}{2} \, . \, T_r \, . \, I_{max} \qquad\qquad\qquad (6.9)$$

$$M \qquad = \qquad \tfrac{1}{2} \, . \, 2W \, . \, M_{max} \qquad\qquad\qquad (6.10)$$

Figure 6-7: Development and Operational Cost Model [on-time entry]

Combining the three models, the resulting profit, or net asset value, can be calculated as:

$$
\begin{aligned}
NAV \qquad &= \qquad -I + C - M \\
&= \qquad \tfrac{1}{2} \, . \, 2W \, . \, C_{max} - \tfrac{1}{2} \, . \, T_r \, . \, I_{max} - \tfrac{1}{2} \, . \, 2W \, . \, M_{max} \qquad (6.11)
\end{aligned}
$$

The resultant break-even point and net asset value are given in Figure 6-8.
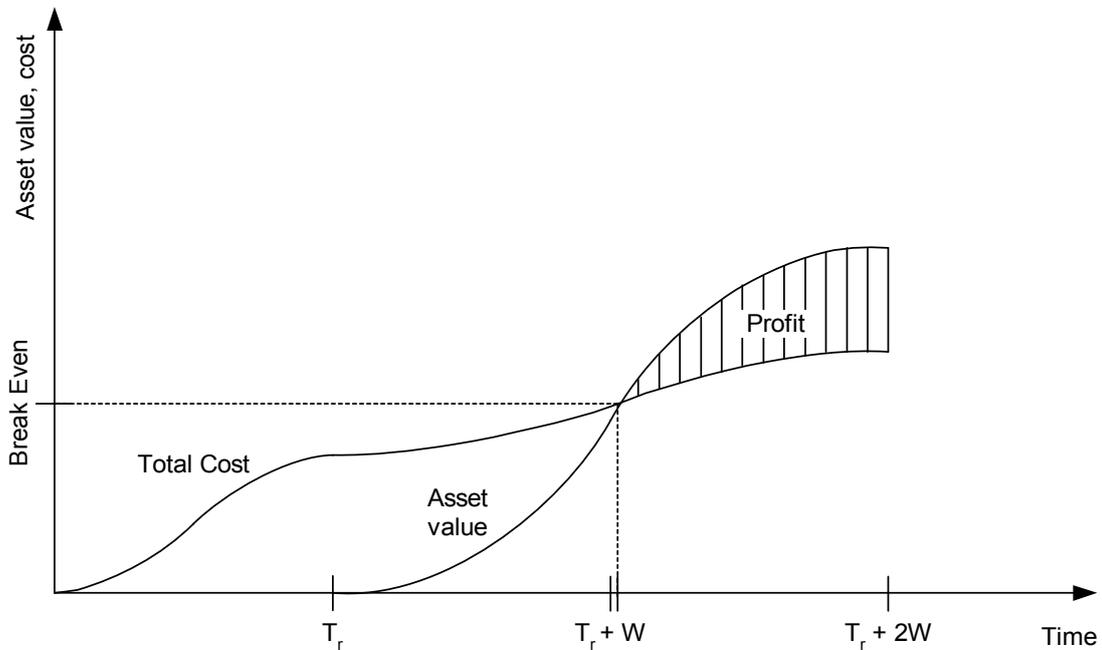
Figure 6-8: Profit Model [on-time entry]

Where a product launch does not meet its initially planned release date T_r [start of market window] but starts with a delay D, and, assuming that the peak of the market is in the middle of the product life-cycle, the three functions become:

❖ Asset value C [Figure 6-3]:
  - Product life time is equal to $2.W$, product is released at $T_r + D$, with peak C_{max}' at $T_r + W$, with $C_{max}' = [(W-D)/W] . C_{max}$.
  - Time of market entry defines a triangle, representing market penetration.
  - Triangle area equals total asset value.

❖ Development cost I [Figure 6-9]:
  - Product development time is equal to $T_r + D$, with peak I_{max}' at $(T_r + D)/2$, with $I_{max}' = [(T_r + D)/T_r] . I_{max}$.
  - Start of project at $T=0$ defines a triangle, representing development cost distribution.
  - Triangle area equals total development cost.

❖ Operational cost M [Figure 6-9]:
  - Peak M_{max}' at $T_r + W$, with $M_{max}' = [(W - D)/W] . M_{max}$.
  - Time of market entry defines a triangle, representing operational cost distribution.
  - Triangle area equals total operational cost.

This leads to the following equations:

$$C' \quad = \quad ½ . (W-D+W) . [(W - D)/W] . C_{max} \qquad\qquad (6.12)$$

$$I' \quad = \quad ½ . (T_r + D) . [(T_r + D)/T_r] . I_{max} \qquad\qquad (6.13)$$

$$M' \quad = \quad ½ . (W-D+W) . [(W – D/W)] . M_{max} \qquad\qquad (6.14)$$
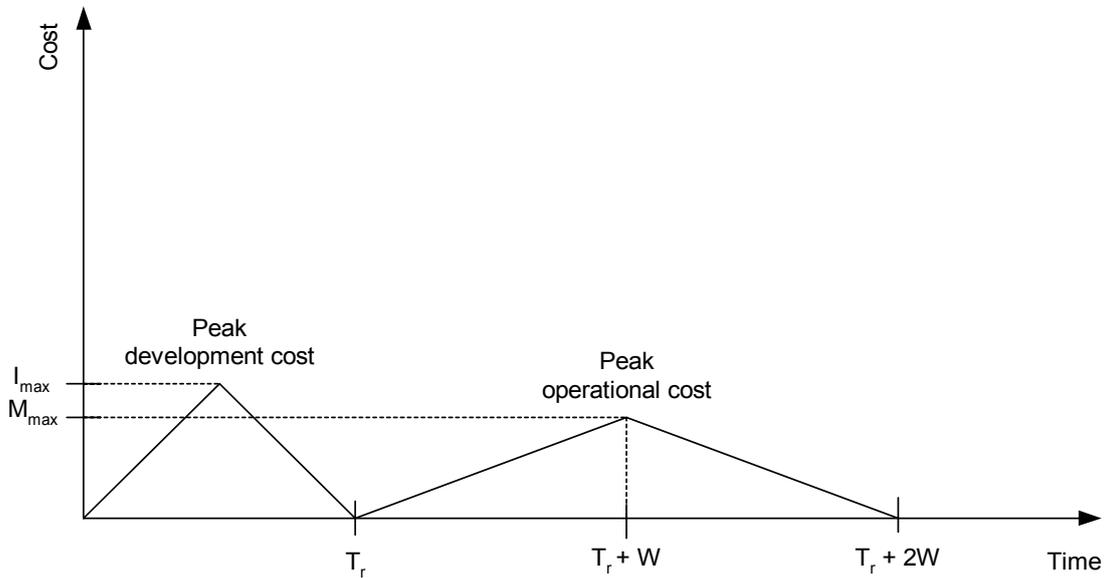

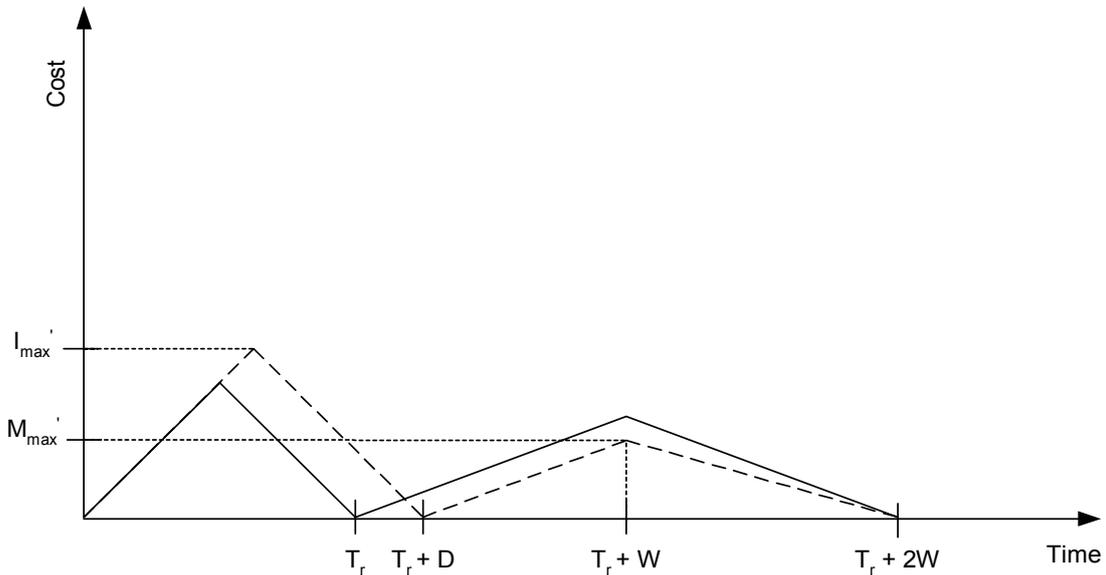**Figure 6-9: Development and Operational Cost Model [delayed market entry]**

Combining the three functions, the resulting profit, or net asset value, can be calculated:

$$
\begin{aligned}
NAV' \quad = \quad & -I' + C' – M' \\
= \quad & ½ . (W-D+W) . [(W-D)/W] . C_{max} \\
& - ½ . (T_r + D) . [(T_r + D)/T_r] . I_{max} \\
& - ½ . (W-D+W) . [(W-D)/W] . M_{max} \qquad\qquad (6.15)
\end{aligned}
$$

The resultant breakeven point and net asset value are given in Figure 6-10.
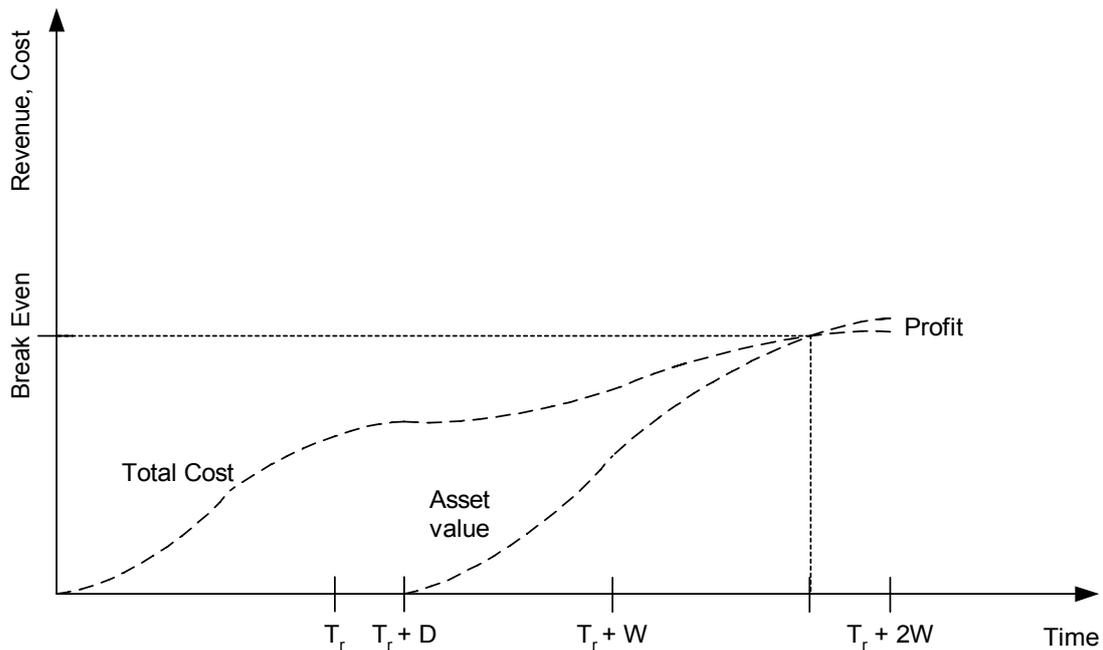

Figure 6-10: Profit Model [delayed market entry]

In Figure 6-11 an example is presented of the relative consequences of a delayed market entry on the profit or net asset value.

T_r = 50 weeks, W = 50 weeks	D = 0 wk	D = 2.5 wk	D = 5 wk	D = 7.5 wk	D = 10 wk
Asset value (C)	-	-7%	-14%	-21%	-28%
Development cost (I)	-	10%	21%	32%	44%
Operational cost (M)	-	-7%	-14%	-21%	-28%
Net asset value (NAV) (C_{max} = 10, I_{max} = 5, M_{max} = 5)	-	-25%	-50%	-75%	-100%

Figure 6-11: Consequences for Delayed Market Entry

In the next Section, the theory on capital budgeting methods and market entry trade-off models is applied to strategic software release decisions.

6.4   *Applicability to Strategic Software Release Decisions*

In theory, the model presented in the previous Section enables a software manufacturer to evaluate different software release alternatives. The model might also be used when evaluating investment decisions or when evaluating different product design alternatives. In practice, further refinements are necessary to make it more usable when comparing software release alternatives and this can be accomplished by integrating it with one of the capital budgeting methods presented in Section 6.2.

The value of expected cash inflows and outflows should be discounted back to the present, by taking into account the time value of money. Alternatives should therefore be expressed as net present values, to enable comparison. The determinants of the economic value of a software product are separated into a development and an operations phase, as in Figure 6-12:
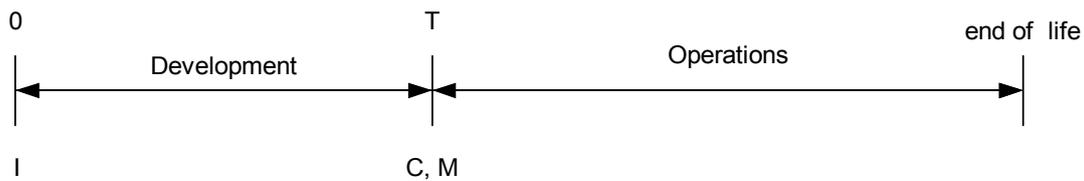
Figure 6-12: Determinants of Economic Value[60]

T is the development time or time-to-market, defined as the elapsed time between the commitment to invest in the project and the time the product is released [start of first major cash inflow from revenues or cost savings]

I is the total present value, at time *0*, of all cash outflows from the time the decision to invest is made to the product release date

C is the total present value at time T of the cash inflows that the product is expected to generate during its lifetime [revenues, direct cost savings], also called the asset value or revenue

M is the total present value at time T of all cash outflows in the operational phase [corrective and adaptive/perfective maintenance], also called operational costs

r is the discount rate representing the systematic risk in the software product.

NPV is taken as the capital budgeting method, being the discounted present value of the difference between total cash inflows and total cash outflows. NPV is the most commonly employed method for investment evaluations (Hirschey 2003, p.599). It can be calculated as the net asset value, equal to $C - M$, from which the cost of development I is deducted, with all cash inflows and outflows expressed in their present value. Equation:

$$NPV \quad = \quad -I + (C - M) / (1 + r)^{T} \tag{6.16}$$

Different alternatives can be evaluated by comparing their NPV values. Erdogmus (1999) introduces a method for comparative evaluation of software development strategies based on NPV-calculations, used to compare custom-built systems and systems based on Commercial 'Off the Shelf' (COTS) software. Erdogmus distinguishes comparison metrics for various variables that influence the NPV of a project. This method is used as the basis for the definition of a method to reflect software release decisions.[61]

Let V be a variable and let V_a and V_b denote the value of variable V for alternatives A and B respectively. A comparison metric is a function of V_a and V_b and for a specific value of a comparison metric, alternative A is said to be favourable over B if for the value of that metric the project NPV for alternative A is superior to the project *NPV* for alternative B, when everything else is equal.
Metrics distinguished are:

  ❖ *Premium*: the relative difference of two quantities [if the value of alternative A is 20% more than the value of alternative B, the premium equals 0.2]. A negative premium is a penalty.

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[60] The NPV could be further extended with a flexibility value, being e.g. the sum of the time-to-build and build option as in Section 6.2.

[61] Some definitions are adapted, and some metrics added, changed or disregarded. Some formulas used have been adapted after communication with the author. See (Erdogmus 1999) to make a detailed comparison.

❖ *Advantage*: the natural logarithm of the ratio of two quantities [for mathematical convenience and ease of interpretation[62]]. A negative advantage is a disadvantage.

❖ *Incentive*: normalized difference of two quantities to allow comparison of alternatives of variable scale. A negative incentive is a disincentive.
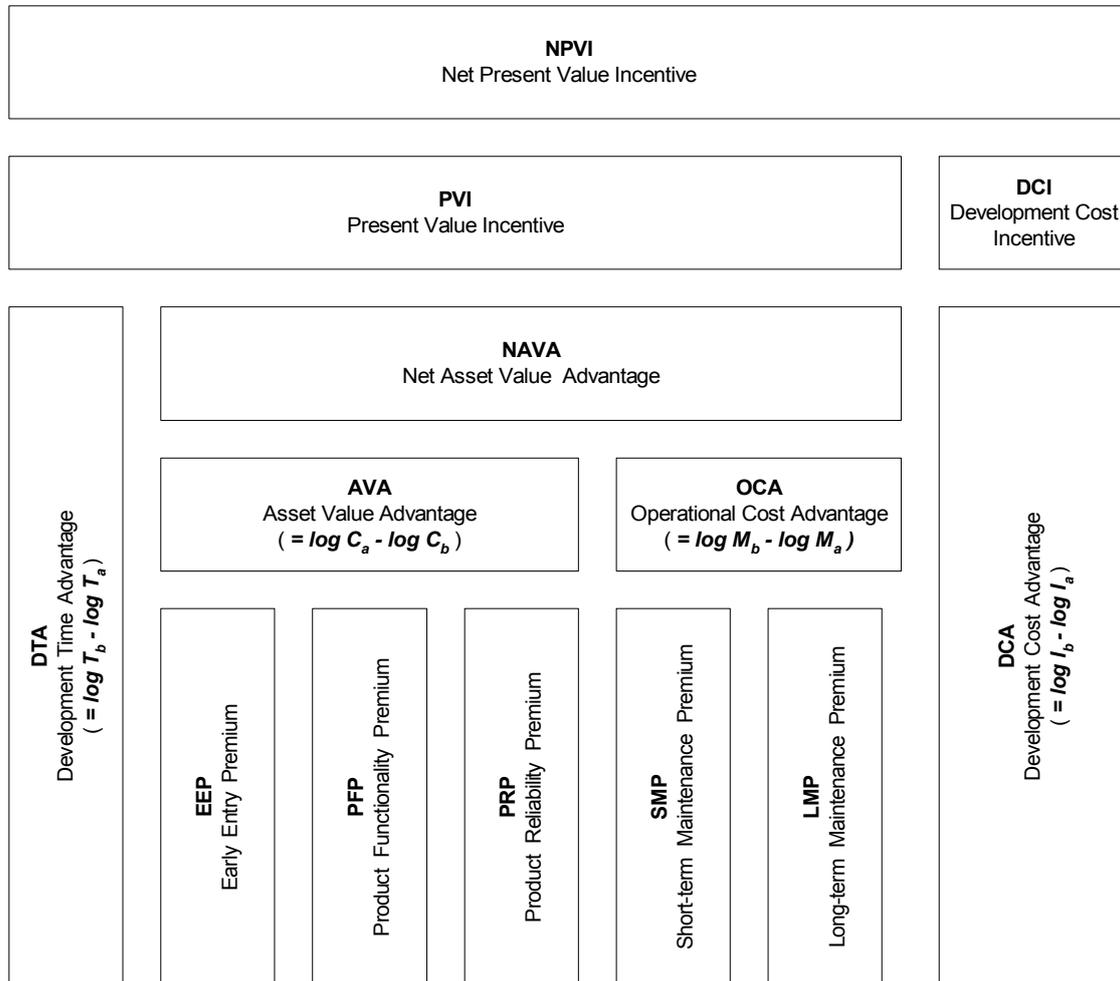
Figure 6-13: Breakdown of NPV Incentive to Lower-level Metrics
[to compare two release alternatives]

The structure of the NPV model with the breakdown into incentives, advantages and premiums is illustrated in Figure 6-13 and is explained in the remainder of this Section.

At the lowest level, two categories of premium metrics are distinguished:

❖ *Asset value premiums*. Three variables influencing the asset value are considered, namely early market entry (*EEP*), product functionality (*PFP*) and product reliability (*PRP*).

❖ *Operational cost premiums*. Two variables influencing the operational cost are considered, namely the short-term costs for corrective maintenance (*SMP*) and the long-term costs for adaptive/perfective maintenance (*LMP*).

The Asset Value Advantage *AVA* is equal to the expected increase in future cash inflows [difference between the two alternatives C_a and C_b] and is the contribution of the Early Entry Premium *EEP*, the Product Functionality Premium *PFP* and the Product Reliability Premium *PRP*:

---

[62] Some basic properties are: $e^0 = 1$; $log\ 1 = 0$; $e^{log\ a} = a$; $log\ a + log\ b = log\ (a * b)$, $log\ a – log\ b = log\ (a/b)$, $de^x/dx = e^x$. Note that when '*log*' is used here, the natural logarithm '*log_e*' or '*ln*' is meant.

$$
\begin{aligned}
AVA \quad &= \quad log\ C_a - log\ C_b \\
&= \quad log\ [\ C_b + C_b\ .\ (EEP + PFP + PRP)\ ]\ - log\ C_b \\
&= \quad log\ (\ 1 + EEP + PFP + PRP\ ) \quad\quad\quad\quad\quad (6.17)
\end{aligned}
$$

The Operational Cost Advantage *OCA* is equal to the future cash outflows savings [difference between the two alternatives M_b and M_a] when the product is transferred to the operational phase and is the contribution of the Short-term Maintenance Premium *SMP* [corrective maintenance] and the Long-term Maintenance Premium *LMP* [adaptive/perfective maintenance]:

$$
\begin{aligned}
OCA \quad &= \quad log\ M_b - log\ M_a \\
&= \quad log\ M_b - log\ [\ M_b - M_b\ .\ (SMP + LMP)\ ] \\
&= \quad log\ [\ 1\ /\ (1 - SMP - LMP)\ ] \\
&= \quad - log\ (\ 1 - SMP - LMP\ ) \quad\quad\quad\quad\quad (6.18)
\end{aligned}
$$

The Asset Value Advantage *AVA* [expected future cash inflows] and the Operational Cost Advantage *OCA* [expected future cash outflows] are combined in the Net Asset Value Advantage *NAVA*:

$$
\begin{aligned}
NAVA \quad &= \quad log\ NAV_a - log\ NAV_b \\
&= \quad log\ (C_a - M_a) + log\ (C_b - M_b) \\
&= \quad log\ (\ e^{AVA}C_b - M_b/e^{OCA}\ ) - log\ NAV_b \quad\quad\quad\quad (6.19)
\end{aligned}
$$

The Present Value Incentive *PVI* is derived from the Net Asset Value Advantage *NAVA*, taking into account the discount rate r and normalizing it to the base alternative NAV_b:

$$
\begin{aligned}
PVI \quad &= \quad [\ PV_a - PV_b\ ]\ /\ NAV_b \\
&= \quad [\ (NAV_a\ /\ (1 + r)^{Ta}) - (NAV_b\ /\ (1 + r)^{Tb})\ ]\ /\ NAV_b \\
&= \quad [\ 1\ /\ (1 + r)^{Tb}\ ]\ .\ [\ e^{NAVA}\ /\ (1 + r)^{Ta - Tb} - 1\ ] \\
&= \quad [\ 1\ /\ (1 + r)^{Tb}\ ]\ .\ [\ e^{NAVA}\ /\ (1 + r)^{\beta} - 1\ ] \quad\quad\quad (6.20)
\end{aligned}
$$

with:
$$
\beta \quad = \quad T_b\ [\ (1/e^{DTA}) - 1\ ] \quad\quad\quad\quad\quad\quad\quad\quad\quad (6.21)
$$

The Development Cost Incentive *DCI* is the normalized difference of the development cost between the two alternatives I_b and I_a considered:

$$
\begin{aligned}
DCI \quad &= \quad (\ I_b - I_a\ )\ /\ I_b \\
&= \quad 1 - (1\ /\ e^{DCA}) \quad\quad\quad\quad\quad\quad\quad\quad\quad (6.22)
\end{aligned}
$$

This leads to the final Net Present Value Incentive *NPVI*, normalized to the project scale:

$$
\begin{aligned}
NPVI \quad &= \quad (\ NPV_a - NPV_b\ )\ /\ (\ NAV_b + I_b\ ) \\
&= \quad (\ PV_a - I_a - PV_b + I_b\ )\ /\ (\ NAV_b + I_b\ ) \\
&= \quad (\ PVI\ .\ NAV_b + DCI\ .\ I_b\ )\ /\ (\ NAV_b + I_b\ ) \quad\quad (6.23)
\end{aligned}
$$

The original method was developed to compare different product development strategies for making investment appraisals. The adjusted method can be used in a similar fashion but more accurately reflects specific criteria related to a software release decision: reliability and expected short-term and long-term maintenance costs. Usage of both models is not restricted to the appraisal of initial product development strategies. They may also be used during product

development, for example, to evaluate different design alternatives or, important for this study, to evaluate different release alternatives.[63] Differences for investment appraisals are:

❖ The development costs already spent should be disregarded, as they are past and irretrievable outflows [*sunk costs*].

❖ Instead of total development time, only the time left until the release date is taken.

In Figure 6-14, an example comparing two release alternatives is illustrated: a test alternative A against a base alternative B. It is assumed test alternative has the following differences to the base alternative:[64]

❖ The product is released earlier to capture an early market-entry reward (*DTA = 0.29*).

❖ It is assumed this has a positive effect of *50%* on the cash inflows C (*EEP = 0.50*), but this effect is largely cancelled, because customers are confronted with less functionality (*20%* less cash inflows, *PFP = -0.20*) and a lower reliability level (*25%* less cash inflows, *PRP = -0.25*). The overall asset value advantage is however still positive (*5%*, or *AVA = 0.05*).

❖ It is assumed the early release, with a lower reliability level, will influence cash outflows *M* during the operational phase in a negative way: an increase of 10% for short-term maintenance costs (*SMP = -0.10*) and an increase of 40% for long-term maintenance costs (*LMP = -0.40*). This leads to a negative operational cost advantage (*OCA = -0.41*).

| Parameters	Base Alternative	Test Alternative	Name	
T: Development time	4	3	$T_b\ T_a$	
I: Initial cash outflows	100	80	$I_b\ I_a$	
C: Expected cash inflows	300	-	C_b	
M: Expected cash outflows	100	-	M_b	
r: discount rate	0.1	0.1	r	
Premiums	**Base Alternative**	**Test Alternative**	**Name**	**Value**
Early Market Entry	-	50%	EEP	0.50
Product Functionality	-	-20%	PFP	-0.20
Product Reliability	-	-25%	PRP	-0.25
Short-term Maintenance	-	-10%	SMP	-0.10
Long-term Maintenance	-	-40%	LMP	-0.40
Advantages	**Base Alternative**	**Test Alternative**	**Name**	**Value**
Development Time	T_b	T_a	DTA	0.29
Development Cost	I_b	I_a	DCA	0.22
Asset Value	C_b	315	AVA	0.05
Operational Cost	M_b	150	OCA	-0.41
Net Asset Value	200	165	NAVA	-0.19
Incentives			**Name**	**Value**
Present Value	137	124	PVI	-0.06
Development Cost	I_b	I_a	DCI	0.20
Net Present Value	37	44	NPVI	0.02

Figure 6-14: Comparison of Two Alternatives

---

[63] Sassenburg (2003) states that the appraisal of a software release decision can be seen as the re-appraisal of an earlier investment decision, probably with less uncertainty. Vice versa, the appraisal of an investment decision is the pre-appraisal of a software release decision probably with high uncertainty. Put differently, available methods or models can be applied to both decision types.

[64] Arbitrary values have been taken for the parameters *T, I, C, M* and *r*, merely to demonstrate the method.

From these assumptions, the net asset value advantage *NAVA* and the resultant present value incentive *PVI* can be calculated. The finding is that the test alternative is less attractive than the base alternative (*PVI = -0.06*). However, assuming the earlier release of the product will reduce the initial cash outflows *I* for product development (*DCA = 0.22*), an incentive for the test strategy is revealed as the Net Present Value Incentive or NPVI is positive (*NPVI = 0.02*).

The method presented also offers the possibility of performing a sensitivity analysis when one, or more, variables are changed. In Figure 6-15, the incentive for the net present value *NPVI* as a function of the development time advantage *DTA* is illustrated for different product risk values *r* [0.05 – 0.10 – 0.15 – 0.20 – 0.25 – 0.30]. Consistently increasing the product risk increases the incentive for the test alternative, especially when the development time advantage increases. Above a certain value for the development time advantage [intersection of different curves], lower product risk values contribute to a higher *NPVI*.

The method can also be used for constrained decision-making, for example, when there is a budget constraint [development cost] or a time constraint [small market window]. In such cases, calculations may, for example, be combined with the Lagrangian Multiplier Method (Thomas 1999). This method imposes a penalty on any proposed solution, proportional to the extent to which the constraint is violated. By choosing the constant of proportionality large enough, the solution can be forced into compliance with the constraint. It however requires knowledge of the relationships between the different parameters [premium metrics]. Software development cost estimations methods like COCOMO II (Boehm *et al.* 2001) may be of aid here when considering the relationship between the development time and development cost [initial cash outflows], and COQUALMO (Chulani 1999) when considering the relationship between development cost/time and reliability.[65]
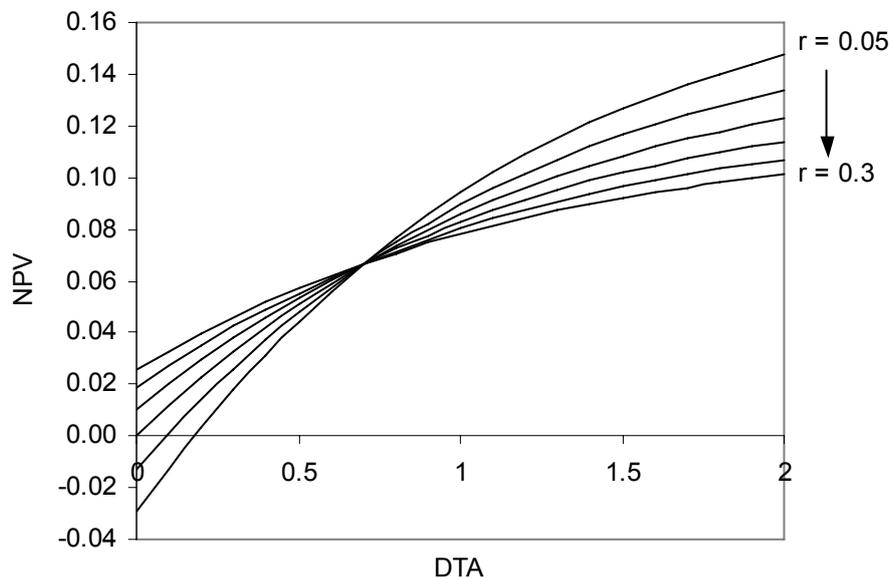
Figure 6-15: Sensitivity Analysis
[comparing NPV incentive with development time advantage
for different product risk values]

It is concluded that the NPVI-method presented here can be used to illustrate the market entry trade-off for a software product and gives an answer to the first secondary research question:

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[65] However, as pointed out in Section 4.4.1, making a strictly computational release decision must be considered a utopia; not all parameters can be quantified without uncertainties and the exact relationships between all parameters will in a practical context be unknown. This is further discussed in following Chapters.

different alternatives can be compared assuming the availability of perfect information. A valid question here is whether NPV is the most suitable approach. Comparisons of financial approaches [like NPV, PI and IRR] reveal a high degree of consistency in terms of their outcomes, but also reveal some differences like the measure of a project's attractiveness [absolute for NPV versus relative for PI], and the assumption about the reinvestment of cash flows during the life of a project [at the organization's cost of capital for NPV and PI versus at the IRR itself for IRR] (Hirschey 2003, p.606). The objective is however to model the market entry trade-off for a release decision, creating the possibility of comparing two different release alternatives. The model described offers this functionality and many differences between financial approaches do not apply in comparisons of two alternatives. It is beyond the scope of this study to build a general model integrating all the different financial approaches, or to build a single model for each individual financial approach.

6.5   Practices Identified

In the previous Sections, the focus is on capital budgeting methods and modelling the market entry trade-of, thus answering the first secondary research question. The *'Release Definition'* process area, as introduced in Chapter 5, is however not limited to modelling the market entry trade-off. This process area is concerned with the definition and control of the product development strategy, including the comparison and evaluation of alternatives meeting this strategy.

Four underlying practices are defined:

1. ***P-A1: Project Objectives.*** The importance of a product development strategy, stating project objectives and their priorities, is discussed in 3.2.1. The project development strategy is derived from *customer and end-user requirements* and *organizational requirements* [like internal standards, schedule and budget constraints]. Both types of requirements are inputs to this process area. Combined, they form the functional and non-functional requirements of the product to be developed. These requirements are used to derive a project plan, describing the project in terms of its objectives [including priorities], organization and uncertainties, and its activities and assigned resources schedule [schedule and resource planning]. From this plan, the *release criteria* can be derived; as can the *project deliverables*. These are considered outputs from this process area to other process areas. The definition of the project objectives takes place during the project proposal phase. Different alternatives might be compared, using the derived NPVI-method in Section 6.4, by determining their incentives when compared to a base alternative.

   The correct implementation of this practice is the responsibility of all stakeholders involved: Senior Management at strategic level and Project Steering Committee at a tactical level.

2. ***P-A2: Project Control.*** In the early phases of the development of a new product uncertainties will be present. As discussed in Section 3.2.2, the unpredictable nature of product development, and dynamics in the external market environment, force an organization to continuously revisit the initially-formulated development strategy. These uncertainties might lead to changes in the initially-defined product development strategy, as confirmed in the case studies (Section 4.4.1). The progress of the project should be monitored against planning, taking into account the *implementation status* of the identified project deliverables. This is an input to this process area. The resulting *project status* is an output from this process area; reported to the controlling organ. Appropriate action, like the redefinition of project objectives, should be taken for significant deviations from the plan. The control of the project takes place after the investment appraisal until the release decision.

The correct implementation of this practice is considered to be the responsibility of Development, assigned to execute the project. Progress with the operational plan will normally be discussed in the Project Steering Committee, but progress made on important milestones will also involve Senior Management.

3. ***P-A3: Uncertainty Management.*** In Section 4.4.3 it is concluded that one of the characteristics of software release decisions is uncertainty. The presence of complete uncertainty is identified, as the chance of occurrence of different scenarios could not be quantified with probability or possibility values. The objective of pro-active uncertainty management is to meet the product development strategy by decreasing the likelihood that future events may cause adverse effects. The management of uncertainties takes place after the investment appraisal until the release decision. The derived NPVI-method in Section 6.4 might be combined with a sensitivity analysis, or a Monte Carlo simulation, to analyse how sensitive the NPV is when variables are changed due to uncertainty. This may be of special interest when comparing different alternatives (see P-A4). Application of the real options approach, as discussed in Section 6.2, might be considered here, as it is considered a managerial approach for dealing with uncertainties.

The correct implementation of this practice is considered the responsibility of Development; assigned to execute the project. Progress in managing uncertainties identified is normally discussed in the Project Steering Committee, but progress made on important milestones will also involve Senior Management.

4. ***P-A4: Selection of Alternatives***. A project is faced with important decisions, especially in its early phases. An example is the selection of the design or architecture of the product, although the case studies show this is not a common practice in industry (Section 4.4.2.). Different alternatives might have different outcomes on the extent to which project objectives, defined in the product development strategy, are met. Alternative A might, for example, be attractive in bringing a product to the market early [short-term], but alternative B might be more attractive for future enhancements of the product [long-term].[66] The availability of a product development strategy, reflecting the latest insights, enables the selection of different project and product alternatives. The selection of alternatives takes place after the investment appraisal until the release decision, with the selection of a design or architecture and the comparison of different release alternatives as important activities. The derived method in Section 6.4 might be used to make a quantitative comparison by determining the NPVI [Net Present Value Incentive].

The correct implementation of this practice is considered the responsibility of Development and Maintenance & Exploitation. Motivation is that different alternatives will often reveal controversial issues between short-term and long-term objectives. Meeting short-term objectives will in general be more attractive to Development, whereas meeting long-term objectives will normally be more attractive to Maintenance & Exploitation. Where no compromise can be found, or where the product development strategy is severely undermined, Marketing and Senior Management may well become involved.

A requirement for all practices described is that initial values (P-A1), and actual values (P-A2), of the dimensions in the product development strategy, the identified uncertainties including the measures taken (P-A3), and the decisions made when selecting alternatives (P-A4), are documented, in describing the project history. The rationale is discussed in Chapter 9.

In Figure 6-16, the data-flow-diagram of the *'Release Definition'* process area is illustrated, and in Appendix F, a summary of the process area is given, including examples of supporting method(s) that can be used for the implementation of each practice.

---

[66] Note that comparing different product development strategies is covered by P-A1.

customer/end-user
requirements

organisational
requirements

project status

project
deliverables

**Release
Definition**

implementation
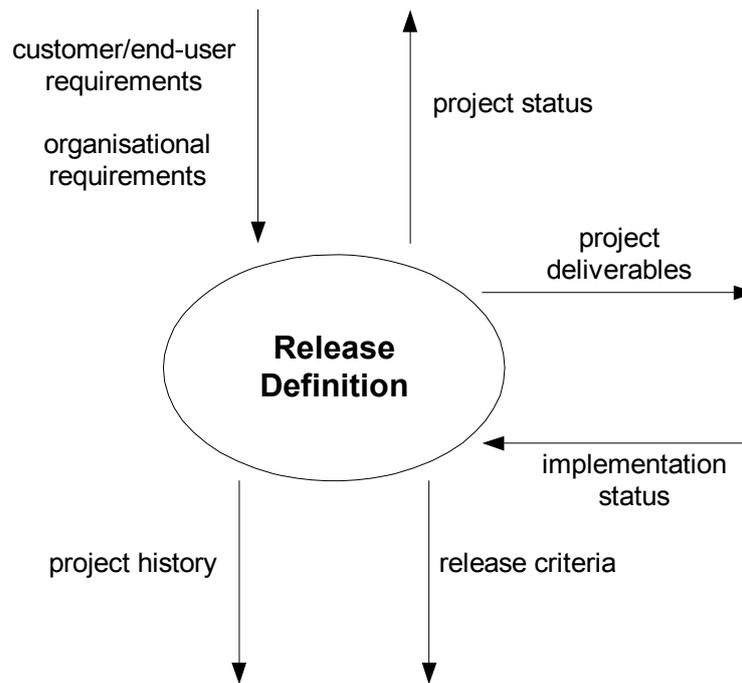status

project history

release criteria

Figure 6-16: Data-flow Diagram *'Release Definition'* Process Area

In Appendix F, a summary of this process area is given including examples of supporting method(s) that can be used for the implementation of each practice.

6.6   *Summary and Conclusions*

The first process area of the framework, *'Release Definition'*, as presented in Chapter 5 is discussed. An overview is given of existing capital budgeting methods to appraise investment decisions. This is important as the suggestion is raised that such methods could possibly also be used to model the market entry trade-off, prior to a release decision, by comparing the evaluation outcomes of different alternatives.

Product life-cycle models, frequently used in the semiconductor industry, are introduced to demonstrate the effects on revenues of a delayed market entry: a triangular model and a triangular model with a saturation period. These models are extended with cost functions for pre-release development costs and post-release operational costs.

Based on these models, a method is defined using the NPV capital budgeting method. Using this financial approach, and taking into account the discounted value of money, the NPVI-method is defined where the difference between two alternatives is expressed in a single variable. This variable, called the Net Present Value Incentive, is calculated from various underlying metrics, and measures the economic incentive to favour one alternative over another. The metrics are classified into premium metrics at the lowest level, advantage metrics at the medium level and incentive metrics at the highest level. This method allows the comparison of different alternatives during different project phases, including release alternatives. This method with the hierarchical metrics framework offers the possibility of analysing the sensitivity of the higher-level incentives to variations in medium-level advantages and lower-level premiums.

How to model the market entry trade-off for a software product? This is the 1st secondary research question, which is answered in this Chapter. The method presented can be used for the

economic valuation of different market entry or release alternatives. The method can, furthermore, be extended, for example, by including flexibility Ω as an incentive. This incentive measures the contribution of the strategic flexibility of a test strategy to its base NPV under uncertain conditions. This flexibility may, for example, exist for a time-to-build [staged investment] and/or growth options [follow-on projects] as advantages, or premiums at a lower level. The resulting equation for the NPV becomes in this case:

$$NPV \quad = \quad -I + (C - M) / (1 + r)^{T} + \Omega \qquad\qquad (6.24)$$

Use of the method is not restricted to specific manufacturer types. Environmental and internal conditions for a software manufacturer will determine the market, or demand, window and will affect the expected cash inflows and outflows. The underlying method is not influenced. A final remark is necessary. Applying the method presented means that all costs and benefits are quantified in monetary terms, including the costs of possible fatalities and injuries in, for example, safety-critical systems. It is however difficult, if not impossible, and may even be unethical, to place any sort of value on human life.

For the *'Release Definition'* process area, reflecting the perspective of maximizing behaviour, four practices are derived. The 'P-A1: Project Objectives' practice concerns the definition of the product development strategy prior to the investment appraisal. When the project is launched, the 'P-A2: Project Control' practice monitors the project's progress towards the accepted product development strategy. The 'P-A3: Uncertainty Management' practice concerns the identification of sources of uncertainty and the implementation of appropriate measures to reduce, or even eliminate, uncertainties towards ensuring the product development strategy is met. Finally, the 'P-A4: Selection of Alternatives' practice concerns the analysis of which alternative is favourable in meeting the product development strategy, taking into account the effect of uncertainties identified.

In the next Chapter, limitations on the concept of maximizing behaviour are discussed.