The Economic Demand for and Consequences of Contracting on Measures of the Drivers of Future Performance

by

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A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Accounting

Waterloo, Ontario, Canada, 1998

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Abstract

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Recent trends in performance evaluation suggest increasing use in practice of measures that reflect drivers of future performance (DFP). These measures include primarily nonfinancial but also forward-looking financial performance measures. There has been relatively little academic research that studies why firms use measures of DFP rather than (or to supplement) traditional performance measures used in incentive contracts. Agency theory offers general insight but does not address specific properties of measures of DFP. This thesis adds specificity to the existing agency literature in presenting a two-period model of the economic conditions that create a demand for measures of DFP both with and without a capital market context. It also explores the economic consequences of variations in both economic conditions and specific properties of the measures of DFP themselves. The central results of this thesis support the view that the use of DFP measures in contracting can be a more cost-effective and timely way in which to reward an agent's farsighted efforts relative to conventional rewards based on financial performance or the stock price. Further, the use of DFP measures can induce agent effort more efficiently across shortsighted and farsighted activities, which can help mitigate the potential for an agent to engage in short-term myopic behaviour.

Key Words: Performance measures, Incentive contracts, Agency theory, Economic Determinants.

Acknowledgements

I am deeply indebted to Dr. Tony Atkinson for his strategic guidance, timely feedback, and resolute support throughout the dissertation process. I am also grateful to my thesis dissertation committee members, Dr. Alan Douglas, Dr. Phelim Boyle, and Dr. Yigal Gerchak who provided encouragement and many helpful insights. I also thank Dr. Raffi Indjejikian who kindly consented to be the external reader of this thesis.

I am especially grateful to Dr. Gordon McDougall and Justin Walawski whose patience and understanding were consistent sources of motivation. I also thank a number of individuals who provided encouragement and support throughout my program including all faculty and PhD students at the School of Accountancy and professors who provided guidance throughout courses I studied in the Departments of Management Sciences, Mathematics, and Economics. In particular, I am grateful to those who have influenced my thinking and who in many cases also provided written comments on my work. They include Dr. John Waterhouse, Dr. Howard Armitage, Dr. Bill Scott, Dr. Gord Richardson, Dr. Ken Klassen, Dr. David Downie, Dr. Tony Wirjanto, Dr. Walter Bossert, Dr. Beth Jewkes, Dr. David Fuller, Kate Bewley, Sue McCracken, Steve Fortin, Marie-Josee Ledoux, Jeff Pittman, Norm Wise, Dr. Raymond Morissette, Dr. Theresa Libby, Dr. Johnny Jermias, Dr. Malcolm Smith, Dr. Keith Houghton, Peter Robinson, and the 1982 starting group at Hendry, Rae and Court.

The completion of this thesis would not have been possible without the encouragement and support of all of my family. Above all my wife, Lynn, and my daughter, Samantha, provided an unyielding and constant source of comfort and inspiration, through their achievements and faith. In addition, while my mother's recent passing was a devastating loss, the strength and courage she showed in her last days provided me with an unsurpassed source of inspiration throughout the dissertation process.

Finally, I am grateful for financial support from the Faculty of Arts at the University of Waterloo, Curtin University (Perth, Australia), and the Ontario Graduate Scholarship program.

To Lynn Marie, Samantha Cleo, and Cleo.

Contents

Chapter 1

Introduction and Literature Review

1.1 Introduction

Recent research has suggested that nonfinancial performance measurement is gaining increasing popularity as a tool for both controlling operations and providing a basis for offering variable employee-based incentives. However, explanations for the increasing popularity have relatively little theoretical grounding. One potential explanation is that nonfinancial performance measurement is closely linked to (or anticipates) the future profitability of the firm. Through this link, the successful management of nonfinancial performance measures in the current period will increase the prospects of prosperous future performance.

The fundamental purpose of this thesis is to develop an understanding of the economic demand for, and consequences of, using current nonfinancial performance measures that predict the future performance of a firm. The present emphasis in practice on nonfinancial performance measures suggests that future economic prosperity may arise from the use of such nonfinancial measures. However, to assess this assertion rigorously, it is important first to understand the conditions supporting the demand for nonfinancial measures and second to analyze the economic consequences of using nonfinancial measures.

One way of disciplining the ex-ante debate on the usefulness of nonfinancial performance measures is to model analytically the use by firms of nonfinancial performance measures. In particular, principal-agent analysis can be used to underpin an analysis of the circumstances in which nonfinancial performance measures become a valuable contracting tool. One limitation is that

principal-agent analysis focuses on the nonfinancial performance measures being used only for contracting purposes and ignores the use of nonfinancial performance measures in non-contracting contexts. In this sense, principal-agent provides a restricted analysis. However, the insights generated are likely to provide testable explanations for why, at least, we see nonfinancial measures being increasingly used in variable incentive contracting.

This thesis comprises three essays that together attempt to develop formal insight about why we see nonfinancial performance measures used the way that they are in incentive contracting. The first essay (Chapter 2) explores, absent a capital market, the general demand for current measures of performance that are correlated with future performance. The second essay (chapter 3) extends the demand analysis and examines the consequences on firm profits of variations in specific attributes of forward-looking performance measures. The third essay (chapter 4) introduces a capital market and explores the tensions between long-term incentive contracting on the firm's stock price, current signals of performance that are correlated with future performance, and future performance signals. Notably, each essay relaxes the restriction that the forward-looking current measure of performance must also be *nonfinancial*. Rather, each essay assumes that the forward-looking measure can be either financial or nonfinancial; the only restriction is that the measure must capture some element of an agent's farsighted effort. The distinction between nonfinancial, and forward-looking or *drivers of future performance* is discussed further in the next section of this chapter.

The remainder of this chapter is organized as follows. In the next section, I distinguish between nonfinancial measures of performance and measures of the drivers of future performance, to link the existing literature that focuses on nonfinancial measures of performance with the less restrictive *drivers of future performance* used throughout this thesis. Next, to set the stage for developing the analytical models in the subsequent chapters, I discuss existing work in nonfinancial performance measurement, especially that which relates to the *choice* of nonfinancial measures of performance for contracting. This leads into an analysis of how the existing literature so described is relevant for this thesis. Finally, I provide an overview of the organization of this thesis.

1.2 The Link Between Nonfinancial Performance Measures and Measures of the Drivers of Future Performance

This sub-section highlights the distinction between the term "nonfinancial performance measures", often used in the literature, and "measures of the drivers of future performance", which is used throughout this thesis. A useful starting point for understanding the distinction is Morissette (1996). He provides a distinction between financial and quantitative nonfinancial performance measures. Essentially, any performance measure that includes a monetary metric (including ratios of monetary and non-monetary metrics) can be regarded as a financial performance measure.

Conversely, quantitative nonfinancial performance measures are those that comprise only non-monetary metrics. Logically, the distinction between monetary versus non-monetary metrics in itself does not enhance our understanding of why nonfinancial performance measurement might be closely linked with the future performance. This is because firms often use current performance measures based on *monetary* metrics that can be logically linked to future performance. Examples include research, development, and capital expenditures.

Since the primary focus in this thesis is to understand the link between current performance measures and future performance, the discussion throughout will not refer specifically to nonfinancial performance measures as predictive of future performance. Rather, a generic performance measure, extractable in the current period, and which conceivably can be either financial or nonfinancial in nature is included throughout this thesis. Thus, while the operationalization of this variable may predominantly be nonfinancial it does not preclude, however, operationalization of the variable as financial measures of performance that are forward-looking in nature.

Notwithstanding this distinction, the literature review in this chapter focuses predominantly on nonfinancial measures as a proxy for drivers of future performance. This emphasis on nonfinancial measures reflects the current trend in the literature, particularly in the use of forward-looking performance measures for incentive contracting purposes.

1.3 Why Contract on Nonfinancial Performance Measures? - A Literature Review

In reviewing the existing literature on nonfinancial measures of performance, three themes emerge. First, the use of nonfinancial performance measures in general is becoming increasingly popular for a variety of purposes. Second, the increasing popularity of the measures in different contexts translates into increasing use of nonfinancial performance measures in contracting. Third, academic research in this area has been relatively slow in developing formal theoretical insight on the determinants of the choice of *nonfinancial* performance measures as predictive[1] contracting variables.

The increasing use of nonfinancial measures, their inclusion in incentive contracts, and findings from academic research about the determinants of their choice in incentive contracts will each be discussed in turn. The purpose of the discussion in each of the three areas is as follows. First, evidence of increased use of nonfinancial performance measurement is presented to provide an understanding of the importance of these types of performance measures in practice, which provides motivation for the research conducted in this thesis. Second, it is important to establish that the use of nonfinancial performance measurement translates to contracting choice to justify the principal-agent framework used throughout this thesis. Third, it is also important to review prior work that relies on the choice of contractible nonfinancial performance measures to identify a basis for identifying the research issues that this thesis addresses in subsequent chapters.

1.3.1 Evidence of Increased Use of Nonfinancial Performance Measurement

Nonfinancial performance measurement has recently received widespread exposure in the management accounting literature. This exposure has corresponded with an apparent increase in the use of nonfinancial performance measures in practice. This purpose of this subsection is to provide evidence of an increase in the use of nonfinancial measures by practitioners.

A natural starting point to extract evidence on the increasing use of nonfinancial performance

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[1] Predictive in this context means that future financial performance is correlated with the current nonfinancial performance measures.

measures is practitioner-oriented literature. Here, over recent years, considerable attention has been devoted to two related issues. First, this literature has highlighted deficiencies in traditional financial performance measures for governance purposes. Second, the literature has strongly promoted performance measurement alternatives.

In a recent research monograph, Waterhouse and Svendsen (1998) capture the thrust of the first of these issues raised in the practitioner-oriented literature. They argue that traditional financial performance measures are often backward focused, do not facilitate organizational learning, and in many cases are not useful for monitoring key processes, accountability, and both implicit and explicit contracts. They identify a need for relatively greater emphasis on nonfinancial performance measures for governance purposes.

In terms of the second issue commonly raised in the practitioner-oriented literature, Kaplan and Norton's (1992) "Balanced Scorecard" approach represents perhaps the best known of the alternative performance measurement approaches. The Balanced Scorecard approach prescribes a mix of financial and nonfinancial performance measures, over distinct dimensions, to manage the firm's operations. The perceived benefits of the Balanced Scorecard approach have been promulgated in numerous practitioner-oriented articles (cf. Otley, 1997; Evans et. al, 1996). Strategic performance measurement is a closely related concept that attempts to bridge the gap between theoretical insights and the practitioner orientation of the Balanced Scorecard approach (e.g. see Atkinson, Waterhouse and Wells, 1997). Atkinson (1998) discusses the link between nonfinancial performance measures arising from establishing the firm's strategy and the reward of the firm's individuals. He shows explicitly how strategic performance measurement can be tied to individuals' compensation.

Given practitioner dissatisfaction with traditional financial performance measures and the emphasis of the Balanced Scorecard on nonfinancial measures, it may be that the popularity of Kaplan and Norton's Balanced Scorecard in itself has motivated some practitioners to adopt increased usage of nonfinancial performance measures in their control systems. Notwithstanding, the following discussion focuses on evidence of the increasing use of nonfinancial performance measurement that is

not necessarily attributable to the popularity of the Balanced Scorecard approach.

Many authors have identified changing economic trends to rationalize the increasing use of nonfinancial performance measures in practice. Banker, Potter and Schroeder (1993) provide empirical evidence of how the adoption of new manufacturing practices necessitated a move away from reporting *financial* measures to workers, toward reporting *nonfinancial* measures to workers. Lessner (1989) similarly argues that changing production technologies, such as the move to just-in-time (JIT) manufacturing creates a need for changes to traditional performance measures. Smith (1990) identifies labour-related sectors as neglected by management accounting research. He documents 65 nonfinancial performance measures used in manufacturing practice that are ripe for adoption into labour-related sectors. Nanni et al. (1992) use case evidence to show that changes in the modern manufacturing environment have created a need for "integrated performance measurement", which focuses centrally on nonfinancial performance measures.

A common theme in these papers is made explicit in the descriptive work of Maskell (1989). He identifies four characteristics of modern firms that may lead to increased use of nonfinancial performance measures. He argues that as firms move toward world class manufacturing, they will consider a new approach to product quality, just-in-time production techniques, changes in the way that the workforce is managed, and a flexible approach to serving customers. He further argues that these changes will lead to "new" performance measurement and lists nonfinancial measures as one of the characteristics of "new" performance measurement.

Despite this relatively large stream of mainly descriptive literature predicting a role for nonfinancial performance measurement, relatively few empirical studies have emerged to show that changes in technology will lead to increases in the use of nonfinancial performance measurement. Ittner and Larcker (1995) show that the introduction of total quality management practices is related to information systems that place greater emphasis on nonfinancial performance measures. Abernethy and Lillis (1995) find that as firms improve manufacturing flexibility, performance measurement systems emphasize nonfinancial rather than cost-based performance measures. Extending this work,

Perera et. al. (1997) find evidence of increased use of nonfinancial performance measures by firms pursuing a customer-focused manufacturing strategy.

The importance and increased use of nonfinancial performance measures has been particularly evident recently in the practice area of supply chain management. Brown (1996) reports that the big 3 motor vehicle manufacturers introduced a requirement that their suppliers were to be QS-9000 accredited.[2] Given the aforementioned empirical findings, one would reasonably expect increased use of nonfinancial performance measures from the motor vehicle manufacturers' requirement. Brown (1997) reports on inventory management trends that emphasize streamlined supply chains. She asserts that these trends generate a greater need for monitoring key nonfinancial performance measures, which ultimately lead to substantial overhead cost savings in the firms she reports. The Economist (1997) also reports a technological trend that creates an enhanced demand for nonfinancial performance measures in supply chain management: Japan Airlines uses the Internet to identify abroad cheaper suppliers of airline consumables. The specifications on which overseas suppliers can tender bids are principally nonfinancial in nature (Japan Airlines, 1998).

Recent survey evidence suggests increasing use of and concern about nonfinancial performance measures by practitioners. Booth (1995) presents evidence that the performance indicators are of significant concern to subscribers to the "Management Accounting Centre of Excellence" in Australia. Stivers et. al. (1997) report survey evidence that shows both Canadian and US firms rely heavily on nonfinancial performance measures in setting the goals of the firm. They find greater emphasis on customer and market-based nonfinancial measures than on other types of nonfinancial measures. Waterhouse and Svendsen's (1998) survey of Canadian firms finds that 80% of respondents receive efficiency, environmental, health, and safety performance information, all of which is non-financial in nature. Each of these sources of evidence supports the view of a growing emphasis on nonfinancial performance measures by practitioners.

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[2] QS-9000 is a product quality certification standard based on the ISO 9000 group of quality standards (that have been

The current popularity of nonfinancial performance measures is also illustrated by the increasing attention on such information in published annual reports. McBride (1997) argues that nonfinancial information is critical for understanding the context in which the financial results are achieved and it provides indications of future performance. Richardson (1998) presents evidence from the voluntary disclosure literature suggesting MD&A (Management Discussion and Analysis) disclosures, which invariably include nonfinancial measures of performance, provide forward-looking information that is not pre-empted by any other channel of firm disclosure. Dempsey et al. (1997) present survey evidence that suggests market analysts rely on more than traditional financial performance measures and use extensively strategic nonfinancial performance measures to assess the long-term success of a firm.

In summary, it seems clear that nonfinancial performance measurement has emerged as a popular information tool and that there has been increased use of the tool in recent years. The literature that provides evidence of increased use has also shown that changes in context, such as new technology, new supplier specifications, or new investor demands can be associated with increased demand for nonfinancial performance measurement.

1.3.2 Evidence of Contracting on Nonfinancial Performance Measures

The discussion in the previous subsection provides evidence that nonfinancial performance measures are an increasingly important tool used by firms for a variety of contracting and non-contracting purposes. To motivate the analysis and underpinning framework used in this thesis, it is also important to identify the extent to which the popularity of nonfinancial measures in practice has specifically translated into the adoption of such measures into incentive contracting plans. This is because increased use of nonfinancial measures in general is not a necessary condition for them to be used in incentive contracts. No study has directly tested this assertion. However, the following discussion indicates that nonfinancial measures are indeed used quite extensively in incentive

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implemented in many companies worldwide) and tailored to the automotive industry.

contracts.[3]

Several textbooks describe the structure of management compensation plans that are based in part on nonfinancial performance measures. Demski (1994) notes that nonfinancial information is commonplace in performance evaluation. He suggests such information naturally arise in settings where financial measures are difficult to extract (for example, in tertiary education) but are also common in manufacturing settings if the nonfinancial information has information content about the workers' efforts. Atkinson, Banker, Kaplan and Young (1997) report on the Chrysler cash bonus plan introduced in 1994, which for top executives amounted to about 80% or more of salary. The bases for the cash bonus were quality, customer satisfaction and profitability. Scott (1997) reviews publicly released information about Rockwell International Corporation's (1995), which refers to both annual and long-term incentives that are based in part on nonfinancial performance measures. Kaplan and Atkinson (1998) discuss McDonalds' incentive plan emphasis on product quality, service, cleanliness, training, sales volume and cost control. The authors speculate that McDonalds' emphasis on these predominantly nonfinancial measures of performance in the short-run, is a key influence on the long-run profitability of the firm. It is clear from these examples that there exist in practice firms adopting nonfinancial performance measures in incentive schemes.

There exist numerous single firm research examples of the recent introduction of nonfinancial performance measures into incentive schemes. Moon and Fitzgerald (1996) provide a detailed case description of the nonfinancial performance measurement system at TNT and how it is used for rewarding performance. Waterhouse and Svendsen (1998) present case evidence of the adoption of nonfinancial performance measures in compensation contracts at five relatively large Canadian companies. Rucci, Kirn and Quinn (1998) document a significant change in 1996 in the executive

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[3] Interestingly, Waterhouse and Svendsen (1998) empirically investigate the strategic fit between the information required by Board of Director members for governance purposes and the information received by members. The authors find that firms adopting professional body recommendations for governance structures are correlated with improvements in the fit between information required and information received. While their study does not directly investigate the use of nonfinancial measures and their explicit adoption in incentive contracts, it does provide indirect evidence that increased use of nonfinancial performance measures does not necessarily address contracting requirements.

reward system at Sears Inc. Long-term executive incentives were changed to be based two-thirds on customer and employee-based nonfinancial performance measures. Banker, Potter and Srinivasan (1997) document the impact of introducing nonfinancial performance measures into a large, multi-site hotel chain. These examples provide detail on how firms implement incentive schemes based on nonfinancial performance measures.

Empirical evidence of increasing use of nonfinancial performance measures in contracting is not limited to single firm examples. However, large sample studies are scarce. Ittner, Larcker and Rajan's (1997) sample of 114 firms using nonfinancial measures had on average a 37.1% weight on nonfinancial performance measures in annual bonus contracts. The authors also cite similar findings in two surveys of US firms as corroborating evidence of firms adopting nonfinancial performance measures in contracting (Ittner, et al. 1997, footnote 13). Using a proprietary compensation database Bushman, Indjejikian and Smith (1996) focus on individual performance evaluation (IPE), which includes nonfinancial measures of performance. Approximately one third of their sample used IPE for incentive contracting. Of firms that used IPE, the weight on IPE was consistently around 43% of the CEO's bonus from 1990 to 1994. In 1995 the weight increased to almost 47%. Waterhouse and Svendsen (1998) find that 75% of their Canadian sample reported adoption of nonfinancial measures in compensation contracts. These companies place on average a 25% weighting on nonfinancial measures. Clearly, these examples show that the emphasis on nonfinancial performance measures in practice is not trivial.

Using survey methods, Chenhall and Langfield-Smith (1998) present descriptive statistics that identify performance evaluation based on nonfinancial performance measures as being relatively highly adopted by Australian manufacturing firms, as having relatively high benefits, and as expecting to have relatively higher benefits in the future. Keating (1996) compiles a sample of 78 divisions in 175 randomly selected US firms. He finds that the importance of divisional operational metrics (which are largely nonfinancial performance measures) relative to firm value and accounting metrics, is 25% when determining division manager base salaries, and is 21% when determining the division

managers' annual bonuses. The field-based finding in Morissette (1996) that the nature of reward systems affects the use of nonfinancial performance measures lends further support to the importance of nonfinancial performance measures for contracting purposes.

In summary, it is clear that the demand for nonfinancial performance measures has not only increased over recent years, but the increased demand has also corresponded with significant levels of contracting on nonfinancial performance measures. Both the large sample empirical evidence and the small sample studies are suggestive that nonfinancial performance measures are an important consideration for compensation contract designers in practice. While it has not directly been tested, the increasing use of nonfinancial performance measures in general would also seem to increase the importance of nonfinancial measures for contracting purposes.

1.3.3 Existing Theoretical Insight

Most academic research about the choice and consequences of nonfinancial performance measures in incentive contracts follows two distinct methodological approaches. The first is analytical research, which often uses the principal-agent framework to develop insight about why we see the choice of performance measures that we do that we do in incentive contracts. The second is empirical (including field-based) research, which mainly uses different branches of the agency literature to generate testable empirical hypotheses about why nonfinancial performance measures might be used in contracting.

1.3.3.1 Nonfinancial Performance Measurement: Related Analytical Research

Much of the analytical stream of academic research related to the topic of nonfinancial performance measurement has its roots in the seminal work of Holmstrom (1979). This paper is famous for yielding the often-quoted "Informativeness Principle", which suggests, for contracting purposes a performance measure will be included in a portfolio of performance measures only if it has incremental information content about the agent's actions over and above other available measures. Holmstrom (1979) inspired numerous principal-agent papers in the economics, accounting and organization literature that analyze optimal incentive contracts with changes in various conditions.

However, a common feature of many such papers is that the models are either too complicated to obtain closed form solutions, or else the closed form solutions are so complex that they do not have practical intuition.

Holmstrom and Milgrom (1987) directly address the issue of intractability and complexity evident in earlier work. Their model generates an optimal compensation scheme that is a *linear* function of the contracting variables. Combined with negative exponential utility and normal distribution of uncertainty, closed form solutions and the associated comparative statics became relatively easy to perform.

Holmstrom and Milgrom (1991) extend the linear principal-agent model to settings where the agent's actions are multi-dimensional. This extension was important in adding another level of sophistication to the principal-agent models, which aligned theirs and future analytical models closer to observed practice. In the accounting literature, Bushman and Indjejikian (1993a) use multi-dimensional action choice in showing how accounting earnings can be used to allocate effort more efficiently over different managerial tasks. Wu (1995) extends the single agent task findings of Banker and Datar (1989 – discussed below) into multi-tasking settings and also extends the Bushman and Indjejikian (1993a) study from exogenous into *endogenous* private investor information gathering. Paul (1992) shows a stock price that is useful for a valuation purpose is inefficient for contracting in multi-task environment. Models that capture multi-dimensional action choices have become common in the contemporary literature on non-financial performance measurement.

An important paper in the accounting literature that builds directly on Holmstrom and Milgrom (1991) is Feltham and Xie (1994). The study generates three key findings. First, if a *single* measure of performance is non-congruent then the contract induces sub-optimal effort allocations across tasks; or if it is noisy, then the contract results in sub-optimal effort intensity. Second, *additional* performance measures can reduce risk and improve congruity of the agent's actions with the principal's objective, assuming non-congruity arises because of either myopia on the short-term or window dressing such as manipulation of accounting numbers. Third, consistent with Paul (1992),

Feltham and Xie find that stock price is *not* an efficient aggregation for incentive contracting purposes (though it can be for valuation purposes). This study is important because it links the economics based literature to an accounting context and show how characteristics of the performance measure (e.g. congruity) can be used in generating the need for additional performance measures in a multi-task environment.

A further paper of importance that builds on the work of Holmstrom and Milgrom (1991) is Hauser, Simester and Wernerfelt (1994). This paper has strong implications for accounting research, since it specifically models the demand for, and provides comparative statics relating to, customer satisfaction incentives. A key theoretical insight from this paper is that efficient contracting on customer satisfaction incentives will depend on how precisely customer satisfaction is measured and to what extent employees are focused on the short-term. A feature of Hauser et al. is the multi-*period* nature of the model. Most theoretical models of nonfinancial performance measurement in the accounting literature are single-period models. Accordingly, few such models are able to capture the potential "predictive" properties of nonfinancial performance measures. The model used throughout this thesis is multi-period in nature.

Banker and Datar (1989) refocus the generic context of Holmstrom and Milgrom (1987) into an accounting context. Their key finding is that the relative weight placed on two linearly aggregated performance measures depends only on the sensitivity and precision of the two measures. *Sensitivity* is defined as the change in the expected value of a performance measure with changes in the level of managerial actions. The *precision* of a performance measure is defined as the inverse of its variance.

The Banker and Datar (1989) study is a particularly important development in the accounting literature for two reasons. First, previous work based on Holmstrom (1979) identified conditions creating a demand for an additional performance measure. However, no previous study had addressed *how much emphasis* to place on the additional informative performance measure. Second, no previous study had explored *the design of the performance measure* in the optimal incentive contract, rather than the *design of the incentive contract itself.* While a number of empirical studies on

executive compensation have used as a basis the theoretical insights of Banker and Datar (1989), there has been relatively little further development of the literature specifically concerning the properties of the performance measure that enters into an agency contract. This thesis in part seeks to address this still unresolved issue further.

Hemmer (1996) is an exception. Hemmer analyzes different *types* of customer satisfaction measures. No previous study had examined theoretical demand for the *type* of nonfinancial performance measure. He specifically analyzes "average" versus "number of" customer satisfaction measures. Hemmer derives three key findings. First, while average customer satisfaction versus the number of satisfied customers are economically equivalent, how they are combined with financial performance is optimally different. Second, introducing average customer satisfaction requires increased weight on financial performance measures, (because "average" discourages sales pressure) while introducing number of satisfied customers requires a decreased weight on financial performance measures (because "number" encourages sales pressure). Third, substitution of customer satisfaction performance measurement for earnings in incentive contracts is optimal only if "number of satisfied customers" is used. A secondary finding from Hemmer (1996) is that the choice between average and "number of" is optimally influenced by whether the customer satisfaction information is collected from actual purchasers or customers in general. An important contribution of Hemmer (1996) is that it is one of the first papers in the accounting literature to address the still relatively unexplored issue of the consequences of variations in the *type* of nonfinancial performance measure.

Theoretical insights about the structure of optimal incentive contracts have been extended to the context of profit signals being non-contractible. Baker (1992) derives an optimal linear incentive contract when the principal's objective is to maximise profit although profit is unavailable for contracting. His analysis generates an intuitive definition of a "good" performance measure; which is when the marginal product of an agent's actions on the performance measure strongly correlates with the marginal product of the actions on the principal's objective. Contexts such as that generated in Baker's research can be interpreted as naturally creating a demand for nonfinancial performance

signals. This thesis examines contexts primarily that allow the principal's objective to be available for contracting but does contain some analysis of contexts where profit signals are non-contractible.

Much of the literature discussed above focuses on tensions between the use of stock price and accounting earnings as contracting variables. Barclay, Gode and Kothari (1997) add to this analytical literature by finding that earnings are a useful contracting variable because in many settings earnings are contemporaneous with *delivered performance*. In their pre-defined settings stock price *leads* delivered performance while cash flows *lag* delivered performance. Thus, contracting on the latter two variables leads to inefficiencies. Interestingly, their paper does not address the issue of nonfinancial measures as contracting variables that might be predictive of future financial performance. This issue of predictability is fundamental to the analysis in this thesis.

Another body of theoretical work generates predictions consistent with the descriptive literature (discussed above) that argues context variations create a demand for nonfinancial performance measures. For example, an implication of Baiman, Fischer and Rajan (1995) is that the type of relationship governing the contract between a firm and its supplier will optimally adjust weights on financial performance measures to weights on measures more nonfinancial in nature. A further example is Datar and Rajan (1995) which models a bottleneck-constrained environment. They show the importance of the principal designing incentives based on nonfinancial measures, to induce non-bottleneck workers not to overproduce for bottleneck resources. While this stream of literature has emerged strongly over recent years, the variation in context is not specifically addressed in this thesis.

In summary, the theoretical research in nonfinancial performance measurement has largely built on Holmstrom's informativeness principle, using multi-task settings and assuming linear incentive contracts with normal distribution of uncertainty. Accordingly, a common theme to the analysis is that there exists a broad range of settings where nonfinancial performance measures become incrementally informative. Some such settings correspond to recent changes in the environmental context of modern organizations.

1.3.3.2 Nonfinancial Performance Measurement: Related Empirical Research

Baiman (1990) classifies the theoretical agency literature into 3 distinct branches. The first branch is the principal-agent framework, which has been the subject of the foregoing discussion. The second branch is transaction cost economics, a theoretical stream in which Baiman identifies there has been relatively little work in management accounting. Drennan (1995) does, however, use transaction cost economics to argue that the demand for changes toward nonfinancial performance measures is driven by performance ambiguity. The third branch is the Rochester model, stemming from the seminal work of Jensen and Meckling (1976), and built upon in Watts and Zimmerman's (1986) "positive accounting theory". The economic intuition from the first branch in particular is emphasized in the theoretical development underlying empirical work that tests hypotheses about nonfinancial performance measurement.

An important study that integrates principal-agent intuition with relatively large-scale empirical evidence is Ittner, Larcker and Rajan (1997). This study finds that variations in regulation, the firm's strategy and the noise in financial performance measures are associated with variations in the emphasis on nonfinancial performance measures in annual bonus contracts. The study is one of the first empirical studies to directly test and find support for the theoretical intuition about nonfinancial performance measurement from the agency literature. The authors find no support for CEO influence and financial distress hypotheses, both of which were generated from literatures other than the agency literature. This paper specifically addresses the issue of choice of performance measures in bonus contracts. However, it does not attempt to address several agency determinants of the contracting choice. The agency determinants are addressed in detail in this thesis.

Bushman, Indjejikian and Smith (1995) use formal agency theory to develop and test predictions that the use of aggregate performance measures relative to localized performance measures is dependent on the extent of interdependencies within the firm. Bushman, Indjejikian and Smith (1996) use standard agency intuition to develop hypotheses about why firms might use individual performance evaluation. The study finds individual performance evaluation increases with

the firm's growth opportunities and product time horizon. To the extent that "localized" and "individual" performance evaluation incorporate nonfinancial performance measures, these papers provide empirical evidence that firms find efficiencies in contracting on nonfinancial measures in the presence of intrafirm interdependencies, growth opportunities, and long product time horizons. The forward-looking perspective of the latter two variables is particularly relevant for this thesis in establishing the relevance of nonfinancial performance measures for long-term contracting.

Keating (1996) explores organizational determinants of the relative choice of nonfinancial performance measures. The study uses organization theory to generate testable hypotheses and survey methods to test the hypotheses empirically. The study finds that the relative use of nonfinancial measures such as divisional operational metrics is positively associated with both sequential divisional interdependencies and division size relative to firm size and negatively associated with both centralized decision-making and firm beta. Morissette's (1996) field study finds several organizational and behavioural variables predictive of the choice of quantitative nonfinancial performance measures used by managers. The explanatory variables include the nature of reward systems; decision types (strategic, tactical or operational); task-technology (routine or non-routine); functional area (production, marketing or human resources); and individual variables (level of training and experience, and perceptions of causal links). These organizational and behavioural determinants of the choice of nonfinancial performance measures add to the relatively little evidence on why such measures are used. However, they are not addressed in the agency analysis of this thesis.

Other empirical papers have focused on establishing the link between current nonfinancial performance and future financial performance. Banker, Potter and Srinivasan (1997) find evidence that customer satisfaction measures are correlated with future financial performance and that introduction of contracting on nonfinancial measures improved both nonfinancial and financial performance. Hayes and Schaefer (1997) show that future performance is positively correlated with unexplained variation in current compensation. One interpretation of this result is that the unexplained variation arises because of the non-public nature of contracting variables such as internal

(to the firm) nonfinancial measures of performance. The study also finds that the noisier the stock price and accounting earnings signals, the greater the association between the unexplained variation in current compensation (potentially attributable to nonfinancial measures) and future financial performance. Links between current performance measures and future performance is a fundamental assumption maintained throughout this thesis.

Relatively more evidence that is empirical addresses the impact of nonfinancial measures that are *not necessarily contractible* on financial performance. These empirical studies have found links between customer satisfaction and customer profitability (Foster and Gupta, 1997; Loveman, 1996), customer satisfaction and future economic performance not captured in stock price or accounting statements (Fornell, Ittner and Larcker, 1996), customer satisfaction and long-run economic returns (Anderson, Fornell and Lehmann, 1994), and non-price related supplier selection/monitoring practices and firm performance (Ittner, Larcker, Nagar and Rajan, 1997). However, no study other than Banker, et al. (1997) and Hayes and Schaefer (1997) has attempted to test the link between *contracted* nonfinancial performance measures and future financial performance. A further point of interest is that no study other than Loveman (1996) appears to have explored the *interactions* between different nonfinancial measures of performance as predictors of financial performance. Of these largely unexplored issues, this thesis specifically adds to our understanding about the link between contracted nonfinancial measures and future performance.

A further stream of empirical research has explored whether the use of nonfinancial performance measures (for contracting or other purposes) can lead to variations in a firm's stock price. Variations in the firm's stock price may ultimately lead to variations in the firm's cost of capital. Interestingly, Martin (1998) reports that since 1994 a distinct correlation exists between the percent change in the Dow Jones Industrial average and the percent change in a 3-month lagged American Customer Satisfaction Index.

The general issue of whether the nature of nonfinancial issues is of importance to the capital market is examined with greater research rigor in Nayyar (1995). This study investigates the impact

of customer service changes on stock price. The study finds that the market values customer service increases (decreases) positively (negatively). Interestingly, the study also finds that variations in the stock market reaction are associated with variations in the type of customer service change. This provides indirect support that the *type* of nonfinancial issue considered by the firm (and it follows the *type* of nonfinancial performance measures gathered by the firm) can lead to differences in the equilibrium stock price of the firm.

Fornell et al. (1996) provides a more direct test of the impact of nonfinancial customer satisfaction measures on stock price. This study finds the public release of customer satisfaction measures is associated with excess stock market returns. Amir and Lev (1996) show that nonfinancial indicators such as growth and market penetration are highly relevant in explaining the security valuation of cellular phone companies. Hirschey, Richardson and Scholz (1998) extend Amir and Lev's findings to the high tech sector and find that nonfinancial patent information is incrementally relevant (over financial information) in valuing the securities of high tech firms. This thesis relies to some extent on the finding that measures of nonfinancial performance are impounded in stock price. Furthermore, this thesis extends research on the issue of the relationship between nonfinancial performance measures and stock price by providing insight on the choice *between* these two variables for contracting purposes.

In summary, the general themes of the formal empirical research have been threefold. First, the empirical research has shown that nonfinancial performance measures are used extensively in managerial decision-making and potentially to a lesser extent for contracting purposes. Second, determinants of the choice of nonfinancial performance measures in a firm's control system can be economic, behavioural or organizationally based. Third, variations in certain nonfinancial performance measures can be associated with variations in both the future profitability and the stock price performance of the firm. The next section of this chapter extracts key elements from the existing literature that are relevant for the purposes of this thesis.

1.4 Implications of the Existing Literature for this Thesis

The literature reviewed in the previous section can be grouped into two broad areas. First, nonfinancial performance measures are the *dependent* variable. Here research examines the determinants of the *choice* of nonfinancial performance measures for decision-making and contracting. Second, nonfinancial performance measures are the *independent* variable. Here research focuses on the *consequences* of using nonfinancial measures for decision-making and contracting.

This classification helps clarify several aspects of the literature that are particularly relevant background for this thesis. These aspects were briefly identified throughout the previous subsection and are summarised and discussed further in the following two subsections as follows. First, I extract issues in the existing literature that are addressed in this thesis. Second, I highlight elements from the existing literature that provide support for modelling assumptions to be used throughout this thesis.

1.4.1 Research Issues For This Thesis

An implication of the literature review contained in this chapter is that there exist several areas in the academic literature surrounding nonfinancial performance measurement that could benefit from further research and in particular from research that is more specific. To understand more clearly the nature of the related issues, I discuss them in the broader context of the management accounting variable of interest being the dependent variable, and then the independent variable.

First, it seems manifest that much of the nonfinancial performance measurement literature examines nonfinancial performance measures as the dependent variable of interest. The majority of that research has looked at the question of what drives the choice of nonfinancial performance measures in *decisionmaking*, and examines (via agency-based literature) the choice of nonfinancial measures for *contracting* purposes.

Relatively little research focuses on the *choice* of variables such as (but not necessarily embracing only) nonfinancial performance measures *that are predictive of future financial performance*. In particular, there has been no explicit work has specifically examines the determinants

of how much contractual emphasis to place on short-term measures that reward long-term performance, relative to more traditional contracting variables. The literature review has identified that such measures are in widespread use, yet existing theory does not explicitly address why we see the emphasis on predictive financial or nonfinancial performance measures that we do in practice.

Second, the remaining part of the literature focuses on nonfinancial performance measurement as an independent variable. This literature shows how variations in nonfinancial performance measures can help explain variations in stock price returns and in particular different aspects of financial performance, including current and future firm profitability, customer profitability, and supplier selection/monitoring practices. Very little work, however, focuses on what and how variations in *properties* of the nonfinancial performance measures might help explain the correlations with financial performance. In essence, the existing research primarily reports that the correlations exist and does not specifically attempt to address how the variations in performance measurement properties might affect the correlations.

This thesis addresses the two above-mentioned issues in three ways. First, using principal-agent analysis, chapter 2 analyzes, absent a capital market, the demand for measures of drivers of future performance as contracting variables. Using a model with two compensation dates, the analysis and subsequent predictions focus on the emphasis that we might expect to see on measures of drivers of future performance relative to traditional financial performance measures. The analysis in chapter 2 adds specificity to the literature on the choice of performance measures for contracting.

Second, chapter 4 introduces the capital market into the modelling. This facilitates a relative analysis of three alternatives for monetarily rewarding workers for effort that enhances a firm's long-term profitability: measures of drivers of future performance, traditional financial performance measures in future periods, and the stock price. The multi-period analysis thus examines the demand for long-term contracting weights in the presence of both stock price and drivers of future performance. Previous work has not addressed this issue. Accordingly, chapter 4 adds further specificity to the literature that looks at why we choose the performance measures that we do for

contracting purposes.

Third, chapter 3 models the performance *consequences* of contracting on measures of drivers of future performance. By doing so, distinct properties of such performance measures are isolated and assessed to be determinants of why we observe certain performance measures, such as many nonfinancial performance measures, to be correlated with future financial performance. In this sense, chapter 3 represents an extension of previous work that examines performance measurement variables as independent variables.

1.4.2 Existing Findings as Support for Modelling Assumptions To Be Used

Several findings from existing work support modelling assumptions used throughout this thesis. Most of the modelling assumptions are self-evident from prior analytical work. However, others that are not so evident deserve special mention. These are as follows:

- Nonfinancial information can affect future performance that is not captured in the stock price or accounting statements (see Fornell, et al. 1996). This finding provides support for the assumption throughout this thesis that measures of drivers of future performance are correlated with future performance.

- The use of unobservable (to the researcher) performance measures, (such as, potentially, measures of drivers of future performance) in incentive contracting is correlated with future observable firm performance (Hayes and Schaefer, 1998). These measures are assumed observable to the contracting parties only and are consistent with the firm not publicly releasing measures of drivers of future performance.

- Firms will rely more on non-publicly released signals of performance (such as measures of drivers of future performance) for rewarding future performance the more noisier that publicly released signals (such as traditional financial performance) are for contracting purposes (Hayes and Schaefer, 1998). This finding empirically supports the use of *internal* measures of performance for contracting purposes rather than or to supplement traditional published measures.

1.5 Overview of the Organization of the Thesis

This thesis is organized as follows. Chapter 2 examines the fundamental demand for a measure of the drivers of future performance, absent a capital market. The chapter emphasizes the impact of variations in the determinants of the demand on the relative choice of weights between a measure of drivers of future performance and traditional financial performance measures in the short and long term. The chapter also briefly explores the impact on contracting choice of the measure of drivers of future performance having signalling capability in *both* the short and long term.

Chapter 3 builds on the basic model in chapter 2 and explores the consequences of the chosen relative weights. In particular, the properties of predictability and precision of the measure of drivers of future performance are explored closely to assess to what extent it is variations in these *properties* that can explain variations in future financial performance. The chapter begins with the optimal incentive contracting results of chapter 2, establishes definitions for precision and predictability, and analytically develops theory to shed light on the nature of properties that performance measures may need to have so that they are useful for foreshadowing long-term profitability.

Chapter 4 extends the theory in chapter 2 by introducing the capital market into the analysis. Basic results consistent with prior work are first established. Two distinct paths are then followed; both of which are based on explanations that create a demand for stock price as a noisy contracting variable. First, the stock price is assumed to contain information about agent effort not otherwise observed by the principal. This assumption is consistent with the analysis presented in Bushman and Indjejikian (1993a), except that the measure of drivers of future performance is included in the present model. Second, the traditional financial performance measures are assumed too costly upon which to contract. Accordingly, the analysis focuses directly on the relative choices between a measure of drivers of future performance and the stock price as the basis for monetary rewards for long-term performance.

Chapter 2

The Demand for Measures of the Drivers of Future Performance

2.1 Introduction

Recent trends suggest the importance of the ability of a firm's internal performance measurement system to capture the drivers of future performance (DFP). A common trait of most DFP measures is the nonfinancial nature of the measurement. Empirical evidence suggests it is becoming increasingly common for firms to use nonfinancial measures in compensation contracts (cf. Ittner, Larcker and Rajan, 1997). Recent field and survey evidence has shown that firms use both non-financial and financial measures in strategic decision-making (Morissette, 1996; Keating, 1996). Big Six audit firms are changing their audit methods to focus on key performance indicators (interpretable as DFP measures) rather than transactions for auditing non-routine transactions (Bell, Marrs, Solomon and Thomas, 1997). Textbooks contend future-oriented, nonfinancial performance measures can provide a leading indicator of future financial performance (cf. Atkinson, Banker, Kaplan and Young, 1997).

There has been relatively little work in the accounting academic literature that focuses on the type of performance measures chosen to represent DFP. More specifically, little work exists to explain why firms use the DFP measures that they do, or why firms choose these measures over other types of performance measures in incentive contracts. DFP measures are often difficult to capture, tend not to be audited, and their measurement process can be much more subjective than that governing the extraction of historical measures of financial performance. Moreover, the DFP measures used are highly unlikely to correlate perfectly to the *true* drivers of future performance. Accordingly, while DFP measures potentially have great value in foreshadowing future firm success,

high uncertainty (relative to traditional financial measures of current performance) surrounds their use. A tension arises between the use of forward-looking but relatively uncertain DFP measures with historically focused but relatively certain financial measures of current performance.[4]

Analytical work in performance evaluation addresses the general tension in choosing between multiple performance measures. The theory derives a demand for additional performance measures, as long as any additional performance measure has incremental information content. A performance measures is incrementally informative only if any existing performance measure is not a sufficient statistic for the pair of performance measures (existing and any additional), with respect to effort (Feltham and Xie, 1994; Hauser, Simester and Wernerfelt, 1994; Hemmer, 1996). This work assumes that the additional performance measure signals an agent's farsighted effort, which is critical to the ongoing long-term success of the firm.

Field and survey work has studied potential determinants of the choice of performance measures in firms' decision-making (cf. Morissette, 1996; Keating, 1996). This work is largely exploratory and the variables of interest are mostly non-economic in nature. Banker, Potter and Srinivasan (1997) find a significant association between customer satisfaction measures and future financial performance. They also find improvements in a firm's nonfinancial measures of performance following introduction of an employee incentive plan based on nonfinancial performance measures. Other empirical work has tested factors affecting the relative weight given to different types of performance measures in reward schemes (Ittner, et. al., 1997; Bushman, Indjejikian and Smith, 1996). The dependent variable in these papers is the relative weighting on nonfinancial versus the financial performance signal, in a reward scheme, at a particular point in time.

Despite these recent developments in the performance measurement literature, agency theory has offered general insight only. No study has addressed the specific issues in choosing between DFP

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[4] The tension referred to here is not unlike the classic tension between the use of earnings numbers and the stock price as separate performance measures in incentive contracts. Theory suggests that earnings signal the performance of assets in place, while the stock price signals performance on aggregate activities (Bushman and Indjejikian, 1993a).

measures and measures of current financial performance in incentive contracts. Previous work also does not explore the impact of variations in economic conditions generating the demand for DFP measures on the relative mix of DFP measures and current financial measures in incentive contracts.[5]

The primary purpose of this chapter is to provide explicit theoretical insight into the observed practice of firms including DFP measures to supplement, or replace, financial performance measures in incentive contracts. Accordingly, the analysis first derives the economic conditions that generate the demand for DFP measures in incentive contracts, and second investigates the economic impact of variations in those economic conditions. Such variations include different proxies for non-DFP measures and variations in the signalling capability of the DFP measure to capture both shortsighted and farsighted effort.

This study makes four contributions. First, it builds on Holmstrom's (1979) informativeness principle and the (multi-dimensional effort) analyses of Hauser, et al. (1994), Feltham and Xie (1994), and Hemmer (1996) by establishing a specific framework that predicts a demand for short-term incentives that reward long-term performance (i.e. measures of DFP). Second, it provides an application of the theory by examining the economic consequences of variations in the underlying economic conditions that generate a demand for DFP measures. Third, it explores the economic consequences of using *alternative* definitions of financial measures of current performance in contracts that are also based on measures of DFP. Fourth, it provides specific insight into the observed practice of firms using DFP measures to signal *both* shortsighted and farsighted effort.

The derivation of optimal incentive weights in this study is closely related to work previously established in the accounting literature. In particular, the optimal incentive weights from the basic

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[5] In essence, this chapter views performance measures in two broad groups: market-based and firm-generated. The chapter excludes market-based performance measures from incentive contracts to isolate the tensions in the choice between different firm-generated performance measures. Firm-generated performance measures are further viewed as either "DFP-oriented" or "non-DFP-oriented". "DFP-oriented" includes both financial and nonfinancial forward-looking measures of performance, but are predominantly represented by nonfinancial performance measures. Essentially "DFP-oriented" measures here are indicators of farsighted managerial activities, which primarily drive future profits in this model. While "non-DFP oriented" might also contain both financial and nonfinancial measures of current performance, this analysis is restricted to non-DFP measures that reflect different proxies of current financial performance measures only.

model in this study can be restated in terms of key results from Feltham and Xie (1994), and Banker and Datar (1989).[6] The contribution of this work relative to these papers is that this work includes a particular parametric structure that aims to capture the specifically observed practice of short-term performance incentives being used to reward long-term performance. This generates additional insight on how various parameters can affect absolute incentive weights in the established setting. By contrast, Feltham and Xie (1994) and Banker and Datar (1989) operate at a more general level. In addition, they both are single period models, whereas the model in this study introduces specific tensions between the short-term and the long-term. The relative contribution of this work is analogous to the relative contribution of section IV of Feltham and Xie (1994) where specific applications of the model are generated to "...provide *further* insight into the two different roles of additional performance measures." (Feltham and Xie, 1994: 440, emphasis added).

This chapter is organized as follows. A basic model of the demand for measures of drivers of future performance is presented in the next section. Section 3 investigates the consequences of variations in economic conditions that generate the demand for DFP measures. Section 4 explores the implications of varying the proxy for the non-DFP contractual signal. Section 5 presents an analysis of variations in the signalling capability of the DFP measure. Section 6 provides concluding remarks.

2.2   Basic Model

Consider a two period model[7] in which a principal hires an agent to operate a firm. It is too costly for the principal to observe the agent's efforts directly. The agent is risk and effort averse. Effort aversion implies that the agent incurs a personal cost to supply effort. The principal can diversify risk and is assumed to be risk neutral. The firm's sales are affected by various exogenous

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[6] See Appendix 3 for an alternative derivation of the optimal incentive weights in this chapter using key formulations in both Feltham and Xie (1994) and Banker and Datar (1989).

[7] Since the compensation for both periods is designed ex-ante and both tasks in the model are performed simultaneously in the first period, the model could be interpreted as a single period model. However, a key feature of this basic model is that there are also two compensation dates and a discount factor, which allows the agent to value compensation in a future period differently to the compensation at the end of period 1. This feature adds a multi-period flavor to the model not normally seen in single period models. Thus, while this may not be a true multi-period model, the two compensation dates

factors captured by the variable, g. These factors increase the prospects of the firm's goods and services being sold.[8] Variable g is observable by both the principal and the agent. The quantity sold by the firm in period 1, q_I, is also affected by the amount of shortsighted effort, ϕ, undertaken by the agent, and the price, p, of the good or service.[9]

Prices and costs in each period are assumed to be observable and exogenously specified. The agent's shortsighted effort is assumed to interact with the exogenous non-price factors affecting the prospect of goods and services being sold. For convenience, and to capture the effect of shortsighted effort increasing sales at a decreasing rate, the logarithmic function of ϕ is built into the quantity function. The quantity to be sold[10] (with normally distributed random component, ε) for period 1 can be expressed as:[11]

$$\tilde{q}_1 = g_1 \ln(\phi) - p_1 + \tilde{\varepsilon}_1 \tag{1}$$

The period 2 price, period 2 exogenous factors, and the agent's farsighted effort, ψ, in period 1 all affect period 2 sales.[12] To isolate the shortsighted versus farsighted effort effects, period 2 is assumed to be an ending period *with no effort*. As with shortsighted effort, farsighted effort is assumed to increase quantity sold at a decreasing rate. Estimated period 2 sales (with normally distributed random component, ε) are:

$$\tilde{q}_2 = g_2 \ln(\psi) - p_2 + \tilde{\varepsilon}_2 \tag{2}$$

At the end of period 1 the principal is, without cost, able to extract a measure of DFP that

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and the discount factor distinguish this model from true single period models.

[8] An example of an applicable exogenous factor is the reputation of the firm.

[9] Shortsighted effort includes any agent action that increases short-term consumption of the firm's product. For example: attracting new customers; discretionary discounts; or increased sales pressure on an existing customer.

[10] Variables denoted with "~" depict random variables. Later denotations of "−" depict mean values. An index to all other notation and the support of each variable used throughout this thesis is presented in Appendix 1.

[11] The essence of the quantity sold function reflects an inverse demand function, which is commonly used in models of this nature (e.g. see Hauser, et al., 1994). This model's quantity sold function deviates slightly from conventional inverse demand functions by assuming an interaction between non-price exogenous factors and the agent's shortsighted or farsighted effort. This deviation later simplifies the mathematical analysis.

[12] Farsighted effort includes any agent action that increases long-term customer or employee loyalty. For example: post-sale customer satisfaction inquiry; discretionary rewards for frequent purchasers; or detailed feedback on an employee's career path.

captures with error the impact of period 1 farsighted effort. In this model, the measure of DFP is

assumed to be an index of nonfinancial measures commonly observed in practice, such as quality,

customer satisfaction, employee satisfaction or productivity. Nonfinancial performance measures are

assumed to be any quantitative performance measures that are not presented as dollar values. Units of

farsighted effort are directly proportional to the index used to capture the measure of DFP. In essence,

the DFP measure captures a function of an unobservable parameter (farsighted effort[13]) that drives

future profits.

For convenience, previous work often assumes the distribution of the measurement error to be

normally distributed with zero mean. However, consistent with Hemmer (1996), this model assumes

that the DFP measure obtains only positive values. As Hemmer observes, performance measures of a

nonfinancial nature rarely obtain negative values.[14]

Accordingly, the functional form of the DFP measure is assumed to be:[15]

$$\tilde{y} = \psi \tilde{\varepsilon}_y \tag{3}$$

with $\ln \varepsilon_y \sim N(0, \sigma_y^2)$. The principal's expected profit, π, in period i, $i=1, 2$ is a function of the

random quantity variable and exogenous specified price and cost parameters and is given by:

$$\tilde{\pi}_i = (p_i - v_i)\tilde{q}_i - f_i \tag{4}$$

where f = fixed costs identified by the accounting system in period i, $i=1, 2$; v is the constant

variable cost per unit sold identified by the accounting system.

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[13] For simplicity and without loss of generality, farsighted effort is measured in units.

[14] An alternative approach would be to assume that the DFP component is the difference between actual and target values and therefore could obtain "negative" values if actual values exceed target. However, the implications of introducing a target variable, subjectively specified, are beyond the scope of this study. Yet another approach would be to construct the DFP functional form in a manner consistent with the construction of the functional form for the quantity variables, since the quantity variables also do not require a zero mean value. However, the assumed quantity functional form and the continuous time nature of the model imply that cumulative quantities follow a Brownian process with drift $E[q_i]$ and variance σ_i^2. I consider the Brownian process to be inappropriate for the DFP measure, since the DFP measure could represent, for example a percentage value between 0 and 100 that does not necessarily correspond to a cumulative derivation.

[15] A normal distribution is required to use the Holmstrom and Milgrom (1987) optimization framework. However, Hemmer also shows how reliance on Holmstrom and Milgrom is still possible (even with only non-negative values of nonfinancial measures) by assuming that the measurement error is lognormally distributed, i.e. $\ln \varepsilon \sim N(0, \sigma^2)$. This assumption requires a substitution of the logarithmic function of the DFP measure for the DFP component in the compensation

At the beginning of period 1, the principal announces the agent's reward systems for both periods. The reward system for period 1 is composed of a fixed salary component, α, a component based on profit, π, and a component based on the DFP measure, y, i.e. the noisy measure of farsighted effort.[16] The reward system compensates both shortsighted and farsighted efforts in period 1 to induce an optimal allocation of agent efforts between shortsighted and farsighted activities in period 1. Adapting Hemmer's (1996) Observation 1, the agent reward system for the period 1 is as follows:[17]

$$\tilde{w}_1 = \alpha_1 + \beta_1 \tilde{\pi}_1 + \gamma \ln(\tilde{y}) \tag{5}$$

In period 2, the component based on the DFP measure is omitted since the second period sales reflect the agent's farsighted effort in the period 1. Accordingly, the agent is rewarded for that farsighted effort in the period 1, to ensure sales are higher in period 2. Hence, rewarding the farsighted effort based on the DFP measure in period 2 is redundant. The agent's reward in period 2 is:

$$\tilde{w}_2 = \alpha_2 + \beta_2 \tilde{\pi}_2 \tag{6}$$

To simplify the mathematical analysis, define $a = \ln(\phi)$ and $b = \ln(\psi)$. That is, each unit of a or b increases the principal's expected return by one unit of g_1 and g_2, respectively. The agent faces different costs associated with the different effort types. The cost of the agent's effort takes the form of a twice-differentiable convex function of a and b:[18]

$$C(a,b) = \frac{a^2}{2} + \frac{b^2}{2} \tag{7}$$

After the announcement of the reward system in period 1, the agent exerts both shortsighted and farsighted effort to maximise his expected utility. The agent's utility function reflects constant

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function (Hemmer, 1996, Observation 1, Appendix B).

[16] The use of a second component in the compensation function is consistent with Holmstrom's (1979) result that a second signal of performance is valuable if it is informative i.e. the first signal is not a sufficient statistic for the pair of performance signals, with respect to effort.

[17] This model makes no claim that linear compensation contracts are optimal. Rather, this model assumes that given linear compensation contracts exist, how might such a contract be optimally structured?

[18] Note that the convexity in the following equation is not convex in the original decision variables, ϕ and ψ. However, the substitution of the original decision variables (the costs of which are not convex) follows that of Hemmer (1996). The results from both this and Hemmer's model are not sensitive to this substitution or to the lack of convexity in the costs of

absolute risk aversion. Accordingly, with the variable r representing the Arrow-Pratt measure of absolute risk aversion, the agent's utility function is:

$$U(\cdot) = 1 - e^{-r\{\tilde{w}_1 + \delta\tilde{w}_2 - C(a,b)\}}$$

(8)

The variable δ represents the discount factor used by the agent to evaluate period 2 values, which enables the agent to assess expected utility at one point in time. δ is assumed non-negative and less than 1. The principal also discounts the future, but her discount factor is normalised to 1. Assuming different discount rates for the principal and the agent provides insight later on the impact of variations in the discount factor on the optimal contractual weights, which has implications for contract design.

The model assumes that the agent discounts the future period at a greater rate than the principal does. This is consistent with a number of descriptively realistic scenarios for how the agent views the future. For example, the agent might not expect to be employed by the principal in the future period and therefore would be unable to collect the end period rewards. This expectation might arise because at the end of period 1 the agent might be planning to retire, get promoted within the firm, or seek better employment prospects external to the firm.

An alternative scenario consistent with the agent's discount factor being less than the principal's is that the agent may be concerned that the principal will decide to change the reward system for the future period, after period 1 has elapsed. This assumes the principal has incentive at the end of period 1 to breach the employment contract offered to the agent at the start of period 1. A third scenario potentially explaining the agent's lower discount factor is that the principal has access to capital markets. Accordingly, assuming the agent is a net borrower of funds, the principal can borrow funds at a lower rate than the agent can.

Overall, the role of the discount factor in this model is to reflect issues observed in practice concerning the management of employees over time. Several issues can be captured by the discount

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the original decision variables.

factor, δ. First, a large value of δ is consistent with firms developing employee loyalty.[19] For example, firms can develop employee loyalty through employee empowerment, internal job-rotation plans, and career development programs (Bernstein, 1998). The model here can provide insight about the impact of employee loyalty on optimal incentive weights and payoffs to the principal.

Second, a small value of δ is consistent with employees having short-term myopia. Excessive focus on the short-term is a commonly observed phenomenon in American corporations (e.g. see Kaplan and Atkinson, 1998). The intuitive impact of short-term myopia is that it will adversely affect the payoffs to the principal and will change the optimal incentives payable to the agent. The model here is capable of showing both of these effects.

Third, δ can be interpreted as capturing the seniority of an employee. The more (less) senior the employee, the less (more) the number of years that an employee must work before retirement, the greater the prospect that the employee will be employed with the firm for life, and the greater (lower) the value of the discount factor. Accordingly, this model could also be regarded as providing insight on the impact of employee seniority on the choice of contracting incentives and the principal's payoffs.

A fourth interpretation of the role of δ is that it can capture specific issues of human resource management such as deferred compensation and severance pay. In the case of deferred compensation, the discount factor can represent the employee's aversion toward deferred compensation. The greater the aversion, the lower the value of δ. In the case of severance pay, the discount factor can represent the relative extent of the severance pay. For example, the longer (shorter) the number of years of

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[19] Employee loyalty can alternatively be defined as the probability of an employee leaving the firm. In this model the probability of leaving the firm could be regarded as being unimportant to the principal, since the employee does not perform any activity in the second period. However, from the point of view of the employee, the rewards payable at the end of the second period will strongly influence the decision of the employee to leave the firm any time before the end of period 2. If the employee perceives he will generate higher utility by accepting employment elsewhere and forgoing rewards with the firm that become payable at the end of period 2 (after exerting no effort in period 2), then he will likely leave. Otherwise he will likely stay with the firm. Thus, despite the employee not exerting effort in period 2, the timing of the payoffs will likely affect the magnitude of the employee's discount factor, such that δ could be interpreted as a probability of the employee leaving the firm before the end of the two periods.

service by the employee, the greater (lower) the relative extent of the severance pay, and the greater (lower) the value of the discount factor. Accordingly, the impact of employee aversion to deferred compensation and the extent of severance pay on both contracting weights and payoffs to a principal can be interpreted from this model.

The operation of the basic model can be summarized as follows. In period 1, the amount of goods or services sold is based on non-price exogenous factors, agent shortsighted effort, and price. At the end of period 1 the principal measures profits, extracts the DFP measure, and rewards the agent. In period 2 quantities are sold based on non-price exogenous factors, price, and the farsighted effort from period 1. At the end of period 2 the principal measures period 2 profits and pays a reward to the agent.

With normally distributed uncertainty and negative exponential utility, the agent's problem can be expressed as maximising the certainty equivalent of the expected utility (Holmstrom and Milgrom, 1987).[20] In this case, the certainty equivalent (CE) is the same as the mean value of the compensation less the risk premium. Formally:

$$ CE = (\alpha_1 + \delta\alpha_2) + (\beta_1\bar{\pi}_1 + \delta\beta_2\bar{\pi}_2) + \gamma\pounds[\ln(y)] - \left(\frac{a^2 + b^2}{2}\right) - \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma^2 \sigma_y^2 + \delta^2 \beta_2^2(p_2 - v_2)^2 \sigma_{q2}^2\right) \quad (9) $$

where σ_i^2 is the variance of the distribution associated with variable i. $i = q_1, q_2, y$.[21]

Substituting equations (1), (2), (3) and (4) into (9) and differentiating with respect to shortsighted and farsighted effort yields the optimal effort choices by the agent. Here:[22]

$$ a^* = \beta_1 g_1(p_1 - v_1) \quad (10) $$

$$ b^* = \gamma + \delta\beta_2 g_2(p_2 - v_2) \quad (11) $$

The results reveal that the agent's optimal shortsighted effort depends on the interaction

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[20] The first-order approach yields a global maximum in this case because of the assumed linearity of the agent's compensation function, which ensures the agent's *overall* decision problem is strictly concave.

[21] Strictly speaking, the subscript notations should be either denoted with "~" (to reflect the random nature of the variance) or refer directly to the error term. However, consistent with notation conventions chosen in related models (e.g. Hauser, et al., 1994), the subscript notations chosen throughout this thesis are simplified to identify the broader variables of interest, i.e. q_1, q_2, y.

between the period 1 weight on the financial performance measure, exogenous non-price factors, and the marginal revenue earned by the firm. The functional relationship is increasing, assuming a positive contribution margin. This seems plausible since any increases in the financial performance incentive weight, exogenous non-price influences, and marginal revenue encourage the agent to exert greater effort. Similarly, the agent's optimal farsighted effort is an increasing function that depends on the corresponding interaction in period 2 plus the weight on the DFP measure in period 1. The agent is thus motivated to provide farsighted effort by both the DFP in period 1 and the expectation of profits in period 2.

The optimal levels of a^* and b^* are likely to be non-negative because of the following:

(i)   the incentive contract weights in equilibrium are non-negative (see analysis below)

(ii)   the impact of exogenous non-price factors is non-negative (otherwise the quantity to be sold will be negative)

(iii) δ is assumed to be non-negative and less than 1.

(iv)   contribution margins are positive or else the firm is better off not producing in the short-run.

Positive values of shortsighted and farsighted effort are consistent with the following intuition. If the principal imposes more risk on a risk averse agent via an incentive contract then she must pay a risk premium to the agent. To receive the risk premium, the agent must respond by exerting positive effort levels.

To ensure the agent accepts the incentive contract, the principal is constrained to meet the agent's reservation utility in each period. For notational simplicity, the agent's reservation utility is assumed to be zero. The individual rationality constraints are assumed to hold period by period.[23] For periods 1 and 2 these constraints can be expressed as:

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[22] Second order conditions confirm a maximum.

[23] Accordingly, the only role for the fixed salary in each period is to balance the individual rationality constraint so that the agent's reservation utility is zero.

$$E[w_1] + \delta E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma^2 \sigma_v^2 + \delta^2(p_2 - v_2)^2 \beta_2^2 \sigma_{q2}^2\right) \quad (12)$$

$$E[w_2] = \frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2 \sigma_{q2}^2\right) \quad (13)$$

The principal's problem is to maximise profits subject to the agent's incentive compatibility and individual rationality constraints. The principal's maximization problem is:

$$\text{Max } \Pi = \overline{\pi}_1 + \overline{\pi}_2 - E[w_1] - E[w_2] \quad (14)$$

Substituting the optimal effort values and appropriate expressions into equation (14) and differentiating with respect to γ yields:

$$\gamma^* = \frac{g_2(p_2 - v_2)(1 - \delta\beta_2)}{1 + r\sigma_v^2} \quad (15)$$

Clearly, γ^* will be zero only if any one of the following conditions hold:

(i)   There is no impact from exogenous non-price factors ($g_2 = 0$)

(ii)   The firm has a zero contribution margin ($v_2 = p_2$) in period 2.

(iii)   The product of the weight on the financial performance measure and the agent's discount factor equals 1.

None of these conditions is likely to hold. First, a plausible assumption would be that non-price factors would always affect the firm's activities. For example, it seems reasonable that customers of a firm would be influenced by factors such as the firm's reputation before choosing to purchase goods. Thus, the first condition would not hold.[24] Second, it is also reasonable to assume that the principal will produce in the short-run only if marginal revenue is positive, so a zero contribution margin (the second condition) will not hold. Third, δ is, by assumption, always less than 1 and β_2, by definition, will always be less than 1 or else the agent would, in effect, be treated as if he was the principal. Accordingly, if either $\delta < 1$ or $\beta_2 < 1$, the third condition will not hold. Thus, the

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[24] Further, zero values of non-price factors generate a (degenerate) negative quantity value, under the assumed quantity functional form.

DFP weight in the agent's incentive contract will most likely take on a non-zero value.

Further analysis reveals that the optimal incentive weights on the financial performance measures and the DFP measure can be expressed in terms of the exogenous variables only.[25] The optimal weight on the financial performance measure in period 1 is:

$$\beta_1^* = \frac{g_1^2}{g_1^2 + r\sigma_{q1}^2} \qquad (16)$$

Under the assumptions of the model, this weight will always be positive. The positive value rewards the agent for allocating effort to shortsighted activities. The weight is independent of both the uncertainty associated with quantities sold in period 2 and the precision[26] of the DFP measure in period 1. Thus, the risk to the agent of this component of the incentive contract is driven only by the exogenous non-price parameters in period 1 and (in an inverse manner) the product of the agent's own risk aversion parameter and the uncertainty of the period 1 sales estimate.

The optimal weight on the financial performance measure in period 2 is:

$$\beta_2^* = \frac{\delta g_2^2 \sigma_y^2}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(r\sigma_y^2 + 1)} \qquad (17)$$

Under the assumptions of the model, the sign of this variable will always be positive. This motivates the agent to exert positive effort on farsighted activities. Observe that the optimal weight depends on *both* the DFP measurement variance (σ_y^2) and exogenous parameters that can affect period 2 financial performance (g_2, δ, σ_{q2}^2). Thus, the optimal weight on the financial performance measure in period 2 rewards the agent's farsighted effort, in period 2. Note though that, in period 1 the weight on the DFP measure will also reward farsighted effort. In essence, β_2 and γ are substitutes in inducing optimal levels of farsighted effort.[27]

The substitution effect works as follows. The principal's objective is to increase the weight

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[25] For proof of optimal incentive weights, see Appendix 2.

[26] Precision is defined throughout this chapter as the inverse of the variance of the distribution.

[27] Note, however, shortsighted effort and farsighted effort are not substitutes in this model.

that will allow her to satisfy the agent's reservation utility and minimize the agency cost caused by the agent's required risk premium. It is clear from the individual rationality constraints (equations (12) and (13)), that the greater the variance in financial performance measure in period 2 (σ^2_{q2}) or the greater the variance in the DFP measure (σ^2_y) then the greater the risk premium payable to the agent. Accordingly, if either variance is relatively high then the principal will place greater emphasis on the substitute performance measure, because emphasizing the substitute will mean that the principal can satisfy the reservation utility and pay a relatively lower risk premium. This leads to higher returns (than if the principal did *not* use substitution) for the principal.

The optimal weight on the DFP measure is as follows:

$$\gamma^* = \frac{g_2 \sigma^2_{q2}(p_2 - v_2)(1 - \delta + \delta^2)}{\delta^2 g_2^2 \sigma^2_y + \sigma^2_{q2}(1 - \delta + \delta^2)(r\sigma^2_y + 1)} \tag{18}$$

Since the DFP measure captures farsighted effort, the determinants of the weight are period 2 exogenous parameters. To avoid duplication, γ^* considers how well β_2^* induces farsighted effort in period 2. At one extreme if the principal had perfect foreknowledge of the quantities to be sold in period 2, then the principal is able to determine the agent's farsighted efforts in period 1 and later reward them in period 2. That is, the DFP incentive component would not be required. Consistent with this intuition, if $\sigma^2_{q2} = 0$ then $\gamma^* = 0$. An implication for incentive contract design is that perfect certainty removes the need for DFP measure.

In the limit if the DFP measure did a perfect job of capturing farsighted effort, then the principal would not need to reward financial performance in period 2. Consistent with this intuition, a perfectly noiseless DFP signal (i.e. $\sigma^2_y = 0$) would cause β_2^* to be zero. Consequently, from equation (18) if the DFP measure was a perfectly noiseless signal then γ^* is simply the interaction of non-price exogenous factors and the period 2 contribution margin. An implication for incentive contract design is that if a DFP measure is a perfect predictor of future profitability, then future financial performance measurement can be removed from the agent's contract.

A further important insight from γ^* concerns the discount factor. At an extreme, if the agent has no intention of remaining employed by the principal in period 2 (i.e. $\delta = 0$), then γ^* remains positive but is now unaffected by the uncertainty of the period 2 sales estimate. This suggests that an important property of a DFP measure is that it can induce allocations of effort to farsighted activities, even if the agent has a very short time horizon.[28] This is because the reward for the DFP measure is paid in period 1, which induces farsighted effort in period 1, so that even if the agent leaves after period 1, the reward system has already induced the optimal levels of farsighted effort to maximise period 2 profitability.

A related insight is that the second period individual rationality constraint limits but does not completely remove the principal's ability to exploit the difference in the time preferences for money. Technically, the individual rationality constraint in period 2 implies that the period 2 expected wages must equal the period 2 risk premium. As δ decreases from 1, therefore, the principal can decrease period 2 expected wages only if the period 2 risk premium decreases. To decrease the period 2 risk premium, β_2 must decrease. The decrease in β_2 is associated with an increase in γ to maintain farsighted effort. The increase in γ (and the associated increase in the period one risk premium) corresponds to an increase in period 1 expected wages. Thus, the relative profitability of compensating the manager with w_1 rather than w_2 (i.e. the quasi money pump arising from assuming a discount factor) does in fact cause the principal to decrease $E[w_2]$ and increase $E[w_1]$.

In general, the optimal value of γ^* generates the same interpretations as those from equation (15). However, since equation (18) is now a function of only exogenous variables, the third condition discussed above becomes redundant under the original assumptions of the model. This suggests the following:

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[28] The same can be said about a contract based on accounting earnings and the firm's stock price. The inclusion of the stock price in the incentive contract provides incentive for the agent *not* to defer, for example, research and development activities to maximize short-term profits and then leave the firm at the end of the short-term. This analysis excludes the stock price as a component of the incentive contract so as to isolate a similar incentive-related property of the DFP measure.

Observation 1:

Under the given assumptions of the model, whenever a firm:

(i)   is affected by exogenous non-price factors;

(ii)   has a positive contribution margin;

then the agent's compensation scheme in period 1 will optimally require an incentive

based on both a net profit performance measure and a DFP measure .

Assuming a non-negative non-prices impact, and a positive contribution margin, one would reasonably expect the coefficient (or weight) on the DFP measure to be positive. A positive weight will mean that profit improvements are non-negative.

In effect, Observation 1 is a restatement of the informativeness principle for the specific context of short-term incentives rewarding *both* short-term and long-term performance. Neither $\ln(y)$ nor π_2 are informative about shortsighted effort. Only π_1 is informative in the sense of Holmstrom (1979) and it will be used as the basis for rewarding short-term performance in the optimal contract in period 1. As the basis for rewards for long-term performance, neither $\ln(y)$ nor π_2 are sufficient for the pair [$\ln(y)$, π_2] in the sense of Holmstrom (1979), so that both $\ln(y)$ and π_2 are contractible. The DFP measure, $\ln(y)$, will be used in the contract in period 1 and π_2 will be used in the contract in period 2.

2.3   Variations in Underlying Economic Variables

The weight on the DFP measure in the optimal incentive contract is a function of a number of different exogenous economic variables. The purpose of this section is to explore variations in the values of those variables to gain insight about the impact of the underlying economic conditions on the choice of the DFP incentive weight. Such analysis generates a systematic framework of predictive observations that can provide a basis for later empirical testing. Throughout the following analysis, comparative statics are used to yield the generalizable observations.

2.3.1   The Impact of Permanent Variations in Contribution Margin

Suppose the principal acquires technology or improves productivity, which causes the contribution margin of its product to increase through decreased variable costs of production per

product.[29] An increase in contribution margin might also arise from an exogenous increase in the price of the good to be sold. Given that γ^* is a function of both prices and variable costs, it is interesting to determine how these structural financial variations will affect the principal's choice of an agent's reward system. Specifically, it is of interest in this chapter to determine whether such variations would, in equilibrium, influence the weight placed on the DFP measure in the incentive contract. If it does, then the analysis highlights a theoretical determinant of variations to incentive contracts based on both financial and DFP measurements.

Since, in (18), γ^* is clearly increasing in contribution margin, $(p_2 - v_2)$, then:

Observation 2:
Under the assumptions of the model, permanent increases (decreases) in contribution margin will lead to a greater (lower) weight on the DFP measure.

Intuitively, increases in the period 2 contribution margin leads to increases in the agent's optimal farsighted effort. Higher effort levels generate higher returns for the principal. To induce the higher levels of farsighted effort, the principal chooses to increase either the β_2 or γ weights. However, as the risk premium expression (equation (12)) indicates, simultaneously increasing contribution margin and β_2 leads to a higher risk premium payable to the agent, relative to simultaneously increasing contribution margin and γ. Thus, if contribution margin increases, the principal will have an incentive to increase γ rather than β_2, to minimize the agent's risk premium payable and maximize the principal's expected return. This intuition is confirmed by examining the β_2^* expression (equation (17)). The β_2^* weight is optimally generated independent of the contribution margin levels.[30]

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[29] Alternatively, the principal may reduce any excess capacity of the workforce, which reduces variable costs per unit sold.

[30] The *effective* incentive weight includes all variables used to induce effort and can be identified in the agent's optimal effort expression. The *explicit* weight is the actual weight variable (e.g. γ, β_2) chosen in the optimal contract. Note that if *effective* rather than *explicit* incentive weights are considered then the insight of Observation 2 applies to both γ and β_2. The *effective* weight for the DFP measure is the same as the explicit weight, i.e. γ. However, the *effective* weight for the financial measure in period 2 is the second term in the optimal farsighted effort level, i.e. $\delta\beta_2 g_2(p_2 - v_2)$, whereas the explicit weight is simply β_2. The derivative of the *effective* weight on the financial performance measure in period 2, with

In general, the model suggests that the substitutability property of the DFP measure in inducing farsighted effort can lead to the principal paying a relatively lower risk premium and earning relatively higher expected returns. Hence, in this case, contribution margin increases (decreases) will in equilibrium lead to the principal increasing (decreasing) in the DFP weight.

2.3.2 The Impact of Variations in An Agent's Discount Factor

Hauser et al. (1994) show that if an agent varies the way she discounts the future, then this will directly affect the optimal weight on a customer satisfaction (i.e. non-financial) incentive. Given that a discount factor appears in the expression for γ^* above, it seems plausible to expect that a similar result will follow. Increases (decreases) in the discount factor can be interpreted as the agent valuing the future more (less) than previously.

By (18), the sign of γ^*, as a function of δ, is determined by the sign of:

$$F(\delta) \equiv \frac{1 - \delta + \delta^2}{L\delta^2 + M(1 - \delta + \delta^2)}$$ (19)

where: $L \equiv g_2^2 \sigma_y^2, (>0)$ and $M \equiv \sigma_{q2}^2(r\sigma_y^2 + 1), (>0)$

This leads to:

Observation 3:

Under the assumptions of the model, increases (decreases) in the agent's discount factor will lead to lower (greater) weight on the DFP measure.

Proof: See Appendix 2.

The implications of this observation is that if a principal has been able to influence the way the agent discounts the future, then it will affect the choices she makes in the agent's reward system, relative to other firms. To illustrate, one way that the agent assesses the discount factor is by analysing the prospects of remaining in the same employment (versus other opportunities) and collecting future remuneration. If an agent perceives his employment context as a temporary position and expects to be employed elsewhere in period 2 then he may apply a discount factor of 0.

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respect to contribution margin, is positive.

If, however, the agent was induced through non-monetary incentives to remain in the same position in period 2 then he might use a discount factor of closer to 1. An example of a non-monetary incentive might be a job title or working hours compatible with a greater balance of life between work and home. This raises the question of to what extent do firms consider a manager's career development (including non-monetary incentives) before determining the weight on a DFP measure. This analysis suggests that in optimality a manager's expectations about future employment prospects have a direct effect on the coefficient chosen on the DFP measure.

An important implication of assuming a discount factor in this model is that the principal will have an incentive to decrease the expected value of the agent's reward in period 2, relative to the expected value of the agent's reward in period 1. Moreover, the existence of a weight on a DFP measure, which acts as a substitute for the weight on the period 2 financial signal, provides the principal with a mechanism with which to exploit this incentive. Technically, since the period 2 individual rationality constraint must hold, the only way the principal can exploit a limited incentive for earning higher payoffs (via a quasi money pump) is to reduce the period 2 risk premium by reducing the weight on the period 2 financial signal, i.e. β_2. To preserve farsighted effort levels, the reduction in β_2 must be accompanied by an increase in γ. Accordingly, the expected value of period 1 rewards (i.e. the risk premium in period 1) will increase relative to the expected value of period 2 rewards (i.e. the risk premium in period 2).

Further insight into the impact of the discount factor can be gained from observing changes in the weight on the period 2 financial signal with respect to changes in δ. The derivative is positive, indicating that the less the agent discounts the future, or the greater the value of δ, the greater the emphasis that can be placed on financial performance incentives in future periods. Overall then, the impact of the discount factor suggests that the greater the bond between the firm and the employee, the greater the emphasis that can be placed on future financial incentives and the less the need for DFP–type incentives. Conversely, financial performance incentives will be less useful and DFP

incentives more useful where employees do not expect to be employed in a particular position in the long-term.

2.3.3 The Impact of Variations in the DFP Measure Precision & The Agent's Risk Aversion

From equation (18) the value of the DFP weight is inversely related to the product of the variance arising from the measurement of the DFP measure and the agent's degree of risk aversion. At one extreme an almost noiseless DFP measure (i.e. variance of y tends to zero) will lead to a large absolute weight on the DFP measure relative to the case where the accounting system generates a poor measure of the DFP. Similarly, an agent with low risk aversion (i.e. r tends to zero) will provide incentive for the principal to place a large weight on the DFP measure relative to the case where the agent is highly risk averse. It is clear from equation (18) that increases in either the DFP measurement variance (i.e. decreases in the DFP measurement precision) or the risk aversion factor will increase the denominator of γ^* and thus have an inverse effect on the DFP measurement weight.[31] Accordingly:

> *Observation 4:*
> *Under the assumptions of the model, if:*
> *(i)   the DFP are measured with greater (lower) precision; or*
> *(ii) the agent, relative to other agents, is less (more) risk averse;*
> *then the principal will place a greater (lower) weight on the DFP measure.*

Proof: See Appendix 2.

This intuition behind this Observation is twofold. First, as DFP are measured more precisely, more of the agent's farsighted effort is observable to the principal. Contracting on a measure that captures more farsighted effort reduces agency costs because it imposes less risk on the agent, resulting in a lower risk premium payable to the agent. Lower agency costs improve the principal's expected returns. Second, as the agent becomes less risk averse, the principal must induce optimal

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[31] I took the derivative of γ^* with respect to the DFP measurement precision and the risk aversion factor, respectively. The resulting expression was negative and confirmed the obvious result that both the DFP measurement variance and risk aversion are inversely related to the DFP contractual weight.

agent effort allocations by imposing more risk on the agent. The reduction in the agent's risk aversion is in effect offset by the principal increasing the incentive part of the contract (i.e. increasing γ).

These insights have practical implications for the design of incentive contracts. If the principal can improve the precision of the DFP in estimating future financial returns, then the incentive contract requires increased weight on the DFP measure. Similarly, if the agent's risk aversion can be reduced without monetary incentive, then the DFP contractual weight needs to be increased to reflect the ability of the principal to impose greater risk on the agent.

2.3.4 The Impact of Variations in the Uncertainty of Sales Quantity Estimates

It is not immediately obvious from equation (18) what impact variations in the uncertainty of sales quantity estimates will have on γ^*. However, the derivative of γ^* with respect to σ^2_{q2} is positive. This suggests the following:

> *Observation 5:*
> *Under the assumptions of the model, if the uncertainty of the sales quantity estimate is increased (decreased), then the principal will place a greater (lower) weight on the DFP measure.*

Proof: See Appendix 2.

This Observation states that if the uncertainty of the sales quantity estimate increases then the optimal γ^* will increase. Greater uncertainty of the sales quantity means the use of β_2^* to induce farsighted effort in period 1 will lead to a relatively higher risk premium. Alternatively, the principal can increase her returns by relying more on γ^*, which generates a relatively lower risk premium, to induce farsighted effort. Thus, the principal will want to increase γ^* and decrease β_2^* to increase her returns. A check of the expression for β_2^* confirms this intuition, since increases in uncertainty cause the optimal β_2^* to decrease. Accordingly, reliance on the DFP measure increases, to provide sufficient overall incentive for the agent to exert farsighted effort at a relatively lower risk premium payable to the agent.

2.3.5   The Impact of Variations in Non-Price Exogenous Factors

It is also not immediately obvious from equation (18) what impact variations in non-price exogenous factors will have on γ^*. Indeed, the derivative of γ^* with respect to g_2 is ambiguous. This suggests the following:

> *Observation 6:*
>
> *In addition to the basic assumptions of the model, assume a variation in the impact of non-price exogenous factors in period 2. The subsequent impact on the optimal DFP measurement weight will depend on the functional relationship between the non-price exogenous factors and the determinants of the relative risk premium payable associated with adjusting the incentive weights that induce farsighted effort.*

Proof: See Appendix 2.

The intuition for this ambiguous result is straightforward. Variations in g_2 directly affect the farsighted effort level. To induce the farsighted effort level back to the optimal level, the principal can choose to adjust either the γ^* or β_2^* incentive weights. The principal's decision is guided by the relative risk premium payable to the agent while adjusting either or both of the incentive weights affecting farsighted effort. The determinants of the relative risk premium payable when choosing between γ^* or β_2^* are the agent's discount factor, the period 2 contribution margin, the uncertainty of the sales quantity estimate and the variance of the DFP measure. Depending on the relative magnitudes of these determinants, the adjustment of the incentive weight in response to variations in g_2 can be either upward or downward.[32]

Additional insight is revealed through further analysis. By (18) the sign of γ^* as a function of

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[32] The comparative statics underlying Observations 2, 4, 5 and 6 can alternatively be derived by manipulating the general parameters of Feltham and Xie (1994) (see Appendix 3 to this thesis for a comparison of the different approaches). In addition Bushman and Indjejikian (1993a), corollaries 1, 2, and 3 generate similar comparative statics. However, the comparative statics presented here differ from the results in each of these papers as follows. First, the analysis here provides insight pertaining to two compensation dates and operates at a more specific level than the general analysis in Feltham and Xie (1994), which does not report comparative statics. Second, the analysis here introduces a non-earnings, non-stock price contractual variable whereas Bushman and Indjejikian (1993a) focus on how differences in the information content of an earnings-based variable can affect the relative weights on an earnings-based and a stock price-based contractual variable. Consequently, the comparative statics presented in this study relate to a more specific setting and to different types of performance measures than the comparative statics presented in Feltham and Xie (1994) or Bushman and

g_2 is determined by the sign of:

$$\gamma *(g_2) \approx \frac{g_2}{Lg_2^2 + M}$$

where: $L \equiv \sigma_y^2 \delta^2, (> 0)$ and $M \equiv \sigma_{q2}^2 (1 - \delta + \delta^2)(r \sigma_y^2 + 1), (> 0)$

Taking the derivative of $\gamma *(g_2)$ with respect to g_2 yields:

$$\frac{\partial \gamma *(g_2)}{\partial g_2} \approx \frac{M - Lg_2^2}{(Lg_2^2 + M)}$$

Now, $M - Lg_2^2 > 0$, if and only if $g_2 < \sqrt{M/L}$. Thus:

$$\frac{\partial \gamma *(g_2)}{\partial g_2} > 0, \text{ if and only if:}$$

$$g_2 < \frac{\sigma_{q2} \sqrt{(1 - \delta + \delta^2)(r \sigma_y^2 + 1)}}{\sigma_y \delta}$$

This implies the following:

(i) If either σ_{q2} or r is small, then the right-hand side of the above equation will be small. Accordingly, in this case, increases (decreases) in period 2 non-price exogenous factors will lead to decreases (increases) in the relative weight on the DFP measure.

(ii) If either δ or σ_y is small, then the right-hand side of the above equation will be relatively large. Accordingly, in this case, increases (decreases) in period 2 non-price exogenous factors will lead to decreases (increases) in the relative weight on the DFP measure.

2.4   Variations in the Proxy for the Financial Performance Measure

Hauser, et al. (1994) analyze the context of customer satisfaction incentives. One of the findings of that paper is qualitatively the same as Observation 1, however, one of the differences in their model is that quantity sold is used as the financial performance measure in the agent reward system. The modelling in this chapter assumes that the financial performance measure used in the

agent reward system incorporates not only quantity, but also product price and the cost of making the good or service available for sale. Two questions arise. First, does a principal's choice of the *type* of financial performance measure in an incentive contract influence whether a DFP measure is optimally desirable in the same contract?[33] Second, do different financial performance measures lead to different DFP contractual weights? To address these questions I analyze four different definitions of a financial performance measure. These definitions are extracted from prior research, textbooks, and commonly observed definitions used in practice. They are:

(i)   Net Accounting Profit: as per Observation 1

(ii)   Gross Revenue: $p_i q_i$

(iii)   Quantity Sold: q_i

(iv)   Residual Income: $(p_i - v_i) q_i - f_i - K(A)$, where K is a percentage parameter and A is net total assets of the firm.[34]

The results of the modelling lead to the following:

Observation 7:

(i)   Qualitatively the same result as Observation 1 obtains irrespective of whether net profit, gross revenue, quantity sold or residual income is used as the financial performance measure.

(ii)   Equivalent incentive weights on the financial performance signal in each period obtain irrespective of the basis used for the financial performance measurement. However, the incentive weight on the DFP measure may depend on the type of financial performance measurement used.

Proof: See Appendix 2.

Three implications of this Observation are relevant for contract design. First, the choice of

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[33] A related question is why do firms choose the financial performance measure that they do in incentive contracts? The model presented here does not attempt to address this related issue. The model intends to show that in equilibrium the type of financial performance measure chosen does not affect the theoretically derived demand for a DFP measure in the incentive contract.

[34] Note that if K is the firm's weighted average cost of capital and A is the firm's capital, then the given expression also resembles the measure, "Economic Value Added" or EVA®, which is a registered trademark of the Stern Stewart & Co. Ltd. (Smith, 1997). Accordingly, in this model, identical results apply to both Residual Income and Economic Value

financial performance measurement basis does not, in itself, affect whether or not a DFP weight is optimally desirable in an incentive contract. Second, the choice of financial performance measurement basis does not necessarily affect the choice of optimal incentive weights on financial performance signals. Third, the choice of financial performance measures can affect the emphasis on the optimal incentive weight on the DFP measure.[35]

The intuition for this third implication lies in the result that optimal levels of farsighted effort vary with the financial performance signal. Variations in optimal effort levels arising from variations in a financial performance signal will provide incentive for the principal to induce different levels of farsighted effort from the agent. For example, if the result of the variation in financial performance signal generates a higher value of the signal, then the principal earns higher returns by increasing the DFP weight (rather than the financial performance measurement weight). This is because a lower risk premium is subsequently payable to the agent relative to the premium payable if the weight on the financial performance measure were to be adjusted. This results in a net (relative) increase in expected returns to the principal.

2.5   The Impact of Multi-Dimensional Signalling Capability

The basic model in the previous sections establishes a framework for analysing the conditions that predict the demand for a DFP measure in incentive contracts. The basic model assumes the measure of DFP is capable of signalling farsighted effort. In practice, however, some performance measures that drive future profits may simultaneously signal the agent's farsighted effort levels and *to*

Added.

[35] Differences in financial performance measures generated by multiplying by or adding a constant to the measure represent only a rescaling of the value of the financial performance measure. This will lead to no change in the incentives required to induce the required task because the information content of the financial performance measure is not altered when one multiplies by (or adds to it) a known constant unrelated to actions. However, in cases where there are changes to the magnitude of effort captured by financial performance measure, it can, as shown in Observation 7, part ii, lead to changes in the explicit weight on the substitute DFP measure. Note also that in the case of performance measures being a function of more than one task (later defined as multi-dimensional signalling), rescaling can raise "congruity" issues along the lines of Feltham and Xie (1994). Both multi-dimensional signalling and congruity issues are beyond the scope of this section.

a restricted degree signal the agent's shortsighted effort levels.[36] Such performance measures can be defined as having multi-dimensional signalling capability; i.e. the signals are capable of simultaneously signalling information about multiple dimensions of an agent's effort. The purpose of this section is to consider the economic consequences of a performance measure having a multi-dimensional signalling capability.

Define $H \in (0,1)$ as the degree (or exponent) to which the DFP measure is capable of signalling shortsighted effort, relative to its simultaneous capability of signalling farsighted effort. Assume then that the DFP measure captures both shortsighted and farsighted effort as follows:

$$\tilde{y} = \sqrt{\phi^H \psi} \, \tilde{\varepsilon}_y \tag{20}$$

The agency program is identical to that used earlier, except the DFP measure has multi-dimensional signalling capability, as represented in the functional form of equation (20). Solving the agent's problem leads to the following optimal effort levels:

$$a^{**} = \beta_1 g_1 (p_1 - v_1) + \tfrac{1}{2} H\gamma \tag{21}$$

$$b^{**} = \delta \beta_2 g_2 (p_2 - v_2) + \tfrac{1}{2}\gamma \tag{22}$$

These optimal effort levels are essentially the same as those derived in the basic model, except the shortsighted effort is now also a function of the DFP incentive weight, γ. Thus, the DFP incentive weight, γ, induces both farsighted and, to a relatively lesser extent, shortsighted effort. The extent to which shortsighted effort is induced by γ is restricted by the coefficient, H. Two implications arise from the assumption that H is less than 1. First, the γ weight always affects shortsighted effort to a relatively lesser degree than the β_1 weight. Second, the γ weight always affects farsighted effort to a relatively greater degree than it affects shortsighted effort.

The introduction of the variable H considerably complicates the derivation of the optimal

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[36] For example, a performance measure that captures "quality" might be predominantly focused on capturing farsighted effort and reflect a driver of future performance. However, variations in quality could also reflect variations in the nature of shortsighted effort supplied by the agent. Thus, the quality measure might simultaneously provide, to a limited degree (relative to the signal of farsighted effort), a signal of shortsighted agent effort.

incentive weights. However, the model is solvable. The optimal incentive weights are:

$$\beta_1^{**} = \frac{g_1\left[\sigma_{a2}^2(\delta^2 - \delta + 1)\{(p_1 - v_1)g_1(4r\sigma_v^2 + 1) - (p_2 - v_2)g_2 H\} + 4\delta^2 g_2^2 \sigma_v^2(p_1 - v_1)g_1\right]}{(p_1 - v_1)\left[\sigma_{a2}^2(\delta^2 - \delta + 1)(r\sigma_{a1}^2 + g_1^2) + \{(\delta^2 - \delta + 1)r\sigma_{a2}^2 + \delta^2 g_2^2\}\{H^2 \sigma_{a1}^2 + 4\sigma_v^2(r\sigma_{a1}^2 + g_1^2)\}\right]} \quad (23)$$

$$\beta_2^{**} = \frac{\delta g_2\left[H\sigma_{a1}^2((p_2 - v_2)g_2 H - (p_1 - v_1)g_1) + 4(p_2 - v_2)g_2\sigma_v^2(r\sigma_{a1}^2 + g_1^2)\right]}{(p_2 - v_2)\left[\sigma_{a2}^2(\delta^2 - \delta + 1)(r\sigma_{a1}^2 + g_1^2) + \{(\delta^2 - \delta + 1)r\sigma_{a2}^2 + \delta^2 g_2^2\}\{H^2 \sigma_{a1}^2 + 4\sigma_v^2(r\sigma_{a1}^2 + g_1^2)\}\right]} \quad (24)$$

$$\gamma^{**} = \frac{2\left[\sigma_{a2}^2(\delta^2 - \delta + 1)\{(p_2 - v_2)g_2(r\sigma_{a1}^2 + g_1^2) + r\sigma_{a1}^2(p_1 - v_1)g_1 H\} + \delta^2 \sigma_{a1}^2(p_2 - v_2)g_1 g_2 H\right]}{\sigma_{a2}^2(\delta^2 - \delta + 1)(r\sigma_{a1}^2 + g_1^2) + \{(\delta^2 - \delta + 1)r\sigma_{a2}^2 + \delta^2 g_2^2\}\{H^2 \sigma_{a1}^2 + 4\sigma_v^2(r\sigma_{a1}^2 + g_1^2)\}} \quad (25)$$

This suggests the following:

Observation 8:

Under the assumptions of the model, the introduction of a DFP measure with multi-dimensional signalling capability leads to the introduction of trade-offs between all three performance measures in the model.

Proof: See Appendix 2.

Accordingly, a fundamental implication of introducing the multi-dimensional signalling capability is that variations in the precision of any of the performance measures will now affect the optimal incentive weights on all three performance measures in the model. In the basic model, a trade-off exists only between the DFP measure and the financial performance measurement weights in period 2. In essence, this result is an application of the types of multi-tasking issues analyzed in Holmstrom and Milgrom (1991), Bushman and Indjejikian (1993a, 1993b) and Feltham and Xie (1994), among others. The difference here is that the context of short-term incentives providing rewards for long-term performance is specifically modelled.

It is clear from the above that γ^{**} will always be a positive value. However, under certain conditions it is possible for either β_1^{**} or β_2^{**} to obtain negative values. Further analysis reveals the possible intuition for this result. The intuition lies in the conflict between the multi-dimensional signalling capability of the DFP measure, and the single dimensional nature of the incentive weight on farsighted effort. The value of γ^{**} that is necessary for helping to induce optimal levels of shortsighted effort is unlikely to be the same value of γ^{**} that is necessary for inducing optimal levels

of farsighted effort. Accordingly, a compensating adjustment of either β_1^{**} or β_2^{**} is necessary to ensure optimal allocation of effort along both the shortsighted and farsighted dimensions.

For example, as the multi-dimensional DFP measure becomes increasingly noiseless (i.e. σ_v^2 tends to 0),[37] a single value of γ^{**} is not able to efficiently perform two separate inducement tasks; i.e. firstly, to induce optimal shortsighted effort and secondly, to induce optimal farsighted effort. Accordingly, the value of γ^{**} is set at a value that helps induce optimal shortsighted effort levels. However, the selected value of γ^{**} leads to higher than optimal levels of farsighted effort. This suboptimal inducement of farsighted effort is remedied by a compensating adjustment of the incentive weight on financial performance in period 2, β_2^{**}. It is possible for the compensating adjustment of β_2^{**} to yield a negative value of β_2^{**}. Thus, under certain conditions, β_2^{**} can be optimally chosen to act as a *disincentive* in the solution to the multi-dimensional signalling model.

2.6 Conclusion

Recent trends suggest increasing use of performance measures that reflect drivers of future performance. Yet, there has been relatively little academic research that studies why firms use DFP measures rather than (or to supplement) financial performance measurement in incentive contracts, or why firms use the weights on the DFP measures that they do. Agency theory offers general insight but does not address specific properties of DFP measures. In particular, textbooks and practitioners contend that many DFP measures, such as nonfinancial measures, are a leading indicator of the future profitability of the firm. This chapter developed an agency model of the economic demand for DFP measures in incentive contracts and explored the economic consequences of variations in the conditions generating the demand for DFP measures.

The results in this chapter show that under the assumptions, the principal will optimally offer an incentive contract that includes positive weight on both financial and DFP measurements.

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[37] Chapter 3 of this thesis explores in greater depth the impact of variations in measurement precision on optimal incentive

Increases (decreases) in contribution margin, an agent's discount factor, the DFP measurement precision, or the uncertainty of the future sales estimate lead to a greater (lower) optimal weight on the DFP measure. Variations in the proxy for the financial performance measure in the model do not qualitatively change the demand for the DFP measure. However, the relative weights on the financial performance measure and the DFP measure, in optimality, vary according to the type of financial performance proxy used. Variations in the signalling capability of the DFP measure leads to increased trade-offs in the substitution of weights on financial performance measures for the weight on the DFP measure.

The results suggest two important intuitive properties of DFP measures that provide insights into the popularity of the measures in practice. First, in incentive contracting, DFP measures can be substituted for current and future financial performance measures to induce farsighted effort more efficiently, leading to greater returns for the principal. Second, DFP measures can overcome the problem of an agent becoming myopically focused on short-term performance and leaving the firm before long-term performance sets in.

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weights and the principal's returns.

Chapter 3

The Economic Consequences of the Precision and Predictability of the Measures of the Drivers of Future Performance

3.1 Introduction

Measures of drivers of future performance (DFP) are being increasingly used in practice for performance evaluation in both the private (see Banker, Potter and Srinivasan, 1997) and public sectors (cf. Government of Alberta, 1997). One possible explanation for their increasing popularity is the assertion that firms that use DFP can earn higher payoffs. Agency theory might be used to argue that higher payoffs might arise in two ways. First, costless improvements in the precision of DFP can lead to a lower relative risk premium payable to the agent, and ultimately increases in the principal's payoffs.[38] Second, if an agent's decision-making was *less* focused on future financial measures of performance, and *more* focused on current DFP, which were highly *predictive* of future profitability, then the overall payoff to the principal improves through reductions in the risk premium payable to the agent.

Limited empirical evidence supports claims of positive associations between the use of DFP and higher payoffs. Foster and Gupta (1997) find that higher customer profitability is associated with customers having higher satisfaction. Banker, Potter and Srinivasan (1997) provide evidence of higher firm profits associated with the introduction of an incentive plan based on non-financial

measures of performance. Each study focuses on one large firm as the unit of analysis.

Despite basic theoretical intuition and empirical evidence supporting the claim that using DFP can be associated with increased payoffs for the principal, the association will not *always* be positive. The net effect on the principal's payoffs is affected by the costs associated with various measurement attributes of the DFP used. For example, it may be possible for a performance measurement system to produce either perfectly noiseless DFP *or* DFP that perfectly predict future profitability. however, the incremental costs of achieving perfection may lead to a net adverse impact on the principal's payoffs. Thus, by using DFP a cost-benefit tension arises in that DFP potentially can foreshadow future economic consequences but at the same time are costly to measure. Accordingly, assuming measurement costs increase in precision, the DFP that a firm uses in incentive contracting will, in optimality, contain measurement error. Further, variations in DFP measurement attributes will lead to variations in the optimal DFP measured with error.

The purpose of this chapter is to develop a theoretical framework for understanding the conditions under which variations in two measurement attributes of DFP used in incentive contracts can lead to variations in payoffs. More specifically, the chapter investigates the economic impact of changes in DFP attributes of *precision* and *predictability* on the design of DFP, the agent's efforts and ultimately on the overall payoffs to the principal. *Precision* is defined as the inverse of the variance of the probability distribution associated with the DFP. *Predictability* is defined as the ability of the current DFP to predict future financial performance.

Research on DFP with different measurement attributes extends the relatively little existing accounting research that explores the economic consequences of alternative designs of internally generated performance measures in incentive contracts. Banker and Datar (1989) find that the relative weights placed on two linearly aggregated performance measures (for contracting purposes) depend only on the sensitivity and precision of the two measures. Feltham and Xie (1994) find that a first-

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[38] The impact of changes in DFP precision on the optimal incentive contract weights was examined in chapter 2.

best solution to their model could be achieved only if a performance measure is perfectly congruent (in inducing agent's actions consistent with the principal's objectives) *and* perfectly noiseless. Hemmer (1996) finds that a principal will optimally prefer different types of performance measures. depending on the source and type of data collected to construct the performance measures.

No previous study has explicitly explored the economic consequences of variations in measurement attributes that lead to alternative designs of a performance measure used for contracting purposes. Studying the consequences of variations in measurement attributes is important for two reasons. First, it provides theoretical insight into why firms choose the measurement attributes that they do in incentive contracting. Second, it provides a basis for establishing cross-sectional empirical predictions of the types of firms that use DFP with different measurement attributes.

This study makes four contributions. First, it establishes a theoretical framework that shows how costless variations in precision and predictability of DFP can lead to variations in the principal's payoffs. Second it provides theoretical support for the use of optimal DFP measured with error, and establishes theoretical determinants of a firm's optimal DFP. Third, it provides a basis for establishing hypotheses about cross-sectional variations in the use of DFP in practice. Fourth, it provides theoretical insight into the observed practice of firms able to induce productive effort levels despite the presence of corporate cost cutting.

This chapter is organized as follows. The next section outlines the basic model, adopted from Chapter 2. A basic model of the impact of DFP precision is presented in Section 3. Section 4 presents a model of the impact of DFP predictability. Section 5 extends the analysis to the setting where one type of effort has multiple performance impacts. Section 6 provides concluding remarks.

3.2   Preliminaries

The analysis in this Chapter is based on the solution to the theoretical model established in Chapter 2 of this thesis. To recap, the model is a two period principal-agent model, where the effort-averse and risk-averse agent (r measures the agent's risk aversion) is rewarded for both shortsighted

(a) and farsighted effort (b). The agent's compensation in period 1 (w_1) is a linear function of a fixed salary (α_1), a component based on a traditional financial performance measure (π_1, which signals shortsighted effort), and a component based on DFP (y, which signals farsighted effort). In period 2 the agent's compensation (w_2) is based on fixed salary (α_2) plus a component based on the traditional financial performance measure (π_2, which also signals farsighted effort).

The agent allocates effort between shortsighted and farsighted activities to maximise utility. The principal chooses incentive weights (β_1, β_2, and γ) to induce incentive-compatible effort levels from the agent, to maximise expected payoffs. The firm's profits are a linear function of sales, q_i, (which are a function of effort, price, p_i, and the impact of non-price exogenous factors, g_i, $i = 1, 2$), price, and costs (variable costs, v_i, and fixed costs, f_i, $i = 1, 2$). σ_j^2 is the variance of the distribution associated with variable j, $j=q_1$, q_2, y. After solving for the optimal effort levels, the total agency program is as follows:[39]

$$\underset{\beta_1,\beta_2,\gamma}{Max}\ E[\pi_1 + \pi_2 - w_1 - w_2] \tag{26}$$

subject to:

$$E[\tilde{w}_1] + \delta E[\tilde{w}_2] = \frac{a^2}{2} + \frac{b^2}{2} + \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2\sigma_{q1}^2 + \gamma\,\sigma_y^2 + \delta^2\,\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right) \tag{27}$$

$$E[\tilde{w}_2] = \frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right) \tag{28}$$

$$a = \beta_1(p_1 - v_1)g_1 \tag{29}$$

$$b = \gamma + \delta\,\beta_2(p_2 - v_2)g_2 \tag{30}$$

The optimal incentive weights are as follows:

$$\beta_1^* = \frac{g_1^2}{g_1^2 + r\,\sigma_{q1}^2} \tag{31}$$

$$\beta_2^* = \frac{\delta g_2^2\,\sigma_y^2}{\delta^2 g_2^2\,\sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(r\sigma_y^2 + 1\right)} \tag{32}$$

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[39] See Chapter 2 of this thesis for further detail of the construction of the basic model.

$$\gamma^* = \frac{g_2 \sigma_{q2}^2 (p_2 - v_2)(1 - \delta + \delta^2)}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(r \sigma_y^2 + 1)} \tag{33}$$

The first-best solution to the problem (not shown in Chapter 2) can be found if farsighted and shortsighted efforts are assumed to be both publicly observable. If the agent accepts the contract that pays a fixed salary plus reimbursement for costs of effort, then the agent's optimal effort levels are:

$$a^F = (p_1 - v_1) g_1 \tag{34}$$

$$b^F = (p_2 - v_2) g_2 \tag{35}$$

3.3   A Model of the Impact of Precision

A measurement attribute of DFP is the precision of the DFP. Precision can be defined as the inverse of the variance of the probability distribution associated with DFP. While variations in DFP precision clearly require a change in the optimal incentive contract weights, it is not obvious how such changes subsequently affect the overall payoff to the principal. For example, improvements in the DFP precision optimally require greater weight to be placed on the DFP in the incentive contract but this does not necessarily improve the overall payoff to the principal. Intuitively, since farsighted effort is more observable, one might expect the agent to exert more effort that is farsighted. A simultaneous increase in shortsighted effort in both periods would lead to increased payoffs to the principal. However a sacrifice of short-sighted effort (to achieve the higher levels of farsighted) in both periods may lead to profit reductions that more than absorb the profit improvements caused by increases in farsighted effort.

3.3.1   The Impact of Variations in DFP Precision on Managerial Behaviour

This model assumes the effort levels of the agent represent managerial behaviour. To explore the impact of variations in DFP precision on effort levels, it is first necessary to substitute the basic model's optimal incentive weights into the optimal effort levels. The optimal effort levels, after substitution of the optimal incentive weights, are as follows:

$$a* = \frac{g_1^3(p_1 - v_1)}{g_1^{\,2} + r\sigma_{q1}^2} \tag{36}$$

$$b* = \frac{g_2(p_2 - v_2)\left(\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2(1 - \delta + \delta^2)\right)}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2(1 - \delta + \delta^2)(r\sigma_y^2 + 1)} \tag{37}$$

These optimal effort levels can be linked directly back to the levels prescribed in the first-best solution. The first-best shortsighted effort levels in equation (34) can be achieved in this case if the agent is risk neutral (i.e. $r = 0$) or if the signal of shortsighted effort is perfectly noiseless (i.e.$\sigma_v^{\,2} = 0$). Similarly, the first-best levels of farsighted effort in equation (35) can be achieved if the agent is risk neutral or if either signal of farsighted effort (*i.e.* β_2 or γ) is perfectly noiseless.[40]

To explore the impact of the precision on the optimal effort levels, take the derivative of the optimal effort levels with respect to the variance of the DFP. The results are zero for the short-sighted effort, and the following for the farsighted effort levels:

$$\frac{\partial b*}{\partial \sigma_y^2} = -\frac{rg_2(p_2 - v_2)(\sigma_{q2}^2)^2(1 - \delta + \delta^2)^2}{\left(\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2(1 - \delta + \delta^2)(r\sigma_y^2 + 1)\right)^2} \tag{38}$$

This implies that under the assumptions of the basic model, the precision of the DFP has no effect on the shortsighted effort level. This is clear from the optimal expression for shortsighted effort (equation (36)), which excludes any DFP variance-related terms. However, increases (decreases) in the precision of DFP lead to increases (decreases) in the agent's farsighted effort.[41] The intuition for these results is as follows. Under the basic model, the DFP is not able to induce shortsighted effort, so any changes in DFP will not change the levels of shortsighted effort. Variations in the precision of DFP will, however, change the observability of the agent's farsighted effort. If an agent's effort level

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[40] Feltham and Xie (1994) find that in multi-dimensional effort space, risk neutrality *or* noiseless signals are not sufficient conditions to achieve the first-best solution. While this result appears inconsistent with the discussion here, Feltham and Xie explicitly model a single performance measure in a two-action, single-period setting, and establish what they define as "non-congruity" between the impact of effort on the performance measure and the impact of effort on the principal's gross payoff. By contrast, this paper models multiple performance measures and multiple actions over multiple periods. The congruity of the performance measure is considered beyond the scope of this study.

[41] The derivative of $b*$ with respect to $\sigma_y^{\,2}$ shows that increases (decreases) in variance lead to decreases (increases) in the optimal farsighted effort level. Since the precision is the inverse of the variance, increases (decreases) in DFP precision

becomes increasingly observable because of increased precision, the lower risk from investing effort mean the agent's optimal effort levels will move towards what they would be under the first-best solution (i.e. with no hidden action problems).

3.3.2 Variations in the Determinants of the Principal's Payoffs

This section examines the impact of the variations in the economic determinants of the principal's payoffs. The first subsection explores the impact of variations in DFP precision. The second subsection discusses the impact of variations of the other exogenous variables determining the principal's payoffs.

3.3.2.1 The Impact of Precision on the Principal's Payoffs

Taking the derivative of the principal's certainty equivalent with respect to changes in DFP precision yields the impact of precision variations on the principal's payoffs. The result is as follows:

$$\frac{\partial \Pi^*}{\partial \sigma_y^2} = -\frac{1}{2} \frac{rg_2^2(p_2 - v_2)^2(\sigma_{q2}^2)^2(1 - \delta + \delta^2)^2}{\left(\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2(1 - \delta + \delta^2)(r\sigma_y^2 + 1)\right)^2} \tag{39}$$

The result follows logically from the intuition that predictable variations in farsighted effort levels are generated from variations in observability. Essentially, as the principal can observe more (less) of the agent's farsighted efforts, the agent will have incentive to increase (decrease) farsighted effort levels. Consequently, period 2 sales increase (decrease), which leads to an increase (decrease) in the overall payoffs, to the principal. Clearly, this shows that the payoffs to the principal are indirectly linked to the observability of the agent's farsighted efforts via the precision of DFP.

However, the benefits of improved DFP precision must be balanced against their costs. To explore the conditions under which costly improvements to DFP precision will improve the principal's overall payoffs, the costs of producing DFP are introduced to the model. To capture the DFP costs, the following expression is deducted from the principal's total payoffs:

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lead to increases (decreases) in farsighted effort.

$$C\left(\frac{1}{\sigma_y^2}\right) = \frac{c^2}{\sigma_y^2}$$ (40)

The function implies that the costs of producing DFP are a function of the level of precision achieved. To simplify the analysis, the marginal cost of improving precision is expressed as squared constant and the functional form of the cost function is assumed linear.[42] In the subsequent analysis of the optimal solution to the costly precision improvement case, the agent's discount factor is assumed to be the same as the principal (i.e. equal to 1), to isolate the tensions between the marginal benefit and marginal costs of improving DFP precision.

Taking the derivative of the principal's payoffs with respect to DFP variance provides insight into the impact of *costly* variations in precision on the principal's payoff. The resultant expression is:

$$\frac{\partial \Pi^{**}}{\partial \sigma_y^2} = \frac{c^2 \Omega^2 - \frac{r}{2}\Xi^2}{\left(\sigma_y^2\right)^2 \Omega^2}$$ (41)

where:

$$\Omega = g_2^2 \, \sigma_y^2 + \sigma_{q2}^2 \left(r \, \sigma_y^2 + 1\right)$$

$$\Xi = g_2 (p_2 - v_2) \sigma_{q2}^2 \, \sigma_y^2$$

Clearly, the sign of the overall expression is ambiguous and depends on the sign of the numerator. This result provides insight into why firms do not attempt to capture perfectly noiseless DFP. Where $c^2\Omega^2 > 0.5r\Xi^2$, the numerator is positive, so that any improvements in precision (i.e. the *inverse* of the variance) will lead to *decreases* in overall payoffs to principal. Intuitively this is because the marginal costs of improving precision exceed the marginal increases in payoffs. Conversely, where $c^2\Omega^2 < 0.5r\Xi^2$, under the assumed cost function for producing DFP, the principal will always have incentive to improve DFP precision. Again, the intuition is based on the marginal increases in payoffs exceeding the marginal costs of improving the precision of DFP. In summary,

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[42] I also tested a quadratic cost functional form, which may be more representative of cost functions observed in practice. However, the interpretation of the increasingly complex math does not add to the theoretical insight discussed in this section.

the model predicts that firms will outlay costs to improve precision only where marginal benefits of precision improvements exceed marginal costs.

An alternative way of interpreting this result is through the analysis of the *optimal level of precision*. In the presence of costly construction of DFP, the optimal level of precision can be determined by first setting the first order condition of equation (41) to zero.[43] Next, solve for the optimal variance level and then invert the result to obtain the optimal level of precision. Accordingly, under the assumptions of the basic model, and assuming that the principal and agent have the same discount factor, the optimal level of DFP precision can be expressed as:[44]

$$\left(\frac{1}{\sigma_y^2}\right)^* = \frac{\sqrt{\frac{r}{2}}(p_2 - v_2)g_2\, \sigma_{q2}^2 - c(r\,\sigma_{q2}^2 + g_2^2)}{c\,\sigma_{q2}^2} \qquad (42)$$

This optimal level of precision implicitly assumes that both the marginal cost of improving precision and the uncertainty of the (period 2) sales estimate are non-zero. Note also that a necessary condition underpinning this optimal level of precision is that the numerator of equation (42) is greater than zero. A numerator equal to, or less than, zero implies the optimal level of precision is non-positive, which is impossible by construction.

The optimal level of precision provides the basis for several comparative statics that can generate empirical implications about the expected level of DFP precision to be found in certain types of firms. For example, by taking the derivative of equation (42) with respect to contribution margin, it is possible to make cross-sectional predictions about the impact of contribution margins on precision levels. The derivative is positive. This implies that, for example, firms with high contribution margins (ceterus paribus) would be expected to have high levels of precision in DFP, relative to firms that have low contribution margins (thereby relying on volumes to drive profits). Intuitively, one might expect firms with higher contribution margins to have relatively more resources

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[43] In the costless case, the optimal level of variance is zero.

to allocate to improving DFP precision than firms with relatively lower contribution margins. Of course, this implicitly assumes that the other determinants of the optimal level of precision, including the incremental cost of improving precision are constant between firms.

3.3.2.2 Variations in Other Determinants of the Principal's Payoffs

The comparative statics on the other determinants of the principal's payoffs support the following theoretical insights. First, increases (decreases) in the precision of the financial performance measure in either period 1 or period 2 lead to the same qualitative results as those arising from variations in DFP precision. The same intuition applies. That is, an increase (decrease) in precision improves the observability of effort, leading to increases (decreases) in the effort level and subsequent increases (decreases) in payoffs to the principal.

Second, increases (decreases) in risk aversion means increased (decreased) risk premium is payable to the agent, which ultimately leads to lower (higher) payoffs to the principal. Third, the more (less) the agent discounts the future, the lower (higher) the discount factor is, which imposes relatively increased (decreased) risk on the agent. This results in higher (lower) risk premiums payable and lower (higher) payoffs to the principal. Fourth, increases (decreases) in the non-price exogenous factors in either period 1 or 2, such as reputation, leads directly to increases (decreases) in sales and increases (decreases) in the payoffs to the principal.

Lastly, the impact of variations in the components of contribution margin on the payoffs to the principal generates ambiguous results. The ambiguity is generated by the firm's inverse demand function but is also affected by the degree of the agent's risk aversion. Intuitively, the inverse demand function implies that when the product price increases, at some point demand will fall and lead to relatively lower overall profits than what would have been achieved had the product price remained unchanged. The magnitude of the ambiguity is affected by the agent's risk aversion. To illustrate, take the derivative of the principal's payoffs with respect to period 1 revenue per unit sold (i.e. product

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[44] Second-order conditions confirm a maximum.

price, p_1):

$$\frac{\partial \Pi^*}{\partial p_1} = \frac{g_1^4(p_1 - v_1) - (g_1^2 + r\sigma_{q1}^2)(2p_1 - v_1)}{(g_1^2 + r\sigma_{q1}^2)} \tag{43}$$

The sign of the derivative is ambiguous. The second term in the numerator reflects the existence of an inverse demand function. Without an inverse demand function (i.e. revenues are linear in quantity sold) the second term in the numerator disappears and the expression in (43) will always be positive.

To assess the impact of risk aversion, assume $r \to 0$.[45] Subsequently, the derivative in equation (43) is always positive if $g_1^2 > (2p_1 - v_1) / (p_1 - v_1)$.[46] The intuitive explanation for this result is as follows. Increases (decreases) in the product price not only leads to increases (decreases) in profits, but it also increases (decreases) the risk imposed on the agent, since the agent's incentives are based, in part, on the contribution margin. At some point, the increments (decrements) in the risk premium payable to the agent, arising from increases in the product price, will exceed the revenue increments (decrements) arising from increases in the product price, leading to net decreases (increases) in the overall payoff to the principal. Accordingly, the ambiguity in sign that emerges when assessing the impact of variations in the components of contribution margin on the principal's payoffs is affected by the degree of the agent's risk aversion.

A similar result follows for variations in the components of the period 2 contribution margin. To illustrate, the derivative of the principal's payoffs with respect to period 2 product price is as follows:

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[45] If the agent is risk neutral then the optimal solution will be that the agent should rent the firm from the principal. However, the purpose of this discussion is to show that the degree of the agent's risk aversion can affect the ambiguity in determining the impact of changes in contribution margin on the principal's overall payoffs.

[46] The derivative with respect to v_1 as r tends to 0 is negative if $g_1^2 > p_1 / (p_1 - v_1)$. This condition will always hold if non-negative sales quantities are to be generated under the basic assumptions of the model. This suggests the ambiguity of the derivative with respect to variable costs in period 1 is *directly* attributable to the risk aversion of the agent. An equivalent result is obtainable from the period 2 parameters.

$$\frac{\partial \Pi^*}{\partial p_2} = \frac{\delta^2 g_2^2 \sigma_y^2 \left(g_2^2(p_2 - v_2) - (2p_2 - v_2)\right) + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(g_2^2(p_2 - v_2) - (2p_2 - v_2)(1 + r\sigma_y^2)\right)}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)} \tag{44}$$

The sign is ambiguous, which arises because of the parameters associated with the inverse demand function. That is, the expression $2p_2 - v_2$ is associated with the inverse demand function and if $2p_2 - v_2 = 0$, then expression (44) is always positive. The derivation of the sign of the above expression is less complicated, however, as $r \to 0$. Here, the expression in (44) collapses so that it will always be positive if $g_2^2 > (2p_2 - v_2) / (p_2 - v_2)$. Again, this indicates that the ambiguous impact on overall payoff of variations in the components of period 2 contribution margin can be affected by the degree of the agent's risk aversion.[47]

In summary, variations in the determinants of the principal's payoffs mostly have a deterministic effect on overall payoff. Two exceptions are contribution margin and costly variations in the precision of DFP. Contribution margin simultaneously affects payoffs both favourably, through increased revenues, and adversely, through increased risk premiums. The ambiguous result is generated by the firm's inverse demand function and the magnitude of the net effect depends in part on the relative degree of the agent's risk aversion. The net impact of costly variations in the precision of DFP depends on the trade-off between the marginal benefit from precision changes and the corresponding incremental costs.

3.4 A Model of the Impact of Predictability

Another measurement attribute of DFP is their *predictability*. In a general sense, predictability can be defined as the ability of current DFP to predict future profitability. In an agency context, predictability is defined as the degree to which DFP are incrementally informative about future profits. A commonly asserted benefit of DFP is that they provide management with

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[47] Note that this result is contrary to the result obtainable from applying the assumptions of this model to Feltham and Xie's (1994) formulae. To be more precise, the derivative of the second best expected surplus in Feltham and Xie (i.e. their equation 9) with respect to the revenue per unit sold will always be positive. Thus, it appears that Feltham and Xie's result in equation 9 does not apply to at least some non-linear revenue functions.

foreknowledge of future profitability. The purpose of this section is to show how variations in the predictability of DFP can lead to variations in payoffs to the principal.

3.4.1 The Impact of Inherent DFP Predictability

Predictability might be modelled as an extension to the basic model summarized earlier and discussed in detail in Chapter 2. While predictability has been defined as predictive of *future profits*, the following analysis reflects predictability as predictive of *farsighted effort*. However, under the basic assumptions, farsighted effort *drives* future profits. Accordingly, the DFP predictability captured in the following analysis is ultimately the predictability of future profits, as originally defined.

Define $D \in (0, 1]$ as the degree of predictability of DFP. Accordingly, the signal of DFP is captured in the following functional form:

$$\tilde{y} = \psi^D \tilde{\varepsilon}_y \tag{45}$$

In essence, the introduction of the exponent, D, redefines part of the measurement noise in DFP as being noise due to an inherent lack of predictability.[48] An example of the difference in the types of noise can be illustrated in the case of the hotel industry. Alternative DFP of a hotel might be reservation rates and customer satisfaction measures. Both are potentially important DFP measured with noise. The overall noise attributable to each measure is unlikely to be systematically greater for either indicator for all firms. However, reservation rates might reasonably be considered to have more *inherent* predictability about future profits than customer satisfaction measures, since it is more directly related to future profitability than customer satisfaction. Accordingly, under the model, the degree of predictability of hotel reservation rates would exceed the degree of predictability of hotel

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[48] In the notation of Feltham and Xie (1994), the variable D here is similar to their μ_{22}. This implies that D could be interpreted as representing the relative sensitivity of the DFP performance measure. Note, however, that the restriction of D to values of between 0 and 1 distinguishes it as a special setting of performance measure sensitivity as defined in Banker and Datar (1989). Moreover, given the two compensation dates in this model, this relative sensitivity is in effect the sensitivity of the DFP measure with respect to effort that impacts a *future* (rather than the current) time period. Accordingly, the predictability variable, D, in this model is viewed as different from a more conventional interpretation of performance measure sensitivity (e.g. see Banker and Datar, 1989).

customer satisfaction measures.

The introduction of the degree of predictability leads to variations in the optimal solution to the agency program. While the optimal short-sighted effort level and incentive weight on the period 1 financial performance measure do not change, farsighted effort, and the incentive weights that induce farsighted effort yield a change in optimal values. The optimal level of farsighted effort becomes:

$$b^* = D\gamma + \delta \beta_2 g_2 (p_2 - v_2)$$

(46)

This implies that the optimal level of farsighted effort is restricted by the degree of predictability of the DFP. When $D = 1$, the DFP does not contain a lack of inherent predictability. Accordingly, the remaining measurement error arises because of uncontrollable exogenous factors such as general economic conditions. Intuitively, any reductions in the predictability of the optimal effort level (i.e. $D < 1$) would lead to reductions in the optimal incentive weights, since the principal cannot induce as high effort levels as the case where the DFP is inherently predictable. Reductions in the optimal incentive weights logically lead to lower levels of payoffs to the principal. Thus, a loss in payoffs occurs because of the inherent lack of predictability. This loss in payoffs may be defined as a *net loss due to the inherent lack of predictability*. Mathematically this net loss can be derived by deducting the principal's payoffs in a regime that includes the predictability variable, from the principal's payoffs in a regime that excludes the predictability variable (i.e. $D = 1$). The resultant expression is the *net loss due to the inherent lack of predictability:*[49]

$$Net\ Loss = \frac{(D^2 - 1)rg_2^2(p_2 - v_2)^2(\sigma_{q2}^2)^2 \sigma_y^2}{2(g_2^2 \sigma_y^2 + \sigma_{q2}^2(1 + r\sigma_y^2))(g_2^2 \sigma_y^2 + \sigma_{q2}^2(D^2 + r\sigma_y^2))}$$

(47)

Whenever inherent lack of predictability exists, the value of the above expression will be negative (i.e. representing a *loss* in payoffs).[50] This is because inherent *lack* of predictability assumes

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[49] To isolate the tensions of interest, the analysis in the section continues to assume the principal and the agent have the same discount factor, i.e. $\delta = 1$.

[50] Indeed, a simpler way of demonstrating the negative sign of this expression is to take the derivative of the firm payoffs with respect to D. However, the purpose of this discussion is not only to identify the sign of the expression. Rather, the discussion also aims to conceptualize the inherent loss in payoffs to the firm that arises because performance measures are

$D < 1$, which causes the sign of the above expression to always be negative. Increases (decreases) in the inherent lack of predictability unambiguously lead to increases (decreases) in profit and thus reductions (increases) in the loss due to the lack of inherent predictability. This result is consistent with the assertion that a principal can earn higher payoffs with relatively increased DFP predictability.

3.4.2 The Choice of Relatively Lower Degrees of Predictability

Clearly, the previous result provides theoretical support for why firms might choose the DFP that they do in incentive contracts. If the chosen DFP has higher inherent predictability relative to other DFP, then ceterus paribus, it will lead to higher payoffs for the principal. However, there are limitations to the generalizability of this result. In particular, if the result was completely generalizable, it fails to explain why firms in the same industry might have incentive to choose contractual DFP with relatively different degrees of inherent predictability. The following analysis explores possible conditions under which firms in the same industry might choose to use DFP in incentive contracts with relatively *lower* degrees of predictability. Ex-ante, choosing DFP with relatively lower degrees of predictability appears to be irrational, since it is inconsistent with the earlier result that increases in predictability lead to higher payoffs.

Suppose the DFP measure used in the agent's incentive contract influenced different types of strategic decisions, the payoffs of which were generated in period 2. Examples of different strategic decisions (influenced by different DFP incentives) might be decisions to refurbish the workplace or to undertake a large advertising campaign. The outcomes of these strategic decisions are assumed to have payoffs for the firm beyond what would have been achieved had no strategic decision been made.

Suppose further that DFP predictability is inversely related to the expected payoffs from strategic decisions influenced by different DFP incentives. Accordingly, DFP with relatively low (high) predictability are assumed to have relatively high (low) incremental expected payoffs from

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not naturally perfectly predictable. The net loss due to the inherent lack of predictability mathematically represents this

strategic decisions influenced by DFP-related incentives.

To illustrate, suppose a hotel could choose between reservation rates (relatively high predictability) or customer satisfaction measures (relatively lower predictability) as alternative DFP to include in incentive contracts. Incentives ultimately based on reservation rates might influence a manager to make strategic decisions that include embarking on an advertising campaign to increase the future occupancy rate. This could lead to expected payoffs beyond what would have been achieved had the advertising campaign not been pursued.

Alternatively, incentives ultimately based on customer satisfaction measures might influence managers to make substantial change to the way that the hotel operates. This could lead to even higher expected payoffs than the incremental payoffs arising from embarking on a new advertising campaign. Thus, despite customer satisfaction measures having relatively lower predictability, the expected incremental payoffs from strategic decisions influenced by incentives based on customer satisfaction are assumed here to exceed the incremental payoffs from strategic decisions influenced by incentives based on reservation rates.[51]

Let $R \mathbin{/} D$ be the expected payoff from strategic decisions influenced by incentives based on DFP at the end of period 1. With this function decreasing in predictability, it captures the assumed inverse nature of the relationship between inherent predictability and expected incremental payoffs. Accordingly, the firm's profits in period 2 are:

$$\tilde{\pi}_2 = (p_2 - v_2)\tilde{q}_2 - f_2 + \frac{R}{D} \tag{48}$$

Re-solving the agency program generates no change to the farsighted optimal effort levels specified in equation (47). However, the impact of variations in predictability on the principal's

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conceptualization.

[51] It is critical here to recognize that it is the promise of incentives based on DFP measures with different levels of predictability and *not* the result of the DFP measure itself that is influencing the strategic decisions. In the latter case, the role of the DFP information would be expanding from decision-influencing to decision-facilitating (see Baiman and Demski, 1980) since the information itself is being used to improve the strategic decision outcomes. However, the manager in this model does not use the DFP measure *before* the action choice to make better decisions, rather, the DFP measure is used *after* the action choice to evaluate actions, i.e. the DFP measure is interpreted here as decision-influencing

payoffs is as follows:

$$\frac{\partial \Pi^{**}}{\partial D} = \frac{R\Delta^2 - rD^3\Phi^2}{D^2\Delta^2}$$

(49)

where:

$$\Delta = g_2^2\, \sigma_y^2 + \sigma_{q2}^2\left(D^2 + r\sigma_y^2\right)$$

$$\Phi = g_2^2(p_2 - v_2)^2\left(\sigma_{q2}^2\right)^2 \sigma_y^2$$

This result shows that variations in predictability can lead to an ambiguous impact on the principal's payoffs. Intuitively, this ambiguity arises because of the trade-off between the expected payoff from strategic decisions based on the DFP and the loss due to the inherent lack of predictability of DFP. For increased payoffs to occur, the increase in predictability from selecting an alternative DFP must lead to expected payoffs that absorb the losses due to the inherent lack of predictability of the new DFP measure.

An important implication of this result is as follows. It is possible that choosing DFP with high levels of predictability (relative to other DFP) will lead to increased payoffs. However, higher levels of predictability will not always lead to increased payoffs. This analysis has shown that it is possible for firms to achieve higher levels of payoffs with paradoxically lower levels of inherent DFP predictability for incentive contracting.

3.5   Multi-Impact Effort Types

The analysis thus far has assumed each type of effort independently affects each period's performance. However, it may be the case that a single effort type has multi-period consequences. For example, an agent's farsighted effort directly increases period 2 profit, but it simultaneously may also generate incremental costs that have a negative impact on period 1 profit. Similarly, an agent's shortsighted effort directly increases period 1 profit, but it simultaneously may also generate incremental costs that negatively impact period 2 profit. Effort types that impact more than one

or providing a contracting role only.

period's performance are defined as *multi-impact effort types*. The purpose of this section is to explore the economic consequences of variations in both precision and predictability on payoffs, in the presence of multi-impact effort types.

At a general level, multi-impact effort types are not unique to this model. For example, the general performance measurement specification in Feltham and Xie (1994) could be interpreted as each effort type having impact on all other effort dimensions. If each effort dimension is aligned to a particular time period (as is the case in this model), then the multi-impact effort type defined here could be interpreted as an alteration of performance measurement sensitivities, which is derivable by manipulating the general specification in Feltham and Xie (1994). However, no other model *explicitly* explores the impact of *conflicting* consequences in different periods. Further, no other model generates *specific* insight about the effect of multi-impact effort types in a context that captures trade-offs between short-term and long-term incentive weights.

3.5.1   A Model of Multi-Impact Effort Types

Assume farsighted effort generates incremental costs that adversely affect period 1 sales and subsequently financial performance. Period 1 quantity sold is assumed to be:

$$\tilde{q}_1 = g_1 \ln(\phi) - Z \ln(\psi) - p_1 + \tilde{\varepsilon}_1 \tag{50}$$

where Z is a coefficient reflecting the extent to which farsighted effort adversely affects period 1 sales and performance.[52] Re-solving the basic agency program, the optimal level of shortsighted effort is unchanged. However, the optimal level of farsighted effort becomes:

$$b^* = \gamma + \delta \beta_2 g_2 (p_2 - v_2) - Z \beta_1 (p_1 - v_1) \tag{51}$$

The optimal farsighted effort level now includes an incentive weight based on period 1 profit. The coefficient on this weight is negative, which means the agent needs to consider that the increases

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[52] Alternatively, shortsighted effort might be assumed as having adverse consequences in period 2. The subsequent results are qualitatively the same as those pertaining to farsighted effort having negative consequences in period 1. I also investigated two further models. First, I compared the payoffs from farsighted effort having adverse consequences in period 1 with the payoffs from shortsighted effort having adverse consequences in period 2. Second, I simultaneously included both shortsighted and farsighted effort having adverse consequences in period 2 and period 1 respectively.

in farsighted effort will increase future profits but also adversely affect period 1 profits. A further feature of this result is that the structure of the optimal farsighted effort level now includes all three incentive weights. Accordingly, the model now incorporates trade-offs between all three performance measure signals. This is most clearly seen in the optimal incentive contract weights, each of which is a function of the random component of the three signals of performance in the model:[53]

$$\beta_1^* = \frac{\left(r\sigma_y^2\sigma_{q2}^2 Z((p_1 - v_1)Z - (p_2 - v_2)g_2) + (p_1 - v_1)g_1^2\left(\sigma_{q2}^2 + \sigma_v^2\left(g_2^2 + r\sigma_{q2}^2\right)\right)\right)}{(p_1 - v_1)\left(r\sigma_y^2\sigma_{q2}^2 Z^2 + \left(\sigma_{q2}^2 + \sigma_v^2\left(g_2^2 + r\sigma_{q2}^2\right)\right)\left(g_1^2 + r\sigma_{q1}^2\right)\right)}$$ (52)

$$\beta_2^* = \frac{g_2\,\sigma_y^2\left((p_1 - v_1)Zr\sigma_{q1}^2 - (p_2 - v_2)g_2\left(g_1^2 + r\sigma_{q1}^2\right)\right)}{(p_2 - v_2)\left(r\sigma_y^2\sigma_{q2}^2 Z^2 + \left(\sigma_{q2}^2 + \sigma_v^2\left(g_2^2 + r\sigma_{q2}^2\right)\right)\left(g_1^2 + r\sigma_{q1}^2\right)\right)}$$ (53)

$$\gamma^* = \frac{\sigma_{q2}^2\left((p_2 - v_2)g_2\left(g_1^2 + r\sigma_{q1}^2\right) - (p_1 - v_1)Zr\sigma_{q1}^2\right)}{\left(r\sigma_y^2\sigma_{q2}^2 Z^2 + \left(\sigma_{q2}^2 + \sigma_v^2\left(g_2^2 + r\sigma_{q2}^2\right)\right)\left(g_1^2 + r\sigma_{q1}^2\right)\right)}$$ (54)

An interesting feature of these optimal incentive weights is that the weight on the financial performance in period 2 and the weight on the DFP have opposite signs. Terms comprising the unsigned component in the respective numerators of the two weights are reversed. This implies that the introduction of the multi-impact effort type makes the incentive weight on period 1 profits much more significant. The incentive weight on period 1 profit essentially substitutes for one of the other two performance measures in inducing farsighted effort.

The impact on the overall payoffs is captured in the difference in optimal profits between the regime *without* multi-impact type effort, and the regime *with* multi-impact type effort. To isolate the effect of multi-impact type effort on payoffs, assume the agent is risk neutral[54] and both the principal and agent have the same discount factor. The difference in optimal profits is as follows:

However, both of these models are too complex to interpret.

[53] $\delta = 1$ in the following analysis. Each of the incentive contract weights is a function of the random component of the three performance signals in the model, regardless the value of δ. The assumption is chosen here to reduce the complexity of the mathematical expressions and improve the clarity of the exposition.

[54] I have also solved the program for the case where the agent is risk averse. While closed form solutions are obtainable, the difference in optimal profits is too complex to extract any interpretable insights. Taking the derivative of this solution with

$$\Pi^{*1} - \Pi^{*2} = \frac{(p_1 - v_1)Z}{2}\left((p_1 - v_1)Z - 2(p_2 - v_2)g_2\right) \tag{55}$$

The result is ambiguous and suggests that overall payoffs depend on contribution margin, non-price exogenous factors in period 2, and the extent to which the multi-impact effort affects short-term performance. The intuition for this result is that the incentive weight on short-term financial performance now has the capacity to induce both shortsighted and farsighted effort. In essence, the principal now has a choice between three incentive weights for inducing farsighted effort. In this case, where the agent is risk neutral, the principal chooses incentive weights that maximise payoffs at the lowest possible reimbursement of agent effort costs. Accordingly, multi-impact effort types leads to increased choice in the use of incentive weights to induce optimal levels of the multi-impact effort. The corresponding impact on payoffs to the principal depends on the choice of substitutable incentive weights that induce farsighted effort. Where the agent is risk neutral, this choice in turn depends on relative costs payable to the agent. The above "differences in optimal profit" equation confirms this intuition, since the unsigned part of the equation represents a linear function of the multipliers (or agent-effort cost-increasing factors) on the respective period 1 and period 2 financial performance weights, in the optimal effort levels.

3.5.2 The Influence of Multi-Impact Effort Types on the Impact of Precision

The introduction of multi-impact type effort into the model changes the structure of the optimal farsighted effort level. Changes to the structure of the farsighted effort level will in turn influence the way in which variations in DFP precision will lead to variations in the principal's payoffs. The purpose of this section is to explore the economic consequences of variations in the precision of DFP in the presence of farsighted effort that has impact on both period 1 and period 2 profits.

From the previous section, the introduction of multi-impact type effort leads to an optimal farsighted effort level that relies on all three incentive weights. Correspondingly, in the revised

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respect to Z leads to an expression that is ambiguous in sign.

solution to the principal's problem all three incentive weights are a function of all three random components of the performance signals in the model. Accordingly, any variations in DFP precision will now affect all incentive weights in the model.

The economic consequences of variations in DFP precision, where farsighted effort has multiple impact, can be determined by taking the derivative of the principal's total certainty equivalent, with respect to DFP variance. The resulting expression is:

$$\frac{\partial \Pi^*}{\partial \sigma_y^2} = -\frac{\frac{r}{2}\left(\sigma_{q2}^2\right)^2\left((p_1 - v_1)Zr\sigma_{q1}^2 - (p_2 - v_2)g_2\left(g_1^2 + r\sigma_{q1}^2\right)\right)^2}{\left(r\sigma_y^2\sigma_{q2}^2Z^2 + \left(\sigma_{q2}^2 + \sigma_y^2\left(g_2^2 + r\sigma_{q2}^2\right)\right)\left(g_1^2 + r\sigma_{q1}^2\right)\right)^2} \tag{56}$$

Clearly, variations in precision (the inverse of variance) continue to be positively associated with variations in the overall principal's payoffs. This result is consistent with a general result found in the literature (e.g. see Bushman and Indjejikian, 1993a), which is not affected by alternative specifications of the sensitivities of performance measures.

In this context, the result can be interpreted as follows. Multi-impact type effort introduces trade-offs between all three incentives, leading to optimal incentive weights that are a function of all three random components of the performance signals in the model. Despite the introduction of these trade-offs, costless increases (decreases) in precision will continue to lead to increases (decreases) in payoffs to the principal.[55] The *magnitude* of the incremental change to payoffs will change with the introduction of multi-impact type effort; however, the sign remains the same. Accordingly, the *sign* of the impact of precision on payoffs is invariant to the introduction of multi-impact effort types.

3.5.3 The Influence of Multi-Impact Effort Types on the Impact of Predictability

Intuitively, multi-impact effort types create a new alternative for inducing the agent to allocate effort to the multi-impact effort type. If that alternative has lower associated risk premium costs than existing alternatives, then use of the alternative will lead to higher payoffs for the principal.

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[55] Costly variations in DFP precision are not considered here. The purpose of this section is to highlight the influence of the multi-impact effort type on the economic consequences of variations in precision. The introduction of costly precision

However, it is not clear what consequence variations in predictability will have, if the effort type, on which variations in predictability are observed, also has impact on multiple periods. As shown earlier, both predictability and multi-impact effort type affects the structure of the optimal effort levels. The purpose of this section is to examine how multi-impact effort types affect the economic consequences of variations in predictability.

Assume two changes to the basic model. First, DFP are restricted by the degree (D) of inherent predictability of farsighted effort. Second, farsighted effort has a positive impact on period 2 sales but a negative impact on period 1 sales.[56] That is, farsighted effort (over which the DFP has limited predictability) also affects both period 1 and period 2 payoffs. The resulting expression for optimal level of farsighted effort level is a combination of earlier equations shown:

$$b^{*} = D\gamma + \delta \beta_2 g_2 (p_2 - v_2) - Z\beta_1 (p_1 - v_1) \tag{57}$$

The introduction of predictability *and* multi-impact effort type clearly affects the structure of the optimal farsighted effort level. Any variations in the degree of predictability requiring simultaneous adjustments to the incentive weight on period 1 financial performance (in accordance with the new effort structure) also directly affects optimal shortsighted effort levels. Thus, the consequences of variations in predictability now potentially can affect both types of effort levels. Variations in the degree of predictability can be determined by taking the derivative of the principal's total certainty equivalent with respect to D:

$$\frac{\partial \Pi^{*}}{\partial D} = \frac{D r \sigma_y^2 (\sigma_{q2}^2)^2 \left((p_1 - v_1) Z r \sigma_{q1}^2 - (p_2 - v_2) g_2 (g_1^2 + r \sigma_{q1}^2) \right)^2}{\left(r \sigma_y^2 \sigma_{q2}^2 Z^2 + (D^2 \sigma_{q2}^2 + \sigma_y^2 (g_2^2 + r \sigma_{q2}^2))(g_1^2 + r \sigma_{q1}^2) \right)^2} \tag{58}$$

The sign of the expression is positive. Thus, despite the influence of multi-impact effort types that extended the impact of variations in predictability to both types of effort, the economic consequences of predictability variations is unambiguous and increasing in payoffs. Multi-impact

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variations to the analysis does not add any insight in addressing the stated purpose.

[56] Strategic decisions based on DFP at the end of period 1 are omitted from this discussion, to highlight the influence of

effort changes the magnitude of the economic consequence of predictability variations; however, the sign of the economic consequence is the same. Accordingly, the sign of the impact of variations in predictability is *invariant* to the introduction of multi-impact effort types.

3.6   Conclusion

Measures of drivers of future performance are being increasingly used for performance evaluation purposes.   Relatively little academic research identifies what attributes of DFP signals make them attractive to firms for designing incentive contracts. Two attributes of DFP are precision and predictability.   Improvements in these attributes are commonly asserted to improve payoffs, but the current literature provides little theoretical support. This chapter extended the basic agency model of the economic demand for DFP in incentive contracts (developed in Chapter 2) to provide insight on the economic consequences of variations in the DFP precision and predictability.

The results in this chapter show that under the assumptions, costless increases (decreases) in precision or predictability will lead to increases (decreases) in payoffs for the principal.   These results hold even in the presence of multi-impact effort types that have positive consequences in one period and negative consequences in the other.   The introduction of costly variations in precision, or strategic payoffs inversely related to predictability leads to ambiguity in the sign of the impact of variations in precision and predictability.   However, I also specify conditions under which increases (decreases) in payoffs arise from increases (decreases) in costly precision or payoffs inversely related to predictability.

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multi-impact effort types on variations in predictability.

Chapter 4

The Determinants of Long-Term Monetary Incentive Weights

4.1   Introduction

Employee compensation plans in practice often include both annual and long-term monetary incentive components. These components are based on both accounting and non-accounting performance measures. Measures that capture the drivers of future performance (**DFP**) are gaining increasing popularity as one of the bases in these incentive plans (cf. Rucci, Kim and Quinn, 1998). In particular, DFP measures are being increasingly used for the long-term component of the incentive plans.

Two ways that long-term monetary incentive plans can be structured are as follows. First, rewards can be based *directly* on a signal of long-term oriented performance. Long-term monetary incentives based on future-oriented measures such as DFP can be paid in the current period, while long-term rewards based on traditional financial measures of performance are paid at the end of a predetermined future period. Second, rewards can be based *indirectly* on long-term oriented performance through firms basing long-term monetary incentives on the stock price and publicly releasing relevant information, such as profit or product quality, which becomes impounded in the firm's stock price. These indirect rewards can be based at any time on the firm's stock price, which likely reflects both past and future-oriented information.

The economic consequences of direct or indirect forms of reward will differ among firms. The obvious cost to the firm of a direct form based on measures of DFP is the actual cost of the

compensation. However, less obvious costs arise if the measure is costly to extract or if it produces unreliable signals, which may make direct reward forms of compensation inefficient or may motivate undesirable behaviour. Similarly, an indirect form of compensation based on a stock price that impounds publicly released measures of performance has obvious costs in the form of the monetary payment to the employee. However, this indirect form may also generate less obvious costs such as the proprietary costs associated with competitors having access to public measures of performance. In particular, the future orientation of publicly released information, such as in DFP measures, may escalate proprietary costs.

Accordingly, there exists variation in the costs and benefits of adopting either direct or indirect forms of long-term monetary compensation. However, the conditions under which either form is economically superior to the other is not obvious. The use of both direct and indirect forms in practice suggests that firms encounter economic conditions supporting variations in emphasis on both forms of long-term monetary compensation. Assuming rationality in practice, this implies that there exist systematic determinants of the choice between direct and indirect forms of long-term monetary compensation. Despite the variation in economic consequences of the choice of compensation form, published research has yet to investigate specifically what, in theory, these determinants might be, and how variations in those determinants affect optimal compensation weightings and firm profits.

The purpose of this chapter is to develop insight into the choice between direct and indirect forms of long-term incentive compensation. I address this problem, using principal-agent analysis, in three steps. First, I present the determinants of long-term incentive weights that are based on financial performance signals and the stock price. Consistent with established intuition, I find no role for a performance measure such as stock price when it simply is a noisy reflection of other directly contractible performance measures.

Second, I introduce into the analysis a component of the incentive contract that is based on a DFP signal. I find that the stock price continues to have no contracting role and that firms will optimally include a positive weight on the DFP signal. Third, I create a role for the stock price in

long-term monetary incentive contracting. Following Bushman and Indjejikian (1993a). I introduce into the analysis a signal of future performance that is gathered privately by market participants. I find results both consistent with the intuition of Bushman and Indjejikian (1993a) and, via the introduction of the DFP signal into the analysis, that extend their insights.

This chapter is organized as follows. The next section describes the basic model. adopted from Chapter 2. Section 3 establishes a analysis of the economic determinants of long-term monetary incentive weights, excluding a DFP signal, to benchmark this work against the existing literature that shows no role for stock price as a contracting variable. Section 4 introduces the impact of including the DFP signal and continues to show no role for the stock price as a contracting variable for long-term monetary incentives. Section 5 introduces private investor acquisition of information in the presence of a DFP signal. It discusses the optimal incentive weights on the long-term contracting variables of future financial performance, the DFP signal, and the stock price respectively. Section 6 focuses the analysis on the DFP and stock price weights, by assuming the financial performance signals are too costly upon which to contract. The first subsection, consistent with Sections 3 and 4, excludes private investor information acquisition. Consistent with Section 5, the second subsection assumes private investor information acquisition, but the subsection explores the implications of this assumption in the costly contracting on financial performance scenario. Section 7 summarises the key results and notes practical implications of the results.

4.2   The Basic Model

A risk neutral board of directors (the principal) hires a risk and effort-averse agent to operate a firm over two periods. It is prohibitively costly for the principal to observe the risk and effort-averse agent's efforts directly. The firm's sales are affected by various exogenous factors (such as reputation) captured by the variable, g_i.[57] These factors are publicly observable and increase the prospects of the

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[57] The interaction of several different factors determines the value of the exogenous variable g. This variable is assumed to process the individual determinant factors (such as reputation) in the same way.

firm's goods and services being sold. The quantity sold by the firm in period 1, q_l, is also affected by the amount of non-negative shortsighted effort, ϕ, undertaken by the agent, and the (exogenously specified) price, p_l, of the good or service. To reflect shortsighted effort increasing sales at a decreasing rate, the quantity function incorporates the logarithmic function of ϕ. The quantity to be sold[58] (of linear functional form with random component, ε_l) in period 1 is:

$$\tilde{q}_1 = g_1 \ln(\phi) - p_1 + \tilde{\varepsilon}_1 \tag{59}$$

The period 2 quantity is affected by the period 2 price, p_2, period 2 exogenous factors, g_2, and the agent's farsighted effort, ψ, which is assumed to increase quantity sold at a decreasing rate and is *exerted in period 1*. To isolate the effects of shortsighted and farsighted effort, period 2 is assumed to be an ending period *with no effort*. The quantity to be sold in period 2 is:

$$\tilde{q}_2 = g_2 \ln(\psi) - p_2 + \tilde{\varepsilon}_2 \tag{60}$$

The principal's expected profit, π, in period i, $i=1, 2$ is a function of the random quantity variable and exogenously specified price and cost parameters:

$$\tilde{\pi}_i = (p_i - v_i)\tilde{q}_i - f_i \tag{61}$$

where f = fixed costs identified by the accounting system in period i, $i=1, 2$; v is variable cost per unit sold identified by the accounting system. To further simplify the mathematical analysis, define $a = \ln(\phi)$ and $b = \ln(\psi)$. Now the above equations can be combined and rewritten as follows[59]:

$$\tilde{\pi}_1 + \tilde{\pi}_2 = h_1\left(a - \frac{p_1}{g_1}\right) + h_2\left(b - \frac{p_2}{g_2}\right) - (f_1 + f_2) - (\tilde{\varepsilon}_1 + \tilde{\varepsilon}_2), \tag{62}$$

where: $h_i = (p_i - v_i)g_i$, $i = 1,2$.

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[58] Variables denoted with "~" depict random variables. Later denotations of "–" depict mean values. An index to all other notation used throughout this chapter is presented in the Appendix.

[59] This combination of equations enables closed form solutions to be obtained later in this chapter. The combination of equations is a simplification of the equations developed in chapters 2 and 3 of this thesis. It is equivalent to using the chapters 2 and 3 equations and normalizing $(p_1 - v_1) = (p_2 - v_2) = 1$, except that the simplification here (with the use of the variable, h) permits comparative statics to be performed on the variables, p and v. Obviously, comparative statics on p and v would not be possible if the difference between p and v were normalized to 1.

Accordingly, each unit of a or b increases the principal's expected payoff[60] by one unit of h_1

and h_2, respectively. The agent faces different costs associated with the different effort types. The

cost of the agent's effort takes the form of a twice-differentiable convex function of a and b:

$$C(a,b) = \frac{a^2}{2} + \frac{b^2}{2} \tag{63}$$

The agent exerts both shortsighted and farsighted effort to maximise his expected utility. The

agent's utility function reflects constant absolute risk aversion at a single point in time, so that[61]:

$$U(\cdot) = 1 - e^{-r(\tilde{w}_1 + \tilde{w}_2 - C(a,b))} \tag{64}$$

The variable w_i represents the wage paid to the agent in period i, $i = 1, 2$.[62] The variable r is

the Arrow-Pratt measure of absolute risk aversion.

The sequence of events in the model is as follows. Before period 1, compensation is set by the

principal choosing in each period the agent's fixed salary plus the incentive weights on the

contractible performance signals. The agent chooses shortsighted and farsighted effort levels. During

period 1, the firm sells goods or services. At the end of period 1 the principal measures performance

and observes the firm's market price. She then uses the appropriate performance signals to reward the

agent. In period 2, the firm sells goods or services. At the end of period 2, the principal measures

financial performance. She then pays to the agent the fixed salary plus, if contracted, an incentive

component based on the financial performance.

The following sections analyze the optimal determinants of long-term incentive contracting

weights under four different contractual regimes. The first regime (the benchmark analysis) assumes

that contracts are based on a current financial performance signal, a future financial performance

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[60] Expected payoff here is intended to reflect the gross payoff to the principal excluding any payment to the agent.

[61] See Hauser, et al. (1994) for another multi-period model that adds multi-period returns in the agent's utility function.

[62] Note that in chapters 2 and 3, the agent uses the variable δ to discount period 2 compensation values and assess expected utility at one point in time. In this chapter δ is implicitly assumed to be equal to 1. The principal also discounts the future, but her discount factor is normalized to equal 1. Thus, this chapter assumes that the agent discounts the future period at the same rate as the principal. This assumption significantly simplifies the later mathematical analysis, which focuses on determinants of optimal incentive weights other than δ. See Hauser, et al. (1994) and Chapters 2 and 3 of this thesis for insights with respect to the impact of assuming *different* discount rates for the principal and the agent (i.e. $\delta < 1$).

signal, and the stock price. The second regime assumes a current DFP signal can be added to the incentive contract. The third regime incorporates investors' private information about the agent's efforts. The fourth regime assumes that the principal finds it too costly to contract on the financial performance signals and focuses on the weight placed on a DFP signal, relative to a weight on the stock price.

4.3 Benchmark Analysis: Financial Performance and Stock Price Incentives

The purpose of this section is to generate a benchmark result that is consistent with prior analytical findings. Both Paul (1992) and Feltham and Xie (1994) show that incentive contracts based on both financial performance and stock price will optimally have no weight on the stock price. Intuitively, this result is due to noise traders. If it is feasible to contract directly on a publicly released financial performance signal, then the principal will find contracting directly on the financial signal more efficient than contracting on a stock price signal of performance that responds to both the financial signal and the actions of noise traders.

The analysis proceeds as follows. First, I describe the structure of the agent's reward system, which contains incentive components based on financial signals and the firm's stock price. Second, by maximising the agent's certainty equivalent, I establish the determinants of the agent's effort levels. Third, I solve the principal's optimisation problem and discuss the economic intuition and implications for management accounting. The results are consistent with the findings of Paul (1992) and Feltham and Xie (1994) in that they will show the conditions under which there is no role for stock price as a contracting variable.

From the previous section, assume at the beginning of period 1 that the principal announces the agent's reward systems for both periods. The reward system for period 1 is composed of a fixed salary component, α, a component based on a financial signal, π_1, and a component based on the

firm's market price, m. The agent's compensation in period 1 is:[63]

$$\tilde{w}_1 = \alpha_1 + \beta_1 \tilde{\pi}_1 + \theta \tilde{m} \tag{65}$$

The firm's market price, m, is influenced by the release of public information about financial performance. Since there is no private investor information gathering, no trade occurs in the marketplace. However, the release of public information moves price without altering the incentives to trade. That is, price changes but investors are assumed to remain equally happy with their asset allocations.

At the end of period 1, two signals are released to the market: a signal of period 1 profit, and a signal of *forecasted* period 2 profit. The assumed functional form of the *forecast* signal of period 2 profit is:

$$\tilde{\pi}_F = \tilde{\pi}_2 + \tilde{\varepsilon}_F \tag{66}$$

where $\varepsilon_F \sim N(0, \sigma_{q2}^2 + \sigma_F^2)$. Given this setting, the rational market price at the end of period 1 can be represented by sum of the period 1 realized values and the conditional expectation of the period 2 payoff given the observed public signals, as follows: [64]

$$\tilde{m} = \tilde{\pi}_1 - \tilde{w}_1 + E\left[(\pi_2 - w_2)\big|\pi_F\right]$$

$$= \tilde{\pi}_1 + \hat{\pi}_2 + \frac{\text{cov}(\tilde{\pi}_2, \tilde{\pi}_F)}{\text{var}(\tilde{\pi}_F)}(\tilde{\pi}_F - \overline{\pi}_F) - (\alpha_1 + \alpha_2 + \beta_1\tilde{\pi}_1 + \hat{\beta}_2\hat{\pi}_2 + \theta\tilde{m}) \tag{67}$$

where $\hat{\pi}_2$ is the market conjecture of period 2 profit.

Rearranging, the expression reduces to:

$$\tilde{m} = \frac{1}{1+\theta}\left((1-\beta_1)\tilde{\pi}_1 + (1-\hat{\beta}_2)\hat{\pi}_2 + \frac{\sigma_{q2}^2}{\sigma_{q2}^2 + \sigma_F^2}(\tilde{\pi}_F - E[\pi_F]) - (\alpha_1 + \alpha_2)\right) \tag{68}$$

The market price at the end of period 1 therefore captures (financial) performance information from both periods. An incentive component based on market price is omitted from period 2 for convenience and to highlight the effect of choosing between two forward-looking performance signals

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[63] This model makes no claim that linear compensation contracts are optimal. Rather, this model studies how a linear compensation contract might be optimally structured.

[64] The following expression uses the formulation for the conditional expectation of a payoff, as noted in Grossman and

(i.e. the DFP signal and the stock price at the end of period 1). Accordingly, the agent's compensation in period 2 is a fixed salary plus an incentive component based only on the financial signal for period 2:

$$\tilde{w}_2 = \alpha_2 + \beta_2 \tilde{\pi}_2 \qquad (69)$$

With normally distributed uncertainty and negative exponential utility, the agent's problem can be expressed as maximising the certainty equivalent of the expected utility (Holmstrom and Milgrom, 1987). In this case, the certainty equivalent (CE) is the same as the mean value of the compensation less the risk premium. Formally:

$$CE = (\alpha_1 + \alpha_2) + (\beta_1 \tilde{\pi}_1 + \beta_2 \tilde{\pi}_2) + \theta E[m] - \left(\frac{a^2 + b^2}{2}\right) - \frac{r}{2}\left(\sum_{i=1}^{2}(\beta_i^2 \sigma_{qi}^2) + 2\beta_1 \theta \operatorname{cov}(\pi_1, m) + \theta^2 \sigma_m^2\right) \qquad (70)$$

where σ_j^2 is the variance of the distribution associated with variable j, $j=q_1$, q_2, m, and $\operatorname{cov}(\pi_i, m)$, $i = 1$, 2, is the covariance of the distributions of the random variables, π_i and m. Substituting equations (62) and (65) through (69) into (70) and differentiating with respect to shortsighted and farsighted effort yields the optimal effort choices by the agent:

$$a^* = \frac{h_1(\beta_1 - \theta)}{1 + \theta} \qquad (71)$$

$$b^* = h_2 \beta_2 \qquad (72)$$

The optimal shortsighted effort level is a linear function of the incentive weights applicable to period 1, scaled by the ratio of the firm-specific exogenous variable (h_1 — see equation (62)) and $(1+\theta)$. The optimal level of farsighted effort is the product of firm-specific characteristics and the incentive weight used to induce farsighted effort. Shortsighted and farsighted effort both are increasing functions of exogenous parameters such as firm-specific exogenous variables and the periodic contribution margin of the firm.[65] Intuitively, increases in these exogenous parameters

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Stiglitz (1980), Appendix A.

[65] It may seem curious that the risk aversion parameter does not directly appear in the expressions for the optimal effort levels. However, the optimal effort levels are an *indirect* function of risk aversion, via the optimal incentive contract weights. After substitutions of the optimal contract weights, the optimal effort levels are a decreasing function of the risk aversion parameter. Intuitively, the incentive weights impose the risk on the agent. Thus, it is reasonable to expect the

increase uncertainty and hence the risk imposed on the agent. The result therefore is consistent with the intuition that if a contract imposes higher (lower) risk on the risk-averse agent, then the agent responds with greater (lower) effort.

The intuition for the optimal relationship between the effort levels and the incentive contract weights can also be thought of in terms of risk reduction. In the case of shortsighted effort, the principal's payoff is based on the period 1 profit. Since this profit signal is contracted upon directly and is perfectly revealed in the stock price, then it seems intuitive that in optimality both the incentive weight on period 1 profit and the stock price might affect the level of shortsighted effort chosen by the agent. Accordingly, if the stock price is noiseless, then the principal will be indifferent between the weights on the period 1 profit signal and the stock price for rewarding shortsighted effort. However, the stock price *does* contain noise in the form of the profit forecast of period 2 profit, so that the period 1 profit signal acts as a sufficient statistic for both the period 1 profit performance and the stock price. Accordingly, the stock price will be redundant for contracting.[66]

The stock price will not influence the level of farsighted effort chosen by the agent. This is because at the end of period 1, the period 2 profit measure is noisily impounded in the stock price via the period 2 profit forecast. Yet, the period 2 profit signal is available directly for contracting. Thus, irrespective of whether the stock price contains other non-output-related noise, the stock price at the end of period 1 will never be more efficient for contracting than the period 2 profit signal directly. Accordingly, the agent's optimal level of farsighted effort excludes any weighting on stock price.

To ensure the agent accepts the incentive contracts, the principal is constrained to meet the agent's reservation utility in each period. For notational simplicity, the agent's reservation utility is assumed to be zero. The individual rationality constraint for periods 1 and 2 can be expressed as:

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incentive weights to introduce the agent's risk aversion parameter into the agent's effort function.

[66] This intuitive result is confirmed in the optimal incentive weights later in this section, which derives no weight on the stock price.

$$E[w_1] + E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}(\text{var}(w_1) + \text{var}(w_2))$$

(73)

The principal's problem is to maximise profits subject to the agent's incentive compatibility constraint, the agent's individual rationality constraint, and the rational market price. The principal's optimization program is:

$$\underset{\beta_1,\beta_2,\theta}{Max}\ E[\pi_1 + \pi_2 - w_1 - w_2]$$

subject to:

$$E[w_1] + E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}\left(\sum_{i=1}^{2}\left(\beta_i^2 \sigma_{qi}^2\right) + \theta^2 \sigma_m^2 + \left(\frac{\theta}{1+\theta}\right)2\beta_1(1-\beta_1)\sigma_{q1}^2\right)$$

$$a^* = \frac{h_1(\beta_1 + \theta)}{1+\theta}$$

$$b^* = h_2\beta_2$$

$$E[m] = \frac{1}{1+\theta}\left((1-\beta_1)E[\pi_1] + (1-\hat{\beta}_2)E[\hat{\pi}_2] + \frac{\sigma_{q2}^2}{\sigma_{q2}^2 + \sigma_F^2}(E[\pi_F] - \overline{\pi}_F) - (\alpha_1 + \alpha_2)\right)$$

The solution to the above program yields the optimal weights:

$$\beta_1^* = \frac{h_1^2}{h_1^2 + r\sigma_{q1}^2}$$

(74)

$$\beta_2^* = \frac{h_2^2}{h_2^2 + r\sigma_{q2}^2}$$

(75)

$$\theta^* = 0$$

(76)

Zero weighting on the stock price performance measure is consistent with findings of Paul (1992) and Feltham and Xie (1994). Intuitively, the stock price reflects a noisy measure of the financial signals in each period. Accordingly, the financial signals themselves are sufficient statistics for both the financial signals and the stock price, to inform the principal about shortsighted and farsighted effort. The stock price is therefore redundant for contracting purposes and the principal is better off contracting on financial signals directly in each period.[67]

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[67] Recall, however, that this analysis assumes $\delta = 1$. A zero weight on the stock price does not hold in this model for when δ < 1. Intuitively, if δ < 1 then the stock price becomes a valuable contracting measure because the incentive for farsighted

4.4 The Impact of An Incentive Component Based on a DFP Signal

This section introduces the impact of using a measure of the drivers of future performance (DFP) as a contracting variable. Suppose at the end of period 1 the principal costlessly extracts a measure of drivers of future performance that captures with error the impact of the (unobservable) period 1 farsighted effort. The DFP measure is expressed as:[68]

$$\tilde{y} = \psi \tilde{\varepsilon}_v \tag{77}$$

with $\ln(\varepsilon_v) \sim N(0, \sigma_v^2)$. The DFP signal, a period 1 performance measure, is correlated with period 2 profits because period 2 profits are a linear function of farsighted effort. Assuming market participants know the structure of the firm's compensation, then the market can conjecture the value of the DFP signal. However, for convenience it is assumed that the DFP signal is not included in the firm's publicly released accounting report. The correlation of a future financial performance and a current performance measure that is not part of the firm's publicly released accounting report is consistent with empirical evidence reported in Hayes and Schaefer (1997). One of their findings is that unexplained variation in current executive compensation is correlated with future financial performance. The unexplained variation in current executive compensation arises because the performance measures used as contracting variables are either not publicly released information or else they were not observable to the researchers.[69]

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effort is paid at the end of period 1, rather than at the end of period 2. When $\delta < 1$, the agent discounts the future (and thus believes future payoffs to be more risky than current payoffs) so the earlier timing of the incentive in effect reduces the agent's risk. This risk reduction arises because the agent is subjected less to variations in exogenous, risk-imposing parameters associated with the operation of the firm in period 2. Accordingly, the agent faces a tradeoff between the earlier payment of the stock price incentive and the non-output related noise in the stock price measure. The actual analytical results for when $\delta < 1$ are too complex to interpret (other than the non-zero weight on the stock price) and thus are not reported here.

[68] A normal distribution is required to use the Holmstrom and Milgrom (1987) optimization framework. However, Hemmer also shows how reliance on Holmstrom and Milgrom is still possible (even with only non-negative values of nonfinancial measures) by assuming that the measurement error is lognormally distributed, i.e. $\ln \varepsilon \sim N(0, \sigma^2)$. This assumption requires a substitution of the logarithmic function of the DFP measure for the DFP component in the compensation function (Hemmer, 1996, Observation 1, Appendix B).

[69] Although the model here assumes that the DFP signal is not released in a public report, the implications of contracting on a DFP signal that is observable *only* to the contracting parties are not considered in this chapter. The model here assumes that market participants will conjecture via the compensation contract, but not directly observe, the value of the DFP signal.

The agent's wage contract now includes an additional component based on this DFP signal, so that the period 1 reward for the agent becomes:

$$\tilde{w}_1 = \alpha_1 + \beta_1 \tilde{\pi}_1 + \gamma \ln(\tilde{y}) + \theta \tilde{m} \tag{78}$$

Since period 2 is an ending period and does not generate any measures of drivers of future performance, an incentive component payable to the agent based on DFP in period 2 is omitted. Thus, the period 2 reward for the agent remains:

$$\tilde{w}_2 = \alpha_2 + \beta_2 \tilde{\pi}_2 \tag{79}$$

With the expanded wage contract, maximising the agent's certainty equivalent with respect to shortsighted and farsighted effort leads to:

$$a^* = \frac{h_1(\beta_1 - \theta)}{1 + \theta} \tag{80}$$

$$b^* = \frac{\beta_2 h_2 + \theta(\beta_2 h_2 + d_y) + \gamma}{1 + \theta} \tag{81}$$

Here the shortsighted effort level does not change with the inclusion of the DFP contracting variable. This is because the DFP signal reflects farsighted effort only and there is also no upper bound on the overall effort that the agent can exert. The optimal level of farsighted effort, however, now includes the incentive weight on the DFP signal and a component reflecting the stock price impact of the DFP signal. This is because the incentive weight on the DFP signal and the market's reaction to the signal are now further inducements to the agent in his choice of farsighted effort level.

The principal's maximization problem becomes:

$$\underset{\beta_1, \beta_2, \theta}{Max}\ E[\pi_1 + \pi_2 - w_1 - w_2]$$

subject to:

$$E[w_1] + E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}\left(\begin{array}{l} \sum_{i=1}^{2}\left(\beta_i^2 \sigma_{qi}^2\right) + \gamma^2 \sigma_y^2 + \theta^2 \sigma_m^2 + \left(\frac{\theta}{1+\theta}\right)2\beta_1(1-\beta_1)\sigma_{q1}^2 \\ + \left(\frac{\theta}{1+\theta}\right)2\gamma(d_y - \gamma)\sigma_y^2 \end{array}\right)$$

$$a^* = \frac{h_1(\beta_1 - d_1\theta)}{1+\theta}$$

$$b^* = \frac{\beta_2 h_2 + \theta(\beta_2 h_2 + d_y) + \gamma}{1+\theta}$$

$$E[m] = \left(\begin{array}{c} (1-\beta_1)E[\pi_1] + (1-\hat{\beta}_2)E[\hat{\pi}_2] + (d_y - \gamma)(E[\ln(y)]) + \frac{\sigma_{q2}^2}{\sigma_{q2}^2 + \sigma_F^2}(E[\pi_F] - \bar{\pi}_F) \\ -(\alpha_1 + \alpha_2) \end{array} \right)$$

The optimal incentive contract weights are:

$$\beta_1^* = \frac{h_1^2}{h_1^2 + r\sigma_{q1}^2} \tag{82}$$

$$\beta_2^* = \frac{h_2^2 \sigma_y^2}{h_2^2 \sigma_y^2 + \sigma_{q2}^2(1 + r\sigma_y^2)} \tag{83}$$

$$\gamma^* = \frac{h_2 \sigma_{q2}^2}{h_2^2 \sigma_y^2 + \sigma_{q2}^2(1 + r\sigma_y^2)} \tag{84}$$

$$\theta^* = 0 \tag{85}$$

Several interpretations can be made. First, the weight on the period 1 financial signal does not change with the introduction of the DFP contracting variable. Second, the stock price continues to have no role as a contracting variable. Third, the weight on the DFP signal acts as a substitute for the weight on the period 2 financial signal in rewarding farsighted effort. Accordingly, the principal will have a choice between two performance signals on which to base rewards for farsighted effort. Fourth, the rate of substitution between the two performance signals depends directly on the relative noise in the period 2 financial signal and the DFP signal.[70] The noisier the signal, the greater the relative weight will be on the substitute performance measure. If either the DFP signal or the period 2 financial signal is perfectly noiseless (i.e. the variance equals zero), then an optimal weight of zero is applicable to the substitute (alternative) performance signal for rewarding farsighted effort.

The fundamental intuition explaining the weight on the DFP signal but not on the stock price

[70] This is in contrast to the result in chapter 2 of this thesis where the relative rate of substitution was more complex. The

is the same as that explaining why the stock price plays no contracting role when contractible financial signals are noisily impounded into the price. The optimal contract for rewarding farsighted effort can potentially include either an agent's reward based directly on the DFP performance signal or an agent's reward based on a noisy measure of the DFP performance signal (i.e. the stock price). However, it is more efficient for the principal always to reward directly on the DFP signal rather than on a noisy stock price that has impounded the DFP signal.

Thus, the DFP signal, and a stock price that impounds both a publicly released forecast of future financial performance and a market-generated conjecture of the DFP signal, are not substitute signals for rewarding farsighted effort. Rather, the DFP signal is a sufficient statistic (for both the DFP signal and the stock price) to inform the principal about the agent's farsighted effort. Ultimately, the measurement error in the DFP signal, ε_y, is assumed statistically uncorrelated to the random component in the principal's payoffs, $\varepsilon_1 + \varepsilon_2$. Accordingly, the DFP signal has no impact on the contracting value of the stock price, irrespective of whether or not the DFP signal is publicly released information.

The analysis so far has shown no role for the stock price as a contracting variable. The following sections extend the analysis to consider two ways in which previous work suggests it is possible to induce a contracting role for the stock price. First, following Bushman and Indjejikian (1993a), investors are assumed to gather private information about farsighted effort, through the revelation of period 2 financial performance in the stock price, at the end of period 1. The period 2 financial performance is, however, assumed initially to remain available as a contracting variable at the termination date of the firm. Second, as also indicated in previous work (e.g. Bushman and Indjejikian, 1993a), publicly released financial signals are assumed to be too costly to contract upon directly at the termination date of the firm.

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difference is because chapter 2 assumes $\delta < 1$, whereas the model in this chapter assumes $\delta = 1$.

4.5   Private Investor Acquisition of Future Financial Performance Information

The purpose of this section is to provide insight about the role of a DFP signal in the presence of a stock price signal that impounds privately gathered information.[71] Private investor information gathering is modelled as follows. At the end of period 1 the firm releases information about the period 1 financial performance and a forecast of period 2 financial performance, as earlier shown. However, now each investor j is able independently to gather the following information signal about the firm's period 2 profits:

$$\tilde{\pi}_{Gj} = \tilde{\pi}_2 + \tilde{\varepsilon}_{Gj} \qquad (86)$$

with idiosyncratic errors $\varepsilon_{Gj} \sim N(0, \sigma_{Gj}^2)$. The firm's market price is determined by the exchange of the firm's shares. The rational market price at the time of the agent's period 1 compensation reflects the intensity with which all available signals are impounded into the market price. The market price is also affected by non-output-related events, z that have a random component $\varepsilon_z \sim N(0, \sigma_z^2)$. These non-output-related events are modelled as the supply of a risky asset and reflect the actions of noise traders who exchange shares, for example, for liquidity purposes.

With no private information and no trading of shares, the price was determined by the conditional expectation of the final payoff (i.e. see sections 4.3 and 4.4). However, in the private information setting, price is determined through investors trading shares based on their information acquisition activities. The market price in this setting with trade can be expressed in two steps. First, a general representation of the price is presented. Second, the rational market price equilibrium is characterized by solving for the optimal price coefficients. At the end of period 1, the general representation of the rational market price, determined in a noisy rational expectations equilibrium, is:

$$\tilde{m} = d_0 + d_1 \tilde{\pi}_1 + d_F \tilde{\pi}_F + d_G \tilde{\pi}_2 + d_y \ln(\tilde{y}) + d_z \tilde{z} - \tilde{w}_1 - \tilde{w}_2 \qquad (87)$$

where $d_j, j = 1, F, G, z$, reflects the intensity with which profit signals and non-output-related

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[71] Examples of the type of information gathered by private investors include analysts forecasts of future profits, news releases from the firm, mutual fund manager reports and *qualitative* information about the firm observed by market

events impact the market price. The stochastic component of the public *forecast* of period 2 financial performance, π_F, has a variance of $\sigma_{q2}^2 + \sigma_F^2$. The private signals are idiosyncratic with variance $\sigma_{q2}^2 + \sigma_G^2$, so that the public information is not sufficient for the private information. It follows from the law of large numbers and the assumption that each of ε_{Gi}'s are independent that *in aggregate* the period 2 financial performance will be perfectly revealed via the firm's stock price, as per expression (87).

In this setting, the competitive rational markets equilibrium price will be characterized by the following coefficients:

$$
d_0 = \frac{\hat{\pi}_2/\sigma_{q2}^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} - \left(\alpha_1 + \alpha_2 + \gamma \ln(\tilde{y}) + \hat{\beta}_2\hat{\pi}_2\right)
$$

$$
d_1 = 1 - \beta_1
$$

$$
d_F = \frac{1/\sigma_F^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} \tag{88}
$$

$$
d_y = 0
$$

$$
\frac{d_Z}{d_G} = \frac{1}{R\sigma_G^2}
$$

where R is the private investors' risk aversion parameter.

Proof: See Appendix 4.

Intuitively, the price coefficient on the period 1 profit will be 1 less the share of profit paid to the agent, because the actual realization of the period 1 profit (net of wages), or payoff to the principal, is known and released to the market. The price coefficient on the DFP signal will in equilibrium be zero. This is because the DFP measurement error term is, by assumption, statistically uncorrelated to the stochastic components of the period 1 and period 2 payoffs to the principal. Intuitively, this means that while the DFP signal is incrementally informative about farsighted effort, it is not incrementally informative about the random components in the period 1 and period 2 profits. Thus, the DFP signal is only useful for contracting on farsighted effort directly and not via a noisy

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participants.

representation of the DFP signal in the stock price.

Notwithstanding the characterization of the optimal values of d_j, $j=1$, F, G, y, z presented above, the following analysis preserves each price parameter as a variable d_j. Further, where applicable later, the analysis will show the substitution of the characterization of the price parameters into the optimal incentive contracting weights. This approach in effect treats the price parameters as exogenous, as a preliminary step to understanding the impact of endogeneity of the market price on the model parameters. In addition, it provides insight as to the optimal model parameters where there exists deviation from the rational markets equilibrium.

Maximising the agent's certainty equivalent yields no change to the optimal shortsighted effort levels. Equation (80) expresses the optimal shortsighted effort. Farsighted effort levels, however, are now affected by the impact of the investors' signal on the stock price. Accordingly,

$$b^{\bullet} = \frac{\beta_2 h_2 + \theta\left(h_2(\beta_2 + d_G) + d_y\right) + \gamma}{1 + \theta} \tag{89}$$

Intuitively, the principal can use three different incentive weights to induce farsighted effort: the weight on financial performance in period 2, on DFP at the end of period 1, and on the stock price at the end of period 1. The importance of each of those weights in inducing farsighted effort depends on the relative firm-specific characteristics (h_2) and the intensity of each of the different sources of information impounded in the stock price.[72]

The principal's maximization problem becomes:

$$\underset{\beta_1,\beta_2,\theta}{Max}\ E[\pi_1 + \pi_2 - w_1 - w_2]$$

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[72] Given the characterization of the rational expectations equilibrium, the expression for the optimal farsighted effort can be rewritten to eliminate price parameters. However, mathematically this substitution is not necessary at this point since none of the price parameters are functions of the optimized variables. In this case, since no significant insights are added by substituting the optimal values of d into farsighted effort, the substitution is omitted.

subject to:

$$E[w_1] + E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}\left(\begin{array}{c}\sum_{i=1}^{2}\left(\beta_i^2 \sigma_{qi}^2\right) + \gamma^2 \sigma_v^2 + \theta^2 \sigma_m^2 + \left(\frac{\theta}{1+\theta}\right)2\beta_1(d_1 - \beta_1)\sigma_{q1}^2 \\ + \left(\frac{\theta}{1+\theta}\right)2\beta_2(d_G)\sigma_{q2}^2 + \left(\frac{\theta}{1+\theta}\right)2\gamma(d_v - \gamma)\sigma_v^2 \end{array}\right)$$

$$a^* = \frac{h_1(\beta_1 - d_1\theta)}{1+\theta}$$

$$b^* = \frac{\beta_2 h_2 + \theta\left(h_2(\beta_2 + d_G) + d_v\right) + \gamma}{1+\theta}$$

$$E[m] = d_0 + d_1 E[\pi_1] + d_F E[\pi_F] + d_G E[\pi_2] + d_v E[\ln(y)] + d_z E[z] - E[w_1] - E[w_2]$$

Simultaneous solution of the set of first order conditions from the above program leads to the following optimal incentive weights:

$$\beta_1^* = \frac{h_1^2}{h_1^2 + r\sigma_{q1}^2} \tag{90}$$

$$\beta_2^* = \frac{h_2^2 \sigma_y^2}{h_2^2 \sigma_y^2 + \sigma_{q2}^2(1 + r\sigma_y^2)} \tag{91}$$

$$\gamma^* = \frac{h_2 \sigma_{q2}^2}{h_2^2 \sigma_y^2 + \sigma_{q2}^2(1 + r\sigma_y^2)} \tag{92}$$

$$\theta^* = 0 \tag{93}$$

The results reveal that there still exists no role for the stock price in contracting. The results are the same as those for the no private information, no trading setting presented in section 4.4. Intuitively, although the stock price in aggregate now fully reveals the value of the period 2 financial performance signal, the stock price remains a noisy measure of performance, relative to contracting on the financial performance signals directly. Thus, both the financial performance signals are sufficient statistics for the respective financial performance signals paired with the stock price with respect to informing the principal about shortsighted and farsighted effort.

The analysis in this section relies heavily on the assumption that private investors gather information about a future financial performance measure that is directly contractible in a future

period. Intuitively, a contracting role for the stock price in the presence of private information could have been induced in three ways. First, suppose the private information was informative about farsighted effort in a manner other than via the financial performance measure in period 2. Subsequently, if the stochastic component of the signal revealed by the private investors was statistically correlated with the stochastic component of the principal's payoffs, then the stock price would become valuable for contracting.

Second, if the principal had incentive to know the value of the period 2 financial performance signal *at the end of period 1*, then this would likely create a contracting role for the stock price. For example, assume that the notion of a discount factor, representing differences in the way the principal and the agent value the future (as in chapter 2), was introduced. Differences in the way the principal and the agent value money in the future may mean it is more efficient to use a relatively noisy stock price *now*, rather than wait until a financial signal is realized in the *future*.

Third, a contracting role for stock price could be induced if the period 2 financial performance is non-contractible. Here, the stock price provides a noisy measure of period 2 financial performance that is not observable elsewhere. Moreover, the DFP signal does not act as a sufficient statistic for the pair of performance measures (DFP signal and stock price) with respect to providing information about farsighted effort.

The next section focuses on the third of these approaches. It examines the interactions between optimal long-term incentive weights on the stock price and on the DFP signal, when financial performance signals are non-contractible. This non-contractability is incorporated by exogenously imposing zero weights on financial performance measures in the model, which corresponds to financial signals that are too costly upon which to contract.

4.6   Costly Contracting on Financial Performance Signals

Feltham and Xie (1994), amongst others, suggest that one of the reasons why firms use stock price as a long-term contracting variable (despite a lack of theoretical support) is that financial performance signals might be too costly upon which to contract. It may be that the stock price is a readily available, efficient alternative that impounds both financial information and other market-based information. The purpose of this section is to formally investigate this costly contracting scenario in the context of the availability of a DFP signal. More specifically, this section explores what impact the omission of financial performance contracting variables has on the optimal weighting mix between the stock price and a DFP signal.

The analysis is presented in two sub-sections. To operationalize costly contracting on financial signals, in both subsections wage contracts in both periods exogenously exclude any incentive component based on financial performance.[73] Then, in the first sub-section, I assume there is no private investor information about future financial performance (i.e. as in sections 4.3 and 4.4 above). In the second sub-section, I introduce private investor information acquisition on future financial performance (as in section 4.5 above).

Both the period 1 and period 2 wage contracts applicable to all of the analysis in this section do not include an incentive component based on financial signals. Accordingly, the reward system for period 1 is composed of a fixed salary component, α, a component based on the DFP measure, y, and a component based on the firm's market price, m:

$$\tilde{w}_1 = \alpha_1 + \gamma \ln(\tilde{y}) + \theta m \tag{94}$$

Since period 2 is an ending period and does not generate any measures of drivers of future performance, an incentive component payable to the agent based on DFP in period 2 is omitted. For convenience and to focus the analysis on a comparison of the forward-looking properties of the DFP signal and the stock price, an incentive component based on market price is also omitted from period.

Thus, the agent's compensation in period 2 is a fixed salary:

$$w_2 = \alpha_2 \tag{95}$$

The agent's certainty equivalent (CE) is the mean value of the compensation less the risk premium. Formally:

$$CE = (\alpha_1 + \alpha_2) + \gamma E[\ln(y)] + \theta E[m] - \left(\frac{a^2 + b^2}{2}\right) - \frac{r}{2}\left(\gamma^2 \sigma_y^2 + 2\gamma\theta \operatorname{cov}(y,m) + \theta^2 \sigma_m^2\right) \tag{96}$$

4.6.1 Costly Contracting on Financial Performance — No Investor Information Acquisition

Suppose private investors do not acquire information about period 2 financial performance. Subsequently, the rational market price of the firm at the end of period 1 is the sum of the period 1 realized values plus the conditional expectation of the period 2 payoff given the observed public signals, as follows: [74]

$$\tilde{m} = \tilde{\pi}_1 - \tilde{w}_1 + E\left[(\pi_2 - w_2)\big|\pi_F\right]$$

$$= \tilde{\pi}_1 + \hat{\pi}_2 + \frac{\operatorname{cov}(\tilde{\pi}_2, \tilde{\pi}_F)}{\operatorname{var}(\tilde{\pi}_F)}(\tilde{\pi}_F - E[\pi_F]) - (\alpha_1 + \alpha_2 + \gamma \ln(\tilde{y}) + \theta\tilde{m}) \tag{97}$$

where $\hat{\pi}_2$ is the market conjecture of period 2 profit.

The above expression can be rewritten as:

$$\tilde{m} = \frac{1}{1+\theta}\left(\tilde{\pi}_1 + \hat{\pi}_2 + \frac{\sigma_{q2}^2}{\sigma_{q2}^2 + \sigma_F^2}(\tilde{\pi}_F - E[\pi_F]) - (\alpha_1 + \alpha_2 + \gamma \ln(\tilde{y}))\right) \tag{98}$$

Substituting the appropriate expressions into equation (96) and maximising the expression with respect to a and b yields:

$$a^* = \frac{h_1\theta}{1+\theta} \tag{99}$$

$$b^* = \frac{\gamma}{1+\theta} \tag{100}$$

The results reveal that incentive compensation coefficients induce the optimal effort levels in different ways. Firstly, only the weight on the share price (θ), scaled by the ratio of firm-specific

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[73] That is, β_1 and β_2 are assumed to equal zero.

parameters and $(1+\theta)$, induces shortsighted effort. Secondly, farsighted effort is induced by the weight on the measure of DFP (γ), scaled by $(1+\theta)$. Intuitively, the compensation weight on the DFP signal has no effect on shortsighted effort because only the period 1 financial signal (impounded in stock price) captures information about shortsighted effort. Assuming the firm has a positive contribution margin, both shortsighted and farsighted effort will optimally be positive. This implies that if the principal imposes risk on the agent through a variable incentive contract, then the agent will respond by choosing to exert positive effort levels.

The principal's optimization program is:

$$\underset{\theta,\gamma}{Max}\, E[\pi_1 + \pi_2 - w_1 - w_2]$$

subject to:

$$E[w_1] + E[w_2] = \left(\frac{a^2}{2}\right) + \left(\frac{b^2}{2}\right) + \frac{r}{2}\left(\gamma^2\,\sigma_y^2 - \frac{2\gamma^2\theta\sigma_y^2}{1+\theta} + \theta^2\,\sigma_m^2\right)$$

$$E[w_2] = 0$$

$$a^* = \frac{h_1\theta}{1+\theta}$$

$$b^* = \frac{\gamma}{1+\theta}$$

$$E[m] = \frac{1}{1+\theta}\left(\tilde{\pi}_1 + E[\hat{\pi}_2] + \frac{\sigma_{q2}^2}{\sigma_{q2}^2 + \sigma_F^2}(E[\pi_F] - \overline{\pi}_F) - (\alpha_1 + \alpha_2 + \gamma E[\ln(y)])\right)$$

The solution to the above program produces the following optimal incentive weights on the DFP signal and on the stock price, respectively

$$\gamma^* = \frac{r(\sigma_{q2}^2)^2 + (h_1^2 + r\sigma_{q1}^2)(\sigma_{q2}^2 + \sigma_F^2)}{r(1 + r\sigma_y^2)\left((\sigma_{q2}^2)^2 + \sigma_{q1}^2(\sigma_{q2}^2 + \sigma_F^2)\right)} \tag{101}$$

$$\theta^* = \frac{h_1^2(\sigma_{q2}^2 + \sigma_F^2)}{r\left((\sigma_{q2}^2)^2 + \sigma_{q1}^2(\sigma_{q2}^2 + \sigma_F^2)\right)} \tag{102}$$

The optimal weight on the stock price includes variables from both periods, indicating that the

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[74] The following expression uses the formulation for the conditional expectation of a payoff, as noted in Grossman and

stock price, in this case, is of use in contracting on both short-term and long-term performance. Thus, despite the absence of private information, the stock price is still useful for contracting. Intuitively, this because the financial performance signals, which are incrementally informative about both types of effort, are not directly contractible but are noisily impounded in the stock price.

The weight on the DFP measure also includes period 1 and period 2 parameters, which could imply that the DFP measure rewards both shortsighted and farsighted effort. This seems counterintuitive since the DFP does not capture incremental information about shortsighted effort. However, this result can be explained as follows. Given that the stock price impounds information about both shortsighted and farsighted effort, then any adjustment to the weight on the stock price will also affect the weight on the DFP measure. Thus, the weight on the DFP measure is sensitive to changes in period 1 parameters (i.e. through changes in the weight on the stock price), despite the DFP signal *not* capturing any information about shortsighted effort.

It is also evident from expressions (101) and (102) that the absolute weights will always be positive. Further insight about the impact of changes in determinants of these weights can be gained by exploring the comparative statics of the weights. The following table presents the comparative statics on each of the absolute contracting weights and a third column that shows the comparative statics on the *relative* weight between the DFP signal and stock price. The comparative statics on the relative weight provide additional insight on the interactions between a DFP signal and stock price as a basis for rewarding long-term performance.

j	$\partial \gamma^* / \partial j$	$\partial \theta^* / \partial j$	$\partial (\gamma^*/\theta^*) / \partial j$
σ_{q1}^2	<0	<0	>0
σ_{q2}^2	<0	<0	>0
σ_F^2	>0	>0	<0
σ_v^2	<0	0	<0
h_1	>0	>0	<0
h_2	>0	0	>0
r	<0	<0	<0

Stiglitz (1980), Appendix A.

Many of the results confirm standard intuition. For example, the absolute weights on the DFP signal and the stock price are both decreasing in risk aversion, which suggests that as the agent becomes less risk averse, the principal can make the agent's contract more risky, i.e. by increasing the variable component of the contract. A more subtle, related insight is how changes in risk aversion affect the weight on the DFP signal *relative* to the stock price. The result from row 8 in the above table is negative, which suggests that as r tends to zero, the increase in weight on the DFP signal relative to the stock price is larger. This implies that with reductions in the agent's risk aversion, the DFP signal is a relatively more efficient form of providing incentives than the stock price.

The results also show that changes in variance of the random components of period 1 and 2 payoffs have the same directional impact on the absolute weights. Intuitively, increased variance increases risk, which would lead to reductions in the incentive component of the contract. From the derivative of the relative weight with respect to $\sigma_{q1}{}^2$ and $\sigma_{q2}{}^2$, the relative impact on the DFP weight is smaller. This seems intuitive since the DFP signal does not directly capture information about the random components in the period 1 and period 2 payoffs. Rather, the impact of these variance changes on the DFP weight is an indirect consequence of the optimally required change to the stock price when these variances change.

A seemingly counterintuitive result is the derivative of the absolute contracting weights with respect to the noise term in the period 2 forecast. The result suggests that as the profit forecast becomes noisier, then the weight on the stock price should be increased. However, the intuition for this result is as follows. As the profit forecast becomes increasingly noisy, the market will increasingly ignore the signal, which makes the existing stock price incrementally informative about period 1 payoffs. Since these payoffs are not directly contractible, the stock price paradoxically becomes increasingly useful for contracting because it provides a "cleaner" measure of period 1 payoffs.

As standard intuition suggests, increases in the noise in the profit forecast makes the "substitute" DFP signal more useful for contracting. Interestingly, the model predicts an optimal

decrease in the weight on the DFP relative to the stock price weight when the profit forecast noise *increases*. This suggests the changes in the noise of the profit forecast has a greater impact on the stock price than it does on the substitute performance measure for rewarding long-term performance, i.e. the DFP signal.

Changes in the noise of the DFP signal as might be expected lead to inverse changes on the absolute weight on the DFP signal. Interestingly, the weight on the stock price is *independent* of changes in the noise of the DFP signal. This implies that the stock price and the DFP signal are *not* direct substitutes for rewarding long-term performance. To illustrate, suppose the noise in the DFP signal tended to zero. The absolute contracting weight on the DFP signal optimally increases, but there is no change to the weight on the stock price. Thus, while the stock price may be incrementally informative about farsighted effort, changes in the precision of a substitute signal about farsighted effort (i.e. the DFP signal) has no effect on the stock price weight.

Finally, increases in the value of firm specific characteristics will increase both absolute contracting weights, except the weight on the stock price in respect of the period 2 firm-specific characteristics. The results other than the exception result can be explained in the same way as changes in the agent's risk aversion. Increases in the value of the firm specific characteristics make the incentive component of the contract relatively less risky, so that the principal can impose greater risk by increasing each of the absolute weights. With increases in the period 1 firm-specific characteristics, the weight on the stock price increases more relative to the weight on the DFP signal. This is intuitive since the DFP signal does not *directly* capture the period 1 firm-specific characteristics.

The exception to this logic is the derivative of the weight on the stock price with respect to period 2 firm-specific characteristics. Here the weight on the stock price is *independent* of firm-specific characteristics in period 2. This confirms that the stock price is not the primary source for rewarding farsighted effort in the presence of a DFP signal.

In summary, three key results were established in this subsection. First, a contracting role for

the stock price arises under conditions other than the case where private information is impounded in the price at the end of period 1. If a profit forecast of period 2 performance is impounded in price and the financial performance signals are not directly contractible, then the stock price will have a relatively small role in rewarding long-term performance, independent of private investor information gathering.

Second, the stock price and the DFP signal are *not* direct substitutes for rewarding long-term performance. This is in contrast to the setting where future financial performance was contractible. There the period 2 financial signal and the DFP signal were direct alternates in rewarding long-term performance (see chapter 2).

Third, there exist conditions in this two-performance-measure model where optimal changes to the absolute weights on the performance measures in response to changes in weight determinants are in the *opposite* direction to the optimal changes in the weight on the DFP signal relative to the stock price. Similar to other contexts, this finding suggest that empirical researchers need to develop with caution the signs that they expect to see on DFP-related coefficients in any empirical testing, depending on whether absolute or relative proxies of DFP signals are measured.

The next sub-section explores the impact of private information about period 2 performance being impounded in the stock price. Intuitively, this creates a further role for the stock price in long-term incentive contracting since the period 2 payoff is perfectly revealed, in aggregate, in the stock price.

4.6.2   Costly Contracting on Financial Signals – Private Investor Information Acquisition

The acquisition of private investor information can be introduced into the costly contracting on financial signals model in the same way as in section 4.5. Accordingly, the market price is specified as:

$$\tilde{m} = d_0 + d_1\tilde{\pi}_1 + d_F\tilde{\pi}_F + d_G\tilde{\pi}_2 + d_y \ln(\tilde{y}) + d_z\tilde{z} - \tilde{w}_1 - \tilde{w}_2 \qquad (103)$$

where d_j, $j = 1, F, G, y, z$, reflects the intensity with which financial/DFP signals and non-output-related events are impounded into the market price. The characterization of the price

parameters in a competitive rational markets equilibrium will be the almost the same as that in expression (88) above. The only difference is that the incentive weights on the financial signals are omitted from the characterization since the financial signals are not contractible. Accordingly, in the non-contractible financial signal setting, the competitive rational markets equilibrium price will be characterized by the following coefficients:

$$d_0 = \frac{\hat{\pi}_2/\sigma_{q2}^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} - \left(\alpha_1 + \alpha_2 + \gamma\ln(\tilde{y})\right)$$

$$d_1 = 1$$

$$d_F = \frac{1/\sigma_F^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} \tag{104}$$

$$d_y = 0$$

$$\frac{d_Z}{d_G} = \frac{1}{R\sigma_G^2}$$

where R is the private investors' risk aversion parameter.

Proof: See Appendix 4.

As in section 4.5, for clarity the d_j, coefficients, $j = 0, 1, F, G, y, z$, will be preserved in the analysis until a final substitution is made into the optim.al incentive weights. Maximizing the agent's certainty equivalent with respect to shortsighted and farsighted effort leads to the following:

$$a^{\bullet} = \frac{\theta h_1 d_1}{1 + \theta} \tag{105}$$

$$b^{\bullet} = \frac{\gamma + \theta\left(d_y + h_2 d_G\right)}{1 + \theta} \tag{106}$$

Both types of effort levels will always be positive. The structure of each relationship is similar to that for the case where the financial performance signals were contractible (see section 4.4). The above weights, however, omit any link to the financial performance signals because here they are not contractible. Shortsighted effort is induced only because the emphasis placed on the stock price scaled by the product of firm specific characteristics and the intensity with which the period 1 profit signal is impounded in price (here $d_1 = 1$), divided by $(1+\theta)$. Farsighted effort is induced by two

incentive components: the weight on the stock price *and* the weight on the DFP signal. This suggests that long-term performance is a function of two different incentive components in the agent's period 1 contract.

Simultaneously solving the first order conditions for the principal's problem provides the optimal incentive weights on the DFP signal and the stock price. While closed form solutions are obtainable, both expressions are highly complex and difficult to interpret separately. To simplify the analysis, the ratio of the optimal weight on the DFP signal, *relative* to the weight on the stock price can be expressed as:

$$\frac{\gamma}{\theta}^* = \frac{h_2\left(r\left(d_1^2\,\sigma_{q1}^2 + d_F^2\left(\sigma_{q2}^2 + \sigma_F^2\right) + d_G^2\,\sigma_{q2}^2 + d_z^2\,\sigma_z^2\right) + h_1^2 d_1\left(d_1 - d_G\right)\right)}{r\,\sigma_y^2\left(h_1^2 d_1^2 + h_2^2 d_G\right) + h_1^2 d_1} - d_y \tag{107}$$

The relative weight can be rewritten by substituting the optimal price parameters from the rational competitive markets equilibrium into the above expression. The relative weight becomes:

$$\frac{\gamma}{\theta}^* = \frac{h_2}{J}\left(\frac{L}{K^2} + \frac{M}{R}\right)$$

where:

$$J \equiv Rh_1^2\left(1 + r\,\sigma_y^2\right) + d_Z\,\sigma_G^2 h_2^2 r\,\sigma_y^2$$

$$K \equiv R^2\,\sigma_Z^2\left(\sigma_{q2}^2 + \sigma_F^2 + \sigma_G^2\right) + \sigma_{q2}^2\sigma_F^2\left(\sigma_G^2\right)^3 \tag{108}$$

$$L \equiv rR^5\left(\sigma_{q2}^2\sigma_G^2\sigma_z^2\right)^2\left(\sigma_{q2}^2 + \sigma_F^2\right)$$

$$M \equiv R^2\left(h_1^2 + r\,\sigma_{q1}^2 + rd_z^2\,\sigma_z^2\right) + d_z\,\sigma_G^2\left(rd_z^2\,\sigma_G^2\sigma_{q2}^2 - Rh_1^2\right)$$

R is the risk aversion parameter for the private investors.

Including the endogenous parameters of the market price in the optimal incentive weights eliminates most of the pricing coefficients from the relative weight. However, the relative weight expression becomes considerably more complicated. An important insight is that the private information signal impounded in price makes the weight on the stock price increasingly substitutable with the weight on the DFP signal for contracting purposes. This is most conveniently illustrated by the case of where σ_y^2 tends to zero. Recall that without private information, there was *no* change to the absolute contracting weight on the stock price even if the measurement error in the DFP signal

tended to zero. However, with private information impounded in the stock price, $\sigma_\tau^{\:} = 0$ means the weight on the absolute stock price contracting weight (not directly reported here) changes to reflect the stock price no longer rewarding long-term performance.

To gain further insight into the relative weight expression that respectively incorporates endogenous and exogenous price parameters, it is useful to examine the optimal adjustments to the incentive weights in response to variations in the determinants of the relative weight.[75] These results are presented in the table below.

j	$\partial(\gamma^*/\theta^*) \, / \, \partial j$ endogenous market price	$\partial\theta^* \, / \, \partial j$ exogenous market price
σ_{q1}^{2}	>0	>0
σ_{q2}^{2}	>0	>0
σ_F^{2}	<0	>0
σ_V^{2}	ambiguous	ambiguous
h_1	ambiguous	ambiguous
h_2	ambiguous	ambiguous
r	ambiguous	ambiguous
d_z	ambiguous	>0
σ_z^{2}	>0	>0
σ_{Gi}^{2}	ambiguous	0
R	ambiguous	0

In the case of the endogenous market price, the first three rows of results are the same as that as when there is no private information gathering but the financial performance signals are not contractible (i.e. as in Section 4.6.1). This implies that increases in the noise associated with price-impounded financial performance signals, *irrespective of whether the realized values of financial performance are contractible*, will lead to a greater increase on the weight of a DFP signal relative to the weight on the stock price.

Similarly, increases in the noise associated with a forecast of future financial performance, *irrespective of whether the realized values of the financial performance are contractible*, will lead to a

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[75] As discussed earlier, comparative statics can also provide the basis for generating empirical predictions.

lower increase in the weight on a DFP signal relative to increase in the weight on the stock price. This result may seem paradoxical. However, as earlier discussed it is due to market participants ignoring the profit forecast more as it becomes noisier. This makes the stock price more revealing of other impounded signals. As the stock price becomes more revealing relative to other contractible variables, then the more valuable it becomes for contracting.

The results also show the impact of using market price endogeneity. From row 3 of the table, the derivative of the relative weight with respect to noise in the period 2 profit forecast is positive (i.e. greater weight on the DFP as forecast noise increases) when exogenous market price is applied. However, the same derivative is negative (i.e. greater weight on the stock price as forecast noise increases), when endogenous *rather* than exogenous market price is applied. This sign reversal emphasizes the importance of researchers using an *endogenous* market price in theoretical analysis of optimal incentive contracting weights, where the stock price is used for contracting.

4.7   Conclusion

This purpose of this chapter was to develop theoretical insight on why firms emphasize the contracting variables that they do in setting long-term monetary incentives. Three types of long-term contracting variable were examined: future financial performance, DFP and the stock price. Consistent with existing theory, the analysis shows that under the conditions of no private investor information gathering and costless direct contracting on financial signals, there is no role for stock price as a long-term contracting variable. Under such conditions, the introduction of a DFP signal into the analysis does not change the role of the stock price for contracting purposes. Assuming contractible financial signals, the analysis in this chapter also showed that private investor information gathering does not in itself create a role for the stock price.

The stock price does, however, become useful for contracting if the financial signals are prohibitively costly for contracting on long-term performance. The chapter shows that there will be varying trade-offs between the contractible variables used to provide long-term monetary rewards, as

well as changes to the short-term incentive structure (since the stock price information impounds information about short-term performance). By assuming private investor information acquisition *and* non-contractible financial signals, substitutability emerges between incentive weights based on stock price and weights based on the DFP signal. This is because the stock price has become incrementally informative about future profits and in turn farsighted effort.

The results have several practical implications about the concurrent use of DFP signals and the stock price for long-term contracting. In particular, when the stock price is uninformative or too noisy for contracting, then the DFP signal can allow firms to offer more:

- cost-effective monetary incentives. For example, if the stock price is too noisy, it follows that it would be cost-prohibitive for contracting. If financial performance signals are similarly cost-prohibitive for contracting, then an emphasis on the DFP signal may yield relative savings for the firm.[76]

- balanced (between short-term and long-term) monetary incentives. If financial performance signals are excessively focused on the short-term then contracting on a DFP signal may induce managers to think more about long-term implications of their actions.

- timely monetary incentives. The more executives progress up the corporate ladder the less useful will be financial performance signals for rewarding long-term performance, since such executives will have moved on *after* the consequences of their actions generate profits for gainsharing purposes. The DFP signal, however, allows the firm to reward in the current period executive's actions that ultimately improve long-term profitability.

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[76] An example of where financial performance measures might be too costly for contracting is where earnings management reduces the value of the measures for contracting and it is too costly for the principal to unravel the effect of earnings management.

Chapter 5

Conclusion and Directions for Future Research

5.1   Introduction

The purpose of this chapter is threefold. First, the chapter summarizes the key findings and intuition from the three essays in this thesis, including implications for incentive contract design. Second, it highlights the contributions that this thesis makes to the existing management accounting literature. Third, this chapter concludes with directions for future research.

5.2   Summary of Chapter Findings

This section summarizes results in chapters 2, 3, and 4 of the thesis.

Chapter 2 of this thesis focuses on the basic demand in incentive contracts for measures of the drivers of future performance (DFP). DFP are factors, such as quality or customer satisfaction, thought to be related with, or cause, future financial performance. Measures of DFP are quantitative expressions of these factors. The DFP measures are often nonfinancial (i.e. comprising non-monetary metrics) in nature, but do not necessarily preclude forward-looking financial performance measures. For comparative purposes, traditional measures of financial performance and measures of DFP are *both* modelled as performance measures on which incentives are based.

To improve the interpretability of the model, the chapter exploits well-established assumptions used in formal modelling. These include: a subordinate worker receives linear compensation (fixed wage plus a variable incentive component based on performance measures); the subordinate is risk averse; and the outcome of any uncertainty is normally distributed. It is further

assumed that the subordinate is paid at the end of each of two different periods. The subordinate also exerts two types of effort. The first type is shortsighted effort, which can be defined as any action that increases the sales of the firm's product in the current period, such as attracting new customers. The second type is farsighted effort, which can be defined as any current actions that increase sales of the firm's product in the *next* period, such as any action that increases long-term customer or employee loyalty. A critical assumption throughout this thesis is that a measure of DFP can provide information to a firm's owner about an employee's farsighted effort.

Chapter 2 identifies the conditions under which a superior will offer a subordinate an incentive contract that is based, at least in part, on a measure of DFP. It then identifies what impact that changes in those conditions will have on the *emphasis* on a measure of DFP in an incentive contract. The results predict that increases (decreases) in contribution margin, an employee's discount factor, the precision[77] of the measure of DFP, or the uncertainty of future sales estimates will lead to increases (decreases) in the weight on the DFP measure.

When a traditional *financial* performance measure is also included as part of the incentive contract, then changes in the *type* of financial performance measure used will also lead to changes in the *emphasis* on the measure of DFP in the contract. For example, consider an incentive contract based in part on a financial performance measure and in part on a measure of DFP. If the firm chooses to change the financial performance measure from accounting earnings to residual income, then there will be changes in the optimal emphasis placed on the measure of DFP. Finally, when the measure of DFP can capture information about *both* shortsighted and farsighted effort, then the measure of DFP can be used as a substitute performance measure in contracting for financial performance measures that reflect both shortsighted effort (now) and farsighted effort (in the future).

Overall, the results in chapter 2 suggest two important properties of measures of DFP that contribute to the theory explaining why we observe measures of DFP being increasingly used in

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[77] Precision can be informally thought of as the lack of noise in a performance measure. Precision is more formally defined

performance evaluation. First, the inclusion of a DFP measure in incentive contracts can mitigate the potential for a subordinate to focus excessively on the short-term and then leave the firm at the expense of the long-term survival of the firm. This is because a measure of DFP rewards the subordinate *now* for farsighted effort that affects *long*-term profitability. Second, under certain conditions, emphasis on a DFP measure can be *substituted* for emphasis on other performance measures in incentive contracts

Chapter 3 of this thesis focuses on how variations in measurement attributes of a DFP measure can lead to variations in overall payoffs. This chapter specifically examines two attributes. First, the chapter studies the impact of *precision*, which is formally defined as the inverse of the variance of the probability distribution associated with the DFP measure. Informally, precision might be thought of as the lack of noise in performance signal. Second, the chapter studies the impact of *predictability*, defined as the ability of the current DFP measure to predict future financial performance.

The basic model developed in chapter 2 is used as the basis for the analysis. However, the model was extended to include a model of both predictability and the costs of changing the precision and predictability measurement attributes. To simplify the analysis, the model was also modified, in parts, to relax the assumption that there exist differences in risk preferences between the superior and subordinate.

A key result of the basic model in chapter 3 is that *costless* increases (decreases) in either precision or predictability will lead to increases (decreases) in payoffs for a firm's owner. Chapter 3 shows that this result holds even in the more complex scenario of a multi-impact effort type that can have positive payoff consequences in one or more periods and negative payoff consequences in other periods. The relaxation of the assumption of *costless* variation in measurement attributes led to three further sets of findings in Chapter 3.

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throughout the thesis as the inverse of the variance of the probability distribution associated with the signal of interest.

First, when costly variations in precision are introduced, the model predicts that increases (decreases) in precision do not always lead to increases (decreases) in payoffs for the owner. Rather, the owner will seek to improve precision only where marginal benefits of precision improvements exceed marginal costs. An optimal level of precision can be derived at the point where the marginal benefits equal the marginal costs. Increases (decreases) in contribution margin lead to increases (decreases) in the optimal level of precision.

Second, chapter 3 also presents the impact of changes in the other determinants of the owner's payoffs. Increases (decreases) in the precision of traditional *financial* performance measures, the discount factor that a subordinate uses to value future compensation, and non-price exogenous factors (such as the firm's reputation), and decreases (increases) in a subordinate's risk aversion all lead to increases (decreases) in the owner's payoffs. Increases (decreases) in contribution margin affect the owner's payoffs *both* favourably (unfavourably) through increases (decreases) in the contribution margin and unfavourably (favourably) through increases (decreases) in the risk premium payable to the subordinate. The net impact depends on the extent of the subordinate's risk aversion. Finally, consistent with the first set of results in chapter 3, the impact of changes in the cost of the precision of a DFP signal will depend on the relationship between the marginal costs and the marginal benefits of the changes in the cost of precision.

The third set of results in chapter 3 relates to the consequences of changes in a measure of DFP's predictability. A critical assumption of this analysis is that performance measures with relatively low (high) levels of predictability are assumed to have relatively high (low) incremental payoffs. For example, in a hotel environment, customer satisfaction measures may convey low levels of predictability about future financial performance, relative to reservation rates. However introducing customer satisfaction measures in incentive contracts may also generate high incremental payoffs to the hotel owners, relative to introducing reservation rates in the incentive contract. This is because emphasis on customer satisfaction measures could induce substantial long-term changes to the hotel's operations and ultimately greater long-term profitability, relative to an emphasis on

reservation rates, which may induce short-term solutions.

Assuming no performance measure can *perfectly* predict future performance, the results show that increases (decreases) in predictability do not always lead to increases (decreases) in overall payoffs to the owner of the firm. Rather, the owner will choose to contract on a DFP signal with relatively higher predictability only when the marginal benefits generated from decisions based on the DFP signal exceed the marginal costs associated with imperfections in the DFP signal's predictability. Thus, this result may provide theoretical insight for why we observe firms in practice not always contracting on DFP performance signals that are likely to have relatively high levels of predictability.

Chapter 4 returns the analysis to an investigation of optimal incentive weights when contracting on a set of performance measures that includes a signal of DFP. Two fundamental differences exist between chapter 2 and chapter 4. First, chapter 4 introduces the capital market to the analysis, so that a firm's owner can contract with employees on the stock price in addition to the internally generated measures of performance. Second, with the availability of the stock price as a contracting variable, the analysis in chapter 4 focuses more closely on the determinants of *long-term* monetary incentives.

Consistent with existing theory, chapter 4 establishes that without private investor information gathering and with costless contracting on financial performance signals, there is no role for stock price as a long-term contracting variable. This is because the stock price does not provide any incremental information about the subordinate's effort over and above that provided by the internally generated performance measures, which are contractible. Thus, the owners find it more efficient to contract directly on the internally generated performance measures.

The chapter finds that the lack of a contracting role for the stock price does not change even with the introduction of a DFP signal as a long-term contracting variable. Further, if the owner's payoffs are directly contractible, private investor information gathering does not in itself make the stock price useful for contracting, since the information ultimately revealed in the stock price by the private information is directly contractible in a future time period. Direct extensions of this work

could examine two related issues. First, the analysis could examine the case where the measurement error in the DFP signal is correlated to the random component in the owner payoffs. Second, the analysis could introduce differences in the time preferences for money. Both extensions would be likely to create a contracting role for the stock price independent of the subsequent analysis in the chapter.

Consistent with existing theory, chapter 4 also establishes that the stock price *does* become valuable for long-term contracting if the financial performance signals are too costly upon which to contract. This is because the stock price now provides incremental information about the effort levels of the subordinate. The chapter then explores how the emphasis changes on a DFP signal in an incentive contract, once the stock price becomes valuable for long-term contracting. Two streams of analysis are presented.

The first stream of analysis examines the case of non-contractible owner payoffs and no private investor information gathering. Three key results emerge from the analysis. First, the stock price has a relatively small role in rewarding long-term performance. Second, the stock price and the DFP signal are *not* direct substitutes in rewarding long-term performance. Third, the directional impact of changes in weight determinants often will vary depending on whether relative or absolute weights are examined.

The second stream of analysis explores the case of non-contractible owner payoffs *with* private investor information gathering. Private information in this model has two fundamental effects. First, the stock price and the DFP signal become direct substitutes in providing monetary rewards for long-term performance, in the same way that contractible future financial signals and the DFP signal were substitutes in chapter 2. Second, the process of endogenizing the gathering of private information can in itself reverse the sign of the impact of changes in certain determinants of the contracting weight on the DFP signal relative to the weight on the stock price.

Assuming the stock price is partly valuable for long-term monetary contracting,[78] three practical implications emerge from the results in chapter 4. First, the use of a DFP signal can be a cost-effective strategy for the firm. Second, the use of a DFP signal can lead to a better balance between short-term and long-term monetary incentives. Third, the use of a DFP signal can provide more timely monetary incentives, particularly for executives that are appointed to positions within the firm for relatively short periods.

Overall, the results in this thesis identify conditions that can generate significant economic benefit if a firm introduces a signal of DFP as a contracting variable to replace or supplement traditional financial performance measures or the stock price as contracting variables. Intuitively, a fundamental problem with traditional financial performance measures such as accounting earnings is that they may be too focused on the short-term. This can lead to employees taking short-term actions that may undermine the long-term profitability of the firm. Further, a fundamental problem with incentives based on stock price is that they may be long-term focused but are also subject to uncontrollable market wide factors. Thus, employee efforts are less observable through the stock price performance signal and this reduction in control can adversely affect long-term profitability. Signals of DFP can be focused on the long-term and are not subject to market wide factors. Thus, the use of DFP can overcome deficiencies in alternative contracting variables. In particular, measures of DFP in theory can emerge as an important basis for rewarding employees for efforts that are focused on the long-term survival of the firm.

5.3   Contributions of This Thesis

This thesis makes four key contributions to the management accounting literature. First, it provides a theoretical framework for understanding the demand for, and consequences of, variations in the use of measures of drivers of future performance in incentive contracts. The literature has

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[78] The chapter suggests that the stock price becomes partly valuable for long-term monetary contracting when private investors impound incremental information in the stock price, or, financial signals are too costly upon which to contract.

explored the value of additional performance measures and comparisons between firm-generated accounting and market-based performance measures. However, no work has examined specifically the value of a measure of DFP or generated explanations for the *emphasis* on a DFP measure relative to other firm-generated and market-based performance measures. The analysis in this thesis separately focuses on the emphasis on a DFP measure relative to other firm-generated performance measures (chapter 2), and the emphasis on a DFP measure relative to market-based performance measures (chapter 4).

Second, it presents a theoretical framework for understanding how variations in different measurement attributes of contracting variables can affect payoffs to an owner (chapter 3). This establishes the management accounting variable of interest (performance measurement) as the *independent* variable, which is in contrast to much of the previous work that examines the choice or emphasis of the management accounting variable as the *dependent* variable. Of the prior work that studies the consequences of performance measurement choices, no previous work has specifically examined the impact on payoffs of variations in the precision and predictability of a DFP measure.

Third, the theoretical framework in this thesis presents a foundation for developing empirical predictions about the emphasis on DFP measures in practice. In particular, the comparative statics can lead to predictions about the types of firms that have a different type of emphasis on a DFP measure relative to other firms in the same industry. For example, consider the modelling result where increases in the noise of a DFP signal lead to increases in the emphasis on stock price in incentive contracts. This result might alternatively be specified as a prediction that firms with high levels of noise in a DFP signal (compared to other firms in the same industry) will rely more heavily on the stock price than on a DFP signal for rewarding farsighted effort from an employee. Despite the increasing anecdotal and survey evidence of the use of DFP-like measures in practice, very little work has presented rigorous evidence of the use of DFP-like measures for contracting. Further, no previous empirical work has been specifically based on formal agency hypotheses to generate predictions about the emphasis on measures of DFP in the same industry.

Fourth, this thesis extends existing performance measurement theory in specific areas. as follows. This thesis:

- examines the economic consequences of using alternative definitions of financial measures of current performance in incentive contracts;

- provides specific insight into the observed practice of firms using DFP-like measures to capture *both* shortsighted and farsighted effort;

- introduces the theoretical concepts, "multi-dimensional signalling capability" and "multi-impact effort types";

- presents theoretical support for the use of an optimal measure of DFP that is measured with error;

- establishes theoretical determinants of a firm's optimal level of precision of a measure of DFP;

- derives conditions under which a DFP signal and the stock price can be substitutes in the short-term for monetarily rewarding the long-term performance of the firm.

5.4   Directions for Future Research

The purpose of this section is to outline four possible directions for future research. First, future research can exploit the formal theoretical framework in this thesis to derive empirical predictions about the why firms in different industries choose the emphasis that they do on measures of DFP.   This would serve two complementary purposes to the modelling in this thesis. The first purpose of the empirical testing would be to provide a form of validation for the underpinning assumptions used in this thesis. The second purpose of the empirical testing would be to provide evidence to resolve ambiguous predictions generated by the comparative statics.

This empirical testing research direction is not easily implemented. Given the internal and often proprietary nature of the data, it is difficult for researchers to compile large cross-sectional archival databases. Previous work has used proprietary compensation databases often supplemented by survey methods, and searches on sophisticated information databases such as Lexis/Nexis. An alternative approach has been to focus empirical work on a single large firm and use employees in

multiple divisions as statistical sampling points.[79] Despite these approaches, relatively little empirical research has been conducted in this area, particularly based on formal agency hypotheses.

In the future, however, we may expect to see an increase in the range of available data sources. Current trends suggest increasing emphasis on reporting nonfinancial measures in published company reports, greater capture of associated news releases in increasingly sophisticated public databases, and the emerging availability of benchmark data from consulting firms. Accordingly, more avenues for empirical data collection could further encourage cross-sectional empirical research in this area. In addition, as firms' experience with DFP measures mature, time-series data may become a useful source of data for researchers. Notwithstanding, the *proprietary* nature of DFP data may continue to hinder progress in empirical testing.

A second direction for future research is to extend the work in chapter 3 on how underlying attributes of the performance measure can affect payoffs. This thesis examines just two attributes: precision and predictability. This stream of research would benefit from exploratory fieldwork that addresses the question what properties or attributes of critical performance indicators used by firms in practice make them so critical. Such properties or attributes might then be modelled to establish predictions about the types of contexts that variations in the attributes would be economically feasible. This research direction could also extend the relatively sparse literature on why performance measures used for contracting purposes are inherently composed or built the way that they are.

A third direction for future research builds on two theoretical concepts introduced in this thesis. Multi-dimensional signalling capability refers to performance measures that can measure an element of *different* types of effort in the same period. A multi-impact effort type refers to an effort type that can have both favourable and adverse impact on the production function, in different periods. Both concepts are treated at a basic level in this thesis. Further modelling of these concepts in different contexts may reveal rich insights about why different performance measures are chosen

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[79] However, this particular approach is appropriate only when the individual is the unit of analysis. Using the firm or the

for contracting in different contexts.

Finally, a fourth direction for future research is to model and compare contracting on specific types of measures of DFP. The measure of DFP used in this thesis is generic and assumes a simple linear relationship between the value of the measure and an employee's farsighted effort. Different types of measures of DFP could have different functional relationships with farsighted effort. In particular, some evidence suggests that the functional relationship between profitability and customer satisfaction may be non-linear and that firms may have incentive to identify an optimal level of customer satisfaction. Previous work on specific measures of DFP types has also focused almost exclusively on customer-based incentives and has ignored opportunities to explore other DFP measurement types. For example, emphasis on employee-based DFP may influence organizational learning, which could affect the way in which different effort types affect the production function.

Research studying the impact of contracting on specific types of DFP may also generate the need for theory explaining how the *interaction* of the different DFP types affects payoffs. Previous research examines different measures of DFP (usually customer satisfaction) in isolation. It may be that different measures of DFP generate conflicting messages of performance. For example, emphasis on customer satisfaction measures may have favourable effects on profitability but may also lead to employee morale problems. Here, the impact of employee morale problems would need to be incorporated in any modelling to present a more complete picture of the impact of a DFP measurement system.

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divisions as the units of analysis raises generalizability or external validity problems.

Appendix 1: Notation Index

Notation Index, Chapter 2

Variable	Support	Description
A	$(-\infty,\infty)$	Net total assets of the firm
a	$[\underline{a},\bar{a}]$	Logarithmic function of shortsighted effort
b	$[\underline{b},\bar{b}]$	Logarithmic function of farsighted effort
$C(a,b)$	$[0,\infty)$	Cost of effort
f_i	$[0,\infty)$	Fixed costs of the firm in period $i, i=1,2$
g_i	$(0,\infty)$	Exogenous non-price factors affecting sales in period $i, i=1,2$
H	$(0,1)$	Degree to which a performance signal is informative about one dimension of effort relative to another dimension.
K	$[0,100]$	Percentage parameter
L, M		Labels used to simplify notation in the proofs
p_i	$(0,\infty)$	Price of goods to be sold in period $i, i=1,2$
q_i	$(-\infty,\infty)$	Quantity of goods to be sold in period $i, i=1,2$
r	$[0,1]$	Agent's risk aversion coefficient
S, T		Labels used to simplify notation in the proofs
$U(.)$	$(-\infty,\infty)$	Agent's utility function
v_i	$[0,\infty)$	Variable costs per unit sold
$w(.)$	$[\underline{w},\bar{w}]$	Agent's incentive contract
x	$(-\infty,\infty)$	Logarithmic function of the drivers of future performance (DFP) signal
y	$(0,\infty)$	Signal of driver of future performance (DFP)
α_i	$(-\infty,\infty)$	Fixed salary component of incentive contract in period $i, i=1,2$
β_i	$(-\infty,\infty)$	Weight on financial performance signal in period $i, i=1,2$
γ	$(-\infty,\infty)$	Weight on the measure of drivers of future performance in period 1
δ	$[0,1)$	Discount factor used by agent to evaluate period 2 values in period 1
ε_i	$(-\infty,\infty)$	Error term associated with distribution of variable $i, i=q_1, q_2, y$
π_i	$(-\infty,\infty)$	Firm profits in period $i, i=1,2$
σ_i^2	$[0,\infty)$	Variance associated with distribution of variable $i, i=q_1, q_2, y$
ϕ	$[\underline{\phi},\bar{\phi}]$	Shortsighted effort
ψ	$[\underline{\psi},\bar{\psi}]$	Farsighted effort

Notation Index, Chapter 3

Variable	Support	Description
a	$[\underline{a},\bar{a}]$	Logarithmic function of shortsighted effort
b	$[\underline{b},\bar{b}]$	Logarithmic function of farsighted effort
$C(a,b)$	$[0,\infty)$	Cost of effort
$C(1/\sigma_i^2)$	$[0,\infty)$	Cost of producing DFP
c	$[0,\infty)$	Marginal cost of producing DFP
D	$(0,1]$	Degree of DFP predictability
f_i	$[0,\infty)$	Fixed costs of the firm in period $i, i=1,2$
g_i	$(0,\infty)$	Exogenous non-price factors affecting sales in period $i, i=1,2$
H	$(0,1)$	Degree to which a performance measure is informative about one dimension of effort relative to another dimension.
p_i	$(0,\infty)$	Price of goods to be sold in period $i, i=1,2$
q_i	$(-\infty,\infty)$	Quantity of goods to be sold in period $i, i=1,2$
r	$[0,1]$	Agent's risk aversion coefficient
$U(.)$	$(-\infty,\infty)$	Agent's utility function
v_i	$[0,\infty)$	Variable costs per unit sold
$w(.)$	$[\underline{w},\bar{w}]$	Agent's incentive contract
x	$(-\infty,\infty)$	Logarithmic function of the drivers of future performance signal
y	$(0,\infty)$	Drivers of future performance signal
Z	$[0,\infty)$	Extent to which effort level has multiple impact
α_i	$(-\infty,\infty)$	Fixed salary component of incentive contract in period $i, i=1,2$
β_i	$(-\infty,\infty)$	Weight on financial performance signal in period $i, i=1,2$
γ	$(-\infty,\infty)$	Weight on DFP measure in period 1
δ	$[0,1]$	Discount factor used by agent to evaluate period 2 values in period 1
ε_i	$(-\infty,\infty)$	Error term associated with distribution of variable i, $i=q_1, q_2, y$
π_i	$(-\infty,\infty)$	Firm profits in period $i, i=1,2$
σ_i^2	$[0,\infty)$	Variance associated with distribution of variable i, $i=q_1, q_2, y$
ϕ	$[\underline{\phi},\bar{\phi}]$	Shortsighted effort
ψ	$[\underline{\psi},\bar{\psi}]$	Farsighted effort
Ω, Ξ		Labels used to simplify exposition of optimal level of DFP precision
Δ, Φ		Labels used to simplify exposition of inherent DFP predictability variations

Notation Index, Chapter 4

Variable	Support	Description
a	$[\underline{a},\bar{a}]$	Logarithmic function of shortsighted effort
b	$[\underline{b},\bar{b}]$	Logarithmic function of farsighted effort
$C(a,b)$	$[0,\infty)$	Cost of effort
d_i	$[0,1]$	"Intensity" coefficients in market price derivation
f_i	$[0,\infty)$	Fixed costs of the firm in period $i, i=1,2$
g_i	$(0,\infty)$	Exogenous non-price factors affecting sales in period $i, i=1,2$
h_i	$(-\infty,\infty)$	The product of contribution margin and non-price exogenous (output) factors
D		Label used to denote the ratio of two of the "intensity" coefficients
F		Label used to denote a *forecast* of period 2 profit
G		Label used to denote private investor related information
J,K,L,M,N,Q		Labels used to clarify presentation of mathematical analysis
m	$(-\infty,\infty)$	Firm's stock price
n	$(-\infty,\infty)$	Normalized stock price signal
p_i	$(0,\infty)$	Price of goods to be sold in period $i, i=1,2$
q_i	$(-\infty,\infty)$	Quantity of goods to be sold in period $i, i=1,2$
r	$[0,1]$	Agent's risk aversion coefficient
S, T		Label used to simplify notation in the proofs
$U(.)$	$(-\infty,\infty)$	Agent's utility function
v_i	$[0,\infty)$	Variable costs per unit sold
$w(.)$	$[\underline{w},\bar{w}]$	Agent's incentive contract
x	$(-\infty,\infty)$	Logarithmic function of drivers of future performance signal
y	$(0,\infty)$	Signal of drivers of future performance
α_i	$(-\infty,\infty)$	Fixed salary component of incentive contract in period $i, i=1,2$
β_i	$(-\infty,\infty)$	Weight on financial performance signal in period $i, i=1,2$
γ	$(-\infty,\infty)$	Weight on the measure of drivers of future performance in period 1
δ	$[0,1]$	Discount factor used by agent to evaluate period 2 values in period 1
θ	$(-\infty,\infty)$	Weight on the firm's stock price
ε_i	$(-\infty,\infty)$	Error term associated with distribution of variable i, $i=q_1, q_2, y$
π_i	$(-\infty,\infty)$	Firm profits in period $i, i=1,2$
σ_i^2	$[0,\infty)$	Variance associated with distribution of variable i, $i=q_1, q_2, y$
ϕ	$[\underline{\phi},\bar{\phi}]$	Shortsighted effort
ψ	$[\underline{\psi},\bar{\psi}]$	Farsighted effort

Appendix 2: Proofs of Observations in Chapter 2

Proof of Optimal Incentive Weights

The agency program is as follows:

$$\underset{\beta_1,\beta_2,\gamma}{Max}\ E[\tilde{\pi}_1 + \tilde{\pi}_2 - \tilde{w}_1 - \tilde{w}_2]$$

subject to:

$$E\left[1 - e^{-r\left(w_1 + \delta w_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)}\right] \geq 0 \qquad\qquad (\text{IR})$$

$$a,b \in \arg\max_{a,b} E\left[1 - e^{-r\left(w_1 + \delta w_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)}\right] \qquad (\text{IC})$$

(Note: setting the right-hand side of IR equal to a constant will only shift w_1 and w_2 and not change the optimal values, because constant absolute risk aversion is assumed.)

<u>The incentive compatibility constraint</u>

First, one needs to show that maximizing the expected utility is the same as maximizing the certainty equivalent,[80] i.e.:

$$\max_{a,b} E\left[1 - e^{-r\left(w_1 + \delta w_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)}\right] \equiv \max_{a,b} \overline{w}_1 + \delta\overline{w}_2 - \frac{a^2}{2} - \frac{b^2}{2} - \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma\ \sigma_v^2 + \delta^2(p_2 - v_2)^2\ \beta_2^2\sigma_{q2}^2\right)$$

This proof requires an assumption of independence of the disturbance terms of the three random variables, and the application of the following:

1. Definition of a Normal Curve:

$$F(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{X-\mu}{\sigma}\right)^2}$$

2. Evaluation of an integral of the following form:

$$\int_{-\infty}^{\infty} e^{\left[-Sa^2 + Ta\right]} da$$

Applying Gradshteyn and Ryzhik's (1965 : 307, 3.323.2) formula (hereafter GR):

$$\int_{-\infty}^{\infty} e^{\left[-Sa^2 + Ta\right]} da = e^{\frac{T^2}{4S}} \sqrt{\frac{\pi}{S}}$$

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[80] Since all the performance measures are normally distributed, the following formal "equivalence" proof can be bypassed by using the definition of a moment generating function of a normal random variable. This result holds even if the normally distributed variables are correlated. The formal analysis here aims to present a more pedagogical approach to the proof.

Now, evaluate expected utility by taking the triple integral of the utility function:

$$\iiint \left(1 - e^{-r\left(w_1 + \delta w_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)} \right) F(q_1)F(x)F(q_2)\,dq_1\,dx\,dq_2$$

$$= \iiint \left(1 - e^{-r\left(\alpha_1 + \beta_1((p_1-v_1)q_1-f_1)+\gamma x+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}\right)} \right) \left[\frac{e^{-\frac{1}{2}\left(\frac{q_1-\bar{q}_1}{\sigma_{q_1}}\right)^2}}{\sqrt{2\pi\sigma^2}} \right] F(x)F(q_2)\,dq_1\,dx\,dq_2$$

$$= 1 - \iiint \left(e^{-r\left(\alpha_1 - \beta_1 f_1 +\gamma x+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}\right)-r\beta_1(p_1-v_1)q_1} \right) \left[\frac{e^{-\frac{1}{2}\left(\frac{q_1^2+\bar{q}_1^2-2q_1\bar{q}_1}{\sigma_{q_1}^2}\right)}}{\sqrt{2\pi\sigma_{q_1}^2}} \right] F(x)F(q_2)\,dq_1\,dx\,dq_2$$

$$= 1 - \iint \left(\frac{e^{-r\left(\alpha_1 - \beta_1 f_1 +\gamma x+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}\right)-\frac{\bar{q}_1^2}{2\sigma_{q_1}^2}}}{\sqrt{2\pi\sigma_{q_1}^2}} \right) \left[\int_{-\infty}^{\infty} e^{\left(\frac{-q_1^2+2q_1(\bar{q}_1-r\beta_1(p_1-v_1)\sigma_{q_1}^2)}{2\sigma_{q_1}^2}\right)}\,dq_1 \right] F(x)F(q_2)\,dx\,dq_2$$

Under GR's formulation, let $S = \dfrac{1}{2\sigma_{q_1}^2}$ and let $T = \dfrac{(\bar{q}_1 - r\beta_1(p_1-v_1)\sigma_{q_1}^2)}{\sigma_{q_1}^2}$

Then, evaluate integral in square brackets, by applying GR:

$$= 1 - \iint \left(\frac{e^{-r\left(\alpha_1 - \beta_1 f_1 +\gamma x+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}\right)-\frac{\bar{q}_1^2}{2\sigma_{q_1}^2}}}{\sqrt{2\pi\sigma_{q_1}^2}} \right) \left[e^{\frac{\left((\bar{q}_1-r\beta_1(p_1-v_1)\sigma_{q_1}^2)/\sigma_{q_1}^2\right)^2}{4\left(1/2\sigma_{q_1}^2\right)}} \sqrt{\frac{\pi}{1/2\sigma_{q_1}^2}} \right] F(x)F(q_2)\,dx\,dq_2$$

which simplifies to:

$$1 - \iint \left(e^{-r\left(\alpha_1 + \beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma x+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2)\right)} \right) F(x)F(q_2)\,dx\,dq_2$$

Next, repeat the evaluation of the inside integral, using the steps above:

$$= 1 - \iint \left(e^{-r\left(\alpha_1 + \beta_1((p_1-v_1)\bar{q}_1-f_1)+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2)\right)-r\gamma x} \right) \left[\frac{e^{-\frac{1}{2}\left(\frac{x^2+\bar{x}^2-2x\bar{x}}{\sigma_x^2}\right)}}{\sqrt{2\pi\sigma_x^2}} \right] F(q_2)\,dx\,dq_2$$

$$= 1 - \int \left(\frac{e^{-r\left(\alpha_1 + \beta_1((p_1-v_1)\bar{q}_1-f_1)+\delta w_2 -\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2)\right)-\frac{\bar{x}^2}{2\sigma_x^2}}}{\sqrt{2\pi\sigma_x^2}} \right) \left[\int_{-\infty}^{\infty} e^{\left(\frac{-x^2+2x(\bar{x}-r\gamma\sigma_x^2)}{2\sigma_x^2}\right)}\,dx \right] F(q_2)\,dq_2$$

Under GR's formulation, let S = $\dfrac{1}{2\sigma_x^2}$ and let T = $\dfrac{\left(\bar{x}-r\gamma\sigma_x^2\right)}{\sigma_x^2}$

Then, evaluate integral in square brackets by applying GR:

$$= 1 - \int_{-\infty}^{\infty} \left(\frac{e^{-r\left(\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\delta w_2-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2)\right)-\frac{\bar{x}_1^2}{2\sigma_x^2}}}{\sqrt{2\pi\sigma_x^2}} \right) \left[e^{-\frac{\left(\left(\bar{x}-r\sigma_x^2\right)/\sigma_x^2\right)^2}{4\left(1/2\sigma_x^2\right)}} \sqrt{\frac{\pi}{1/2\sigma_x^2}} \right] F(q_2)dq_2$$

which simplifies to:

$$= 1 - \int_{-\infty}^{\infty} e^{-r\left(\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma\bar{x}+\delta w_2-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2+\gamma^2\sigma_x^2)\right)} F(q_2)dq_2$$

$$= 1 - \int_{-\infty}^{\infty} e^{-r\left(\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma\bar{x}+\delta(\alpha_2+\beta_2((p_2-v_2)q_2-f_2))-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2+\gamma^2\sigma_x^2)\right)} \left[\frac{e^{-\frac{1}{2}\left(\frac{q_2^2+\bar{q}_2^2-2q_2\bar{q}_2}{\sigma_{q_2}^2}\right)}}{\sqrt{2\pi\sigma_{q_2}^2}} \right] dq_2$$

$$= 1 - \left(\frac{e^{-r\left(\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma\bar{x}+\delta(\alpha_1-\beta_2f_2)-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2+\gamma^2\sigma_x^2)\right)-\frac{\bar{q}_2^2}{2\sigma_{q_2}^2}}}{\sqrt{2\pi\sigma_{q_2}^2}} \right) \left[\int_{-\infty}^{\infty} e^{\left(\frac{-q_2^2+2q_2(\bar{q}_2-r\delta\beta_2(p_2-v_2)\sigma_{q_2}^2)}{2\sigma_{q_2}^2}\right)} dq_2 \right]$$

Under GR's formulation, let S = $\dfrac{1}{2\sigma_{q_2}^2}$ and let T = $\dfrac{\left(\bar{q}_2 - r\delta\beta_2(p_2-v_2)\sigma_{q_2}^2\right)}{\sigma_{q_2}^2}$

Then, evaluate integral in square brackets, by applying GR:

$$= 1 - \left(\frac{e^{-r\left(\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma\bar{x}+\delta(\alpha_2-\beta_2f_2)-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2+\gamma^2\sigma_x^2)\right)-\frac{\bar{q}_2^2}{2\sigma_{q_2}^2}}}{\sqrt{2\pi\sigma_{q_2}^2}} \right) \left[e^{-\frac{\left(\left(\bar{q}_2-r\delta\beta_2(p_2-v_2)\sigma_{q_2}^2\right)/\sigma_{q_2}^2\right)^2}{4\left(1/2\sigma_{q_2}^2\right)}} \sqrt{\frac{\pi}{1/2\sigma_{q_2}^2}} \right]$$

which simplifies to:

$$1 - e^{-r\left[\alpha_1+\beta_1((p_1-v_1)\bar{q}_1-f_1)+\gamma\bar{x}+\delta(\alpha_2+\beta_2((p_2-v_2)\bar{q}_2-f_2))-\frac{a^2}{2}-\frac{b^2}{2}-\frac{r}{2}(\beta_1^2(p_1-v_1)^2\sigma_{q_1}^2+\gamma^2\sigma_x^2+\delta^2\beta_2^2(p_2-v_2)^2\sigma_{q_2}^2)\right]}$$

Note that the term inside the square brackets in the above expression is the agent's certainty equivalent, because this model assumes the agent's utility function is of a negative exponential form. Further, maximising this expression leads to first order conditions that are exactly the same as the first order conditions from maximising the certainty equivalent expression directly.

Thus, we can now proceed to maximising the agent's certainty equivalent:

$$\Rightarrow \max_{a,b} \alpha_1 + \beta_1 \bar{\pi}_1 + \delta(\alpha_2 + \beta_2 \bar{\pi}_2) + \gamma E[\ln y] - \frac{a^2}{2} - \frac{b^2}{2} - \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma^2 \sigma_y^2 + \delta^2 \beta_2^2(p_2 - v_2)^2 \sigma_{q2}^2\right)$$

$$\Rightarrow \max_{a,b} \alpha_1 + \delta \alpha_2 + \beta_1\{(p_1 - v_1)q_1 - f_1\} + \delta \beta_2\{(p_2 - v_2)q_2 - f_2\} + \gamma(\ln \psi) - \frac{a^2}{2} - \frac{b^2}{2}$$

$$- \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma^2 \sigma_y^2 + \delta^2 \beta_2^2(p_2 - v_2)^2 \sigma_{q2}^2\right)$$

$$\Rightarrow \max_{a,b} \alpha_1 + \delta \alpha_2 + \beta_1\{(p_1 - v_1)(g_1 a - p_1) - f_1\} + \delta \beta_2\{(p_2 - v_2)(g_2 b - p_2) - f_2\} + \gamma b - \frac{a^2}{2} - \frac{b^2}{2}$$

$$- \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma^2 \sigma_y^2 + \delta^2 \beta_2^2(p_2 - v_2)^2 \sigma_{q2}^2\right)$$

First Order Conditions:

$$a^* = \beta_1(p_1 - v_1)g_1$$

$$b^* = \gamma + \delta \beta_2(p_2 - v_2)g_2$$

Second Order Conditions:

$$H = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$$

Principal Minor $= -1, \; < 0$

$$|H| = 1, > 0$$

$\therefore$ H is negative definite, satisfying second order conditions for a maximum.

The individual rationality constraint

This applies to both periods. In period 1, the individual rationality applies to the expected value of the agent's compensation for both periods. At the start of period 2, the individual rationality constraint applies to the expected compensation for period 2. Accordingly, the individual rationality constraint for period 1 is:

$$E\left[1 - e^{-r\left(w_1 + \delta w_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)}\right] \geq 0$$

If reservation utility $= 0$, then:

$$E\left[e^{-r\left(\tilde{w}_1 + \delta \tilde{w}_2 - \frac{a^2}{2} - \frac{b^2}{2}\right)}\right] = 1$$

$$\Rightarrow -rE\left[\tilde{w}_1 + \delta \tilde{w}_2 - \frac{a^2}{2} - \frac{b^2}{2} - \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma \sigma_y^2 + \delta^2(p_2 - v_2)^2 \beta_2^2 \sigma_{q2}^2\right)\right] = 0$$

$$\Rightarrow E[\tilde{w}_1 + \delta \tilde{w}_2] = \frac{a^2}{2} + \frac{b^2}{2} + \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma \sigma_y^2 + \delta^2(p_2 - v_2)^2 \beta_2^2 \sigma_{q2}^2\right)$$

$$\Rightarrow E[\tilde{w}_1] + \delta E[\tilde{w}_2] = \frac{a^2}{2} + \frac{b^2}{2} + \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2 \sigma_{q1}^2 + \gamma \sigma_y^2 + \delta^2(p_2 - v_2)^2 \beta_2^2 \sigma_{q2}^2\right)$$

Next, in period 2 the agent exerts no effort so the principal need only reward the agent for incremental risk premium. This reward is necessary to prevent the agent leaving at the end of period 1. The individual rationality constraint for period 2 is:

$$E\left[e^{-r(\tilde{w}_2)}\right] = 1$$

$$\Rightarrow -r\left(E[\tilde{w}_2] - \frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right)\right) = 0$$

$$\Rightarrow E[\tilde{w}_2] = \frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right)$$

Now, the principal's problem becomes:

$$\underset{\beta_1,\beta_2,\gamma}{Max}\, E[\tilde{\pi}_1 + \tilde{\pi}_2 - \tilde{w}_1 - \tilde{w}_2]$$

subject to:

$$E[\tilde{w}_1] + \delta E[\tilde{w}_2] = \frac{a^2}{2} + \frac{b^2}{2} + \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2\sigma_{q1}^2 + \gamma^2\sigma_y^2 + \delta^2\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right)$$

$$E[\tilde{w}_2] = \frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right)$$

$$a = \beta_1(p_1 - v_1)g_1$$

$$b = \gamma + \delta\beta_2(p_2 - v_2)g_2$$

Substitute constraints into objective function:

$$\Rightarrow E[\tilde{\pi}_1 + \tilde{\pi}_2 - \tilde{w}_1 - \tilde{w}_2]$$

$$= E[\tilde{\pi}_1] + E[\tilde{\pi}_2] - E[\tilde{w}_1] - \delta E[\tilde{w}_2] - (1-\delta)E[\tilde{w}_2]$$

$$= (p_1 - v_1)(g_1^2\,\beta_1(p_1 - v_1) - p_1) - f_1 + (p_2 - v_2)(g_2(\gamma + \delta\beta_2(p_2 - v_2)g_2) - p_2) - f_2 - \frac{(\beta_1(p_1 - v_1)g_1)^2}{2}$$

$$- \frac{(\gamma + \delta\beta_2(p_2 - v_2)g_2)^2}{2} - \frac{r}{2}\left(\beta_1^2(p_1 - v_1)^2\sigma_{q1}^2 + \gamma^2\sigma_y^2 + \delta^2\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right) - (1-\delta)\frac{r}{2}\left(\beta_2^2(p_2 - v_2)^2\sigma_{q2}^2\right)$$

First Order Conditions:

$$\frac{\partial\Pi}{\partial\beta_1^*} = (p_1 - v_1)^2 g_1^2 - \beta_1^*(p_1 - v_1)^2 g_1^2 - r\left(\beta_1^*(p_1 - v_1)^2\sigma_{q1}^2\right) = 0$$

$$\beta_1^* = \frac{g_1^2}{g_1^2 + r\sigma_{q1}^2}$$

$$\frac{\partial\Pi}{\partial\beta_2^*} = \delta(p_2 - v_2)^2 g_2^2 - \delta(p_2 - v_2)g_2\left(\gamma + \delta(p_2 - v_2)g_2\,\beta_2^*\right) - r\beta_2^*\delta^2(p_2 - v_2)^2\sigma_{q2}^2 - (1-\delta)\left(r\beta_2^*(p_2 - v_2)^2\sigma_{q2}^2\right) = 0$$

$$\beta_2^* = \frac{\delta g_2\left((p_2 - v_2)g_2 - \gamma\right)}{(p_2 - v_2)\left(\delta^2 g_2^2 + r\delta^2\sigma_{q2}^2 + (1-\delta)r\sigma_{q2}^2\right)}$$

$$\frac{\partial\Pi}{\partial\gamma^*} = (p_2 - v_2)g_2 - \left(\gamma^* + \delta(p_2 - v_2)g_2\,\beta_2\right) - r\sigma_y^2\gamma^* = 0$$

$$\gamma^* = \frac{(p_2 - v_2)g_2(1 - \delta\beta_2)}{1 + r\sigma_y^2}$$

Substituting γ^* into β_2^* and solving for β_2^*:

$$\beta_2^* = \frac{\delta g_2 \left((p_2 - v_2)g_2 - \frac{(p_2 - v_2)g_2\left(1 - \delta\beta_2^*\right)}{1 + r\sigma_y^2} \right)}{(p_2 - v_2)\left(\delta^2 g_2^2 + r\delta^2 \sigma_{q2}^2 + (1 - \delta)r\sigma_{q2}^2\right)}$$

$$\beta_2^* = \frac{\delta g_2^2 \sigma_y^2}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)}$$

Now solving for γ^* as a function of exogenous parameters:

$$\gamma^* = \frac{(p_2 - v_2)g_2\left(1 - \delta\left(\frac{\delta g_2^2 \sigma_y^2}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)}\right)\right)}{1 + r\sigma_y^2}$$

which simplifies to:

$$\gamma^* = \frac{(p_2 - v_2)g_2 \sigma_{q2}^2\left(1 - \delta + \delta^2\right)}{\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)}$$

Proof of Observation 3:

Differentiate (19) with respect to δ, and the numerator, which determines the sign, is:

$$= -L\delta^2 - M + M\delta - M\delta^2 + 2L\delta^3 + 2M\delta - 2M\delta^2 + 2M\delta^3 - 2L\delta + M - 2M\delta + 2L\delta^2 - M\delta$$
$$+ 2M\delta^2 - 2L\delta^3 + M\delta^2 - 2M\delta^3$$

$$= -2L\delta + L\delta^2$$

$$= L\delta(\delta - 2), \quad < 0$$

Proof of Observation 4(i):

$$\frac{\partial\gamma^*}{\partial\sigma_y^2} = \frac{0 - (p_2 - v_2)g_2 \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(\delta^2 g_2^2 + r\sigma_{q2}^2\left(1 - \delta + \delta^2\right)\right)}{\left(\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)\right)^2}$$

which simplifies to

$$\frac{\partial\gamma^*}{\partial\sigma_y^2} = \frac{(-1)\left((p_2 - v_2)g_2^3 \sigma_{q2}^2 \delta^2\left(1 - \delta + \delta^2\right) + r(p_2 - v_2)g_2\left(\sigma_{q2}^2\right)^2\left(1 - \delta + \delta^2\right)^2\right)}{\left(\delta^2 g_2^2 \sigma_y^2 + \sigma_{q2}^2\left(1 - \delta + \delta^2\right)\left(1 + r\sigma_y^2\right)\right)^2}$$

The model assumes all parameters are positive and that $0 \leq \delta < 1$. Therefore, the above term must be negative because of the presence of a -1 multiplier in the numerator.

Proof of Observation 4(ii):

$$\frac{\partial \gamma}{\partial r}^* = \frac{0 - (p_2 - v_2)g_2 \, \sigma_{q2}^2 (1 - \delta + \delta^2)(\sigma_v^2 \sigma_{q2}^2)(1 - \delta + \delta^2)}{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)^2}$$

which simplifies to

$$\frac{\partial \gamma}{\partial r}^* = \frac{(-1)\left((p_2 - v_2)g_2 \, \sigma_v^2 (\sigma_{q2}^2)^2 (1 - \delta + \delta^2)^2\right)}{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)^2}$$

The model assumes all parameters are positive and that $0 \le \delta < 1$. Therefore, the above term must be negative because of the presence of a negative sign in the numerator.

Proof of Observation 5:

$$\frac{\partial \gamma}{\partial \sigma_{q2}^2}^* = \frac{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)(p_2 - v_2)g_2(1 - \delta + \delta^2) - (p_2 - v_2)g_2 \, \sigma_v^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)(1 - \delta + \delta^2)}{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)^2}$$

which simplifies to

$$\frac{\partial \gamma}{\partial \sigma_{q2}^2}^* = \frac{(p_2 - v_2)g_2^3 \, \sigma_v^2 \delta^2 (1 - \delta + \delta^2)^2}{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)^2}$$

The model assumes all parameters are positive and that $0 \le \delta < 1$. Therefore, the above term must be positive because both the numerator and denominator will generate positive values.

Proof of Observation 6:

$$\frac{\partial \gamma}{\partial g_2}^* = \frac{(p_2 - v_2)\sigma_{q2}^2 \left((1 - \delta + \delta^2)^2 \, \sigma_{q2}^2 (1 + r\sigma_v^2) - \delta^2 (1 - \delta + \delta^2)g_2^2 \, \sigma_v^2\right)}{\left(\delta^2 g_2^2 \, \sigma_v^2 + \sigma_{q2}^2 (1 - \delta + \delta^2)(1 + r\sigma_v^2)\right)^2}$$

The model assumes all parameters are positive and that $0 \le \delta < 1$. The denominator will clearly generate a positive value. However, the numerator can generate either positive or negative values, depending on the magnitudes of the elements of the numerator. Each element in the numerator is a determinant of the relative risk premium payable to the agent, when choosing to adjust either γ^* or β_2^*. Therefore, the sign of the above term (and hence the direction of the change to the optimal DFP weight when g_2 changes) will clearly depend on the magnitudes of the determinants of the relative risk premium payable when choosing to adjust either γ^* or β_2^*.

Proof of Observation 7:

Need to show:

1. A positive weight on the DFP measure will obtain, irrespective of the financial performance measure used.

2. Different financial performance measures can lead to different optimal incentive weights on the DFP measure.

Part 1:

i.   See above proof of optimal incentive weights to see that a positive DFP measure obtains using profit as the financial performance measure.

ii.   Using revenue as the financial performance measure is equivalent to substituting p_i for $(p_i - v_i)$ in the proof of the optimal incentive weights. Identical results obtain except whenever $(p_i - v_i)$ appears in the original results, replace with p_i. Therefore, the optimal DFP weight using revenue as a financial performance measure yields:

$$\gamma^{*R} = \frac{p_2 g_2 \, \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)}{\delta^2 g_2^2 \, \sigma_y^2 + \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)\left(1 + r \, \sigma_y^2\right)}$$

Under the assumptions of the model, the value of this variable must be positive.

iii.   Using quantity sold as the financial performance measure is equivalent to deleting $(p_i - v_i)$ from the proof of the optimal incentive weights. Identical results obtain except delete the expression $(p_i - v_i)$ in the original results. Therefore, the optimal DFP weight using quantity sold as a financial performance measure yields:

$$\gamma^{*Q} = \frac{g_2 \, \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)}{\delta^2 g_2^2 \, \sigma_y^2 + \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)\left(1 + r \, \sigma_y^2\right)}$$

Under the assumptions of the model, the value of this variable must be positive.

iv.   Using residual income as the financial performance measure is equivalent to using profit as the financial performance measure. The cost of assets charge deducted from profit in the residual income measure becomes irrelevant in the first order conditions of the profit optimisation problem. The original proof for the optimal incentive weights (earlier) shows the DFP weight will be a positive value.

Part 2:

i.   See proof of optimal incentive weights to see the derivation of the "benchmark" DFP weight that is used to assess the potential equivalence of the DFP weights using the other financial performance measures. The benchmark DFP weight is as follows:

$$\gamma^* = \frac{(p_2 - v_2) g_2 \, \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)}{\delta^2 g_2^2 \, \sigma_y^2 + \sigma_{q2}^2 \left(1 - \delta + \delta^2\right)\left(1 + r \, \sigma_y^2\right)}$$

ii.   The DFP benchmark weight in i) is equivalent to the DFP weight in ii) if and only if the variable costs of the firm are equal to zero. This is impossible, given that the principal hires an agent and offers a variable component to the agent's compensation. Thus, the incentive contract weight on the DFP is clearly affected by the type of financial performance measure used.

iii.   The DFP benchmark weight in i) is equivalent to the DFP weight in iii), if and only if the contribution margin of the firm equals 1. The only restriction on contribution margin is that it must be greater than zero, or else the principal will not produce output in the short run. Thus, if the value of the contribution margin equals 1, the optimal incentive contract weight on the DFP will be equivalent using either profit or quantity as the financial performance measure.

iv.   Since the DFP benchmark weight is the same DFP weight as in iv), the two weights are equivalent, despite the difference in financial performance measures.

Proof of Observation 8:

The agency program is the same as that for the optimal incentive weights, except substitute equation (20) for equation (3). The resulting optimal effort levels are those reported in equations (21) and (22). The resulting optimal incentive weights are those reported in equations (23), (24) and (25). Each optimal incentive weight function includes the precision of each of the three performance measures, implying a trade-off between all three performance measures.

Appendix 3: Alternative Derivations of Optimal Incentive Weights in Chapter 2

The optimal incentive weights from the basic model in chapter 2 can be derived from the formulations of two related papers in the accounting literature: Feltham and Xie (1994) and Banker and Datar (1989). The contribution of the work in chapter 2 relative to these papers is that this work includes a particular parametric structure that aims to capture the specifically observed phenomena of short-term performance incentive being used to reward long-term performance. This generates additional insight on how various parameters can affect incentive weights. By contrast, Feltham and Xie (1994) and Banker and Datar (1989) operate at a more general level. The relative contribution of this work is analogous to the relative contribution of section IV of Feltham and Xie (1994) where specific applications of the model are generated to "...provide *further* insight into the two different roles of additional performance measures." (Feltham and Xie, 1994: 440, emphasis added).

As a useful comparison, the mathematical relationship between much of the settings in the basic model in Chapter 2 and both Feltham and Xie (1994) and Banker and Datar (1989) is presented in this appendix. To facilitate the comparisons, assume $\delta = 1$ in chapter 2, since $0 < \delta < 1$ as presented in chapter 2 implies a two period model and Feltham and Xie (1994) and Banker and Datar (1989) are both single period models.

Derivation of Absolute Incentive Weights Using Feltham and Xie (1994)

In Feltham and Xie (1994), effort is characterized as a multidimensional vector, a, with a corresponding marginal payoff vector, b. The agent's compensation is based on a vector of performance measures, $y = \mu a + \varepsilon$, where μ represents a matrix of performance measure "sensitivities" and ε is a normally distributed vector with means 0, and a variance-covariance matrix, Σ. The agent's compensation is assumed linear and of the form, $w = \text{constant} + v'y$.

Now I apply the assumptions and most of the settings established in chapter 2 in terms of Feltham and Xie's notation. First, the agent's effort is:

$$\mathbf{a} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \ln(\phi) \\ \ln(\psi) \end{bmatrix}$$

The marginal payoff from the agent's effort is:

$$\mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} g_1(p_1 - v_1) \\ g_2(p_2 - v_2) \end{bmatrix}$$

The set of performance measures is:

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} \pi_1 \\ \ln(y) \\ \pi_2 \end{bmatrix}$$

The matrix of performance measure "sensitivities" is:

$$\mu = \begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \\ \mu_{31} & \mu_{32} \end{bmatrix} = \begin{bmatrix} g_1(p_1 - v_1) & 0 \\ 0 & 1 \\ 0 & g_2(p_2 - v_2) \end{bmatrix}$$

The variance-covariance matrix associated with the performance measures is:

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} & \Sigma_{13} \\ \Sigma_{21} & \Sigma_{22} & \Sigma_{23} \\ \Sigma_{31} & \Sigma_{32} & \Sigma_{33} \end{bmatrix} = \begin{bmatrix} (p_1 - v_1)^2 \sigma_{q1}^2 & 0 & 0 \\ 0 & \sigma_y^2 & 0 \\ 0 & 0 & (p_2 - v_2)^2 \sigma_{q2}^2 \end{bmatrix}$$

Note that non-zero values appear only in the diagonals, which reflects the independence of each of the error terms associated with the three different performance measures.

Feltham and Xie (1994) show that optimal incentive weights can be derived as follows:

$$v = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = [\mu\mu' + r\Sigma]^{-1} \mu b$$

Substituting the assumed parameters from chapter 2 (expressed in terms of Feltham and Xie (1994) notation, as per above), into the above formulation for v leads to:

$$v^* = \begin{bmatrix} \beta_1 \\ \gamma \\ \beta_2 \end{bmatrix} = \begin{bmatrix} (p_1 - v_1)^2(g_1^2 + r\sigma_{q1}^2) & 0 & 0 \\ 0 & (1 + r\sigma_y^2) & g_2(p_2 - v_2) \\ 0 & g_2(p_2 - v_2) & (p_2 - v_2)^2(g_1^2 + r\sigma_{q2}^2) \end{bmatrix}^{-1} \begin{bmatrix} g_1^2(p_1 - v_1)^2 \\ g_2(p_2 - v_2) \\ g_2^2(p_2 - v_2)^2 \end{bmatrix}$$

Matrix multiplication of v^* leads to the same expressions for the optimal incentive weights as in equations (16), (17), and (18), assuming $\delta = 1$.

Derivation of Relative Incentive Weights Using Banker and Datar (1989)

The key finding from Banker and Datar (1989) is that relative incentive weights can be expressed, under certain conditions, as the ratio of the sensitivity (with respect to effort) times the precision of the respective performance measures. Given that the conditions generated in this model satisfy the requirements for application of Banker and Datar (1989), the ratio of γ / β_2 in chapter 2 can be characterized (assuming $\delta = 1$) as follows:

$$\frac{\gamma}{\beta_2} = \left(\frac{(\text{sensitivity X precision) of } \ln(y)}{(\text{sensitivity X precision) of } \pi_2} \right)$$

$$= \left(\frac{\dfrac{\partial E[\ln(y)]}{\partial \psi} \Big/ \text{Var}[\ln(y)]}{\dfrac{\partial E[\pi_2]}{\partial \psi} \Big/ \text{Var}[\pi_2]} \right)$$

$$= \left(\dfrac{\dfrac{1}{\psi} \Big/ \sigma_r^2}{\dfrac{g_2(p_2 - v_2)}{\psi} \Big/ (p_2 - v_2)^2 \, \sigma_{q2}^2} \right)$$

$$= \dfrac{g_2 \, \sigma_r^2}{(p_2 - v_2) \sigma_{q2}^2}$$

Assuming $\delta = 1$, this expression is the same as that generated from dividing equation (18) by equation (17), i.e. γ^* / β_2^*.

Appendix 4: Proof of Rational Market Price Equilibrium

Contractible Financial Signal Setting (Section 4.5)

The structure of the following proof is similar to that found in Kim and Suh (1993 : 29-32). In a rational expectations equilibrium, market participants conjecture the relationship between the market price and information held by the participants. The conjecture is self-fulfilling. Assume the conjecture is given by:

$$\tilde{m} = d_0 + d_1\tilde{\pi}_1 + d_F\tilde{\pi}_F + d_G\tilde{\pi}_2 + d_y \ln(\tilde{y}) + d_z\tilde{z} - \tilde{w}_1 - \tilde{w}_2 \tag{109}$$

A normalized price signal can be defined as:

$$\tilde{n} = \frac{1}{d_G}\left(\tilde{m} - d_0 - d_1\tilde{\pi}_1 - d_F\tilde{\pi}_F - d_y \ln(\tilde{y}) + \tilde{w}_1 - \tilde{w}_2\right)$$

$$= \tilde{\pi}_2 + D\tilde{z} \tag{110}$$

where $D = d_z / d_G$. The signal n represents the pure addition of knowledge due to observing price, beyond what is available from other pieces of information. For convenience, the normalized price signal is used in the calculation of the optimal incentive contract weights. The next step is to define, at the end of period 1, the conditional expectation of the final payoff. This will be the sum of the realized period 1 payoff plus the weighted average of the different sources of information used by the market to infer the period 2 payoff. Accordingly:

$$\tilde{\Pi} = \tilde{\pi}_1 - \tilde{w}_1 + E\left[(\tilde{\pi}_2 - \tilde{w}_2)\big|\tilde{\pi}_F, \tilde{\pi}_{Gj}, \tilde{n}\right]$$

$$= \tilde{\pi}_1 + \frac{1}{Q}\left(\frac{\hat{\pi}_2}{\sigma_{q2}^2} + \frac{\tilde{\pi}_F}{\sigma_F^2} + \frac{\tilde{\pi}_{Gj}}{\sigma_G^2} + \frac{\tilde{n}}{D^2\sigma_z^2}\right) - \left(\alpha_1 + \beta_1\tilde{\pi}_1 + \theta\tilde{n} + \gamma\ln(\tilde{y})\right) - \left(\alpha_2 + \hat{\beta}_2\tilde{\pi}_2\right) \tag{111}$$

where:

$$Q \equiv \text{var}\left[(\tilde{\pi}_2 - \tilde{w}_2)\big|\tilde{\pi}_F, \tilde{\pi}_{Gj}, \tilde{n}\right]$$

$$= \sigma_{q2}^2 + \sigma_F^2 + \sigma_{Gj}^2 + D^2\sigma_z^2 \tag{112}$$

Q is calculated using the standard derivation for the variance of conditional on observed signals (cf. Grossman and Stiglitz, 1980, Appendix A). Given three observed signals, it is necessary to compute the determinant of a 4 X 4 matrix, divided by the determinant of a 3 X 3 matrix to derive the value of Q specified in expression (112).

The private investors are assumed to exhibit constant absolute risk aversion and their expected utility is given by:

$$E[I] = -\exp\left(-\frac{W}{R}\right) \tag{113}$$

where R is the investors' risk tolerance. Using the moment-generating function of a normal random variable, the investors' expected utility conditional on the observed information signals is:

$$E\left[I\big|\tilde{\pi}_F, \tilde{\pi}_{Gj}, \tilde{n}\right] = E\left[-\exp\left(-(\tilde{\pi}_1 + \tilde{\pi}_2 - \tilde{m})\frac{Z_j}{R}\right)\bigg|\tilde{\pi}_F, \tilde{\pi}_{Gj}, \tilde{n}\right]$$

$$= -\exp\left(-\left(\tilde{\pi}_1 + \left(E\left[\tilde{\pi}_2\big|\tilde{\pi}_F, \tilde{\pi}_{Gj}, \tilde{n}\right] - \tilde{m}\right)\right)\frac{Z_j}{R} + \frac{1}{2Q}\left(\frac{Z_j}{R}\right)^2\right) \tag{114}$$

The first order condition that maximizes utility, with respect to the demand for shares, Z_j is:

$$Z_j = RQ\left[\tilde{\pi}_1 + \frac{1}{Q}\left(\frac{\hat{\pi}_2}{\sigma_{q2}^2} + \frac{\tilde{\pi}_F}{\sigma_F^2} + \frac{\tilde{\pi}_{G_j}}{\sigma_G^2} + \frac{\tilde{n}}{D^2\sigma_z^2}\right) - \left(\alpha_1 + \beta_1\tilde{\pi}_1 \cdot \theta\tilde{n} + \gamma \ln(\tilde{y})\right) - \left(\alpha_2 + \hat{\beta}_2\hat{\pi}_2\right) - \tilde{m}\right] \quad (115)$$

Aggregating over j and applying a zero excess demand condition leads to:

$$\tilde{m} = \tilde{\pi}_1 + \frac{1}{Q}\left(\frac{\hat{\pi}_2}{\sigma_{q2}^2} + \frac{\tilde{\pi}_F}{\sigma_F^2} + \frac{\tilde{\pi}_2}{\sigma_G^2} + \frac{\tilde{n}}{D^2\sigma_z^2}\right) - \left(\alpha_1 + \beta_1\tilde{\pi}_1 \cdot \theta\tilde{n} + \gamma \ln(\tilde{y})\right) - \left(\alpha_2 + \hat{\beta}_2\hat{\pi}_2\right) - \frac{\bar{z}}{RQ} \quad (116)$$

Since the initial conjecture by the market participants must be self-fulfilling, (109) and (116) are equivalent in equilibrium. Thus:

$$D \equiv \frac{d_z}{d_G} = \frac{\dfrac{1}{QD\sigma_z^2} - \theta D + \dfrac{1}{RQ}}{\dfrac{1}{Q\sigma_G^2} + \dfrac{1}{QD^2\sigma_z^2} - \theta} \quad (117)$$

$$\Rightarrow \frac{d_z}{d_G} = \frac{1}{R\sigma_G^2}$$

It follows that:

$$d_0 = \frac{\hat{\pi}_2/\sigma_{q2}^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} - \left(\alpha_1 + \alpha_2 + \gamma \ln(\tilde{y}) + \hat{\beta}_2\hat{\pi}_2\right)$$

$$d_1 = 1 - \beta_1$$

$$d_F = \frac{1/\sigma_F^2}{1/\sigma_{q2}^2 + 1/\sigma_F^2 + 1/\sigma_G^2 + d_G^2/d_z^2\sigma_z^2} \quad (118)$$

$$d_y = 0$$

$$\frac{d_Z}{d_G} = \frac{1}{R\sigma_G^2}$$

Non-contractible Financial Signal Setting (Section 4.6.2)

Eliminate the weights on the financial signals and follow the same steps as above in this appendix. This will yield a competitive rational expectations equilibrium characterized by the price coefficients in expression (104).

References

Abernethy, M.A. and A.M. Lillis. 1995. The impact of manufacturing flexibility on management control system design. *Accounting, Organizations and Society.* 20 : 241-258.

Amir, E. and B. Lev. 1996. Value-relevance of nonfinancial information. *Journal of Accounting and Economics.* 22(1-3) : 3-30.

Anderson, E.W., C. Fornell, and D. Lehmann. 1994. Customer satisfaction, market share, and profitability: findings from Sweden. *Journal of Marketing.* 58 : 53-66.

Atkinson, A.A. 1998. Strategic performance measurement and incentive compensation. *European Management Journal.* Forthcoming.

_____, R.D. Banker, R.S. Kaplan, and S.M. Young. 1997. *Management Accounting.* Prentice-Hall : Englewood Cliffs, New Jersey.

_____, J.H. Waterhouse, and R. Wells. 1997. A stakeholder approach to strategic performance measurement. *Sloan Management Review.* Spring. 38(3) : 25-37.

Baiman, S. 1982. Agency research in managerial accounting: a survey. *Journal of Accounting Literature.* 1 : 154-213.

_____. 1990. Agency research in managerial accounting: a second look. *Accounting, Organizations and Society.* 15(4) : 341-371.

_____ and Demski, J.S. 1980. Economically optimal performance evaluation and control systems. *Journal of Accounting Research.* 18 (Supplement) : 184-220.

_____, D.F. Larcker, and M.V. Rajan. 1995. Organizational design for business units. *Journal of Accounting Research.* 33(2) : 205-229.

_____, P.E. Fischer, and M.V. Rajan. 1995. Supplier relationships, monitoring, and product quality. Working Paper, University of Pennsylvania.

Baker, G.P. 1992. Incentive contracts and performance measurement. *Journal of Political Economy.* 100(3) : 598-614.

Banker, R.D. and S. Datar. 1989. Sensitivity, precision, and linear aggregation of signals for performance evaluation. *Journal of Accounting Research.* 27(1): 21-39.

_____, G. Potter, and R.G. Schroeder. 1993. Reporting manufacturing performance measures to workers: an empirical study. *Journal of Management Accounting Research.* 5 : 33-55.

_____, _____, and D. Srinivasan. 1997. An empirical investigation of an incentive plan based on nonfinancial performance measures. Working Paper, University of Pittsburgh.

Barclay, M.J., D. Gode, and S.P. Kothari. 1997. Measuring delivered performance. Working Paper, University of Rochester.

Bell, T.B., F.O. Marrs, I. Solomon, and H. Thomas. 1997. Auditing Organizations Through a Strategic-Systems Lens: The KPMG Measurement Process. KPMG Peat Marwick LLP.

Bernstein, A. 1998. We want you to stay. Really. *Business Week.* June 22: 67-72.

Booth, P. 1995. The future of management accounting. *Management Accounting Issues Report.* Management Accounting Centre of Excellence. June 1 : 1-12.
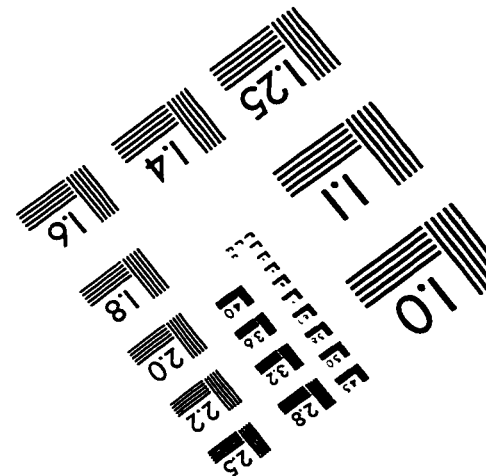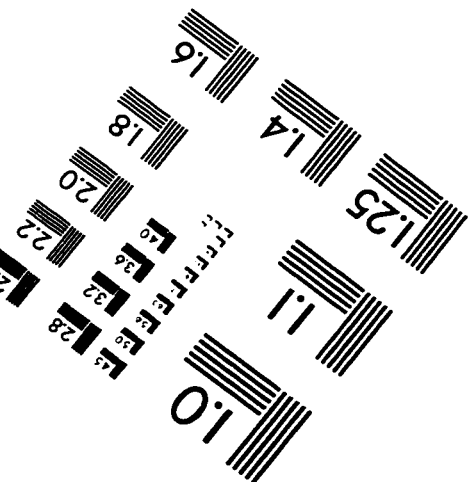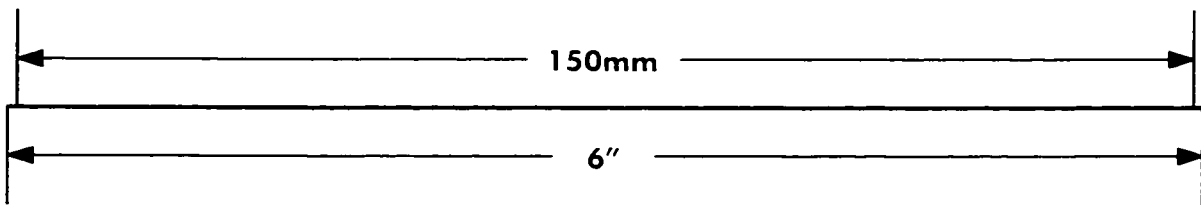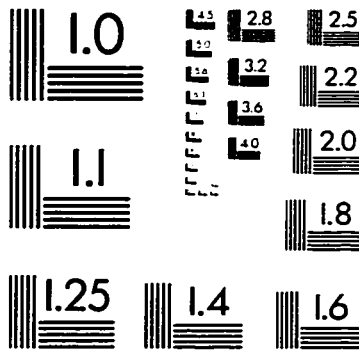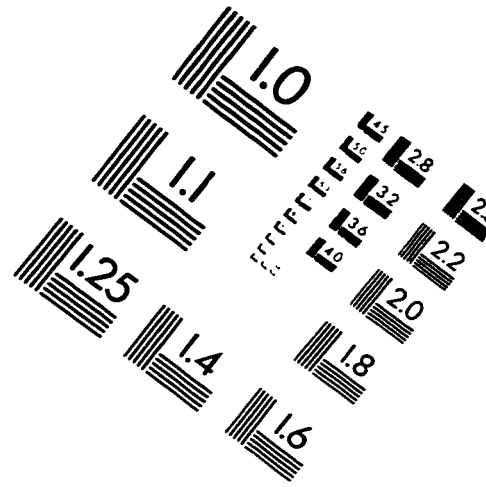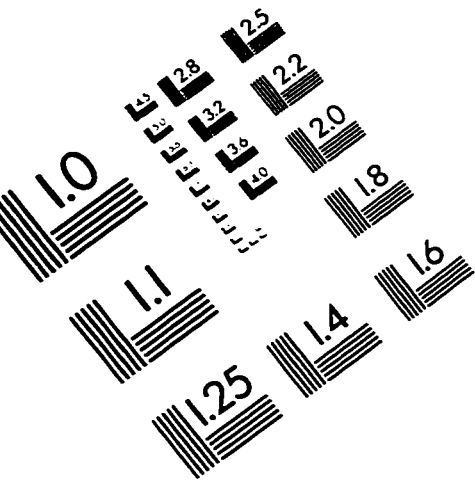
Brown, E. 1997. The push to streamline supply chains. *Fortune.* March 3 : 108[C]-108[R].

Brown, S.F. 1996. Detroit to suppliers: quality or else. *Fortune.* September 30 : 134[C]-134[H].

Brownell, P. 1995. *Research Methods in Management Accounting.* Coopers & Lybrand Accounting Research Methodology Monograph No.2. Coopers & Lybrand, Melbourne, Australia.

Bushman, R.M. and R.J. Indjejikian. 1993a. Accounting income, stock price, and managerial compensation. *Journal of Accounting and Economics.* 16: 3-23.

_____ and _____. 1993b. Stewardship value of distorted accounting disclosures. *The Accounting Review.* 68(4): 765-782.

_____, _____, and A. Smith. 1995. Aggregate performance measures in business unit manager compensation: the role of intrafirm interdependencies. *Journal of Accounting Research.* 33 (supplement) : 101-128.

_____, _____, and _____. 1996. CEO compensation: the role of individual performance evaluation. *Journal of Accounting and Economics.* 21: 161-193.

Chenhall, R.H. and K. Langfield-Smith. 1998. Adoption and benefits of management accounting practices: an Australian study. *Management Accounting Research.* 9 : 1-19.

Datar, S.M. and M.V. Rajan. 1995. Optimal incentive schemes in bottleneck-constrained production environments. *Journal of Accounting Research.* 33(1) : 33-57.

Dempsey, S.J., J.F. Gatti, D.J. Grinell, and W.L. Cats-Baril. 1997. The use of strategic performance variables in financial analysts' forecasts. *Journal of Financial Statement Analysis.* Summer.

Demski, J.1994. *Managerial Uses of Accounting Information.* Kluwer Academic Publishers, Norwell, Massachusetts.

Diamond, D.W. and R.E. Verrecchia. 1981. Information aggregation in a noisy rational expectations economy. *Journal of Financial Economics.* 9 : 221-235.

Drennan. L. 1995. The determinants of firm performance control. Working Paper, University of Queensland.

Evans, H., G. Ashworth, J. Gooch, and R. Davies. 1996. Who needs performance management? *Management Accounting (UK).* December : 20-25.

Feltham, G. A. and J. Xie. 1994. Performance measure congruity and diversity in multi-task principal/agent relations. *The Accounting Review.* 69(3): 429-453.

Fornell, C., C.D. Ittner, and D. F. Larcker. 1996. The valuation consequences of customer satisfaction. Working Paper. Universities of Michigan and Pennsylvania.

Foster, G. and M. Gupta. 1997. The customer profitability implications of customer satisfaction. Working Paper, Stanford University.

Government of Alberta. 1997. Alberta Treasury "Measuring Up '97" Report - Introduction. http://www.treas.gov.ab.ca/comm/measup97/

Gradshteyn, I.S., and I.M. Ryzhik. 1965. *Tables of Integrals Series and Products.* Academic Press.

Grossman, S.J. and J.E. Stiglitz. 1980. On the impossibility of informationally efficient markets. *American Economic Review.* June : 393-408.

Hayes, R.M. and S. Schaefer. 1997. Implicit contracts and the explanatory power of top executive compensation for future performance. Working Paper. Northwestern University.

Hauser, J.R., D.I. Simester, and B. Wernerfelt. 1994. Customer satisfaction incentives. *Marketing Science.* 13(4): 327-350.

Hemmer, T. 1996. On the design and choice of "modern" management accounting measures. *Journal of Management Accounting Research.* 8: 87-116.

Hirschey, M., V.J. Richardson, and S. Scholz. 1998. Value relevance of nonfinancial information: the case of patent data. Working Paper, University of Kansas.

Holmstrom, B. 1979. Moral hazard and observability. *The Bell Journal of Economics.* Spring: 74-91.

_____, and P. Milgrom. 1987. Aggregation and linearity in the provision of inter-temporal incentives. *Econometrica.* 55(2): 303-328.

_____, and _____. 1991. Multitask principal-agent analyses: incentive contracts, asset ownership, and job design. *Journal of Law, Economics and Organization.* 7: 524-552.

Ittner, C.D. and D.F. Larcker. 1995. Total quality management and the choice of information and reward systems. *Journal of Accounting Research.* 33 (Supplement) : 1-34.

_____ and _____. 1996. Quality strategy, strategic control systems, and organizational performance. *Accounting, Organizations and Society.* April/May, 22 (3-4) : 293-314.

_____ and _____. 1998. Are non-financial measures leading indicators of financial performance? an analysis of customer satisfaction. Working Paper, University of Pennsylvania.

_____, _____, V. Nagar, and M.V. Rajan. 1997. Supplier selection, monitoring practices and firm performance. Working Paper, University of Pennsylvania.

_____, _____, and M.V. Rajan. 1997. The choice of performance measures in annual bonus contracts. *The Accounting Review.* 72(2): 231-256.

Japan Airlines. 1998. Japan Airlines Procurement Information. From the Japan Airlines website at http://www.jal.co.jp/procure/index_e.html

Jensen, M.C. and W.H. Meckling. 1976. Theory of the firm: managerial behaviour, agency costs, and ownership structure. *Journal of Financial Economics.* 11 : 5-51.

Kaplan, R.S. and A.A. Atkinson. 1998. *Advanced Management Accounting.* Third Edition. Prentice-Hall, Englewood Cliffs, New Jersey.

_____, and D.P. Norton. 1992. The balanced scorecard – measures that drive performance. *Harvard Business Review.* January-February : 71-79.

_____, and _____. 1993. Putting the balanced scorecard to work. *Harvard Business Review.* September-October : 134-142.

Keating, S. 1996. Accounting metrics for division manager performance evaluation. Working Paper, University of Rochester.

Kim, O. and Y. Suh. 1993. Incentive efficiency of compensation based on accounting and market performance. *Journal of Accounting and Economics.* 16 : 25-53.

Lessner, J. 1989. Performance measurement in a Just-In-Time environment: can traditional performance measurements still be used? *Journal of Cost Management.* Fall : 22-28.

Loveman, G.W. 1996. The service profit chain: large sample evidence from the financial services sector. Working Paper, Harvard Business School.

Martin, J. 1998. As customers go, so goes the Dow. *Fortune.* February 16 : 168.

Maskell, B.H. 1989. Performance measurement for world class manufacturing. *Management Accounting. (UK).* May : 32-33.

McBride, P. 1997. Reporting non-financial information. *Australian Accountant.* September : 20-21.

Moon, P. and L. Fitzgerald. 1996. Delivering the goods at TNT: the role of the performance measurement system. *Management Accounting Research.* 7 : 431-457.

Morissette, R. 1996. Toward a theory of information choices in organisations: an integrative approach. Unpublished Doctoral Thesis Dissertation, University of Waterloo.

Nanni, A.J., J.R. Dixon, and T.E. Vollmann. 1992. Integrated performance measurement: management accounting to support the new manufacturing realities. *Journal of Management Accounting Research.* 4 : 1-19.

Nayyar, P. R. 1995. Stock market reactions to customer service changes. *Strategic Management Journal.* 16 : 39-53.

Otley, D. 1997. Better performance management. *Management Accounting (UK).* January : 44.

Paul, J.M. 1992. On the efficiency of stock-based compensation. *Review of Financial Studies.* 5(3) : 471-502.

Perera. S., G. Harrison. and M. Poole. 1997. Customer-focused manufacturing strategy and the use of operations-based non-financial performance measures: a research note. *Accounting, Organizations and Society.* 22(6) : 557-572.

Richardson, G.D. 1998. Signals and signs. *CA Magazine.* March : 37-39.

Rucci, A.J., S.P. Kim, and R.T. Quinn. 1998. The employee-customer-profit chain at Sears. *Harvard Business Review.* January-February: 82-97.

Scott, W.R. 1997. *Financial Accounting Theory.* Prentice-Hall, Englewood Cliffs, New Jersey.

Smith, G.M. 1990. The rise and rise of the NFI. *Management Accounting (UK).* May : 24-26.

_____. 1997. *Strategic Management Accounting: Issues and Cases.* 2nd Edition. Butterworths, Australia. www.butterworths.com.au

Srinivasan, D. 1995. Relation between financial and nonfinancial measures of performance. Working Paper, University of Minnesota.

Stivers, B.P., T.J. Covin, N.G. Hall, and S.W.Smalt. 1997. Harnessing corporate IQ. *CA Magazine.* April : 26-29.

The Economist. 1997. Webbed Flight. February 8th : 66.

Thomas, G.B. and R.L. Finney. 1992. *Calculus and Analytic Geometry.* Addison-Wesley Publishing Company, New York.

Waterhouse, J.H. and A. Svendsen. 1998. *Strategic Performance Monitoring and Management: Using Non-Financial Measures to Improve Corporate Governance.* Research Monograph, Canadian Institute of Chartered Accountants, forthcoming.

Watts, R. and J. Zimmerman. 1986. *Positive Accounting Theory.* Prentice-Hall, Englewood Cliffs, New Jersey.

Wu, M.G.H. 1995. Public report, private information, managerial compensation and effort allocation. Working Paper, University of British Columbia.

IMAGE EVALUATION
TEST TARGET (QA-3)

150mm

6"