Strategic Metrics for Product Development at Ford Motor Company

by

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Abstract

This thesis aims at developing a practical method to adjust product development metrics, which will enable effective management of the product development (PD) process. A set of good metrics is crucial to the success of a product, as metrics direct the development process by driving the actions and decisions of the PD team members which in turn define the product. Emphasizing or "weighting" certain metrics more than others can make the difference between success and failure. Through empirical exploration of metrics we seek to determine the weights, and the impact of different metrics on product success.

Unlike its use in the engineering literature, the management use of the term "metric" includes both quantitative and qualitative measures which the PD team members can influence through their efforts. The theory used to determine the correct weight of a metric has its roots in the principles of Agency Theory and has been developed by "engineering" the theory to obtain two key parameters which define the weight of a metric. These two parameters are "leverage" and "risk discount factor" (RDF). Leverage is the amount by which a metric can impact the profitability of a product and RDF takes into account the inherent risk averse nature of the PD team members that influence their decisions.

In order to evaluate the PD metrics and their weights within a firm, data was collected for a set of metrics across 17 programs at Ford Motor Company. The values for each metric were assigned based on information obtained through program documentation and interviews with multiple team members across various functions within the organization. Different success measures were collected and the impact and leverage of each metric was determined through empirical exploration of the various relationships.

The key findings to date include:

- Cronbach's Alpha for metrics regrouped using factor analysis average 0.7 demonstrating internal reliability.
- Customer satisfaction correlates significantly with the rigor of the PD process, and internal coordination and communication between the core team and the other members of the value chain.
- Time to market shows consistent correlation with profit and profit residuals.
- The calculated weights suggest higher emphasis on capturing manufacturing need and using robust design practices, technology, and differentiation will increase profitability.
- The measured RDF does not change the relative weightings of the metrics as obtained through the leverage calculation.

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My experience at MIT was much more than I had hoped for when I came here two years ago. This research has contributed tremendously to my learning and I feel I am a richer person because of it. It would be an understatement to say how grateful I am to all the people who helped me and contributed to making this possible.

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Chapter 1: Introduction

This chapter discusses the motivation and the theoretical background to this thesis. The layout of the rest of the thesis is briefly described.

1.1 MOTIVATION AND OVERVIEW

1.1.1 Motivation

Developing new products, capturing and retaining market interest has become essential for survival for all companies. New product development, which many years ago had been just another function of an organization, today differentiates the winner from the loser, in a marketplace which is not only extremely fast paced but also very discerning and impatient. This has necessitated the need to measure and control the product development process to ensure that the end product is exactly what the customer wants in every possible way.

Metrics, therefore, have become an integral part of the product development process. Unlike many other processes, measuring the product development process is a challenge because of the enormous complexity associated with it. Developing a moderately complex product involves a large number of people, parts, drawings, and numerous decisions (Ulrich and Eppinger, 1994). The detailed knowledge of these activities and the expertise rest only with the Product Development (PD) team/s and therefore, it is next to impossible for upper management to observe and dictate all the actions and decisions. The challenge for upper management then becomes to set "strategic priorities" which will define and guide the right actions and decisions so as to maximize long term profits.

The Center for Innovation in Product Development is sponsoring an ongoing research effort to help define the theory and practical methodology, which will address this challenge. The goal is to provide an adaptive system by which a firm can realign its metrics such as customer satisfaction, time to market, and platform reuse so that PD teams know how to make the detailed tradeoffs that will maximize the long-term profitability of the firm. This goal has been the motivation for this thesis research.

1.1.2 Overview of This Thesis

This thesis is organized as follows:

The rest of Chapter 1 will discuss the theoretical background to this study, how the theory has been made practical, and prior work done in this field.

Chapter 2 will describe the context of the Site Company, Ford Motor Company, and the experimental design and measurement strategy.

Chapter 3 will describe the actual data collection process at Ford. This will also describe the information sources for the data, and lessons learned.

Chapter 4 will discuss in detail the scales and rules used to quantify the measures studied. This will be augmented with Ford specific observations and examples.

Chapter 5 will detail the analysis of the Ford data, present key findings and discuss directions for future research.

1.2 THEORY

1.2.1 Metrics and Their Incentive Role

The word metric, as understood by most engineering organizations, is something that can be precisely measured. This leads to the rejection of judgmental measures as metrics because of high measurement error associated with them. Although, low measurement error is a good quality of a metric, the precision with which the metric can measure the "right" outcome takes precedence. Therefore, a precise metric can be precisely wrong whereas a vague measure can be vaguely right. An example is the number of hours of training that a PD team undergoes. This is very easy to measure but using it, as an indicator of a successful product can be precisely wrong if the training imparted was not the right one. On the other hand it is more difficult to measure the number of hours in the right form of training. There often exists a tradeoff between the two.

Metrics mainly perform three different functions:

1. Evaluate past performance: Namely, "How did we do?"
2. Evaluate current status and predict future outcome: Namely, "Where are we and where are we going?"
3. Motivate future action: Namely, "What should we be doing?"

Prior work done on Research, Development and Engineering (R, D & E) metrics have shown that the same set of metrics cannot be used for all three purposes (Hauser, 1992). However, the three are interrelated through a feedback loop described as "you are what you measure" (Hauser and Katz, 1998) as described and illustrated below:

> If a firm measures a, b, and c, but not x, y, and z, then managers begin to pay more attention to a, b, and c. Soon these managers who do well on a, b, and c are promoted or are given more responsibilities. Increased respect and perhaps, bonuses follow. Recognizing these rewards, managers start asking their employees to make decisions and take actions that improve the metrics. (Often they don't even need to ask!). Soon the entire organization is focused on ways to improve the metrics. The firm gains core strengths in producing a, b, and c. The firm becomes what it measures....
>
> If maximizing a, b, and c leads to long-term profits, the metrics are effective. If a, b and c leads to counterproductive decision and actions, then the metrics have failed. But it is even worse! Once the enterprise is committed to these metrics, the

metrics gain tremendous inertia. Those who know how to maximize a. b, and c fear to change course. It is extremely hard to refocus the enterprise on new goals. The firm becomes what it measures. (Hauser and Katz, 1998)

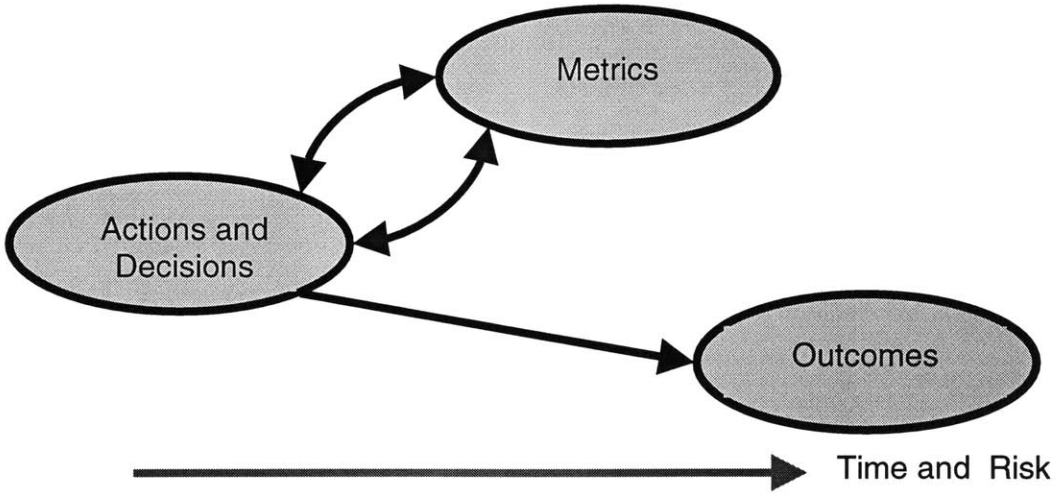

Fig 1.1 "You are what you measure" © John Hauser

The aim of this thesis is to explore the incentive implications of metrics in the PD setting and develop a methodology which will enable the selection of a set of metrics that create the best incentives for a PD team. In order to do so, we will define "metric" as a measure, which can be impacted by the effort of the PD team members and hence create incentives for them. This will include measures that are judgment based. We will call measures which the PD team cannot impact - "covariates". This distinction is not set in stone, as depending on the viewpoint and the level of decision making a covariate can be a metric or vice versa. We will explain the rationale as we go along.

1.2.2 Selection of metrics

As illustrated by Baker (1992) under information asymmetry if the selected performance measures do not predict outcome i.e. if the effect of effort on the performance measure is not the same as that on the outcome measures, incentives based on the same performance measure lead to imperfect results. PD teams know much more than management does. This creates information asymmetry and in turn introduces certain issues with the selection of a set of metrics.

1. Profit: Tying metrics to market outcomes may not always give the best result as has been seen in R, D & E settings (Hauser, 1998). Although the end goal is to increase long term profitability of the firm, it can create a short-sited approach or create a better product at the expense of another.

2. Cost of measurement: More is not always better. A large number of metrics can reduce the error variance per metric but it is also expensive for an organization to

measure too many things as it reduces the amount of productive time spent in the actual task of product development. Thus, one has to be careful about adding metrics and should do so only if it increases productivity.

3. Risk: Individual members of the PD team and hence the team itself is likely to be risk averse relative to the publicly traded firm. Therefore, the team will prefer those metrics over which they have greater control and discount those over which they do not. Judging the team working on the power train of a car on the overall customer satisfaction which can be impacted by a variety of other things, vs. judging them on the customer satisfaction related to the power of the engine and ride of the car may lead to counterproductive results.

1.2.3 Making the theory practical

The discussion below is based completely on the work done by Prof. John Hauser and others in the Sloan School of Management and is drawn from Hauser, (1999). The Baker-Gibbons model of Agency Theory has been modified and augmented to provide insight into the practical problem of selecting metrics for product development.

Making the theory practical required four major challenges to be overcome:
1. The theory should fit the entire PD organization vs. individual projects within the organization even though each project may differ from the others.
2. An adaptive control method should be developed to use information about the current system so that suggested changes in priorities converge to "optimal" priorities.
3. The constructs in the equation should be measurable in a practical real world setting.
4. Estimation procedures must be developed to determine simultaneous changes in the priorities applied to multiple metrics.

Unlike Holmstrom's (1979) classical interpretation where metrics are noisy indicators of output, here the metrics are measures such as time to market and customer satisfaction which are directly impacted by the PD team's actions and decisions. The objective is to develop a set of metrics, which induce the team members to take the right actions and make the right decisions. What follows is an overview of the development of the theory. For a more detailed discussion of the derivations in sections 1.2.3.1 and 1.2.3.2, please see Appendix A

1.2.3.1 A Single PD project

Let us first take a single PD project. The team has to expend various types of effort such as capturing the Voice of the Customer (Griffin and Hauser, 1993), designing the product and system interfaces etc. Each metric is a noisy measure that depends on the team's effort and we can represent this as

1. $\tilde{m}_i = m_i(e_1, e_2, ..., e_L) + error_i$

   Here e_ℓ is the amount of effort of type ℓ and $\tilde{m}_i$, is a noisy measure that depends on the team's efforts.

The error is a zero-mean normal random variable with variance σ_i^2. The team incurs some cost $c(e_1, e_2, ..., e_L)$ but top management does not easily measure this cost, as it is difficult for them to observe it.

Continuing with the incentive implication of metrics we can represent the reward function as:

2. $rewards = w_0 + w_1\tilde{m}_1 + w_2\tilde{m}_2 + w_n\tilde{m}_n$

   where w_0 is the base salary and w_1, w_2 ...w_n, is the "weight" put on the corresponding metric.

The weight is set when the firm sets certain policies or emphasizes certain priorities over others. Although this relationship is rarely linear, a linear approximation works for a fairly homogeneous set of PD projects.

We assume that the PD team is constantly risk averse with respect to the firm and the measurement errors are uncorrelated. This leads to the team maximizing the following certainty equivalent (Keeney and Raiffa, 1976):

3. $c.e. = w_0 + w_1\tilde{m}_1 + w_2\tilde{m}_2 + w_I\tilde{m}_I - c(e_1, e_2, ..., e_I) - \frac{1}{2}rw_1^2\sigma_1^2 - \frac{1}{2}rw_2^2\sigma_2^2 - ... - \frac{1}{2}rw_I^2\sigma_I^2$

   where r is the risk aversion constant and describes the degree of risk aversion. A higher value of r means the team is more risk averse.

The firm will choose to maximize its profits based on the following equation:

4. $net\ profit = \pi(e_1, e_2, ..., e_L) - w_o - w_1\tilde{m}_1 - w_2\tilde{m}_2 - ... - w_n\tilde{m}_n$

   where $\pi(e_1, e_2, ..., e_L)$ is the "incremental" profit due to the "incremental" effort of the PD team.

Here the firm will set w_0 only as high as required to keep the team members from leaving. The firm's revised profit equation now can be written as

5. $\max net\ profit = \pi(e_1, e_2, ..., e_L) - W_o - c(e_1, e_2, ..., e_L) - \frac{1}{2}rw_1^2\sigma_1^2 - ... - \frac{1}{2}rw_n^2\sigma_n^2$

Maximizing equation 3 and substituting the solution in equation 5 under the assumption that the metrics are "targeted" i.e. each metric is affected by a single type of effort, we obtain the following equation:

6. $$w_i^* = \frac{\left(\frac{\partial \pi}{\partial e_i^*}\right) \Big/ \left(\frac{\partial m_1}{\partial e_i^*}\right)}{\left[1 + \left(r\frac{\partial^2 c}{\partial e_i^2}\right)\left\{\sigma_i \Big/ \left(\frac{\partial m_i}{\partial e_i^*}\right)\right\}^2\right]}$$

   where w_i is the optimal weight of the metric.

Here the numerator term is the "leverage" because it represents the marginal change in the profit due to effort relative to the marginal change in the metric due to the same effort. This suggests that the firm should weigh metrics which have a high marginal effect on profit more than others. The denominator is made up of two terms. The risk/cost term is a reflection of the scale on risk aversion and the scale on cost. The term in { }

which can be defined as the Signal-to-Noise ratio. σ_i, represents the magnitude of the error or noise and $\partial m_i / \partial e_i^*$ represents the scale of the errorless signal from the metric.

1.2.3.2 Multiple PD projects

It is not feasible to set metrics for individual projects and hence the following linear quadratic model is developed which will ensure that the sum of the profits across various projects is maximized.

7. $\tilde{m}_{ij} \cong k_{ij} + \alpha_{ij} e_{ij} + error_{ij} \qquad c_{ij} \cong k_{ij}^c + \frac{1}{2} b_{ij} e_{ij}^2 \qquad \tilde{\pi}_{ij} \cong k_{ij}^{\pi} + \beta_{ij} e_{ij} + error_{ij}^{\pi}$

where $k_{ij}, k_{ij}^c, k_{ij}^{\pi}$ are constants, $\alpha_{ij} = \partial m_{ij} / \partial e_{ij}, \beta_{ij} = \partial \pi_{ij} / \partial e_{ij}$, and $b_{ij} = \partial^2 c_j / \partial e_{ij}^2$

As the constants do not affect the maximization, they are ignored. For a group of projects the optimal result is as follows:

8. $$w_i^o = \frac{\frac{E_j[\beta_{ij}]}{E_j[\alpha_{ij}]} + \frac{\mathrm{cov}(\alpha_{ij}, \beta_{ij})}{E_j[\alpha_{ij}]}}{1 + \frac{\mathrm{var}(\alpha_{ij})}{E_j^2[\alpha_{ij}]} + \frac{r \sigma_i^e b_i}{E_j^2[\alpha_{ij}]}}$$

With further transformations, Equation 8 becomes:

9. $$w_i^o = \frac{E_j[\pi_{ij}^o] / E[m_{ij}^o]}{1 + 2\left[\frac{E_j[rewards_j] - E_j[c.e._j]}{E_j[rewards_j]}\right]}$$

The term in the brackets is called the Risk Discount Factor (RDF) and is defined as the amount by which the team will discount the real, risky rewards relative to a situation where the reward is guaranteed given a certain set of priorities. It is possible to measure RDF by constructing a survey instrument. The numerator term is the leverage and $E_j[\pi_{ij}^o]$ is the "incremental" profit due to the metric driven actions. This is still difficult to measure, therefore with further transformations the final equation can be represented as

10. $$\hat{w}_i^o = \frac{\hat{\lambda}_i}{1 + 2RDF_i}$$

where $\hat{\lambda}_i$ is the regression estimate of metric i. As in equation 6, with the increase of the leverage, the weight or emphasis on the metric increases.

1.3 PRIOR WORK

The desire to understand and develop effective PD metrics, which can successfully predict outcomes, has fuelled many studies. McGrath and Romeri (1994) introduced the R&D Effectiveness Index - the ratio of the revenue from new products due to R&D to the amount spent on R&D, as a metric which could be used successfully to measure the overall success of PD. They studied 45 electronic systems companies.

Nobeoka and Cusumano (1997) conducted a study of 210 projects in the automobile industry to understand some success factors behind multi-project PD. They illustrated that platform strategy, leveraging technology across platforms, and the speed and level of concurrency at which the design is transferred to other overlapping projects determine the success of products.

House and Price (1991) wrote about using a "Return Map" very successfully at Hewlett-Packard to track PD teams. This map was a two dimensional graph with costs and revenues plotted vs. time over the PD process. Every team spent considerable time in the beginning to sketch out a map and then tracked it over time ensuring that any deviation was well discussed and understood instead of avoiding the issues and letting them escalate.

Other studies have included the study of new PD projects across companies and industries conducted by Cooper and Kleinschmidt (1987) to determine what distinguishes a failure from success. They found that many aspects of PD such as "product advantage, proficiency of predevelopment activities" correlated significantly with success measures.

Pien (1997) and later Kim (1998) studied the correlation between metrics and success in R&D settings. Pien successfully demonstrated strong correlation between success and summed measures at the Charles Stark Drake Laboratory, as did Kim at LG Industries in Korea. Their study did not distinguish between effort-based measure and non-effort based measures.

Lafountain (1998) studied the problem from an incentive perspective focusing on selecting and weighting a set of effort-based metrics within a single firm. He found strong correlation between customer satisfaction and profit and profit residuals as between time to market performance and overall success. Further analysis of the same data (Hauser, 1999) showed that greater emphasis on customer satisfaction definitely bore well for the firm however the firm was over emphasizing "reuse", and had just the right emphasis on time to market.

This thesis research is an extension of the study conducted by LaFountain. The aim is not only to compare data across industries but also to corroborate the theory as discussed in Sections 1.2.3.1 and 1.2.3.2.

1.4 GOALS

This study is exploratory in nature and has the following four goals:

1. To select and explore a set of metrics within a single PD organization to determine the current emphasis or weights on those metrics
2. To then determine how those weights could be changed to lead to better outcomes.
3. To continue testing the theory and look for empirical evidence that test the current assumptions
4. To compare data across industries.

The Site Company for this study is Ford Motor Company, Dearborn, Michigan.

Chapter 2: Ford Context and Experimental Methodology

This chapter is a brief overview of the product development process at Ford Motor Company and the empirical methodology.

2.1 FORD: THE PRODUCT DEVELOPMENT CONTEXT

The Ford Product Development System (FPDS) governs the product development process. It consists of 4 major phases. Each of the phases has it's own program events and deliverables. Each of these deliverables has to be met before a program can "graduate" to the next event or phase. For confidentiality reasons the details of these events or the deliverables will not be discussed. What follows is a generalized interpretation.

2.1.1 The product definition phase

This is the front end of the PD process wherein the feasibility of the program, the market and customer requirements are defined and agreed upon. The scope and strategy for the program are finalized, overall targets are set and handed over to the program team. Thus the direction and impetus are determined. Resource commitment also occurs during this time. The program team then works on defining and fine-tuning these strategies and on creating detailed targets and laying out the basic framework for the program to move ahead.

2.1.2 The design phase

This phase is where the team takes the data from the first phase to define and design technical requirements such as quality, engineering, technology, style etc. Due to the system engineering emphasis of FPDS this phase is not only well grounded in the customer and market requirements but also on a top down approach. All the detailed design and development activities are carried out. Building in reliability is a big component of this phase. Manufacturing is an integral part of the process, as are the suppliers. Thus, this is the phase where concepts become reality.

2.1.3 The verify and launch phase

This is the final phase in the product development process. The designed product is now tested very rigorously using software tools as well as through prototype. Sample market tests are also conducted and any changes are made during this time. The design is then frozen and all the tested and validated manufacturing tools, technology, parts are put into production. The vehicle is now ready to be manufactured and sold.

2.1.4 The manage phase

This phase spans the entire process and is the task of project management. This provides overall support to the three phases and takes care of coordination and communication as

well as maintaining the necessary documentation, and tracking resource allocation. In other words, this phase can be defined as the very foundation, which builds and facilitates the processes of all the other phases.

2.1.5 FPDS vs. WCP

Prior to FPDS, the World Class Process (WCP) governed product development. Although WCP was very similar to FPDS, the process contained lesser program events and it lacked the rigorous front-end activities, which characterize the FPDS process. It also had a less aggressive timeline. Most of the programs in this study followed the WCP events and timeline.

2.1.4 FPDS Metrics

Ford has a set of "metrics" which are used to track product programs. Almost all of these metrics are very easily quantifiable. These metrics are individually defined for the role and level of responsibility within the PD team and at every program event. As an example, checking whether targets are set in the first phase of FPDS is a "yes/no" metric for the Project Manager. All metrics may not be numerical measures but they all have a very objective focus.

2.2 EMPIRICAL METHODOLOGY

2.2.1 Metric and Covariate selection process

This study examines 9 high-level metrics and 5 high-level covariates. Except for one metric, each of these measures in turn is composed of a sum of low-level measures. This methodology was followed due to two major reasons. For a limited sample of programs, summation of low-level measures into high level measures allows for a more powerful statistical analysis. Also, low level measures with un-correlated measurement error when summed lead to a more robust higher level measure (Hogg and Tanis, 1997).

The list of measures was chosen based on the deliverables, goals and the driving philosophy of the FPDS process program events and milestones. This list was validated through discussions with senior managers very familiar with the process. This list, although not exhaustive, was judged to encompass the core elements of the FPDS process.

Table 2.1 contains the final list of metrics and covariates for which values were collected. Chapter 4 will discuss each measure in detail.

2.2.2 Measurement methodology

As seen in Chapter 1, profit is one of the major drivers of leverage. Therefore the programs targeted in this study had to be ones which were already in the market. Thus,

the metrics and covariates were collected from historical data. The main sources of data were:

- Existing program documentation
- Interviews with program team members.
- Surveys for "overall success" and RDF

Table 2.1 List of Measures

HIGH LEVEL MEASURE	LOW LEVEL MEASURE
Metric 1: **Understanding of Markets and Customers**	• Ford's experience in this market • Effort undertaken by team to study market characteristics • Thoroughness of team's market understanding • Effort to gather customer requirements • Effort to understand needs of the distribution channel
Metric 2: **Product Designed for Market Needs**	• Product achieves intended differentiation • Product fills a gap in Ford's Product Line • Attention paid to compliance with Regulatory, Environmental, and Industry Standards • Compliance with standards
Metric 3: **Product designed for advantageous relationship with other products**	• Degree of differentiation from competitive vehicles in this segment • Degree of differentiation from own vehicles in this segment • Vehicle platform is flexible, robust • Product leverages platform elements well • Reuse by this product of previous product elements • Expected reuse from this product
Metric 4: **Rigor of Design Process**	• Design Process consideration of manufacturing capability • Design process consideration of sales • Design process consideration of service • Use of robust design practices
Metric 5: **Appropriate Technology Selection**	• Ford's advantage in technology with this product • Richness of technology options • Maturity of technology • Technology is implementation ready • Architecture of product allows easy integration of new technology
Metric 6: **Coordination and Communication**	• Level of Coordination Achieved within team • Level of Coordination Achieved between

HIGH LEVEL MEASURE	LOW LEVEL MEASURE
	team and internal value chain partners • Level of Coordination Achieved between team and external value chain partners • Documentation of program • Quality of integrated plan • Number of Major Issues assessed at Milestone review
Metric 7: **Health of Relationships with Suppliers, Partners**	• Reliance on external suppliers for development of product • Health of relationships with existing suppliers • Confidence in delivery by suppliers already selected • Flexibility in selection of suppliers • Early selection of suppliers • Maturity of relationship with suppliers
Metric 8: **Time To Market Performance**	• Schedule overshoot
Metric 9: **Customer Satisfaction**	• 1st quarter customers satisfied with Overall Vehicle • Things Gone Wrong • 1st quarter customers very satisfied with 0 TGW
Covariate 1: **Product Fits with Ford**	• Product fits with Ford's image • Product aligns with corporate strategy and core competencies • Product is grounded in marketing plan
Covariate 2: **Size of Strategic Opportunity**	• Strategic market advantage to be gained • Strategic technology advantage to be gained
Covariate 3: **Size of Financial Opportunity**	• Expected Lifetime Profit • Return on Investment • Expected Sales • Expected Revenue
Covariate 4: **Availability of Resources**	• Resources available for continuance • Skills available for continuance
Covariate 5: **Coordination Difficulty of Team**	• Core Team Size • Extended Team Size • Core Team Dispersion • Extended Team Dispersion

This list consists of both quantitative and qualitative measures. For the qualitative measures, an approximate scale was developed (1 to 5) and values were assigned for each

program studied based on the information available. The scales were defined based on the type and amount of information available, and the practices at Ford. The scales and their rationale are explained in greater detail in Chapter 4.

2.2.3 Program Selection

In order to collect values of all the measures, the programs selected not only had to be completed and in the market for some time but also had to have the information still available. This and the requirement of a good number of programs to ensure statistical robustness in the analysis proved to be a challenge in the selection of programs.

As it was not possible to satisfy these criteria within one division of Ford, programs were selected from 3 different divisions and spanned 6 vehicle segments. A total of 18 programs were selected, of which a couple had very little documentation. Though still a part of the data set these two programs have been tagged and will be treated with caution.

2.2.4 Measuring Leverage Constituents

2.2.4.1 Profit

The goal of this study is to understand what would be a good set of metrics, which would motivate the PD team members to increase the long-term profitability of the firm. The theory determines leverage based on the incremental profit, which is due to the additional, metric driven effort exerted by the team members.

Long term profit for a program consists of immediate profit enabled directly by the program (profit now) and future profit enabled indirectly by the program through reuse of program elements in future programs (profit later). Although the former is fairly easy to measure, the latter is extremely difficult to capture even through judgments, as managers are not willing to speculate on corporate policy and what is perceived to be completely unknown.

For the purposes of this study, the following was collected:

- Gross profit to date was obtained for each program. The financial analysts of the programs gave this data. This was used as "profit now".
- Expected future profit. This was collected for those programs, which have just been introduced and will continue to remain in the market for a few more years. This was used as "profit later"
- Overall success. Senior managers in the company judged this.

2.2.4.2 Risk Discount Factor

The Risk Discount Factor was measured through a survey instrument. The survey and its administration procedure are dealt with in Chapter 3.

2.3 IDENTIFIED WEAKNESSES

This section outlines the weaknesses in the empirical methodology and the program sample

2.3.1 Empirical Methodology

This methodology requires incremental profit as discussed earlier. This is incremental relative to a world with no metrics. Although total profit is easy to measure, this cannot be used as incremental profit even though incremental profits are probably a major component of the total.

Also, companies have always been using some form of process control with its own measuring systems for a very long time and hence, it is not possible to extrapolate from history what the incremental profits could be. Besides, in reality, metrics are not completely targeted, i.e. efforts exerted for one metric will positively or negatively influence other metrics as well.

Given these difficulties, the best approach is to regress profits on covariates and use the residuals. The closest approximation to the leverage term can then be obtained by correlating metrics with the residuals. Thus, omitting important metrics and covariates in the regression can lead to erroneous results. The covariates and metrics selected are those perceived to be important in the PD world. Certain factors not factored in are changes in the economy such as rising or falling gas prices that can skew the profit results for vehicles regardless of the effort or general economic upheavals, which influence purchase decisions. As this is not only an exploratory but also a pilot study, the results will be preliminary and interpreted with caution.

2.3.2 Program Sample

The sample consists of 18 programs with varying scope. While some programs were new vehicles, others were major or minor freshening programs. The size and diversity of the sample set of programs studied detract from the statistical power of any findings and observations. The size limits the regression analysis whereas the diversity leads to the possibility of getting non-constant leverage.

In many cases the documentation for these programs could not be used as the primary sources of information due to either lack of availability or the sparse nature. In such cases the values for the measures were obtained from the judgment of the team members and/or the team leaders.

Although the thesis treats the "team/s" as the unit, the RDF survey was conducted at the individual level and not at the team level under the assumption that individuals not only make up the team but also benefit or lose from the team's actions.

Chapter 3: The Data Collection process

This chapter describes the data collection process at Ford Motor Company. The following sections discuss the methods employed for gathering data for the three major components of leverage, namely metrics and covariates (measures), profits and the RDF.

3.1 COLLECTION PROCESS FOR MEASURES

This section is a descriptive account of the methodology I followed to get the measure-related data for all the programs, the challenges I faced along the way and the types of sources I found and used. Like LaFountain (1998), this section is meant to primarily help students doing similar work in the future. It is also my hope that any student who goes out to a company for any type of research work will find this section helpful.

The main objective was to find reliable information that could be used to assign a value to the low-level measures as outlined in Chapter 2. The primary target sources of information were program documentation (henceforth described as "paper source") and program team members (henceforth described as "people source"). The size of Ford Motor Company and the decentralized management style made this a challenge from the very beginning. I had four key contacts to help me find my way around and facilitate the process for me. In the beginning I was provided with the names of the Chief Program Engineers (CPE) and the Project Managers for each of the programs on my list and a note was sent to the CPEs of all the programs introducing my project and me.

As previous experience (LaFountain, 1998) has shown that pursuing paper sources alone can be both troublesome, time consuming and can quickly lead to dead ends, I decided to pursue the people source and use that to guide me to the paper source. Figure 3.1 is a diagrammatic representation of the process I followed in most cases. The execution of a relatively simple task proved to be difficult due to the following reasons:

- People are very busy and hence the lead times can be very long. Also, people move on to different jobs or move out of the company
- The information required spans many functions within the company and hence the complexity and delays get compounded very easily
- Documents are either not available or are proprietary, thereby reducing access. Some programs have better documentation than others

The next few sections address each of the above challenges in greater detail. The paper sources found and used are described. Program specific paper sources are not documented in the thesis but are documented with CIPD.

The nature of the delays and what was done to reduce them are outlined. The process I followed to track progress and track contacts are included. Lessons learned from this exercise are also described.

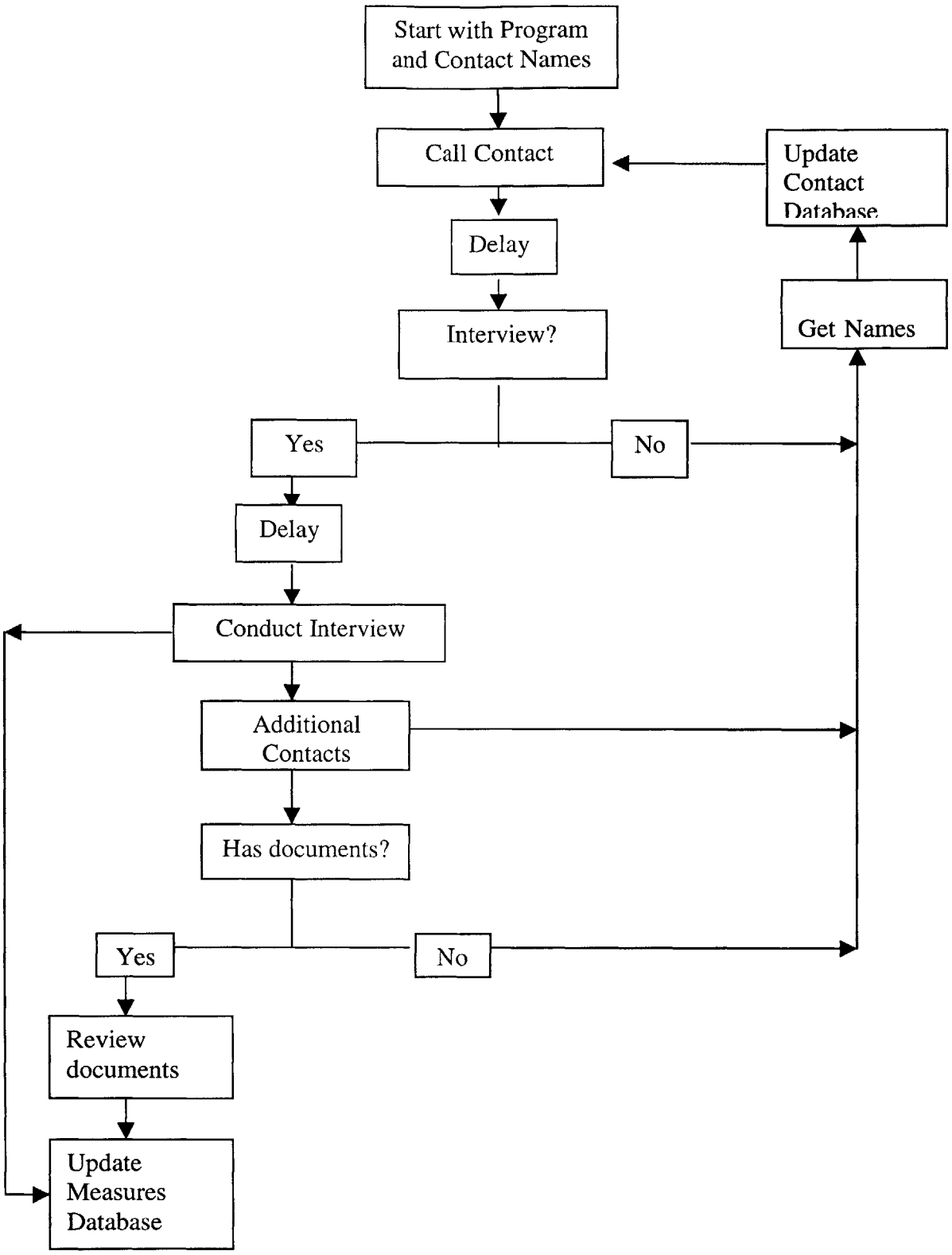

Fig 3.1 Data Gathering Process Flow Diagram

3.1.1 Paper Source

Documents are a source of information that are not subject to memory errors, and this makes it imperative to gain access to them. The ease with which the documents for a specific program could be located was a function of the "age" of the program. For more recent programs, the documents were either easily available with a program contact or could be accessed through Ford's internal Internet. For the older programs this was not the case and therefore a lot more effort was required to locate the person who still might have the documents.

Ford has a Central Archive located at the World Headquarters, which stores certain documents according to ISO guidelines. Although this was not an all-inclusive source for documents it proved to be helpful in finding the information without having to spend additional time in locating the right people.

For other documents such as the market research papers or initial strategy documents that were not available in the Central Archive, the concerned program people had to be contacted individually for access. This also proved a challenge in most cases as these documents are proprietary and therefore getting access to them was a function of how convinced the individual would be of the nature and purpose of the request.

In all cases, the documents contained more information than required and a considerable amount of time was spent to filter through all the available information to find what was needed. Increasing familiarity with the documents did result in reduction of the time needed to sift through. The types of documents are outlined in the next sections.

3.1.1.1 Marketing and Strategy Papers

These papers existed for all but the minor programs. Usually available with the marketing contact or with the Business Office contact for a specific program, these papers were very helpful in understanding the market analysis and the customer needs and wants for a specific vehicle. The details in the papers varied from program to program. These documents are part of the up-front work done prior to the start of the work on the program and the information from these papers is utilized to determine internal targets. These papers also helped in understanding the nature of the competition and some of the key differentiating factors both internal as well as external to the company.

3.1.1.2 Program Papers

The phases of the FPDS process described in Section 2.1 are made up of program events and milestones, which the program passes through. Each of these milestones, in turn, has certain requirements and criteria that a program must satisfy before moving on to the next milestone.

Depending on the nature of the milestone, senior management is a part of the meeting that takes place in order to determine if the program is qualified to move on to the next

event or milestone. These meetings have representations from the various functional areas within which one person is usually assigned the task of reporting on his/her section. These paper reports are collated to form what is called a program paper. The status of the requirements and targets is tracked through a color scheme of green, yellow and red where green stands for "on track", yellow stands for "more work required" and red indicates "off track". The papers where senior management was part of the review process were found in the Central Archive. As these milestones were key to the program, these papers were helpful in getting information for the low-level measures. The following was common to all the papers:

1. Introduction: This contained an overview of the program including the key market and customer wants, competitive positioning and the scope of the program. An overview of the long-term strategy for the vehicle line in terms of future program direction was sometimes included.

2. Financial Objective or Business Case: This included s forecast of the number of units to be produced along with the costs, expected revenues and some key financial ratios.

3. Objectives / Targets: The targets and their status (Green, Yellow or Red) were included along with the future direction. Solutions for issues (if any) were always documented right next to the issues.

4. Timeline: This included the high-level schedule for the program.

5. Recommendation: This contained the recommendation of the program team to move on to the next event or milestone. A summary of the reasons behind the recommendation always supported this statement.

6. Lessons Learned: This contained a detailed list of the positive and the negative experiences of the program in every aspect of product development if it was significant enough to be documented.

7. Program Charts: The targets of the programs were broken down into separate "charts" which in a very objective manner described the current status and future strategy for the specific target.

Each of the above was helpful in determining the low level values for some of the measures.

3.1.1.3 Post Program Paper

This contained the status of the program after it had just been introduced into the marketplace. This paper tracked the immediate performance of the program vs. the planned objectives. Although this was not very detailed and was also very early in the process, it helped to get a sense of the direction that the program was taking.

3.1.1.4 Marketing Presentations for Launch

This was the "positioning" documentation for the program. It highlighted the key features and characteristics and was an outward looking documentation as it was meant for the press and the market and was prepared for the official launch of the program. It was only for very few programs that this presentation was available. This was helpful in comparing the initial objectives as outlined in the up-front marketing paper with the final product.

3.1.1.5 General Lessons Learned and Best Practices Database

Besides the program papers, lessons learned and best practices are documented and maintained in a central database which is available in Ford's internal Internet. One has to do a search with the program specific name to find program specific information. This source augmented the information found in the papers.

3.1.2 People Source

As mentioned in Section 3.1, I decided to approach the data collection process by first interviewing the concerned program contact/s and then soliciting his/her help in finding the necessary documentation. This proved to be an uphill task.

People are extremely busy and in most cases have moved on to different jobs and programs. In certain cases, they have either left the company or have moved on to international assignments. The former makes it very difficult to get a hold of the contacts while the latter makes it impossible to do so. Also as an "outsider" to a company as large as Ford, it takes good convincing skills to convince a person of the intent and nature of the study. As the voicemail system is not adequate for the aforementioned purpose, it can take very long for a person to respond. Even after they respond, they may tell you that they are not the right contacts, directing you to another person and then the process begins afresh.

Although there are no easy solutions to this issue, there are certain steps that if followed can reduce the delays. I document them here based on my experience and what worked for me. The message left should be short and should clearly outline the objectives, and the name/s of the key company contacts. This helps to give an internal context to the purpose of the request. Mentioning previously held conversations with people who the person being contacted may know helps to give a better understanding as well. It is very important to be proactive and leave more messages after a suitable period of time instead of waiting long for the person to return the call. In certain cases it is helpful to drop by a person's office and try one's luck at meeting him/her as a face to face meeting helps alleviate questions and builds familiarity which can be leveraged to schedule a longer meeting afterwards.

It is important to remember that there are certain tradeoffs between the perceived priority of the project in people's minds and the priority in the mind of the research student. One

should be careful about stressing the end value of the project to the people one meets without being extremely aggressive.

The approach to the interview depended on my prior knowledge about both the program and the person I was scheduled to meet. In almost all the cases, I sent the list of measures to the person prior to the meeting so as not to catch him/her unaware and to prepare him/her. This list of measures was used as an interview guide more often when I knew little about the program and/or about the interviewee. When meeting people from specific functional areas such as marketing, technical, purchasing etc. I tailored the questions to those specific functions and used that as an interview guide after first having briefly explained the overall objective of the research.

3.1.3 Managing the Process

As the list of contact names for the programs grew longer, I realized that keeping paper records would be cumbersome. To that end I created a simple Access database, which was designed, to hold the detailed contact information of the entire program contacts which I collected from Ford's internal web site. This database was also used to keep track of when the people were being contacted and the time and nature of their response. This proved to be very helpful as beyond a certain point of time it became impossible to commit to memory the details of who I had met or spoken with and what had transpired. This also helped to keep the follow-up process on track.

The other purpose of the database was to keep a softcopy of the information being gathered for all the programs. This allowed easy linking of the information obtained with the people involved for a specific program.

Although I did have a laptop at my disposal I did not use it very extensively during the interviews as I found writing the notes more friendly to the interviewee vs. typing them up during the process. The laptop was very helpful in reducing the amount of paper that I needed to carry with me when making research trips to Ford.

Over and above the database, I used a multi colored matrix to keep track of the amount of information I had at any point in time on all the measures for all the programs. See Appendix B for details. The rows represented the programs and the columns represented the measures. Both high-level and their constituent low-level measures were shown in this matrix. Each color represented the level of information. This was helpful in understanding the status of my work at a single glance. I updated this matrix on a weekly basis.

3.2 COLLECTION PROCESS FOR PROFIT

Collecting profit information for all the programs proved to be much more difficult than anticipated. The purpose was to understand what the total profit for all the programs were as outlined in Section 2.2.4.1.

3.2.1 Profit Now

This was the gross profit since launch. As the data is highly proprietary it was decided to solicit the help of one of my key contacts in the Company. He was the recipient of all the data and he masked the data before handing it over. The financial analysts of the programs gave this information. For programs that had already been replaced by other programs, this was also the total profit.

3.2.2 Profit Later

This was obtained for those programs, which had just been introduced into the market. An 10-point scale was used to obtain the judgments of some financial analysts and program managers, as not enough historical information was available to arrive at a dollar figure for this data.

3.2.3 Judged "Overall Success"

This was obtained for the sample set of programs through a questionnaire, which asked the respondent to judge the overall success of the program with which they were familiar. This was judged on a 10-point scale. The respondents were very senior managers and executives in the company. Out of the 25 questionnaires sent, 14 were received with at least 6 responses for each program.

3.3 COLLECTION PROCESS FOR RDF

The Risk Discount Factor (Equation 10, Section 1.2.3.2) is a major component in determining the "weight" or emphasis given to a certain measure. It is in the denominator of the equation and hence is inversely proportional to the weight, meaning that a higher value of RDF will reduce the weight on the measure.

3.3.1 Team vs. Individual RDF

For a measure that applies to an individual, the RDF can be calculated from a survey question, which explores a person's preference for guaranteed rewards over metrics-based rewards. The response will primarily be a function of the perceived error in the measure and the person's risk aversion.

Although Equation 10 (Section 1.2.3.2) deals with team based metrics, it is the individual who ultimately benefits from the actions of the team and his/her personal RDF affects

that of the team. The value of RDF for each individual will depend on his/her influence on the measure and hence can be expected to differ for different people.

3.3.2 Description of the Survey

The survey had four parts. The entire questionnaire is in Appendix C. A brief description is included in this section.

Each part contained the same 13 measures. These measures were the nine high-level metrics, achievement of cost targets, achievement of revenue targets, achievement of strategic success goals and achievement of quality targets. Part I of the Survey asked each respondent to indicate on a 7-point scale what he/she felt was his/her influence on a specific measure in his/her current role in the program team. Part II asked for the judgment on the accuracy with which someone, not on the program team, could assess each measure. Part III measured the RDF and it presented the respondent with the following two scenarios:

Scenario A: *You decide how much effort to put in to the aspect of performance. Your reward is based on the judgment or measurement of the aspect of performance by someone outside the team.* You cannot be certain what the judged or measured value of your performance will actually be, therefore the amount of reward you will receive is not certain. For the amount of effort that you have chosen to allocate, there is some average expected reward that could be calculated across many projects of the same type. However, there is uncertainty for any individual (i.e., your) project.

Scenario B: *You allocate the same amount of effort as in Scenario A to the aspect of performance.* However, the amount of reward you receive for this is determined in advance. There is no uncertainty.

Scenario A is the judgment or metrics-based reward while Scenario B is the guaranteed reward. In both cases the effort exerted by the respondent would remain the same. The question asked the respondent to indicate at what percentage of the average or expected judgement based reward should his/her guaranteed reward be in order for him/her to be indifferent between the two. The percentage answer was therefore (1 – RDF).

Part IV of the survey asked the respondent to indicate what is the relative importance of each of the 13 measures when determining the rewards today in the company. This in essence measured the current perception of the weights of the measures.

3.3.3 Administration of the Survey

A pretest of the survey conducted at Ford showed that the time required for answering the survey varied from a half-hour to an hour. Also, it was very evident that presence of an administrator was required to answer the respondent's questions. Part III, proved to be a conceptual challenge for many.

The time required to administer the survey made it difficult to target a large number of people. Out of the 20 people approached, 16 agreed to take the survey. The respondents were from various functions within the PD organization. This was intentional. The purpose of aiming at breadth rather than depth was to try and capture the varying influences of the different team members. The breakdown of the respondents is as follows:

Table 3.1 Breakdown of RDF Survey Respondents

POSITION / ROLE	NUMBER OF RESPONDENTS
Project Managers	4
Marketing Managers	3
Technical / Engineering Manager	6
Quality Managers	3

The results from the survey are discussed in Chapter 5.

Chapter 4: Scales and Judgment for the Measures

This chapter defines the metrics and covariates in detail, laying out the scales and the rationale behind each for every low-level measure. The following are also documented:

- The sources used to obtain the necessary information
- Observations about common practices at Ford
- The underlying question behind each measure

4.1 SUMMATION AND QUANTIFICATION

4.1.1 Summation of Low-Level Measures

The high-level measures are calculated as the sum of the low-level measures. This rule applies to all but Metric 8, Time to Market which does not have an underlying low-level measure. Equal weighting has been applied to perform this calculation. Section 2.2.1 discusses some of the reasons for adopting this methodology.

The names of the high-level measures were therefore selected in a way that would make intuitive sense as the sum of the low-level measures. The scaling convention of the individual low-level measures had to determined carefully as well. Also, the distinction between metric and covariate at the high-level may not be exact because some of the underlying measures for a metric can be covariates and vice-versa. Such deviations have been clearly identified in the following sections.

4.1.2 Quantification of Low-Level Measures

This study considered both judgment based and objective measures. As discussed in Chapter 1 (Section 1.2.1), objective measures alone may not be successful in driving the right effort to ensure a successful product and high long-term profits. Therefore a low measurement error does not imply a higher leverage. Often objective measures have subjectivity embedded in them. These reasons drove the selection.

The subjective or judgment based measures are worded in a way that allows judgment to be made. The judgments are based on information that is available. These measures have therefore been quantified via a scale. Defining a scale for these measures was not trivial, as there were many factors to take into account to ensure robustness. These factors can be summarized as follows:

- Uniformity and applicability across programs
- Repeatability for future use
- Capturing the essence of the metric or covariate being measured

In each case a 5-point scale was used, however they were defined in two distinct ways. The definition depended on the amount of information available. For measures with more information the scale used was anchored according to observable characteristics with the

endpoints fixed at realistic extremes for Ford. The points in between were defined to keep the scale linear and repeatable. An example of this type of scale is as shown below:

Scale for "Effort to Gather Customer Requirements" is defined as follows

1	No dedicated effort, no reliance on old requirements. Reliance on customer satisfaction surveys and service reports as primary source
2	Use of recent VOC data from former programs at program outset, or ad hoc informal customer contact throughout program, no dedicated VOC effort early in the program
3	Some dedicated VOC effort early in the program. (some focus groups)
4	Significant VOC effort early in the program
5	Whole team exposed to the VOC process

This is fairly rigidly defined and repeatable. The challenge with this definition is to avoid straying from the right construct into convenience measure of easily quantifiable things. (LaFountain, 1998). Thus, in many cases judgment was used to adjust the program value.

The second type of scale employed had its midpoint anchored to standard Ford practice. This was preferred over the former when the paper source was not sufficient and programs team members' judgments were the main source of the data. An example of this type of scale is as follows:

Scale for "Product Leverages Platform Elements Well"

1	Far below average
2	Below avg.
3	Avg. leveraging of platform elements
4	Above avg.
5	Far above avg.

In order to reduce any errors that might be introduced due to different points of reference for different individuals, a possibility with this type of definition, multiple judgments were obtained to ensure uniformity in interpretation. Where necessary, a hybrid of the above two types of definitions was used.

4.2 SCALES AND RATIONALE FOR METRICS

This section defines each high-level metric and its constituent low-level measure, explains the rationale behind the scales and sites examples of the types of information sources used to obtain the values for the programs.

4.2.1 Metric 1: Understanding of Markets and Customers

This high level metric is made up of 5 low-level measures. They are defined as follows:

1. Ford's experience in this market

   Type: Covariate
   Information Source: Marketing and program papers, interviews

   This is a function of the number of years a specific vehicle had been in the marketplace. Thus, experience here is that of Ford as a company and not that of the team members. This information was very easy to find as not only do the papers mention the number of years but also, program team members are completely aware of the history and "heritage" of the vehicle they are working on. Besides, in many cases it is common knowledge.

   As per the definition of the scale below, a Ford Truck, an area where Ford has been a major player for decades, would score a "5". On the other hand a vehicle even if it had been around for a long time, but the program was meant to target a completely new market and customer base, would score a "1".

   Scale:

1	This is Ford's first product in this market
2	Ford's knowledge about this market will increase before the end of the program
3	This is a second major freshening of the product
4	Ford has been in this market for 5 to 10 years
5	This is a very old product in this market (>10 years)

2. Team's effort to understand market requirements

   Type: Metric
   Information Source: Program papers, lessons learned database, and interviews

   This is a measure of the effort put in by the team to understand market growth, size and segmentation; competitive trends and threats. The responsibility of this function lies primarily with marketing. The amount of program specific effort is a function of the size of the program. In most cases, for a larger program, the team plays a much bigger role whereas for a minor program, existing understanding is used.

   This scale was defined based on the involvement of the team members and the timing of the marketing studies done for the vehicle line. In some interviews marketing personnel cited examples where program team members preferred "gut-feeling" to specific data.

Scale:

1	Little or no effort, team relies primarily on existing understanding
2	Marketing person puts in some effort, not up front but in parallel with development. Effort is functional, and not dedicated to the program and understanding is passed over to the team
3	Some work done up front but more functional not program or team specific
4	Significant work done up front but team has little involvement
5	Significant work done up front with team members involved directly with study

3. Thoroughness of team's market understanding

Type: Metric / Covariate
Information Source: Interviews, post program papers

This measure can be a covariate or a metric because the thoroughness of the understanding need not be a function of the program specific effort, which makes it a covariate as per our definition. In certain cases the team is very well aware of the market by virtue of having worked on the vehicle line for years or because of the 'excitement factor" associated with a particular vehicle which easily percolates down to the team. On the other hand, if the analysis from the program specific marketing effort is communicated well to the team, the team can become very knowledgeable about the market. In that case this measure becomes a metric.

There were very few paper sources, which corroborated this measure, and hence program team members' judgments as well as the judgment of the marketing managers were used to quantify this measure. The value for the programs was obtained from the answer to the question "What do you think was the understanding of the market was at that time, given what you know now?"

Scale:

1	Major flaws exist in understanding of market characteristics/ customer needs or uncertainty in market characteristics
2	No major flaws but many needs or details missed
3	Avg. performance, some aspect or needs were not understood, but understanding was satisfactory
4	V. thorough understanding, few missed points
5	Superlative understanding

4. Effort to gather customer requirements

Type: Metric
Information Source: Marketing papers, program papers, and interviews

The FPDS process stresses on a very good understanding of the markets and capturing the customer requirements up-front in the product development process. This metric was an attempt to measure this up-front work done by the marketing personnel as well as the involvement of the team

Almost always, the amount of effort put in was again a function of the size of the program. In certain cases however the marketing manager took extra effort to include team members ranging from quality, technical and even finance in the theme clinics or conferences with customers. The program papers documented the findings and resulting actions from these studies and hence it was relatively easy to find information on this metric.

Scale:

1	No dedicated effort, no reliance on old requirements. Reliance on customer satisfaction surveys and service reports as primary source
2	Use of recent VOC data from other programs at program outset, or ad hoc informal customer contact throughout program, no dedicated VOC effort early in the program
3	Some dedicated VOC effort early in the program. (some focus groups)
4	Significant VOC effort early in the program
5	Whole team exposed to the VOC process

5. Effort to understand needs of the distribution channel

Type: Metric
Information Source: Primarily interviews, some program papers

There is ongoing contact with the dealers for every vehicle line. However, the dealers' "voice" was captured specifically for newer programs. Marketing Managers' and Project Managers' judgments were used to get a good understanding of this metric as the paper source did not explicitly state dealers requirements other than the service issues which were given serious attention in all programs.

A program which used the regular channels of information flow scored a "2" on the scale below, whereas a program which roped in dealers to understand if there were any specific requirements at that end scored a "4". An interesting observation made was that dealers tend to be more short-sited than the customers are when understanding future trends.

Scale:

1	No significant effort
2	Some attention paid to capturing dealers' needs but no direct contact early in the program
3	Attention paid to capturing needs early but only in context with incidental contact with sales force. No explicit dedicated effort
4	Some explicit dedicated effort is made early in the program
5	Much explicit dedicated effort made early in the program.

4.2.2 Metric 2: Product Designed for Market Needs

This metric is composed of 4 low-level measures. These are defined as follows:

1. Product achieves intended differentiation

Type: Metric
Information Source: Program papers at the beginning and the end of the program, and interviews

Each program is undertaken as part of the strategy for the vehicle line which also defines the nature and hence the differentiating features of the program from the previous program. However, this measure is considered a metric because the team members can influence the number of changes that are done under a specific program and hence set the yardstick for the current and future programs.

Although the customers' perception would have been the true form of measure, the scope of the study limited our ability to gather that data. Therefore we used surrogates for the customers' opinion by studying how well the program had met its objectives which were based on the long term strategy, customer requirements and goals of the program. This information was available through program papers and interviews with project managers.

Scale:

1	Differentiation not achieved whatsoever
2	Partially achieved
3	Half and half
4	Mostly achieved
5	Totally achieved

2. Product Fills a Gap in Ford's Product Line

Type: Covariate
Information Source: Marketing and strategy papers, interviews

Programs are meant to fill some existing gap and hence their existence, however, this covariate is a measure of how large a gap is being filled by the program. In certain cases a program may be a "filler" program between two major programs with the purpose of keeping the product "fresh" in the minds of the customers. Such a program would score a "2" per the scale. In other cases, the program serves to expand the customer and market base for the company. A program which achieves this would score a "5".

This scale is defined based on general practice and not only Ford's internal practice. For example, addition of two extra doors on a truck, which has not been done by any other manufacturer before, would qualify as a "large functional gap" filler and would score a "4' on the scale.

Scale:

1	Little or no gap to fill-serious doubts about need for existence of program
2	Small gap, arguable minuscule
3	Medium gap, product is update of old product or is temporal gap filler bet. Products
4	Product fills large functional gap
5	Product expands product line into new market

3. Attention paid to Compliance with Regulatory, Environmental, and Industry Standards

Type: Metric
Information Source: Program papers, program charts, and interviews

This is a must for all automotive companies and Ford is no exception. All vehicles have to meet the standards set by the Government or else they will not be allowed into the market.

Over and above the requirements Ford is very forward-looking in this aspect. For almost all the programs the company tries to stay a step ahead of the specified requirements. This is also a function of the investment constraints and therefore a program may end up meeting and not exceeding the requirements. Sometimes a program is only driven by regulatory requirements and not by customer or market needs.

As can be concluded from the above explanation, no program scored below a "3". The information was readily available in program charts and papers. This was also augmented by interviews.

Scale:

1	Well below business as usual, major issues exist at MS reviews
2	Somewhat below usual practice or minor issues at MS reviews
3	Business as usual, all went according to the process
4	Somewhat above usual practice
5	Well above

4. Compliance with standards

Type: Metric
Information Source: Program papers, program charts, and interviews

This measure comprises Ford's internal standards and requirements that every program follows. As in the previous case this is a given. Although some deviations may be written for any program, each deviation has to be debated, discussed and signed off by senior management.

Some programs spent more than the usual effort to comply with as many standards as possible. A project manager proudly mentioned how the team went to extra lengths to make total compliance a reality.

This information was also available in the program papers. Interviews were also used as a source of information as team members were well aware of what had happened. No program scored below "3".

Scale:

1	Failed to comply with many standards
2	Compiled at the end but with serious issues along the way or chose not to comply w/ some at the outset
3	Usual practice
4	Exceeded some std, but business as usual for most
5	Exceeded many std.

4.2.3 Metric 3: Product designed for advantageous relationship with other products

Six low-level measures make up this high-level metric. These measures are as follows:

1. Degree of differentiation from competitive vehicles in this segment

Type: Covariate
Information Source: Marketing papers, marketing presentations, program papers, interviews

This covariate is a measure of how different the end product is from the competition as a result of the program. This is not a metric as the underlying differentiators are a function of the overall vehicle line strategy. Also, this is a function of the program investment, which the team can be constrained by.

Although the customer is a better judge of this measure, evidence of this was sought in the marketing and program papers that highlighted the key differentiating factors from the competition in terms of features, look and feel of the vehicle. Interviews with marketing managers were also very helpful in understanding this measure.

In some cases the program was a catch-on with competition, in which case it scored a "1". There were cases where there was evidence of the vehicle containing features and/or technologies, which clearly distinguished them from their nearest competition. In such an event the program scored a "4".

Scale:

1	Virtually identical except for usual differentiators
2	Minor difference
3	Moderate difference
4	Large difference
5	Radical difference

2. Degree of differentiation from own vehicles in this segment

Type: Covariate
Information Source: Marketing papers, marketing presentations, program papers, interviews

This covariate is a measure of how different the end product is from its nearest Ford neighbor. Like the "Product fills a gap in the product line" measure, it is inward looking however this measure looks across to similar vehicle lines within the company versus looking at its own vehicle line as the former measure tries to quantify. This measure is a covariate by our definition for the very same reasons as stated above.

In certain cases the vehicle line may be unique to the company and therefore a program scored "5". In some instances the marketing manager pointed out that the

vehicle is purposely not differentiated from its nearest neighbor in order to leverage off of a certain positive image the customer has.

Scale:

1	Virtually identical to the nearest neighbor
2	Minor difference
3	Moderate difference
4	Large difference
5	Radical difference

3. Platform is flexible, robust

Type: Covariate / Metric
Information Source: Primarily interviews, some lessons learned database

For programs which are minor or major freshenings this measure is a covariate as the platform is a given, whereas for a brand new program developing a new platform this is a metric. For certain new programs too this can be a covariate as the new vehicle can be built off an existing platform in which case the team members have little influence over the flexibility

Flexibility is defined as the ease with which the changes could be implemented. This data was hard to find in paper sources and therefore there was a greater emphasis on obtaining this information through interviews. In cases where this measure is a covariate, it was easier to judge as program team members remembered the issues or lack of them in carrying out the changes.

For programs where this is a metric it was harder to judge due to the futuristic nature of the question. However, the answer the information was sought through the question of how many programs and vehicles were planned off this new platform with the conclusion that if many programs were planned on the same platform, the platform would have to have flexibility designed in.

Scale:

1	Significant areas exist where the platform is inflexible and hampering
2	Variants require much tinkering but can be done
3	Avg. flexibility, some significant effort reqd. to do variants
4	Above avg. flexibility
5	Very flexible and robust

4. Product leverages platform elements well

Type: Metric
Information Source: Interviews

This measure was applicable to programs that were freshening programs and for those new programs, which were new vehicles built off an existing platform. As with some other measures in the list the information for this measure was not obvious from the documentation and interviews were used as the primary information source.

The question being asked here is 'Was the reuse from the platform or the previous product appropriate to meet the goals of the program?" The answer was tied to a midpoint-anchored scale.

Scale:

1	Far below average
2	Below avg.
3	Avg. leveraging of platform elements
4	Above avg.
5	Far above avg.

5. Reuse by this product of previous product elements

Type: Covariate
Information Source: Program papers, interviews, and program charts

This measure is mainly a covariate as the amount of reuse or "carry-over parts" to be used in a program is defined by the program investment and scope of the program. This was a very easily quantifiable measure as program paper contained the percentage. Team members also remembered this number with ease.

The scale is very easily defined and is self-explanatory. This measure attempts at understanding a different facet of reuse. Generally the size of the program was directly related to the amount of reuse, however there were some exceptions where even though the program was a new one, the carry over percentage was high.

Scale:

1	20%
2	40%
3	60%
4	80%
5	100%

6. Expected reuse from this product

   Type: Covariate / Metric
   Information Source: Interviews, some program papers

   Like the previous two measures this tries to understand a different aspect of reuse which is "What is the future reuse of this product or platform expected to be?" This is tied to the platform strategy. The platforms are usually designed for a specific number of years and are replaced at the end of those years, therefore if the program was the last variant on that platform; future reuse from that program would be very low. On the other hand for a program built off a brand new platform future reuse could be expected to be high.

   This is also tied to the scope of the program and like the above, a future minor program would be expected to reuse a larger percentage of the previous program as compared to a program which is scheduled as a major program.

   Scale:

1	No reuse expected
2	Low
3	Medium
4	High
5	All

4.2.4 Metric 4: Rigor of Design Process

This is made up of 4 low-level measures that are defined as follows:

1. Design Process consideration of manufacturing capability

   Type: Metric
   Information Source: Program charts, papers, and interviews

   Manufacturing costs are a major component of the total costs of a program and this metric tries to assess the level of effort expended by the team to understand the needs and requirements of manufacturing.

   For all the programs the team consisted of manufacturing personnel but the level of involvement differed from program to program. In certain instances, in spite of good interaction with manufacturing there were significant issues during production. Such a program would score a "2" on the scale below.

The scale is a hybrid of the endpoint-anchored and the midpoint-anchored scales. Program charts and papers were used to obtain information on this measure. Lessons learned sometimes documented the positives or negatives in this area. Interviews helped to add to the paper sources.

Scale:

1	Low, manufacturing neglected, very serious issues at MS reviews
2	Significant issues but resolvable
3	No significant issues
4	Above avg. emphasis within the program
5	Well above avg.

2. Design process consideration of sales and marketing

Type: Metric
Information Source: Interviews, lessons learned database, program papers

This metric quantifies the effort put in to understand the marketing and sales requirements during the development process. The value is a function of the amount of involvement of sales and marketing personnel in the team.

For some programs an active effort was made to include the marketing personnel as the product was developed. Such an involvement would place the program on the higher end of the scale. For other programs this was not the case. For some programs the involvement during the process was not deemed necessary due to the minor nature or the regulatory focus of the program.

There was little that could be gleaned about this metric from the documentation other than some mention in lessons learned. Interviews were the primary source for this measure.

Scale:

1	No involvement, sales and marketing people had no input during the process of development
2	Less than avg. Ford involvement
3	Avg. involvement
4	Above avg. involvement, such as active marketing feedback during design
5	Represented on team with significant I/P

3. Design Process Consideration of Service

Type: Metric
Information Source: Program charts, program papers, and interviews

This metric assesses the team's efforts to understand the service requirements. The information was fairly easy to find in program charts and papers as the requirements are quantified in the company and the progress is tracked throughout the process with any deviations carefully accounted for. Interviews were also a good source for this metric as program team members could easily remember the nature of involvement and how helpful that was.

For almost all the programs service personnel were part of the team. However, the level of involvement differed across programs.
Scale:

1	Little or none, or critical issues exist at MS reviews
2	Some infrequent involvement of service w/`major issues existing at MS reviews
3	Frequent periodic involvement of service
4	Service personnel members of team with emphasis on service issues
5	Superlative emphasis on service

4. Use of robust design practices

Type: Metric
Information Source: Program papers, and interviews

The FPDS process stresses on "building in" quality instead of finding solutions to problems afterwards. Although full blown QFDs are rarely generated at Ford, various other tests and analyses exist to ensure reliability and robustness in the product. All programs use these tests to some degree and this metric measures the degree to which these practices have been used.

Program papers documented the level of analysis used. Interviews with quality supervisors were very helpful in understanding, not only the level of usage but also the results obtained.

Scale:

1	No use
2	Little use, not emphasized
3	Some use
4	Emphasized
5	Full use

4.2.5 Metric 5: Appropriate Technology Selection

This high-level measure tries to understand the various aspects of technology selection and their contribution to the success of the product. From the data collected it seems evident that the technology employed is largely a function of the type of vehicle being developed. For some programs the focus was less on technology, as the customers did not care much about it. The 5 constituent low-level measures are defined as follows:

1. Ford's advantage in technology with this product

   Type: Covariate / Metric
   Information Source: Interviews, Program charts, program papers, and marketing papers

   This measure seeks the answer to what is the level of technological competency and whether it translates into a competitive advantage to Ford. This measure is more of a covariate because the technology chosen is part of a broader set which the PD team has very little influence over. However, their decisions affect the technology selected from the existing suite.

   As a company Ford has an edge over its competition in some areas whereas the competition has an advantage in others. This measure rates the program relative to the competition.

   Scale:

1	Major disadvantage.
2	Minor disadvantage.
3	Equal to competition
4	Minor adv.
5	Major adv.

2. Richness of technology options

   Type: Covariate
   Information Source: Interviews

   This measure is a covariate because the PD team does not determine the suite of options. This measures the level of choice, which the PD team has when picking a particular technology for the program.

   The project managers and technical team members were the main source of information for this measure as there was hardly any documentation that discussed the number of options. A few managers mentioned that the technology shelf needs to be fuller than it is now.

Most of the programs studied did not have a large suite of options to choose from. For the minor programs this was determined by the technology used in the previous major or new program.

Scale:

1	Constrained to a single option
2	Some have more options
3	More that one option for many technologies but others are constrained
4	Most technologies have more than one option
5	Full suite of options available for technologies

3. Maturity of technology

Type: Covariate
Information Source: Program charts, program papers, and interviews

This is a measure of the newness of technology used in a program. This information was available in program papers and program charts. Interviews corroborated the information from the paper source.

The paper sources identified the technology as new to the industry, new to the segment and/or new to Ford and this same distinction was used to define the scale for this measure.

1	Technology new to Ford, to the segment and to the industry
2	Technology new to Ford and segment but not new to industry
3	First Ford product to incorporate this technology
4	Most of the technology is not new to the segment and not new to Ford
5	All technologies mature

4. Technology is implementation ready

Type: Covariate / Metric
Information Source: Program papers, and interviews

This measures the effort put in by the team to reduce the risk and simplify the implementation of new technology in the program. As the status of this measure changes over time, it was examined at the milestone preceding full-fledged production.

This measure is a covariate in situations where the technology has been handed over to the team to be used, however it can be considered a metric because the product can be designed to ensure smooth implementation of the technology.

Program papers sometimes mentioned issues and the solutions. Interviews were used to augment the information from the program papers. For minor programs most of the technology was mature and hence also implementation ready as there were no major platform or product changes.

Scale:

1	Critical issues exist at MS reviews, judgment deems readiness at high risk
2	Major issues exist at MS reviews
3	Some risk, no major issues, likelihood of readiness is good
4	Tech is nearly validated and ready at outset of program
5	Validation already achieved before program. begins

5. Architecture of product allows easy integration of new technology

Type: Metric / Covariate
Information Source: Interviews

Like the measure "Platform is flexible, robust" this measure is a metric when teams are designing a new platform and it is a covariate if the team is using an existing platform. However, it is even more difficult to quantify as the exact characteristics of future technology are difficult to determine. The underlying question being answered is "How did the existing architecture help the introduction of new technology?"

Interviews were the primary source of information for this measure as there was very little mentioned in documents. As above, this was not a concern for minor programs.

1	Architecture is prohibitive to all technologies except to ones already used
2	Few technologies other than those used can be integrated into the architecture
3	Many current and expected technology can be easily integrated
4	Most current and expected tech could be integrated with relative ease
5	Architecture allows current and expected technologies to be easily integrated

4.2.6 Metric 6: Coordination and Communication

This metric determines the effort expended to ensure smooth functioning of the PD process for a given program. It is made up of the following 6 underlying measures:

1. Level of Coordination Achieved within team

Type: Metric
Information Source: Lessons learned, and interviews

This metric measure the internal coordination of the PD team/s. Almost all the programs had some reference to the team work and how certain actions or steps taken may have helped the communication process. This data was augmented by the information obtained through interviews.

Interviewees often cited examples of how they achieved better or worse coordination than other teams. For one of the programs the project manager mentioned how effectively the program utilized the web site to document all the action points and responsibilities and this resulted in smooth functioning with very few delays. Such a program scored a "4" on the scale below.

Scale:

1	Low, serious issues persist
2	Below avg. some issues persist
3	Adequate, average for Ford
4	High above average
5	Very high

2. Level of Coordination Achieved between team and internal value chain partners

Type: Metric
Information Source: Lessons learned, interviews

The internal value chain partners are the internal "customers" of the PD team/s and are members of what can be called the "extended" team. They include manufacturing, marketing. The values were obtained through information obtained in lessons learned database and interviews with program team members. Not all programs mentioned this facet of communication and in the absence of documentation interviews were the primary source

Some programs mentioned collocation of the extended team as a major plus in achieving coordination and smooth transition. Such a program scored a "4" on the scale. Some other project managers talked about issues due to lack of proper communication scoring either "1" or "2" depending on the seriousness of the issues.

Scale:

1	Low, serious issues persist
2	Below avg. some issues persist

3	Adequate, average for Ford
4	High above average
5	Very high

3. Level of Coordination Achieved between team and external value chain partners

Type: Metric
Information Source: Program papers, lessons learned, and interviews

Scaled very similar to the above two measures this metric measures the quality of communication and coordination between the team and suppliers or any external partners. In this case program papers also contained information from which the nature of the communication could be gleaned. Lessons learned were also a good source. Interviews corroborated the information from the above sources.

Ford changed its supplier strategy a few years ago. Programs, which fell into the transition period, did not enjoy a smooth functioning and project managers spoke of a lack of proper communication that resulted in certain delays or problems. Such programs scored low on the scale. For certain other programs the lessons learned mentioned how certain steps taken, such as collocation or web sites not only improved communication but also resulted in very few delays. These programs scored higher.

Scale:

1	Low, serious issues persist
2	Below avg. some issues persist
3	Adequate, average for Ford
4	High above average
5	Very high

4. Documentation of program

Type: Metric
Information Source: Interviews, and availability of program documents

Due to ISO requirements all programs need to document their PD process, however some programs are more thorough than others. Also, not all programs had papers stored in the Central Archive. The minor programs had very little to no documents available and programs that were older were not as thorough as the latter and more recent programs.

This metric measures the level of effort put in to document the process. Interviews, and document availability were used to quantify this measure. Certain programs had

designed and used web sites emphasizing on keeping everything updated. This gave them a score of "4" on the scale below. This was true of all new programs and also of programs, which involved team members located globally.

Scale:

1	Little or no documentation
2	Some documentation, but below average
3	Average pretty much the essentials required of the process
4	Above avg. priority more than process requirements
5	Very excellent and thorough

5. Quality of Integrated Plan

Type: Metric / Covariate
Information Source: Program papers, and interviews

The underlying question this measure asks is "Did the original plan or roadmap for the program stand the program in good stead?" Although the plan can change over time, this measure tries to assess the overall quality in retrospect.

This is a metric in that the program team can influence the execution of the plan. This can also be a covariate under those instances where sudden changes in program strategy due to various reasons as dictated by upper management can "dislocate" a program team from the current path into a new and more tumultuous one over which they then have very little control.

Interviews were a major source for this measure as program team members remembered any deviation from the average very vividly accounting and supporting their statements with examples. Some program papers contained information, which was used to understand the answer to the above question

Scale:

1	Critical planning related issues at MS review or judgment deems plans far below avg.
2	Plans below avg. major planning related issues at reviews
3	No significant issues plans average
4	Very good plans
5	Excellent, thorough plans

6. Number of Major Issues assessed at MS review

   Type: Metric
   Information Source: Program papers, some interviews

   This metric measures the quality of work done by the PD team. One can argue that certain situations may arise which will increase the number of issues without any "contribution" on the part of the team members. However in most cases it is fairly safe to assume that if the work progressed smoothly as per the plan then the number of issues will also be less.

   Program papers were a good source of documentation and the color-coding scheme described in section 3.1.1.2 was used to determine the severity of the issue. The scale is defined such that "1" would be the score for a program with many more than the average number of issues and "5" would be the score for a program with much lesser than the average number of issues. A program with a average number of issues would score a "3". This was mainly assessed at the significant milestones focusing on the milestone prior to production

   Scale:

1	Many issues
2	
3	
4	
5	Few issues

4.2.7 Metric 7: Health of Relationships with Suppliers, Partners

This high-level measure is a sum score of 5 low-level measures. The first low level measure is not included, as it does not indicate the "health" of relationship. The descriptions are as follows:

1. Reliance on suppliers for development of product

   Type: Covariate
   Information Source: Program papers, interviews

   Companies are relying more and more on suppliers (Fine, 1998) and Ford is no exception. This measure tries to understand how much of the product has been developed by an "outsider".

   Although, this differs from program to program, most of the recent programs had a higher reliance as compared to older programs due to the change in trend. This measure is a covariate because it is driven by company policy and the PD team

members have very little influence over the decision of how much external involvement should be allowed.

Program papers documented the number of suppliers and also the number of important subsystem suppliers. This information along with that obtained through conversations with PD team members were used to score a program on the scale below.

Scale:

1	No reliance on suppliers
2	Single minor subsystem supplier
3	Some co-development /supply
4	Some reliance for major subsystem
5	Heavy reliance for major subsystems

2. Health of relationships with existing suppliers

Type: Metric
Information Source: Interviews, lessons learned

The measure "Level of Coordination achieved between team and external partners" is a facet of this measure, which is a metric because the team has a very strong influence in this area. This measures the effort put in by the team to ensure good overall health of relationship.

This information was easier to gauge from interviews, as program papers did not make any direct references to overall health. Some programs documented certain incidents in their lessons learned which was also used to get an understanding of where the program lay on the scale.

Scale:

1	Poor
2	Below average
3	Average
4	Above average
5	Excellent

3. Confidence in delivery by suppliers already selected

Type: Covariate
Information Source: Interviews, program papers, and lessons learned

As the program team cannot influence this measure, it is a covariate. This seeks an answer to the question of how sure the program team was that their suppliers would be able to deliver a quality product within the time limit specified to them.

As was the case above, this was obtained primarily through interviews although anecdotal evidence in the program papers and lessons learned where present were also used to get a good understanding. Confidence normally increased with the age of the working relationship with the supplier, i.e. the "older" the relationship with the company the better the confidence.

Scale:

1	Low
2	Lower than average
3	Average confidence (not established trusting relationship, but no explicit concern)
4	Higher than Average
5	Near absolute certainty

4. Flexibility in selection of suppliers

Type: Covariate
Information Source: Interviews

This measures the program team's flexibility when choosing suppliers. This was measured according to the number of options the program team had.

For most programs there was very little choice as Purchasing has a target list of suppliers who they recommend. Also, for certain major subsystems very few suppliers are out there who have the capability to deliver within the time and quality requirements. These two factors reduced the flexibility in most cases.

This measure was scored based on data gathered during the interview process. Worth mentioning however is the trend towards greater participation from the PD team members to select suppliers. There were very few programs, which were part of this new trend, for most other programs the team members were asked to work with a specific set of suppliers

Scale:

1	None
2	More than one option for less than half of the suppliers
3	More than one option for a majority of suppliers
4	Several option for most suppliers
5	Several options for all suppliers

5. Early selection of suppliers

Type: Metric
Information Source: Program papers, and interviews

This metric is a measure of the degree to which suppliers are selected at the beginning of the program. For most programs program papers indicated the status of supplier selection and this information was used to score the program.

The FPDS process requires suppliers to be part of the development process before a certain early and major milestone. All programs therefore selected their suppliers early in the process, however there were some older programs, which did select a few suppliers towards the middle of the process. Such programs scored a "4" as per the scale.

Scale:

1	Some not selected till very late in the process
2	Only some selected early, others very late in the process
3	Most selected in the beginning, some towards the end
4	Most selected in the beginning, some towards the middle
5	All selected in the beginning

6. Maturity of relationship with suppliers

Type: Covariate
Information Source: Interviews

This measures the "age" of the working relationship between the company and the supplier. In almost all respects this is a covariate as the team can do little to increase the maturity other than working with the supplier.

The information was obtained primarily through interviews with experienced members of the program team. This measure was fairly easy to judge. Very rarely did a program score anything more than "2". The average maturity is calculated here. However this may introduce some hidden non-linearity because in a case where there are two suppliers with one being new and the other mature the score would be the same as two of moderate maturity. Although mathematically equal the program team may not view the situation the same way.

Scale:

1	All relationships are mature
2	Relationships on average are between moderate and full maturity
3	Relationships on average are of moderate maturity

4	Relationships on average are not new, but are of low maturity
5	All relationships are new

4.2.8 Metric 8: Time To Market Performance

This is measured by the number of days the program slipped from two major milestone dates scaled to a maximum of "5".

4.2.9 Metric 9: Customer Satisfaction

This was taken from Ford's customer satisfaction survey, which the company measures, in the first and third quarters of every year. For consistency purposes the data for all the programs was taken from the first quarter after program introduction.

This measure is calculated from the sum score of customers who were satisfied with the vehicle and the customers who were "very" satisfied with their vehicle. The score was scaled to a maximum of "5".

4.3 SCALES AND RATIONALE FOR COVARIATES

This section defines each high-level covariate and its constituent low-level measure, explains the rationale behind the scales and sites examples of the types of information sources used to obtain the values for the programs.

4.3.1 Covariate 1: Product Fits with Ford

This high-level measure is made up of 3 low-level measure described as follows:

1. Product fits with Ford's image

   Type: Covariate
   Information Source: Marketing papers, strategy papers, and interviews

   The PD team has little control over this measure and hence it is defined as a covariate. Although the customer is a better judge of "fit", descriptions in the marketing papers and conversations with marketing managers were used as surrogate information in order to assign a value to a program.

   For every Ford brand the customers have a preconceived image which has built over the years. Trucks use the slogan "Built Ford Tough" and therefore it would be important for a truck program to live up to the tough image in the mind of the customer. Most programs were a perfect fit with this image. Some exceptions were in cases where the company targeted a new customer base and hence the deviation from this image was intentional.

Scale:

1	Does not fit with the image at all
2	Fits somewhat with the image of Ford
3	Average fit
4	Above average
5	Total fit

2. Product aligns with corporate strategy and core competencies

Type: Metric / Covariate
Information Source: Program paper, strategy paper, and interviews

This measure tries to quantify the program alignment with the long-term strategy of the company and its core competencies. This is more of a covariate than a metric as the PD team has very little control over the strategy but the team can control the direction of the program through the actions that it takes.

For one of the programs, the project manager mentioned that although the program aligned very well with the corporate strategy it did not align well with the core competency as the core competency in itself had not changed to support the overall strategy. Such a program scored "3" on the scale below.

When available strategy papers were the source of this measure. Most of the minor programs did not have such a paper and hence marketing papers and interviews were used to obtain information.

Scale:

1	Does not align
2	
3	
4	
5	Aligns completely

3. Product is grounded in marketing plan

Type: Covariate
Information Source: Marketing presentations, and interviews

This tries to quantify the marketing strategy of the program after completion. The minor programs did not have any specific marketing plans but for new introductions and major programs the effort was put in by the marketing personnel to ensure that the product was launched right.

The source for this measure was mainly interviews with marketing managers and any launch presentations that were available. The television and print media advertisements were also looked at to get a better understanding of how the product fit the long term marketing strategy.

Scale:

1	Ad-hoc product proposal was the basis for the program
2	Product not foreseen but within the context of the product family
3	Foreseen to some extent but its relationship to the parent or platform is not planned
4	Product is planned variant from a platform or is creating a new platform for future planned action
5	Product is an integral part of the strategy

4.3.2 Covariate 2: Size of Strategic Opportunity

This is made up of two low-level measures. These are defined as follows:

1. Strategic market advantage to be gained

   Type: Covariate
   Information Source: Marketing papers, program papers, and interviews

   This covariate measures the strategic success of the product in the minds of the customers. Some programs helped Ford get their foot in the door, which would allow the company to build on, while other programs were merely a continuation without a major strategic focus.

   Marketing papers indicated the nature of strategic advantage expected from the market. Interviews with marketing managers also helped glean valuable information. A product which was projected to capture market share from an incumbent and grow its share scored a "5" , whereas a program which was designed to be a filler scored a "3"

1	None
2	Little, very little opportunity to aid future products
3	Some, product is meant to hold or fill a gap in the marketplace
4	Considerable, much learning expected with possibility of enabling future profits
5	High, product is meant to directly enable large profits from future variants

2. Strategic Technology advantage to be gained

Type: Covariate
Information Source: Interviews

This examines the advantages gained, relative to competition by introducing a new technology in the product. New introductions and major programs usually have the largest share of new technology and in certain cases this new technology can translate into a major advantage. However, the advantage is usually short-lived as competitors catch-up within a year or a little over. Some of the Ford products have played catch-up as well.

Although program papers indicated the "newness" of the technology, the advantage was not very evident, hence interviews were used as a main source of information for this covariate.

Scale:

1	None
2	Little, product improves incrementally on core technology
3	Some,
4	Major, product makes major strides in a strategically important area of technical competence
5	Breakthrough product, star technologically

4.3.3. Covariate 3: Size of Financial Opportunity

1. Expected Lifetime Profit
2. Return on Investment
3. Expected Sales
4. Expected Revenue

Each of these low-level covariates constitutes the high-level covariate. These are determined at the start of the program and are updated as the program progresses. Each was scaled to a maximum of "5" where 5 indicates high profits, revenues etc. To maintain consistency and to "mask" the actual data the numbers were scaled. The financial analysts for the programs gave this data.

4.3.3 Covariate 4: Availability of Resources

This covariate is a sum score of two low-level measures that are:

1. Resources available for continuance

Type: Covariate
Information Source: Interviews, and post program papers

This is a measure of the financial and material resources available to support the program after the last major milestone has been cleared. Most project managers mentioned that the resources were lesser than what was required to support the program. A rapid ramping down of resources seemed to be a characteristic for many projects.

Post program papers did sometimes indicate the support, however interviews were the main source of information for this measure.

Scale:

1	Critical shortfalls persist
2	Major shortfalls, more than avg.
3	Avg. for a Ford program
4	Resources more plentiful than avg.
5	Resources far more plentiful

2. Skills available for continuance

Type: Covariate
Information Source: Interviews, and post program papers

This is a measure of the personnel resources available to support the program after the last major milestone has been cleared. As described above, the project managers spoke of a shortfall. The data for this measure was also gleaned mainly from interviews.

Scale:

1	Critical shortfalls persist
2	Major shortfalls, more than avg.
3	Avg. for a Ford program
4	Resources more plentiful than avg.
5	Resources far more plentiful

4.3.4 Covariate 5: Coordination Difficulty of Team

Four low-level measures constitute this high-level measure.

1. Core Team Size

Type: Covariate
Information Source: Organization charts (where available), and interviews

This measures the number of people who were part of the dedicated team. Although the number varies over time this was measured at a time when the number was at its peak.

Scale: The number was scaled to a maximum of 5.

2. Extended Team Size

Type: Covariate
Information Source: Organization charts (where available), and interviews

This measures the number of people who were part of the total team, including the supporting team members. Although the number varies over time this was measured at a time when the number was at its peak.

Scale: The number was scaled to a maximum of 5.

3. Core Team Dispersion
4. Extended Team Dispersion

Type: Covariate
Information Source: Organization charts (where available), and interviews

Programs where the team was collocated documented better coordination and communication. For one of the programs the project manager mentioned how the global dispersion of the PD team created certain challenges which required additional effort to address.

Scale:

1	Entire team collocated
2	Bulk of team collocated, some local dispersion
3	Bulk of team collocated, some global dispersion
4	Bulk of team locally dispersed, some global
5	Team globally dispersed

Chapter 5: Analysis and Results

This chapter presents key findings from the preliminary analysis of the Ford data. The findings and observations are the result of empirical exploration and are therefore directions for further analysis rather than final recommendations.

5.1 RDF SURVEY RESULTS

The survey sampled 16 respondents from different functions and levels of responsibility within the PD teams. (See Table 3.1). For each metric the survey measured four aspects of the team member's perception of the PD process as it relates to him / her. These four aspects are as follows:

1. The perceived influence of the individual on the metric (scaled from 1 to 7, where 7 indicated highest influence).
2. The perceived accuracy with which the metric could be measured (scaled from 1 to 7, where 7 indicated highest precision).
3. The Risk Discount Factor (RDF) as a percent of some unspecified reward (including non-monetary).
4. Actual importance of the metric in today's Ford culture in determining rewards for the PD team members.

The mean responses for the first three are summarized in Table 5.1 below. The fourth aspect is discussed in a later section.

Table 5.1 Mean Values from the RDF Survey

Metric	Mean RDF	Mean Influence	Mean Precision
Metric 1: Understanding of Markets and Customers	0.25	5.81	4.75
Metric 2: Product Designed for Market Needs	0.38	5.56	5.13
Metric 3: Product designed for Advantageous Relationship with Other Products	0.47	4.50	5.56
Metric 4: Rigor of the Design Process	0.43	4.00	3.50
Metric 5: Appropriate Technology Selection	0.51	3.88	4.94
Metric 6: Coordination and Communication	0.38	5.38	3.75
Metric 7: Health of Relationship with Suppliers and Partners	0.52	3.69	3.56
Metric 8: Time to Market Performance	0.33	4.50	6.50
Metric 9: Customer Satisfaction	0.56	4.44	4.88
Achievement of Cost Targets	0.44	3.56	6.50
Achievement of Revenue Targets	0.49	3.56	6.13
Achievement of Quality Targets	0.44	4.38	4.50
Achievement of Strategic Goals	0.39	4.50	4.94

The size of the sample does not allow for further analysis on the distribution of the responses across the different functions. The sample is thus treated as a whole for the analysis. The variance calculated across the sample was large and therefore the data is treated with caution.

Table 5.2 shows the correlation between influence, precision and RDF. To test for additive and multiplicative relationships both raw correlations and correlations of natural logs were used. The theory as discussed in Chapter 1 and Appendix A indicates a strong relationship between precision and RDF and also between influence and RDF. Consistent with the expectation, influence shows a significant negative correlation with RDF. Precision shows a very weak negative correlation with RDF

Table 5.2: Correlation Relationships among Influence, Precision, and RDF

	Correlation with RDF	**Significance**
Influence	-0.698**	0.008
Precision	-0.092	0.766
	Correlation with Log(RDF)	**Significance**
Log(Influence)	-0.698**	0.008
Log(Precision)	-0.088	0.775
	Correlation with Precision	**Significance**
Influence	-0.177	0.564

** Significance of 0.05 or better

Table 5.3 shows the results of the regression of RDF on influence and precision. The regression is significant for both the raw and the log values. The regression coefficient for influence is more than twice the coefficient for precision. This comparison is possible because of the uniformity of the scale used for both. This reflects the comment made by some of the survey respondents who said that their influence played a larger role in determining their metric specific reward preferences.

Table 5.3: Regression of RDF on Influence and Precision

Regression of RDF on Influence and Precision	
Adjusted R^2	0.442
Constant	0.884
Coefficient. of Influence	-3.366
Coefficient of Precision	-1.013
Regression of Log(RDF) on Log(Influence) and Log(Precision)	
Adjusted R^2	0.425
Constant	0.819
Coefficient. of Log(Influence)	-3.275
Coefficient of Log(Precision)	-0.846

Significant at the 0.05 level

5.2 EXPLORATION OF LEVERAGE AND WEIGHTS

In order to determine leverage, ($\hat{\lambda}_i$ from Equation 10 in Chapter 1) regression estimates of each metric were obtained. Positive leverage for a metric indicates that increase in the emphasis or weight of the metric will increase profitability, while a negative leverage is an indicator of over emphasis.

Relationships of the measures with profit were also explored through correlations with profit and profit residuals. Profit residuals were obtained by regressing profit on covariates. As discussed in Chapter 1, we are interested in determining "incremental" profit or profit which the PD team members can impact through their efforts. Residuals obtained by regressing profit on covariates are therefore that portion of profit, which is impacted by the effort expended on the metrics.

The residual method may not work well under situations where the covariates and metrics are significantly correlated. This is because the resulting residual would not be correlated with any given metric and hence would underestimate the leverage of the metric. On the other hand, correlating metrics with the entire profit is likely to overestimate the leverage, as the effects due to covariates are not removed.

The following sections document all the exploratory analysis performed on the data and the results obtained.

5.2.1 Measures of Profit

The profit measures collected (as per Section 2.2.4.1) and used for the analyses of leverage are summarized in Table 5.4. The different measures were collected and calculated with the intention of capturing all the aspects of program success without sacrificing accuracy.

Table 5.4: Profit Measures

Measure	Definition
Total Gross Profit	Gross profit from date of launch through the end of 1999
Gross Profit Rate	The rate of gross profit since launch in dollars per day
Profit Later	Expected future profit from the program (by program manager or financial analyst)
Judged Overall Success	Overall success as judged by senior managers obtained through a written questionnaire (Appendix D)

The correlation among the profit measures were tested and are tabulated in Table 5.5

Table 5.5: Correlation among Profit Measures

	Gross Profit		Gross Profit Rate		Profit Later		Judged Overall Success	
	Correl	Signif	Correl	Signif	Correl	Signif	Correl	Signif
Gross Profit								
Gross Profit Rate	0.927**	0.000						
Profit Later	0.562*	0.046	0.667*	0.013				
Judged Overall Success	0.419	0.095	0.465	0.060	0.675*	0.011		

* = Significance of 0.10 or better
** = Significance of 0.05 or better

Judged Overall Success correlates insignificantly with both gross profit and gross profit rate, a derivative of gross profit. This may be due to the fact the gross profit favors those products, which have been in the market for the longest period of time. In order to correct for the length in the market bias, gross profit rate was calculated. However, this is not a perfect measure because it assumes a constant profit rate.

Judged Success was obtained through a survey instrument and asked the respondents, very senior managers, to judge the success of each program holistically. Appendix D contains the questionnaire used.

The information for Profit Later was not available for all the programs. Therefore, for the purposes of calculating leverage both the gross profit, and profit rate were considered.

5.2.2 Correlation of Original Metrics with Profit Measures

All the original measures were correlated with the profit measures in order to determine any initial significant correlations, which could then be explored further. These correlations, and the significance are tabulated in Table 5.6 in the next page.

Table 5.6: Correlation of Original Metrics with Profit Measures

Measures	Judged Overall Success		Profit Later		Actual Profit		Profit Rate	
	Coeff	Signif	Coeff	Signif	Coeff	Signif	Coeff	Signif
Metric 1: Understanding of Markets and Customers	0.282	0.273	0.224	0.462	0.203	0.435	0.073	0.78
Metric 2: Product Designed for market Needs	-0.005	0.984	-0.564*	0.045	0.215	0.408	0.105	0.69
Metric 3: Product Designed for Advantageous Relationship with Other Products	0.333	0.191	-0.053	0.863	0.284	0.27	0.074	0.78
Metric 4: Rigor of the Design Process	0.199	0.444	-0.199	0.515	0.344	0.177	0.269	0.3
Metric 5: Appropriate Technology Selected	0.021	0.936	0.121	0.694	0.141	0.59	0.043	0.87
Metric 6: Coordination and Communication	0.112	0.667	0.32	0.286	0.217	0.403	0.056	0.83
Metric 7: Relationship with Suppliers	0.241	0.351	0.211	0.49	0.512*	0.036	0.341	0.18
Metric 8: Time to Market	-0.095	0.716	0.178	0.562	0.523*	0.031	0.568*	0.02
Metric 9: Customer Satisfaction	0.246	0.342	0.214	0.482	0.183	0.481	0.227	0.38
Covariate 1: Fit with Ford	0.439	0.078	0.664*	0.013	0.238	0.357	0.394	0.12
Covariate 2: Size of Strategic Opportunity	0.490*	0.046	0.046	0.881	0.315	0.218	0.266	0.3
Covariate 3: Size of Financial Opportunity	0.273	0.29	0.096	0.754	0.204	0.431	0.288	0.26
Covariate 4: Availability of Resources	0.172	0.508	0.062	0.839	0.04	0.879	-0.008	0.97
Covariate 5: Coordination Difficulty of Team	0.11	0.674	-0.094	0.76	0.355	0.162	0.168	0.52

The results can be summarized as follows:

Among the metrics, Product Designed for Market Needs correlates negatively with profit later while Relationship with Suppliers correlates positively with Actual Gross Profit. Time to Market correlates significantly with both Gross Profit and Profit Rate.

Among the covariates, Covariate 2: Size of Strategic Opportunity correlates significantly with Judged Overall Success while Covariate 1: Product Fits with Ford correlates highly with Profit Later.

Customer Satisfaction does not correlate with any of the profit measures. This presents interesting implications, as Customer Satisfaction is an important metric at Ford. In order to examine the relationship of customer satisfaction with other measures, each low-level measure of customer satisfaction was treated independently for all further analysis.

All the relationships are explored further as outlined in the following sections.

5.2.3 Factor Analysis: Purified Measures

The measures as outlined in Table 2.1 were grouped according to similarity of purpose. This grouping was examined through factor analysis in order to identify orthogonal low-level measures that would influence the leverage calculations. This analysis also enabled splitting the categories into more meaningful ones so as to get a better understanding of the relationships within the measures, and leverage. Some low-level measures were eliminated from the new high level measures.

The purified measures are listed in Table 5.7 in the following page. Appendix E contains the details of the factor analysis component matrix on which the purified measures are based.

Table 5.7: Purified Measures

High Level Measure	Low Level Measures Included in Sum
M1_Pure	• Effort undertaken by team to study market characteristics • Thoroughness of team's market understanding • Effort to gather customer requirements
M1_Exp	• Ford's experience in this market
M2_Pure	• Product achieves intended differentiation • Product fills a gap in Ford's product line
M3_Pure1	• Degree of differentiation from competitive vehicles in this segment • Degree of differentiation from own vehicles in this segment • Expected reuse from this product
M3_Pure2	• Vehicle platform is flexible, robust • Product leverages platform elements well
M4_Pure	• Design process consideration of manufacturing capability • Use of robust design practices
M5_Pure	• Maturity of technology • Technology is implementation ready • Architecture of product allows easy integration of new technology
M6_Pure1	• Level of Coordination Achieved within team • Level of Coordination Achieved between team and external value chain partners • Quality of integrated plan • Number of Major Issues assessed at Milestone review
M6_Pure2	• Level of Coordination Achieved between team and internal value chain partners • Documentation of program
M7_Pure	• Confidence in delivery by suppliers already selected • Early selection of suppliers
M7_Hltsp	• Health of relationships with existing suppliers
M8	• Time to Market (unchanged from original measure)
M9_CS	• Customer Satisfaction with Overall Vehicle
M9_TGW	• Things Gone Wrong for overall vehicle
M9_CVS	• High Satisfaction with 0 TGW
C1	• Product fits with Ford (unchanged from original measure)
C2	• Size of Strategic Opportunity (unchanged from original measure)
C3_Pure	• Expected Lifetime Profit • Expected Sales • Expected Revenue
C4	• Availability of Resources (unchanged from original measure)
C5_Pure	• Core Team Size • Extended Team Size

In order to examine internal consistency of the new measures, and the level of error Cronbach's Alpha was calculated for each of the measures where appropriate (J. Paul Peter, 1979). The values are recorded in Table 5.8. The Alphas for the metrics average 0.7 demonstrating internal reliability.

Table 5.8: Reliability Analysis of the Purified Measures

Measures	Cronbach's Alpha
M1_Pure: Effort to understand markets and customers	0.8
M2_Pure: Internal differentiation and gap	0.4
M3_Pure1: External differentiation and reuse	0.6
M3_Pure2: Platform flexibility and leverage	0.6
M4_Pure: Manufacturing needs and robust design	0.7
M5_Pure: Maturity of technology	0.9
M6_Pure1: Coordination and issues	0.7
M6_Pure2: Internal communication and documentation	0.5
M7_Pure: Supplier confidence and selection	0.3
M9: Customer satisfaction	0.7
C1: Fit	0.7
C2: Strategic opportunity	0.7
C3_Pure: Financial opportunity	0.8
C4: Resources	0.9
C5_Pure: Team size	0.9

5.2.4 Correlations of Purified Measures with Profit Measures

The purified measures were correlated with Gross Profit and Profit Rate. The results, which are tabulated in Table 5.9 in the following page, can be summarized as follows:

Both the purified Metric 2 (M2_Pure) and purified Metric 4 (M4_Pure) have significant positive correlation with Gross Profit. This is unlike the results obtained earlier (Table 5.6) where the correlation of profit with the original Metrics 2 and 4 were not significant.

The results indicate that greater differentiation from the previous product, filling a gap in the product line, capturing manufacturing needs well during the PD process, and using robust design practices will improve profitability. However, as these correlations are with the entire profit and not the incremental profit one must be careful about interpreting the results. Also, as Cronbach's Alpha for M2_Pure is not very high, one should proceed with caution.

Table 5.9: Correlations of Purified Measures with Profit Measures

Measures	Gross Profit		Profit Rate	
	Coeff	Signif	Coeff	Signif
M1_Pure: Effort to understand markets and customers	0.175	0.503	0.03	0.909
M1_Exp: Ford's Experience in the market	-0.169	0.516	-0.105	0.688
M2_Pure: Internal differentiation and gap	0.501*	0.04	0.319	0.212
M3_Pure1: External differentiation and reuse	0.18	0.49	0.01	0.969
M3_Pure2: Platform flexibility and leverage	0.134	0.608	-0.08	0.761
M4_Pure: Manufacturing needs and robust design	0.483*	0.05	0.385	0.127
M5_Pure: Maturity of technology	0.312	0.223	0.294	0.253
M6_Pure1: Coordination and issues	0.277	0.282	0.101	0.7
M6_Pure2: Internal communication and documentation	0.014	0.957	-0.029	0.913
M7_Pure: Supplier confidence and selection	0.313	0.221	0.188	0.471
M7_Hlstp: Health with suppliers	0.087	0.74	-0.106	0.684
M8TTM: Time to market	0.523*	0.031	0.568	0.017
M9_CS: Customer satisfaction with overall vehicle	0.232	0.371	0.252	0.329
M9_TGW: Things Gone Wrong	0.066	0.802	0.136	0.602
M9_CVS: High satisfaction with 0 TGW	-0.015	0.957	0.008	0.977
C1: Fit	0.238	0.357	0.394	0.118
C2: Strategic opportunity	0.315	0.218	0.266	0.303
C3_Pure: Financial opportunity	0.079	0.763	0.149	0.568
C4: Resources	0.04	0.879	-0.008	0.974
C5_Pure: Team size	0.33	0.23	0.141	0.615

* = Significant at the 0.10 level

5.2.5 Correlation of Purified Metrics and Covariates

The correlation between measures was examined. The results are reported in Table 5.10. The detailed values can be found in Appendix F.

Customer Satisfaction measured as "Satisfaction with the Overall vehicle" is seen to correlate significantly with some of the other purified measures. As per the matrix, products with older technology detract from customer satisfaction, while increased internal coordination and communication between the core team and others in the value chain, and better documentation can improve customer satisfaction. Size of Strategic opportunity also correlates positively with customer satisfaction.

Except for Covariate 2: Size of Strategic Opportunity, none of the other covariates is significantly correlated with metrics.

Table 5.10: Correlation Matrix for Purified Measures

	M1_Pure: Effort for Market, VOC and Understanding	**M1_Exp**: Experience in Market	**M2_Pure**: Internal Differentiation, and Gap	**M3_Pure1**: Differentiation, Expected Reuse	**M3_Pure2**: Platform Flexibility and Leverage	**M4_Pure**: Manufacturing Needs, Robust Design Practices	**M5_Pure**: Technology maturity, readiness and Ease of Implementation	**M6_Pure1**: Coordination within team, with Suppliers and Reviews	**M6_Pure2**: Coordination with internal value chain , Documentation	**M7_Pure**: Confidence in Suppliers, Early selection	**M7_Hltsp**: Health of relationship	**M8**: Time to market	**M9_CS**: Customer Satisfaction with Overall Vehicle	**M9_TGW**: Things Gone Wrong	**M9_CVS**: High Satisfaction with 0 TGW	**C1**: Fit with Ford	**C2**: Strategic Opportunity	**C3_Pure**: Financial Opportunity	**C4**: Availability of Resources	**C5_Pure**: Size of core and Extended Team
M1_Pure: Effort for Market, VOC and Understanding	1		+	+		+	-		+								+			
M1_Exp: Experience in Market		1	-	-					-											
M2_Pure: Internal Differentiation, and Gap	+	-	1	+		+			+								+			
M3_Pure1: Differentiation, Expected Reuse	+	-	+	1										-			+			
M3_Pure2: Platform Flexibility and Leverage					1							-				-				+
M4_Pure: Manufacturing Needs, Robust Design Practices	+		+			1			+								+			
M5_Pure: Technology maturity, readiness and Ease of Implementation	-						1		-				-				-	-		
M6_Pure1: Coordination within team, with Suppliers and Reviews								1		+										
M6_Pure2: Coordination with internal value chain , Documentation	+	-	+			+	-		1				+				+			
M7_Pure: Confidence in Suppliers, Early selection								+		1				-					-	
M7_Hltsp: Health of relationship										+	1									
M8: Time to market					-							1								
M9_CS: Customer Satisfaction with overall vehicle							-		+				1		+		+			
M9_TGW: Things Gone Wrong				-						-				1						
M9_CVS: High Satisfaction with 0 TGW													+		1					
C1: Fit with Ford					-											1				
C2: Strategic Opportunity	+		+	+		+	-		+				+				1			
C3_Pure: Financial Opportunity							-											1		
C4: Availability of Resources										-									1	
C5_Pure: Size of core and Extended Team					+															1

+ = Significant Positive Correlation

- = Significant Negative Correlation

5.2.6 Correlation of Purified Metrics with Profit Residuals

Gross Profit was regressed on many combinations of covariates. As Covariate 2 correlated highly with the purified metrics (Table 5.10) it was not used in the regressions for the very reasons outlined in Section 5.2. The results reported in Table 5.11 are the correlations of the purified metrics on the residuals obtained from regressing Gross Profit and Profit Rate on Covariate 4: Availability of Resources.

As can be seen in the Table, M2_Pure: Internal Differentiation, and Gap, M4_Pure: Platform Flexibility, and Leverage, and M8: Time to Market, correlate significantly with the residual from Gross Profit. Time to Market also correlates with the residual from the Profit rate regression.

Table 5.11: Correlation of Purified Metrics with Residuals from Regression of Gross Profit, and Profit rate on Covariate 4: Availability of Resources

Measures	Gross Profit		Profit Rate	
	Coeff	Signif	Coeff	Signif
M1_Pure: Effort to understand markets and customers	0.174	0.503	0.03	0.908
M1_Exp: Ford's Experience in the market	-0.186	0.475	-0.102	0.698
M2_Pure: Internal differentiation and gap	0.501*	0.04	0.319	0.212
M3_Pure1: External differentiation and reuse	0.174	0.505	0.011	0.965
M3_Pure2: Platform flexibility and leverage	0.123	0.639	-0.077	0.768
M4_Pure: Manufacturing needs and robust design	0.485*	0.049	0.385	0.127
M5_Pure: Maturity of technology	0.314	0.22	0.293	0.253
M6_Pure1: Coordination and issues	0.288	0.262	0.098	0.707
M6_Pure2: Internal communication and documentation	0.022	0.933	-0.03	0.908
M7_Pure: Supplier confidence and selection	0.335	0.188	0.183	0.482
M7_Hlstp: Health with suppliers	0.101	0.7	-0.109	0.696
M8TTM: Time to market	0.532*	0.028	0.567*	0.018
M9_CS: Customer satisfaction with overall vehicle	0.226	0.382	0.253	0.326
M9_TGW: Things Gone Wrong	0.067	0.8	0.136	0.602
M9_CVS: High satisfaction with 0 TGW	-0.03	0.912	0.011	0.967

* = Significance of 0.10 or better

5.2.7 Regression Analysis of the Measures

As per Equation 10 (Chapter 1), the leverage of each metric is its regression estimate. The exact weight is then determined using the RDF value for the specific metric. A positive weight or leverage indicates room for increasing profitability by increasing the emphasis on the metric, whereas a negative weight indicates more than optimum emphasis on the metric. A zero value indicates either the "right" emphasis, or no affect on profit (Hauser, 1999). This is difficult to conclude without further consultation with managers at Ford and therefore will not be discussed with the current analysis.

Results on two regression models are reported. The first model did not include the last measure of customer satisfaction, namely "High Satisfaction with 0 TGW".

Table 5.12: Regression Analysis of Purified Measures – Model 1[1]

Measures	Gross Profit		M8TTM		M2_Pure		M3_Pure	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
M8TTM	0.768	3.843					-0.58	-2.667
M3_Pure2	0.47	2.289	-0.547	-2.531				
M2_Pure	0.369	2.145						
M1_Pure								
M1_Exp					-0.76	-5.101		
M3_Pure1								
M4_Pure					0.507	3.777		
M5_Pure								
M6_Pure1								
M6_Pure2								
M7_Pure								
M7_Hltsp								
M9_CS								
M9_TGW								
M9_CVS								
C1								
C2								
C3_Pure								
C4					0.369	2.495		
C5_Pure								

The second column reports the results of regressing gross profit as a dependent variable on the rest of the purified measures. Time to market, platform flexibility and leverage, and degree of differentiation with previous product and the gap filled in the product line, affect gross profit. Each of these measures enters the model with significant t-stats. From these results it can be suggested that increasing the emphasis on time to market,

[1] The values in columns 3 and 5 suggest endogeineity and collinearity. This has to be examined further

designing platforms which are more flexible and allows variants, and differentiating the products from their previous versions will improve profitability.

The next three columns report the results of regressing each of the profit enablers on other purified measures. The purpose of this is to understand which of the rest of the measures affect the profit enablers and how the ones that do can be used to improve the enablers thereby indirectly increasing profitability.

The other measures, which enter the model, are Ford's experience in the market, manufacturing needs and robust design practices, and availability of resources. None of the other measures make it into the model. The negative coefficient of Ford's experience in the market with degree of differentiation suggests that greater experience makes it more difficult to achieve differentiation. The other values indicate that including manufacturing needs early in the PD process and using robust design tools will increase profitability of the product. Greater resources will also impact product profitability.

The second regression model was obtained by including the measure "High satisfaction with 0 TGW". The results are in Table 5.13

Table 5.13: Regression Analysis of Purified Measures – Model 2[2]

Measures	Actual Profit		M4_Pure		M5_Pure		M9_CS	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
M4_Pure	0.684	3.93						
M5_Pure	0.651	3.344						
M9_CS	0.375	1.913						
M1_Pure								
M1_Exp								
M2_Pure			0.689	3.56				
M3_Pure1								
M3_Pure2								
M6_Pure1								
M6_Pure2					-0.641	-3.52	0.598	3.509
M7_Pure					0.436	2.395		
M7_Hltsp								
M8TTM								
M9_TGW							0.307	1.792
M9_CVS							0.48	2.745
C1								
C2								
C3_Pure								
C4								
C5_Pure								

[2] The differing results in models 1 and 2 suggest collinearity in the data. This has to be examined

The results obtained here are different from that in model 1. The major profit enablers in this model are manufacturing needs and robust design practices, technology maturity, and customer satisfaction with overall vehicle. The positive values indicate profit potential with greater emphasis on each of these measures.

Degree of differentiation with previous product and gap, early selection of suppliers and confidence in their capabilities, things gone wrong, and high satisfaction with 0 TGW all make it into the model and have positive coefficients with the different profit enabling measures. Coordination with internal value chain and documentation has a negative coefficient with technology maturity and a positive coefficient with customer satisfaction. This suggests that while increased coordination and documentation will increase customer satisfaction, it will make implementing technology more difficult. This is an interesting finding and needs to be explored further.

A couple of measures appear in both the models. These are M2_Pure (differentiation from previous product, gap) and M4_Pure (manufacturing needs, and robust design practices). The differing results need to be reconciled with further analysis on the data.

5.2.8 Determination of Weights

The weight on a metric is calculated by the following equation (Equation 10, Chapter 1):

$\hat{w}_i^o = \frac{\hat{\lambda}_i}{1+2RDF_i}$ where $\hat{\lambda}_i$ is the leverage, calculated as the regression coefficient of a metric. Results from regression model 2 are used to calculate the weights. This was done because model 2 included all the purified measures in the regression.

Table 5.14 Calculated Weights[3]

Measures	RDF (From Survey)	Leverage (From Regressions)	Weights
M4_Pure: Manufacturing needs and robust design	0.43	0.684	**0.367742**
M5_Pure: Maturity of technology	0.51	0.651	**0.322277**
M9_CS: Customer satisfaction with overall vehicle	0.44	0.375	**0.199468**
M2_Pure: Internal differentiation and gap	0.38	0.689	**0.391477**
M6_Pure2: Internal communication and documentation	0.38	-0.043	**-0.02443**
M7_Pure: Supplier confidence and selection	0.52	0.436	**0.213725**
M9_TGW: Things Gone Wrong	0.44	0.307	**0.163298**
M9_CVS: High satisfaction with 0 TGW	0.44	0.48	**0.255319**

[3] The other measures did not make it into the model as discussed in Section 5.2.7

It can be seen by inspection that the RDF did not change the rank order of the metrics as determined by the leverage. As per the weights the greatest profit potential is in increasing emphasis on internal differentiation and filling a gap in the product line.

5.3 COMPARISON OF CALCULATED WEIGHTS AND PERCEIVED WEIGHTS FROM RDF SURVEY

In order to understand how the calculated weights compare to the perceived weights at Ford Motor Company, the results from Part 4 of the RDF survey are presented. Table 5.15 contains the mean values from the survey.

Table 5.15: Mean Actual / Perceived Importance of Metrics from the RDF Survey

Metric	Mean Perceived Importance from RDF Survey
Met 1: Understanding of Markets and Customers	5.00
Met 2: Product Designed for market Needs	5.19
Met 3: Product Designed for Advantageous Relationship with Other Products	4.00
Met 4: Rigor of the Design Process	3.94
Met 5: Appropriate technology Selection	4.13
Met 6: Coordination and Communication	3.38
Met 7: Health of Relationships with Suppliers, Partners	2.69
Met 8: Time to Market	4.94
Met 9: Customer Satisfaction	5.94

The ranks of the metrics as per the calculated weights and the perceived weights are illustrated in the following table, Table 5.16.

Table 5.16: Comparison of Ranks[4]

Rank	Perceived Weights	Calculated Weights
Highest	Metric 9	Metric 2
	Metric 2	Metric 4
	Metric 5	Metric 5
	Metric 4	Metric 7
	Metric 6	Metric 9
Lowest	Metric 7	Metric 6

The comparison shows that as per the perceived weights, Customer Satisfaction is ranked the highest, whereas as per the calculated weights, it ranks fifth. This data suggests that there is more than required emphasis on customer satisfaction, however, the data needs to be analyzed further before such conclusions can be drawn.

[4] This table compares those metrics which made it into the model.

5.4 KEY FINDINGS AND DIRECTIONS FOR FUTURE WORK

5.4.1 Key Findings

The key findings from the empirical explorations are as summarized below. These findings are based on preliminary analysis of the data and provide direction for further work.

1. Cronbach's Alpha for purified metrics average 0.7 demonstrating internal reliability.

2. Customer satisfaction correlates significantly with the rigor of the PD process, and internal coordination and communication between the core team and the other members of the value chain.

3. Time to market shows consistent correlation with profit and profit residuals but has a low or insignificant correlation with the other measures.

4. The calculated weights suggest higher emphasis on capturing manufacturing need and using robust design practices, technology, and differentiation will increase profitability.

5. The measured RDF does not change the relative weightings of the metrics as obtained through the leverage calculation.

6. The perceived weights of the metrics, obtained from the RDF survey, do not match the calculated weights.

7. The metrics and covariates are not very interrelated.

5.4.2 Further Work on this Data Set

This preliminary analysis has provided certain signals that need to be explored. The analysis has also brought out certain weaknesses in the data set, which need to be tested.

The RDF data needs to be analyzed for functional influence. Results in Tables 5.12 and 5.13 suggest collinearity in the data. This needs to be examined and analyzed. High-influence data points need to be identified.

Further analysis will enable more robust conclusions, which can help initiate beneficial changes in the PD process at Ford Motor Company, and can be used as levers for future work at Ford and elsewhere.

5.4.3 Future Work

This study was a pilot study at Ford Motor Company. It would be interesting to conduct follow-up studies, which can explore in greater depth the results obtained from the analysis of this data set.

Future studies should seek a larger sample of programs. It would be important to have documentation for those programs. This makes it important to target companies or organizations, which store documents that are easily accessible. It would be important to target programs that are within a single division so as to enable ease in data collection.

Ideally, the programs selected for study should have similar market introduction dates. This would allow for more precise comparisons of profit and profit rates. This is important because profits are used to determine the leverage of a metric.

This model has been applied in "for-profit" organizations. It would be interesting to apply it to companies, which are "not-for-profit", or those, which do not have tangible products but design and develop services instead.

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Appendix A

Derivation of Model for Determining the Weight of a Metric

This material is extracted from Hauser (1999). The derivation starts with the premise of a single project that is then expanded to the division. For simplicity let us assume that there are two types of efforts e_1, and e_2 and then carry that forward to arrive at the final equation for weight.

Notation and Definitions

Metrics and Rewards

Let e_1 and e_2 be two types of efforts. (The following derivation extends nicely to n types of efforts.) Let $\tilde{m}_1$, and $\tilde{m}_2$ be metrics that attempt to measure e_1 and e_2. Let $\tilde{\pi}$ be the incremental profits when the PD team puts for efforts e_1 and e_2. The tilde (~) indicates that these metrics and profit are random variables. Specifically:

A.1
$$\tilde{m}_1 = m_1(e_1, e_2) + error_1$$
$$\tilde{m}_2 = m_2(e_1, e_2) + error_2$$
$$\tilde{\pi} = \pi(e_1, e_2) + error_\pi$$

We assume that the errors are zero-mean normal random variables with variances σ_1^2, σ_2^2, and σ_π^2, respectively. Note that the errors (and the variances) are independent of the effort levels.

The team is rewarded for its efforts based on the metrics. This can be represented as

A.2 $$rewards = w_o + w_1\tilde{m}_1 + w_2\tilde{m}_2$$

The linearity assumption is chosen because it is a good approximation for a set of relatively homogeneous PD projects. Also, observation of explicit and implicit PD team rewards at many firms suggest that linearity is a better approximation to what exists compared to highly non-linear systems. These rewards include both monetary and non-monetary rewards.

PD Team

The team incurs some cost, $c(e_1, e_2)$, while expending the effort. The team is aware of this cost, which is otherwise unobservable to top management. The team is also constantly risk averse compared to the risk neutral publicly traded company. The team's certainty equivalent is given by

A.3 $$(c.e.) = w_1 E(m_1) - \tfrac{1}{2} r w_i^2 \sigma_i^2$$

The net reward to the PD team will be the rewards paid by the firm minus its perceived costs. If the utility function for the PD team is constantly risk averse, then the above equation can be used to obtain the following equation as the maximization problem that the PD team will attempt to solve:

A.4 $\max rewards = w_o + w_1 m_1 + w_2 m_2 - c(e_1, e_2) - \frac{1}{2} r w_1^2 \sigma_1^2 - \frac{1}{2} r w_2^2 \sigma_2^2$

The PD team will maximize these rewards subject to the constraint that the net rewards are at least as large as the market wage plus switching costs. Call this number, W_o.
If the metrics are observed in a future period, then the PD team will discount them more than the firm. Including discount terms in Equation A.4 can capture this effect. This can be done by simply replacing w_1 with $\gamma_1 w_1$ where γ_1 is the discount factor for the first metric. The same can be done for metric 2. The discount term will not be tracked through all the steps of the derivation. Including the discount term in the above equation results in

A.4' $\max rewards = w_o + \gamma_1 w_1 m_1 + \gamma_2 w_2 m_2 - c(e_1, e_2) - \frac{1}{2} r \gamma_1^2 w_1^2 \sigma_1^2 - \frac{1}{2} r \gamma_2^2 w_2^2 \sigma_2^2$

The Firm

The firm will maximize its net profits by selecting the fixed wages, w_0 and the weights or strategic priorities w_1, w_2 etc. The following represents the firm's net profits

A.5 $net\ profit = \pi(e_1, e_2) - w_0 - w_1 m_1 - w_2 m_2$

The firm will try to keep wages as low as feasible, it will choose w_o to keep the maximum rewards as low as is feasible, hence it will choose w_o to maintain wages only as high as is necessary to prevent the team from leaving the firm. That is, it will select $rewards \geq W_o$ where W_o represents the wages the team could earn elsewhere after taking switching costs into account. This implies that the firm's formal maximization problem can be written as follows.

A.6 $\max\ profit = \pi(e_1, e_2) - W_o - c(e_1, e_2) - \frac{1}{2} r w_1^2 \sigma_1^2 - \frac{1}{2} r w_2^2 \sigma_2^2$

The constant, W_o, does not affect the maximization problem so, for the remainder of this note, we will set it to zero.

Derivation for a Single Project

The PD team will select its efforts to maximize Equation A.4. We assume an interior solution. (This is not a bad assumption if costs are non-linear. We will have to revisit it if we model costs as linear.) This results in the following first-order condition (FOC) for e_1:

A.7 $$w_1 \frac{\partial m_1}{\partial e_1} + w_2 \frac{\partial m_2}{\partial e_1} - \frac{\partial c}{\partial e_1} = 0$$

We get a similar FOC for e_2. We now make a critical assumption that the metrics are targeted. That is, that $\partial m_1 / \partial e_2 = 0$. This gives us the following FOCs:

A.7' $$w_1 \frac{\partial m_1}{\partial e_1} - \frac{\partial c}{\partial e_1} = 0$$

$$w_2 \frac{\partial m_2}{\partial e_2} - \frac{\partial c}{\partial e_2} = 0$$

Equation A.7' can be used to solve for the efforts that the team will put forth based on the w's. Call these efforts e^* with the appropriate subscripts. We now substitute this back into the firm's optimization problem to get:

A.8 $$\frac{\partial \pi}{\partial e_1^*} \frac{\partial e_1^*}{\partial w_1} + \frac{\partial \pi}{\partial e_2^*} \frac{\partial e_2^*}{\partial w_1} - \frac{\partial c}{\partial e_1^*} \frac{\partial e_1^*}{\partial w_1} - \frac{\partial c}{\partial e_2^*} \frac{\partial e_2^*}{\partial w_1} - r w_1 \sigma_1^2 = 0$$

We would like to simplify Equation A.8 as we did Equation A.7. We have already assumed $\partial m_1/\partial e_2=0$. If we assume, in addition, that $\partial^2 m_2/\partial e_2\partial e_1=0$ and $\partial^2 c/\partial e_2\partial e_1=0$, then we can simplify Equation A.8. (Basically, these two assumptions decouple the two equations in Equations A.7'.) The first assumption is not a very bad additional assumption. It says simply that the level of e_2 does not affect the slope of m_1 with respect to e_1. The second assumption is, unfortunately, a significant assumption because it makes the costs separable. We will have to address this later in this note.
With these assumptions we get:

A.8' $$\frac{\partial \pi}{\partial e_1^*}\frac{\partial e_1^*}{\partial w_1}-\frac{\partial c}{\partial e_1^*}\frac{\partial e_1^*}{\partial w_1}-rw_1\sigma_1^2=0$$

We now use the implicit function theorem on Equation A.7' to get the following equation.

A.9 $$\frac{\partial e_1^*}{\partial w_1}=\frac{\partial m_1}{\partial e_1^*}\left[\frac{\partial^2 c}{\partial e_1^2}-w_1\frac{\partial^2 m_1}{\partial e_1^2}\right]^{-1}$$

Here we make a technical assumption that the expression in brackets is non-zero. I wouldn't worry too much about this assumption. We substitute Equation A.9 into Equation A.8' to get:

A.10 $$\left[\frac{\partial \pi}{\partial e_1^*}-\frac{\partial c_1}{\partial e_1^*}\right]\frac{\partial m_1}{\partial e_1}\left[\frac{\partial^2 c}{\partial e_1^2}-w_1\frac{\partial^2 m_1}{\partial e_1^2}\right]^{-1}=rw_1\sigma_1^2$$

We recognize that we can use Equation 7' to simplify the first term in brackets (substitute for $\partial c_1/\partial e_1$). After some algebra we get an expression for the optimal weight on the first metric. We can repeat this derivation for the optimal weight on the second metric.

A.11 $$w_1^*=\frac{\left(\frac{\partial \pi}{\partial e_1^*}\right)\left(\frac{\partial m_1}{\partial e_1^*}\right)}{\left[\left(\frac{\partial m_1}{\partial e_1^*}\right)^2+r\sigma_1^2\frac{\partial^2 c}{\partial e_1^2}-rw_1\sigma_1^2\frac{\partial^2 m_1}{\partial e_1^2}\right]}$$

This is the final expression under the assumptions we have made and assuming that there is only one project. We can make one more assumption to simplify the expression further. If we assume that the metric is linear in efforts then the last term in the denominator bracket vanishes. That is, if we assume that $\partial^2 m_1/\partial e_1^2 = 0$, then we get a metric of the form, $m_1 = \alpha e_1 + error_1$. In any real case, this will be true only approximately. We will make this assumption for now. We can investigate it later. Once this assumption is made, we can put the optimal weight in a simple-to-interpret form:

A.12 $$w_1^*=\frac{\left(\frac{\partial \pi}{\partial e_1^*}\right)\Big/\left(\frac{\partial m_1}{\partial e_1^*}\right)}{\left[1+\left(r\frac{\partial^2 c}{\partial e_1^2}\right)\left\{\sigma_1^2\Big/\left(\frac{\partial m_1}{\partial e_1^*}\right)^2\right\}\right]}$$

Finally, if we re-introduce the discount factor, we get Equation A.12'.

A.12' $$w_1^* = \frac{\gamma^{-1}\left(\frac{\partial \pi}{\partial e_1^*}\right)\Big/\left(\frac{\partial m_1}{\partial e_1^*}\right)}{\left[1+\left(r\frac{\partial^2 c}{\partial e_1^2}\right)\left\{\sigma_1^2\Big/\left(\frac{\partial m_1}{\partial e_1^*}\right)^2\right\}\right]}$$

This is equivalent to Equation 6 in Chapter 1.

Derivation for a Division

The practical challenge that top management faces is to set strategic priorities for the firm, or at least for a division. They do not have the knowledge or the expertise to set separate priorities for each PD project. Thus, we define the firm's problem as selecting a single set of strategic priorities, w_i^o's, such that the sum of profits across all PD projects is maximized.

More importantly, we recognize that these firms are ongoing concerns with existing priorities. The observations that we make represent how the organization (the multiple PD teams) responds to the current priorities. Thus, rather than set priorities from scratch, we can seek measures which tell us how to change existing priorities to improve profits. This concept is known as adaptive control and is used successfully to set relative spending levels for marketing mix variables (e.g., Little 1966). Under the right technical conditions, these changes in priorities will converge to the optimal priorities.

To implement adaptive control, we approximate the underlying response functions with a linear-quadratic model. Specifically, if j indexes the PD projects, then we use the following approximations:

A.13 $$\tilde{m}_{ij} \cong k_{ij} + \alpha_{ij} e_{ij} + error_{ij} \qquad c_{ij} \cong k_{ij}^c + \tfrac{1}{2} b_{ij} e_{ij}^2 \qquad \tilde{\pi}_{ij} \cong k_{ij}^{\pi} + \beta_{ij} e_{ij} + error_{ij}^{\pi}$$

where $k_{ij}, k_{ij}^c, k_{ij}^{\pi}$ are constants, $\alpha_{ij} = \partial m_{ij} / \partial e_{ij}$, $\beta_{ij} = \partial \pi_{ij} / \partial e_{ij}$, and $b_{ij} = \partial^2 c_j / \partial e_{ij}^2$. The derivatives are evaluated at the firm's current operating conditions and apply only for changes about these extant conditions. The constants do not affect the maximization problems, so we ignore them in the following derivations.

By substituting Equation A.13 into Equation A.6 we obtain the division's total incremental expected profits due to product development.[1]

A.14 $$\Pi^o = E\left[\sum_j \sum_i \left\{\beta_{ij} e_{ij}^o - \tfrac{1}{2} b_i (e_{ij}^o)^2 - \tfrac{1}{2} r \sigma_i^2 (w_i^o)^2 + error_{ij}^{\pi}\right\}\right]$$

For a given set of division priorities, w_i^o's, each team will select its efforts to maximize its certainty equivalent. We determine these efforts by solving Equation A.4 to show that

[1] We ignore all constants that do not affect the maximization problem. Equation A.14 assumes that neither b_{ij} nor σ_{ij} vary by j. This is for notational convenience only. The reader is invited to extend the derivations.

$e_{ij}^o = w_i^o \alpha_{ij} / b_{ij}$. Recognizing that publicly traded firms should be risk neutral, we substitute these optimal efforts into Equation A.14.

A.15 $$\Pi^o = \sum_j \sum_i \left\{ \frac{w_i^o \alpha_{ij} \beta_{ij}}{b_i} - \frac{1}{2} \frac{(w_i^o)^2 \alpha_{ij}^2}{b_i} - \frac{r}{2} \sigma_i^2 (w_i^o)^2 \right\}$$

Differentiating Equation 9 with respect to w_i^o and recognizing that (1/J) times the sum over projects is just the (empirically estimated) expected value, we obtain:

A.16 $$w_i^o = \frac{E_j[\beta_{ij} \alpha_{ij}]}{E_j[\alpha_{ij}^2] + r b_i \sigma_i^2}$$

Finally, if we use the definitions of the variance and covariance[2], we derive an expression for the strategic priorities as a function of definable, but hard-to-measure, quantities:

A.17 $$w_i^o = \frac{\frac{E_j[\beta_{ij}]}{E_j[\alpha_{ij}]} + \frac{\mathrm{cov}(\alpha_{ij}, \beta_{ij})}{E_j[\alpha_{ij}]}}{1 + \frac{\mathrm{var}(\alpha_{ij})}{E_j^2[\alpha_{ij}]} + \frac{r \sigma_i^e b_i}{E_j^2[\alpha_{ij}]}}$$

Equation A.17 provides useful and intuitive interpretations, which we state formally as a result before we proceed to empirical estimation. The proof is by inspection.

For a division, the strategic priority on a metric is larger if, for the same effort:
(1) the expected increase in profit is large compared to the expected increase in the metric,
(2) the increase in profit is correlated across projects with increases in the metric,
(3) there is little variation across projects in the ability to increase the metric, and
(4) the expected signal-to-noise ratio is large.

Equation A.17 still contains many quantities that are extremely difficult, if not impossible, to measure. We transform the equation further to make it practical. Because the errors are zero-mean and uncorrelated, we substitute the expression for e_{ij}^o into Equation A.13 and take expectations to show that:

A.18 $$E_j[\pi_{ij}^o] = \frac{w_i^o}{b_i} E_j[\beta_{ij} \alpha_{ij}] \qquad E_j[m_{ij}^o] = \frac{w_i^o}{b_i} E_j[\alpha_{ij}^2]$$

We then substitute Equation A.18 into Equation A.16 to obtain the following recursive equation for w_i^o.

A.19 $$w_i^o = \frac{E_j[\pi_{ij}^o] / E_j[m_{ij}^o]}{1 + \frac{r w_i^o \sigma_i^2}{E_j[m_{ij}^o]}}$$

Finally, by recognizing that the certainty equivalent for the net rewards based on metric *i* is just $c.e. = w_i^o m_{ij}^o - \frac{1}{2} r (w_i^o)^2 \sigma_i^2$ and the expected rewards are just $w_i^o E_j[m_{ij}^o]$, we obtain:

[2] Var(x) = E[x^2] – E^2[x] and cov(x,y) = E[xy] – E[x]E[y].

A.20 $$w_i^o = \frac{E_j[\pi_{ij}^o]/E[m_{ij}^o]}{1+2\left[\frac{E_j[rewards_j]-E_j[c.e._j]}{E_j[rewards_j]}\right]}$$

The bracketed term in the denominator is now a measurable quantity, which we have come to call the *risk discount factor (RDF).* For a given set of priorities, it is the amount by which the team will discount the real, risky rewards relative to a situation where the rewards can be guaranteed. We have pretested a number of measures of RDF and have found that team members understand the concept and can provide consistent answers that they feel represent RDF.

Although the definition of RDF is recursive, we have found empirically that it does not vary dramatically. Thus, we feel that it is consistent with the adaptive-control philosophy upon which the linear-quadratic approximation is based. That is, RDF is a measure of the current state of the organization which represents the net effect of risk aversion, effort aversion, and the signal-to-noise ratio.

At first glance, the numerator of Equation A.20 appears to be easily measured as the average profit divided by the average value of the metric, but it is really more complex because $E_j[\pi_{ij}^o]$ represents the expected *incremental* profit due to actions *influenced by metric i.* This is a much more difficult quantity to measure. Instead, we use a statistical approach to parse the marginal impact of each metric. We begin with the expression for e_{ij}^o to show that:

A.21 $$\tilde{\pi}_j^o = \sum_i \frac{\beta_{ij}}{\alpha_{ij}}\tilde{m}_{ij}^o + \sum_i (error_{ij}^{\pi} - \frac{\beta_{ij}}{\alpha_{ij}} error_{ij}) \equiv \sum_i \frac{\beta_{ij}}{\alpha_{ij}}\tilde{m}_{ij}^o + error_j^{'}$$

Note that $error_j^{'}$ is itself a zero-mean, normal random variable. Thus, if the ratio, β_{ij}/α_{ij}, is reasonably constant for all PD projects in the division, then Equation A.22 is simply a multiple regression equation.[3] The observed incremental profits, as measured for each PD project, is the dependent variable; the metric values for each project are the explanatory variables. If $\hat{\lambda}_i$ is the regression estimate for metric *i*, then the empirical estimate of the strategic priority for metric *i* is given by:

A.23 $$\hat{w}_i^o = \frac{\hat{\lambda}_i}{1+2RDF_i}$$

Appendix A Extracted from
Hauser, John R. (1999), Strategic Priorities for Product Development. MIT Working Paper.

[3] Even if the ratio is not constant, the regression equation might prove to be a reasonable estimate.

Appendix B

Status Tracking Matrix

Research Status

	M1	M2	M3	M4	M5	M6	M7	M8	M9	C1	C2	C3	C4	C5	Profit	Remaining / Scheduled Tasks
Prog 1																Customer satisfaction data will come in May
Prog 2																Done!
Prog 3																Done!
Prog 4																Done!
Prog 5																Done!
Prog 6																Done!
Prog 7																Done!
Prog 8																Profit and customer satisfaction data will come in May
Prog 9																Done!
Prog 10																Done!
Prog 11																Done!
Prog 12																Done!
Prog 13																Done!
Prog 14																Done!
Prog 15																Done!
Prog 16																Done!
Prog 17																Done!
Prog 18																Done!

Color Key

Dark Green	100% Complete
Med Green	>50% Complete
Light Green	25 % - 50 % Complete
Orange	No data yet, contact name available
Red	No data, establish contacts
Grey	Latter additions
Yellow	Difficulty in nailing the right contacts
In Red	No Documents available
Brown	Data will be available in May
Maroon	Projections not created for these programs

Column Key

Metrics

M1	Understanding of Markets and Customers
M2	Product Designed for Market Needs
M3	Product Designed for Advantageous Relationship with other products
M4	Rigor of Design Process
M5	Appropriate Technology Selection
M6	Coordination and Communication
M7	Health of Relationship with Suppliers, Partners
M8	Time to Market Performance
M9	Customer Satisfaction

Covariates

C1	Product Fits with Ford
C2	Size of Strategic Opportunity
C3	Size of Financial Opportunity
C4	Availability of Resources
C5	Coordination Difficulty of Team

Appendix C

Survey for Influence, RDF, Precision and Importance

Thank you for taking the time to answer the questions in this survey. This four-part questionnaire is part of a yearlong study on Ford's product development metrics. The purpose is to understand your influence on various aspects of the product development process, the importance of these aspects to Ford, and some factors, which influence the praise, recognition, and rewards you would receive at the end of the program. Your input is very important. Your responses will be kept confidential.

PART I

Imagine that you are on a team about to embark on a new product development program as a member of a program team. Assume that your role as a team member (for example, program manager, technical manager, engineer etc.) will be one that you are familiar with based on your experience to date.

Your role is _____

Below is a list of thirteen aspects of performance, which might be judged or measured by someone outside the team. Considering the role you will play on this team, please answer the following question for each of the thirteen aspects of performance:

How much influence are you likely to have on this aspect of performance?

Please indicate your response by checking the box that you think best represents your judgment of the answer to the above question

1 = very low influence	7 = very high influence

Aspect of Performance	1	2	3	4	5	6	7
1. Team's understanding of the market and customers' needs	☐	☐	☐	☐	☐	☐	☐
2. How well the product is designed to meet customer needs and program objectives	☐	☐	☐	☐	☐	☐	☐
3. Whether product is designed to have advantageous relationships with other Ford products (such as reuse of platform elements) as well as with competitive products	☐	☐	☐	☐	☐	☐	☐
4. Rigor of the design process (use of reliability studies etc)	☐	☐	☐	☐	☐	☐	☐
5. Appropriate selection of technology to be used in the program	☐	☐	☐	☐	☐	☐	☐
6. Coordination within the team, between the team and other areas of Ford, and between the team and external partners	☐	☐	☐	☐	☐	☐	☐

Aspect of Performance	1	2	3	4	5	6	7
7. Health of relationship with suppliers and partners	☐	☐	☐	☐	☐	☐	☐
8. Achievement of Time to Market and meeting all milestone dates	☐	☐	☐	☐	☐	☐	☐
9. Achievement of cost targets for development and manufacturing	☐	☐	☐	☐	☐	☐	☐
10. Achievement of revenue targets	☐	☐	☐	☐	☐	☐	☐
11. Achievement of quality and reliability targets	☐	☐	☐	☐	☐	☐	☐
12. Customer satisfaction of product after purchase	☐	☐	☐	☐	☐	☐	☐
13. Achievement of strategic success targets for the product	☐	☐	☐	☐	☐	☐	☐

PART II

Please consider each aspect of performance below. For each, we are interested in your judgment regarding how precisely it can be measured or judged. Please answer the following question for each aspect of performance:

With what precision can this aspect of performance be measured or judged by someone not on the team?

Please indicate your response by checking the box that you think best represents your judgment of the answer to the above question.

	1 = very low precision						7 = very high precision
Aspect of Performance	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Team's understanding of the market and customers' needs	☐	☐	☐	☐	☐	☐	☐
2. How well the product is designed to meet customer needs and program objectives	☐	☐	☐	☐	☐	☐	☐
3. Whether product is designed to have advantageous relationships with other Ford products (such as reuse of platform elements) as well as with competitive products	☐	☐	☐	☐	☐	☐	☐
4. Rigor of the design process (use of reliability studies etc)	☐	☐	☐	☐	☐	☐	☐
5. Appropriate selection of technology to be used in the program	☐	☐	☐	☐	☐	☐	☐
6. Coordination within the team, between the team and other areas of Ford, and between the team and external partners	☐	☐	☐	☐	☐	☐	☐
7. Health of relationship with suppliers and partners	☐	☐	☐	☐	☐	☐	☐
8. Achievement of Time to Market and meeting all milestone dates	☐	☐	☐	☐	☐	☐	☐
9. Achievement of cost targets for development and manufacturing	☐	☐	☐	☐	☐	☐	☐
10. Achievement of revenue targets	☐	☐	☐	☐	☐	☐	☐
11. Achievement of quality and reliability targets	☐	☐	☐	☐	☐	☐	☐
12. Customer satisfaction of product after purchase	☐	☐	☐	☐	☐	☐	☐
13. Achievement of strategic success targets for the product	☐	☐	☐	☐	☐	☐	☐

PART III

Recall the situation from Part I – you are on a team about to embark on a project to design and develop a new product. You will fill the functional role you chose in Part I. This will be a balanced cross-functional team, consisting of team members similar to those you have worked with previously.

You will receive many rewards--above and beyond your salary--based on your team's performance. Some of these might include:

- Monetary bonuses
- Promotion
- Respect from colleagues
- **Opportunities to work on interesting programs in the future**
- **Praise and recognition**

Some of the above-mentioned rewards may be explicit—for example, they are formally determined by contracts with management. Others are implicit—the reward structure exists within the culture of Ford. In this survey, we ask you to consider ALL the rewards, explicit and implicit, that you might receive based on your team's performance on a product development project.

On the following page are several aspects of your team's performance that might be judged, observed, or measured by others to determine the rewards (explicit *and* implicit) that you receive. You and your team have the opportunity to impact these aspects of performance through your efforts.

For each aspect of performance on the list, imagine that you determine *up front* how much effort you will expend to affect it. Do not worry about determining what that effort would actually be. Then consider the following two scenarios. They differ in how your explicit and implicit rewards are determined. *Note that for each aspect of performance you would choose the same amount of effort for Scenario B as for Scenario A.*

Scenario A: *You decide how much effort to put in to the aspect of performance. Someone outside the team bases your reward on the judgment or measurement of the aspect of performance.* You cannot be certain what the judged or measured value of your performance will actually be, therefore the amount of reward you will receive is not certain. For the amount of effort that you have chosen to allocate, there is some average expected reward that could be calculated across many projects of the same type. However, there is uncertainty for any individual (i.e., your) project.

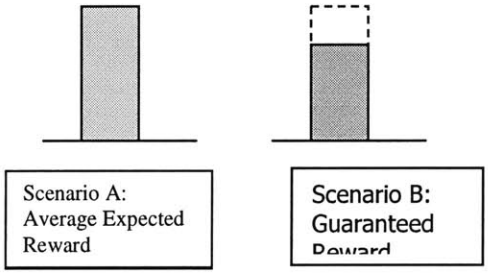
Scenario B: *You allocate the same amount of effort as in Scenario A to the aspect of performance.* However, the amount of reward you receive for this is determined in advance. There is no uncertainty.

If the guaranteed rewards from Scenario B were equal to or greater than the average expected rewards from Scenario A, most people would prefer Scenario B because Scenario B eliminates risk. In fact, some people would prefer Scenario B even if the guaranteed rewards were less than the average expected rewards from Scenario A.

For each aspect of performance, we would like you to answer the following:

> At what value of the guaranteed rewards from Scenario B (as a percentage of the average respected reward from Scenario A) would you be indifferent between the two scenarios?

For example, you might prefer Scenario B if the guaranteed rewards were equal to 99 percent of the average expected rewards from Scenario A. But you might prefer Scenario A if the guaranteed rewards were equal to 1 percent of the average expected rewards from Scenario A. Thus there would be some percentage between 1 and 99 for which you would be indifferent between the two scenarios.



Aspect of Performance	Guaranteed Reward from Scenario B (as a percent of expected reward from Scenario A) at which you are indifferent
1. Team's understanding of the market and customers' needs	_____% of reward from A
2. How well the product is designed to meet customer needs and program objectives	_____% of reward from A
3. Whether product is designed to have advantageous relationships with other Ford products (such as reuse of platform elements) as well as with competitive products	_____% of reward from A
4. Rigor of the design process (use of reliability studies etc)	_____% of reward from A
5. Appropriate selection of technology to be used in the program	_____% of reward from A
6. Coordination within the team, between the team and other areas of Ford, and between the team and external partners	_____% of reward from A
7. Health of relationship with suppliers and partners	_____% of reward from A

Aspect of Performance	Guaranteed Reward from Scenario B (as a percent of expected reward from Scenario A) at which you are indifferent
8. Achievement of Time to Market and meeting all milestone dates	_____% of reward from A
9. Achievement of cost targets for development and manufacturing	_____% of reward from A
10. Achievement of revenue targets	_____% of reward from A
11. Achievement of quality and reliability targets	_____% of reward from A
12. Customer satisfaction of product after purchase	_____% of reward from A
13. Achievement of strategic success targets for the product	_____% of reward from A

PART IV

Please recall the concept of explicit and implicit rewards from Part III. In Part III we were interested in your preferences for how you might be rewarded based on various aspects of performance for a hypothetical project.

In this part we are interested in your judgment of the answer to the following question:

In today's Ford culture, what is the relative importance of each aspect of success when determining the rewards, both explicit and implicit, that a program team may receive?
Please indicate your response by checking the appropriate box on the 7-point scale

	1 = very low importance						7 = very high importance
Aspect of Performance	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Team's understanding of the market and customers' needs	☐	☐	☐	☐	☐	☐	☐
2. How well the product is designed to meet customer needs and program objectives	☐	☐	☐	☐	☐	☐	☐
3. Whether product is designed to have advantageous relationships with other Ford products (such as reuse of platform elements) as well as with competitive products	☐	☐	☐	☐	☐	☐	☐
4. Rigor of the design process (use of reliability studies etc)	☐	☐	☐	☐	☐	☐	☐
5. Appropriate selection of technology to be used in the program	☐	☐	☐	☐	☐	☐	☐
6. Coordination within the team, between the team and other areas of Ford, and between the team and external partners	☐	☐	☐	☐	☐	☐	☐
7. Health of relationship with suppliers and partners	☐	☐	☐	☐	☐	☐	☐
8. Achievement of Time to Market and meeting all milestone dates	☐	☐	☐	☐	☐	☐	☐
9. Achievement of cost targets for development and manufacturing	☐	☐	☐	☐	☐	☐	☐
10. Achievement of revenue targets	☐	☐	☐	☐	☐	☐	☐
11. Achievement of quality and reliability targets	☐	☐	☐	☐	☐	☐	☐
12. Customer satisfaction of product after purchase	☐	☐	☐	☐	☐	☐	☐
13. Achievement of strategic success targets for the product	☐	☐	☐	☐	☐	☐	☐

Appendix D

Survey of Judged Overall Success

PURPOSE AND INSTRUCTIONS

Thank you for taking the time to help us understand the drivers of success at Ford. This questionnaire is part of a yearlong study on Ford's product development metrics. We have now collected into a single database the metrics that Ford collects on its product platforms – these metrics include indicators of both short-term and long-term profit. However, some projects provide more (or less) to Ford than just profits alone. Other benefits might include strategic success in a market, technological success that can be leveraged across platforms, the development of new processes or best practices, or, valuable lessons that can be shared widely. We want to be sure that we include such measures of success in our database. To this end we are asking you to judge the overall success of specific Ford vehicle programs. It should take less than 10 minutes of your time to help us by completing the attached questionnaire. In return we will share with you the results of our metrics analyses. Naturally, all data are confidential and will not be identified by name.

Specifically, this questionnaire asks you to judge the overall success of 18 vehicle programs. In judging success you should take the profit or projected profit into account, but you may want to include other aspects such as those listed above. Please judge the overall success of only those programs with which you are familiar. The scale runs from 1 to 10 where 1 is the lowest possible score of success and 10 is the highest possible score. If you are not familiar with the program please check the "Not Sure" box.

If you think that the success of a program is not yet known please estimate what you think its success will be, knowing what you now know. Also, please feel free to write comments in the margin if you wish to qualify your answer. Your answer will be used to understand the outcome of the program and will not be quoted or cited individually.

Please contact Arpita Majumder at 25515 (AMAJUMD1) once you have finished.

Once again, your help is greatly appreciated.

In your judgment what was the overall success of each of the following programs?

Program	Overall Success											Comments (If any)
	1	2	3	4	5	6	7	8	9	10	Not Sure	
Program 1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 3	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 4	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 5	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 6	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 9	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 10	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 11	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 12	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 13	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 14	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 15	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 16	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 17	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Program 18	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Appendix E

Components from Factor Analysis of Original Measures

Metric 1:

Rotated Component Matrix[a]

	Component	
	1	2
[m1_xexp] Ford's experience in this market	-.256	-.742
[m1_efmkt] Effort undertaken by team to study market characteristics	.865	.343
[m1_thund] Thoroughness of team's market understanding	.720	-.133
[[m1_efvoc] Efffort to gather the voice of the customer	.848	.308
[m1_efdc] Effort to understand the needs of the distribution channel	-1.23E-02	.868

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Metric 2:

Component Matrix[a]

	Component
	1
[m2_vod] Product acheives intended differentiation	.530
[m2_gap] Product fills a gap in Ford's product line	.644
[m2_attsd] Attention paid to Compliance with Regulatory, Environmental, and Industry Standards	.732
[m2_comsd] Compliance with Standards	.753

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Metric 3:

Rotated Component Matrix[a]

	Component	
	1	2
[m3_dcomp] Degree of differentiation from competetive products	.889	.239
[m3_down] Degree of differentiation from own product	.518	-.473
[m3_pflex] Platform is flexible, robust	-.161	.840
[m3_levp] Product leverages platform elements well	.201	.847
[m3_reuby] Reuse by this product of previous product elements	-.694	.190
[m3_reuof] Expected reuse from this product	.671	2.316E-05

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Metric 4:

Component Matrix[a]

	Component
	1
[m4_dfmfg] Design process consideration of manufacturing capability	.869
[m4_dfsal] Design process consideration of sales	.244
[m4_dfsvc] Design process consideration of service	.665
[m4_robd] Use of Robust Design Practices	.811

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Metric 5:

Component Matrix[a]

	Component
	1
[m5_xadv] Ford's advantage in technology with this product	-.789
[m5_rchop] Richness of technology options	-.534
[m5_mattc] Maturity of technology	.931
[m5_readi] Likelihood of readiness, validation	.931
[m5_arint] Architecture of product allows easy integration of technology	.869

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Metric 6:

Rotated Component Matrix[a]

	Component	
	1	2
[m6_cintm] Level of coordination acheived within team	.617	.586
[m6_invcp] Level of coordination acheived between team and internal value chain partners	.395	.772
[m6_exvcp] Level of coordination acheived between team and external value chain partners	.688	.133
[m6_docn] Documentation of program	-.141	.790
[m6_quaip] Quality of integrated plan	.905	.114
[m6_mjiss] Number of major issues assessed at phase review	.767	-.525

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Metric 7:

Rotated Component Matrix[a]

	Component	
	1	2
[m7_relia] Reliance on external partners for development of product	4.960E-02	-.706
[m7_hltsp] Health of relationship with existing suppliers/partners	.792	.357
[m7_cnfsp] Confidence in delivery by suppliers already selected	.567	.571
[m7_flxsp] Flexibility in selection of suppliers	-.398	-.554
[m7_dgsel] Early selection of Suppliers	8.052E-02	.731
[m7-matsp] Maturity of relationships with suppliers	-.855	.200

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Covariate 1:

Component Matrix[a]

	Component
	1
[c1_image] Product fits with Ford's image	.654
[c1_strat] Product aligns with corporate strategy and core competencies	.706
[c1_map] Product is grounded in Marketing Plan	.940

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Covariate 3:

Rotated Component Matrix[a]

	Component	
	1	2
[c3_prof] Expected Lifetime Profit	.818	.509
[c3_roi] Return on Sales	6.215E-02	.989
[c3_units] Number of units expected to sell	.922	3.007E-02
[c3_rev] Expected Revenue	.967	4.204E-02

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Covariate 5:

Rotated Component Matrix[a]

	Component	
	1	2
[c5_corsz] Core Team Size	.984	-.104
[c5_exsz] Extended Team Size	.855	.453
[c5_crdsp] Core Team Dispersion	-.295	-.543
[c5_exdsp] Extended Team Dispersion	-9.64E-02	.923

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Appendix F

Correlation Metrics for Purified Measures

		M1_Pure: Effort to understand markets and customers	M1_Exp: Ford's Experience in Market	M2_Pure: Internal differentiation and gap	M3_Pure1: External differentiation and reuse	M3_Pure2: Platform flexibility and leverage	M4_Pure: Manufacturing needs and robust design	M5_Pure: Tech advantage, richness, easy integration	M6_Pure1: Coordination and issues	M6_Pure2: Internal communication and documentation	M7_Pure: Supplier confidence and selection
M1_Pure: Effort to understand markets and customers	correl	1.00	-0.43	0.50	0.89	-0.01	0.69	-0.60	0.27	0.57	-0.10
	signif	.	0.08	0.04	0.00	0.98	0.00	0.11	0.29	0.02	0.69
M1_Exp: Ford's Experience in Market	correl	-0.43	1.00	-0.68	-0.52	-0.15	-0.44	0.27	-0.35	-0.62	-0.13
	signif	0.08	.	0.00	0.03	0.56	0.08	0.29	0.16	0.00	0.61
M2_Pure: Internal differentiation and gap	correl	0.50	-0.68	1.00	0.59	0.23	0.60	-0.23	0.34	0.62	0.17
	signif	0.04	0.00	.	0.01	0.37	0.01	0.36	0.18	0.00	0.51
M3_Pure1: External differentiation and reuse	correl	-0.89	-0.52	0.59	1.00	0.11	0.53	-0.39	0.21	0.48	-0.25
	signif	0.00	0.03	0.01	.	0.67	0.03	0.12	0.41	0.19	0.32
M3_Pure2: Platform flexibility and leverage	correl	-0.01	-0.15	0.23	0.11	1.00	0.08	0.12	0.37	-0.24	0.10
	signif	0.98	0.56	0.37	0.67	.	0.98	0.65	0.14	0.36	0.69
M4_Pure: Manufacturing needs and robust design	correl	0.69	-0.44	0.60	0.53	0.01	1.00	-0.65	0.41	0.68	0.10
	signif	0.00	0.08	0.01	0.03	0.98	.	0.00	0.10	0.00	0.69
M5_Pure: Tech advantage, richness, easy integration	correl	-0.60	0.27	-0.23	-0.39	0.12	-0.65	1.00	-0.04	-0.67	0.36
	signif	0.01	0.29	0.36	0.12	0.65	0.00	.	0.87	0.00	0.15
M6_Pure1: Coordination and issues	correl	0.27	-0.35	0.60	0.21	0.37	0.41	-0.04	1.00	0.25	0.52
	signif	0.29	0.16	0.01	0.41	0.14	0.10	0.87	.	0.32	0.03
M6_Pure2: Internal communication and documentation	correl	0.57	-0.61	0.34	0.48	-0.24	0.68	-0.67	0.25	1.00	0.56
	signif	0.01	0.00	0.18	0.05	0.36	0.00	0.00	0.32	.	0.83
M7_Pure: Supplier confidence and selection	correl	-0.10	-0.13	0.17	-0.25	0.10	0.10	0.36	0.52	0.05	1.00
	signif	0.69	0.61	0.51	0.32	0.69	0.69	0.15	0.03	0.83	.
M7_Hlstp: Health with Suppliers	correl	0.18	0.11	-0.07	0.06	0.23	0.29	0.15	0.48	-0.12	0.59
	signif	0.48	0.67	0.78	0.82	0.38	0.24	0.55	0.05	0.63	0.01
M8: Time to Market	correl	-0.00	0.25	0.03	-0.14	-0.57	0.00	0.24	-0.05	-0.04	0.27
	signif	0.98	0.34	0.90	0.58	0.02	0.98	0.36	0.86	0.86	0.29
M9_CS: Satisfaction with Overall Vehicle	correl	0.33	-0.40	0.38	0.26	0.13	0.56	-0.48	0.17	0.63	-0.10
	signif	0.19	0.10	0.13	0.29	0.60	0.19	0.04	0.51	0.00	0.68
M9_TGW: Things Gone Wrong	correl	-0.32	0.43	-0.1	-0.53	-0.21	0.28	-0.18	0.03	0.18	0.17
	signif	0.21	0.08	0.54	0.03	0.41	0.26	0.48	0.90	0.64	0.49
M9_CVS: High Satisfaction w_ 0 TGW	correl	0.44	-0.1	0.00	0.40	0.08	0.23	-0.42	-0.0	0.27	-0.5
	signif	0.08	0.65	0.97	0.11	0.75	0.37	0.10	0.83	0.31	0.02
C1: Fit with Ford	correl	-0.07	0.30	-0.21	-0.06	-0.51	-0.02	0.21	-0.23	-0.16	-0.13
	signif	0.79	0.22	0.40	0.82	0.03	0.94	0.41	0.37	0.53	0.60
C2: Strategic Opportunity	correl	0.70	-0.45	0.49	0.72	0.07	0.79	-0.55	0.41	0.53	-0.22
	signif	0.00	0.07	0.04	0.00	0.78	0.00	0.02	0.10	0.02	0.40
C3_Pure: Financial Opportunity	correl	0.35	0.29	-0.04	0.11	-0.30	0.28	-0.49	-0.06	0.26	-0.17
	signif	0.16	0.25	0.87	0.67	0.23	0.27	0.04	0.81	0.29	0.50
C4: Availability of Resources	correl	0.01	0.41	0.01	0.15	0.28	-0.00	-0.03	-0.27	-0.19	-0.54
	signif	0.97	0.09	0.96	0.57	0.26	0.99	0.88	0.27	0.44	0.02
C5_Pure: Size of core and extended team	correl	0.48	-0.12	0.33	0.43	0.65	0.34	-0.18	0.12	-0.07	-0.02
	signif	0.06	0.68	0.22	0.11	0.00	0.21	0.51	0.67	0.80	0.93

		M7_Hlstp: Health with Suppliers	**M8:** Time to Market	**M9_CS:** Satisfaction with Overall Vehicle	**M9_TGW:** Things Gone Wrong	**M9_CVS:** High Satisfaction w_ 0 TGW	**C1:** Fit with Ford	**C2:** Strategic Opportunity	**C3_Pure:** Financial Opportunity	**C4:** Availability of Resources	**C5_Pure:** Size of core and extended team
M1_Pure: Effort to understand markets and customers	correl	**0.18**	**-0.00**	**0.33**	**-0.31**	**0.44**	**-0.07**	**0.71**	**0.35**	**0.01**	**0.48**
	signif	0.48	0.97	0.19	0.21	0.08	0.79	0.00	0.16	0.97	0.06
M1_Exp: Ford's Experience in Market	correl	**0.11**	**0.25**	**-0.40**	**0.44**	**-0.12**	**0.31**	**-0.45**	**0.29**	**0.41**	**-0.12**
	signif	0.67	0.34	0.10	0.08	0.65	0.22	0.07	0.25	0.09	0.68
M2_Pure: Internal differentiation and gap	correl	**-0.07**	**0.03**	**0.38**	**-0.1**	**0.00**	**-0.21**	**0.49**	**-0.04**	**0.01**	**0.33**
	signif	0.78	0.90	0.13	**0.54**	**0.97**	0.40	0.04	0.87	0.96	0.22
M3_Pure1: External differentiation and reuse	correl	**0.06**	**-0.15**	**0.27**	**-0.53**	**0.40**	**-0.06**	**0.72**	**0.11**	**0.15**	**0.43**
	signif	0.82	0.57	0.29	0.03	0.12	0.82	0.00	0.67	0.57	0.11
M3_Pure2: Platform flexibility and leverage	correl	**0.23**	**-0.54**	**0.14**	**-0.21**	**0.08**	**-0.51**	**0.07**	**-0.31**	**0.28**	**0.65**
	signif	0.38	0.02	0.60	0.41	0.75	0.03	0.78	0.23	0.26	0.00
M4_Pure: Manufacturing needs and robust design	correl	**0.29**	**0.00**	**0.56**	**0.28**	**0.24**	**-0.02**	**0.79**	**0.28**	**-0.00**	**0.34**
	signif	0.24	0.98	0.01	0.26	0.37	0.94	0.00	0.27	0.99	0.21
M5_Pure: Tech advantage, richness, easy integration	correl	**0.15**	**0.24**	**-0.48**	**-0.18**	**-0.42**	**0.21**	**-0.55**	**-0.49**	**-0.04**	**-0.18**
	signif	0.55	0.36	0.04	0.48	0.10	0.41	0.02	0.04	0.88	0.51
M6_Pure1: Coordination and issues	correl	**0.48**	**-0.04**	**0.17**	**0.03**	**-0.05**	**-0.23**	**0.41**	**-0.06**	**-0.27**	**0.12**
	signif	0.05	0.85	0.51	0.90	0.83	0.37	0.10	0.81	0.27	0.67
M6_Pure2: Internal communication and documentation	correl	**-0.12**	**0.04**	**0.63**	**0.02**	**0.26**	**-0.16**	**0.54**	**0.26**	**-0.19**	**-0.07**
	signif	0.63	0.88	0.00	0.94	0.31	0.53	0.02	0.29	0.44	0.80
M7_Pure: Supplier confidence and selection	correl	**0.59**	**0.27**	**-0.11**	**0.17**	**-0.56**	**-0.13**	**-0.22**	**-0.17**	**-0.54**	**-0.02**
	signif	0.01	0.29	0.68	0.49	0.02	0.60	0.40	0.50	0.02	0.93
M7_Hlstp: Health with Suppliers	correl	**1.00**	**-0.03**	**-0.21**	**0.21**	**-0.27**	**0.04**	**0.09**	**-0.20**	**-0.34**	0.28
	signif	.	0.89	0.40	0.40	0.31	0.87	0.71	0.43	0.17	0.31
M8: Time to Market	correl	**-0.03**	**1.00**	**-0.02**	**0.23**	**-0.07**	**0.41**	**-0.09**	**0.48**	**-0.20**	**-0.17**
	signif	0.89	.	0.93	0.36	0.79	0.09	0.71	0.05	0.42	0.54
M9_CS: Satisfaction with Overall Vehicle	correl	**-0.21**	**-0.02**	**1.00**	**0.05**	**0.55**	**-0.02**	**0.53**	**0.33**	**0.14**	**0.09**
	signif	0.40	0.94	.	0.82	0.02	0.92	0.03	0.19	0.59	0.74
M9_TGW: Things Gone Wrong	correl	**0.21**	**0.24**	**0.06**	**1.00**	**-0.29**	**0.22**	**0.02**	**0.24**	**-0.01**	**-0.12**
	signif	0.40	0.36	0.82	.	0.27	0.38	0.93	0.35	0.95	0.67
M9_CVS: High Satisfaction w_ 0 TGW	correl	**-0.27**	**-0.07**	**0.55**	**-0.29**	**1.00**	**-0.07**	**0.44**	**0.23**	**0.37**	**0.31**
	signif	0.31	0.79	0.02	0.27	.	0.97	0.08	0.38	0.15	0.27
C1: Fit with Ford	correl	**0.04**	**0.41**	**-0.02**	**0.22**	**-0.07**	**1.00**	**0.17**	**0.25**	**-0.07**	**-0.48**
	signif	0.87	0.09	0.92	0.38	0.97	.	**0.49**	0.33	0.78	0.07
C2: Strategic Opportunity	correl	**0.09**	**-0.09**	**0.52**	**0.02**	**0.44**	**0.18**	**1.00**	**0.28**	**0.05**	**0.28**
	signif	0.71	0.71	0.03	0.93	0.08	0.49	.	0.26	0.85	0.31
C3_Pure: Financial Opportunity	correl	**-0.20**	**0.48**	**0.33**	**0.24**	**0.23**	**0.25**	**0.28**	**1.00**	**0.13**	**-0.02**
	signif	0.43	0.05	0.19	0.35	0.38	0.33	0.26	.	0.60	0.94
C4: Availability of Resources	correl	**-0.34**	**-0.20**	**0.14**	**-0.01**	**0.37**	**-0.07**	**0.05**	**0.14**	**1.00**	**0.23**
	signif	0.17	0.42	0.59	0.95	0.15	0.78	0.85	0.60	.	0.40
C5_Pure: Size of core and extended team	correl	0.28	-0.1	0.09	-0.12	0.32	-0.48	0.28	-0.0	0.23	**1.00**
	signif	0.31	0.54	0.74	0.67	0.27	0.07	0.31	0.94	0.40	.