Psychology Models of Management Accounting

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Psychology Models of Management Accounting

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Abstract

This review identifies subjective decision-making processes related to management accounting (MA) and uses these processes as a basis for organizing psychology-based research on MA. For each decision process we identify families of related psychology models that have supported robust theory-consistent empirical results. This MA literature addresses four main themes. First, individuals' subjective valuation of monetary payoffs often depends on frames (reference points) provided by MA, and frames can influence the use of MA information in decision making. Second, the subjective value of non-monetary (social) payoffs from sources such as fairness, honesty, reciprocity, social identity or affect influence and are influenced by individuals' MA-related decisions. Third, individuals' subjective models of MA-related decisions often incorporate predictable simplifications that influence and are influenced by MA. Fourth, MA can influence — sometimes bias or limit — individuals'

learning, and learning influences MA, as individuals acquire parameter and variable values or the information to estimate them subjectively. We also identify two emerging themes and three gaps in the psychology-based MA literature.

1

Introduction

Management accounting (MA) practices (e.g., budgeting, cost estimation, performance measurement, and evaluation) support a variety of organizational activities, including the design of incentive contracts, the allocation of resources, and the legitimation of power (Chapman et al., 2007a,b, 2009). Much research has focused on the role of MA in providing information for individuals (e.g., accountants, engineers, managers) to solve problems, formulate judgments, and make decisions.[1] (Hereafter all three cognitive tasks will be called decisions unless we are referring only to problem-solving or judgments.) In our review we analyze the contributions of psychology-based research to explaining patterns in individuals' MA-related decision making.

Psychology is the science of the human mind (e.g., affect, attitudes, cognition, motivation, social interaction) and behavior (e.g., actions,

[1] A *problem* occurs when an individual has a goal but does not know immediately how to attain it (Newell and Simon, 1972). A *judgment* is a comparison of a stimulus to another stimulus or the evaluation of a stimulus in relation to a standard (e.g., manager A's performance is better than manager B's performance, manager A's performance is excellent in relation to the organization's evaluation criteria). A *decision* is the choice of a stimulus (action, alternative) from a set of stimuli (e.g., a manager decides to produce product A and not products B and C).

communications) (Birnberg et al., 2007). It focuses on behavior by individuals and small groups rather than by markets and organizations, and on subjective (cognitive) phenomena such as mental representations. Subjective phenomena play an important role in MA because subjective decision making is widely prevalent in organizations, in spite of the array of sophisticated quantitative techniques available to support managerial decisions.[2] For example, research on product pricing has shown that some firms estimate demand functions econometrically, other firms rely on managers' subjective judgments of the relation between product price and quantity, and still other firms use rules of thumb that base product pricing decisions on production costs or competitors' prices without explicitly considering demand (Blinder et al., 1998). The use of subjective decision making instead of or in addition to the use of quantitative techniques remains widespread, as indicated by surveys of practice over time and around the world (Green et al., 1977; Kathawala, 1988; Lam, 1993; Naudé et al., 1997; Francis and Minchington, 1999).[3] A 2008 survey of executives by Accenture indicates that 40% of major corporate decisions are subjective rather than based on quantitative techniques (Wailgum, 2009). Even when quantitative techniques substitute for subjective judgment, as Einhorn and Hogarth (1981) point out, subjective decisions are required to select among multiple techniques, none of which is an exact fit to the decision at hand because each makes different simplifications.[4]

[2] Subjective decision making can take a variety of forms, such as deciding subjectively which of a number of alternative quantitative techniques to use, or thinking carefully through the steps of a rule of thumb decision model (e.g., "price just a little lower than the most important competitor"), or purely intuitive (automated or gut feel) decisions, in which the decision-maker is not fully conscious of why one alternative "feels right" and others do not. Even purely intuitive decisions typically exhibit consistent patterns and can therefore be modeled.

[3] These surveys identify a number of reasons for reliance on subjective decision making. In some cases quantitative techniques have not yet been developed that are appropriate for the decisions managers make. When relevant models exist, their benefits may be uncertain, the data required by the techniques may be too costly to acquire, and/or use of the techniques may be hampered by employees' limited quantitative skills — "a shortage of analytical talent" (Wailgum, 2009).

[4] Decision makers can also subjectively combine output from multiple models. Karmin (2008) describes the management of one of the largest currency-trading firms in the world as aggregating recommendations from about 20 quantitative models and then subjectively "tweaking" the results.

The psychology theories used in the research we review assume that subjective decision making depends on individuals' mental representations of their environment (March, 1994; Markman, 1999; Markman and Gentner, 2001; Weber and Johnson, 2009). Mental representations are relevant to understanding decision-makers' preferences as well as their beliefs: "We want what we want [i.e., prefer] because of the way we think about it." (Wendt, 1999, p. 119) In psychology theory, mental representations "act as *the effective environment* which arouses motives and emotions, and guides overt behavior toward its target or goal." (Baldwin, 1969, p. 326, emphasis added).

Psychology-based research thus takes a broad view of the roles of MA in decision making. A narrow view would restrict the role of MA to populating a decision model with values of parameters and variables — for example, the expected selling price and variable cost per unit of each product for a product-mix decision model or the realized values of multiple performance measures for a model of performance evaluation and reward.

In contrast, in the broad view supported by the psychology literature, MA also influences individuals' choice and valuation of decision objectives and the structure of their subjective decision models; it influences their choices of what variables to include and their judgments about the forms of relations and magnitudes of parameters and variables in their subjective decision models. For example, MA control systems can help define social relations in an organization and thus influence whether decision makers act only to maximize their own payoffs or also act to follow social norms of cooperation with other individuals with whom they identify socially (Rowe, 2004; Rowe et al., 2008). MA's provision of anchor (initial) values of parameters and variables (e.g., cost per unit) can support individuals' use of anchoring-and-adjustment heuristic decision models to make decisions that are more completely modeled as complex system dynamics problems (Sterman, 2000). Accounting classifications and report formats can direct individuals' attention and prompt their mental representations in ways that increase or decrease their performance in identifying relevant predictor variables or in estimating parameters in their subjective decision models (Vera-Muñoz, 1998; Luft and Shields, 2001).

Psychology theory and research methods have a long history in MA (Birnberg et al., 2007). Starting in the 1950s several fields of psychology, in particular, cognitive, motivational, organizational, and social psychology, have been used to provide insight into issues such as how MA influences individuals' motivation (e.g., through budget goal setting) and social interaction (e.g., budget negotiations), and how individuals and small groups use MA to make planning and control decisions (e.g., cost-based pricing, performance evaluation). Recent MA research uses behavioral-economic models to investigate how individuals trade off the utility of monetary payoffs against utility of non-monetary payoffs derived from social psychological objectives such as fairness, honesty, and reciprocity.

Behavioral economics combines psychology theories with neoclassical economic theories in order to increase the theories' explanatory and predictive ability (Rabin, 1998; Camerer et al., 2004; Camerer, 2006; Della Vigna, 2009). One of the difficulties that researchers have encountered in integrating psychology with economics and accounting, however, is choice overload: "There are too many behavioral theories." (Fudenberg, 2006, p. 697). Psychology theories are numerous, diverse, and not necessarily consistent with each other. One way of mitigating this choice difficulty for MA researchers is to focus on the psychology theories that have proved to be robust predictors of MA-related behavior. The psychology-based MA studies that we review are robust in two ways. First, they draw on basic insights of psychology theory that are common to a variety of specific, related psychology models: thus the basic insights are robust to minor variation in model specifics. Second, their empirical results are robust to variation in research method choices such as experimental tasks, participants, and compensation magnitude.

The literature that we review in detail below addresses four main themes. Two additional themes emerge from recurring, but not always predicted, observations in this literature. The six themes are summarized in Table 1.1.

First, *framing and reference points*, often created by MA, can influence individuals' subjective valuation of monetary payoffs. For example, framing monetary payoffs in incentive contracts as gains rather than

Table 1.1. Themes of psychology-based MA research.

A. Main Themes Addressed in Existing Research

1. *Framing and reference points: subjective valuations of MA-related monetary payoffs*
   The subjective valuation of a given monetary payoff can depend on how the payoff is framed (e.g., whether an individual's subjective reference point is above or below the payoff). For example, MA reports and budgets can frame payoffs by creating reference points (e.g., budget goals), and these frames can influence the use of MA information in making subjective decisions.
2. *Social influences on MA: subjective valuations of non-monetary payoffs*
   How individuals make MA-related decisions can depend on how they value non-monetary (social) payoffs derived from objectives such as fairness, honesty, reciprocity, or social comparisons. For example, honesty or fairness concerns influence the accuracy of individuals' reporting of their private information in budgeting. Conversely, features of MA can influence the extent to which individuals value honesty or fairness.
3. *Predictably simplified subjective decision models for MA-related tasks*
   Subjective decision models often include predictable simplifications that influence and are influenced by MA. For example, individuals making performance evaluations tend to use subjective decision models that simplify by omitting or under-using some information in order to avoid trade-offs between multiple dimensions of performance. These tendencies are exacerbated by MA that makes large quantities of information available.
4. *Limitations on learning: acquiring and subjectively estimating parameters and variables in MA-related decision models*
   MA influences — sometimes biases or limits — individuals' learning, and learning influences MA as individuals acquire MA parameter and variable values or the information to estimate them subjectively. For example, characteristics of MA (e.g., classification, aggregation, report format) can influence individuals' learning of cost-driver and profit-driver relations by affecting their attention and memory. Conversely, MA is influenced by individuals' learning of parameters and variables that become part of MA (e.g., activity time estimates).

B. Emerging Themes

5. *Limited heterogeneity of subjective decision models*
   Often the MA-related decision behavior of individuals can be accounted for by two or three distinct subjective models. Subjective models are neither so diverse as to be unpredictable nor so similar as to cluster around a single type. Aggregate behavior depends on the proportions and interactions of the limited number of subjective decision models.
6. *Deliberative and intuitive decision making*
   MA-related decision making is not always deliberative (consciously controlled). Individuals often make intuitive (automatic or gut feel) decisions. The effects of MA on subjective decision making can differ depending on whether the decisions are deliberative or intuitive.

avoided losses can change the magnitude of the payoffs principals offer and agents accept (Frederickson and Waller, 2005), and budget goals can provide reference points that influence individuals' willingness to

exert effort and take risks, holding monetary payoffs constant (Sprinkle et al., 2008).

Second, individuals' *valuation of non-monetary (social) payoffs* influences MA, and individuals' valuation of these non-monetary payoffs can in turn be influenced by MA. For example, the most effective MA control system for an organization in which some individuals value honest communication or social identity will be different from the most effective system for an organization in which no individuals have such preferences (Evans et al., 2001; Towry, 2003). Conversely, characteristics of an MA control system such as budgeting procedures and compensation can influence the extent to which individuals put high values on honesty and/or fairness (Rankin et al., 2008; Zhang, 2008).

Third, *subjective decision models simplify the structure* of complex[5] MA-related decisions in predictable ways, often omitting variables, truncating long chains of causal relations, and/or avoiding trade-offs. For example, individuals making performance evaluations tend to use subjective decision models that simplify by omitting or under-using some information in order to avoid trade-offs between multiple dimensions of performance (Lipe and Salterio, 2000). These tendencies are exacerbated by MA systems that make larger quantities of information available (Shields, 1980).

Fourth, there are *limitations on learning* as individuals acquire MA-related parameter and variable values or the information to estimate them subjectively from reports or from their experience. Characteristics of MA (e.g., classification, aggregation, report format), as well as characteristics of decision settings and decision makers, influence — sometimes bias or limit — individuals' attention, memory, and other learning-related subjective information processing. For example, capitalizing or expensing intangibles expenditures for internal reporting influences individuals' focus of attention and thus influences how well they learn the relationship between expenditures and profits from examining information on the two variables; individuals' learning then influences their performance in predicting future profits (Luft and

[5] See Bonner (1994) for a definition of decision complexity.

Shields, 2001). Conversely, MA itself is influenced by individuals' learning of parameters and variables such as activity times.

These four themes have been investigated extensively in the MA literature, yielding results that appear robust across specific MA decisions, decision makers, and settings. Two additional themes have emerged in this literature as recurring (sometimes unpredicted) observations with important implications for future research.

The first of these emerging themes is the *limited heterogeneity of subjective decision models.* For a number of the MA-related decisions studied in the literature, two or three models account for the behavior of most individuals (e.g., Lewis et al., 1983; Ball et al., 1998). Thus, individual behavior is neither unpredictable because of its extreme diversity, nor is a single representative model sufficient. Rather, aggregate behavior depends on the proportions and interactions of the limited number of subjective decision models.

Second, subjective decision making is not a homogeneous construct, and one important dimension on which subjective decisions can differ is whether they are *deliberative* (consciously controlled) or *intuitive* (automatic or gut feel). The factors that influence subjective decisions are often different in these two cases. Intuitive decisions can be systematically influenced by information and/or motivations that individuals might not choose to include in their decision models if they were conscious of the influence. For example, many individuals invest some self-esteem in their economic success and therefore tend to screen out or reinterpret information that implies they are not performing well economically (Bloomfield and Luft, 2006; Tayler, 2010). This bias in information processing can reduce economic performance by leading to poorer decisions (Bloomfield and Luft, 2006). Therefore it is unlikely to be consciously chosen, and in consequence, it can be difficult (though not impossible) to mitigate (Tayler, 2010).

The first four themes described above are addressed in separate sections: the first theme is developed in Section 3, the second in Section 4, the third in Section 5, and the fourth in Section 6. The fifth and sixth (emerging) themes recur in a variety of studies and thus appear repeatedly across Sections 3–6. Before developing these themes in detail, we explain in Section 2 the organizing framework employed in our review.

2

Organizing Framework

In this section, we first explain why we organize the psychology-based MA literature by major subjective decision processes and how we identified these decision processes (Section 2.1). We then briefly describe the decision processes and introduce the families of psychology models that describe and explain these processes (Section 2.2).

2.1 Modeling MA Tasks

A management accounting task like budgeting, transfer pricing, or designing performance measurement and reward systems consists of multiple interdependent specific decisions. For example, individuals designing a performance measurement and reward system must decide on the objective of the system (i.e., what behavior they want the system to motivate) and estimate the preferences and outside opportunities of individuals whose performance will be measured. They also need to estimate the statistical properties of the available performance measures (e.g., precision, correlation of multiple measures), and combine all of their estimates to choose performance measures and decide how to weight them in the reward system.

In order to provide valid tests of well-specified causal hypotheses, psychology-based studies of MA often have a limited focus. They often examine a single specific decision and automate, hold constant, or eliminate other components of a task and its environment that might create confounds or noise in the hypothesis tests. Thus, for example, some studies examine a single budgetary communication from subordinate to superior, rather than the entire task of budgeting (Hannan et al., 2006), or a single judgment made during a transfer price negotiation rather than the entire task of transfer pricing (Luft and Libby, 1997).

In principle it would be interesting to assemble the results of these studies in a way that provides a more complete, psychologically informed, view of major MA-related tasks and thus provides general models of these tasks (budgeting, transfer pricing, etc.). The literature is not yet sufficiently advanced for such an undertaking, however, in two respects. First, there are large gaps in the literature. For example, there are several studies of how subordinates decide to communicate private information to superiors in budgeting, but there is little research on other, equally important decisions in budgeting such as how subordinates acquire their private information (e.g., how they decide on methods and effort levels for private forecasting) or how superiors judge the credibility of the communications they receive. Second, although some gaps can be readily identified, like those in the preceding examples, others cannot, because of the absence of cognitive task analyses in the MA literature.

Cognitive task analysis is an area of psychology research that provides descriptions and analyses of the knowledge and cognitive activities required for high performance on specific tasks (Baron, 1988; Peters, 1993; Schraagen et al., 2000). A cognitive task analysis of a MA-related task would, in effect, provide a checklist of the specific decisions involved in this task; researchers could then identify which of these specific decisions have been extensively studied and which have not, and whether some frequently studied decisions actually play little or no role in the MA-related task. In addition, a cognitive task analysis would identify the information and the decision-maker characteristics (e.g., knowledge, preferences, cognitive abilities) needed to perform well on the task as a whole, not merely on one of the multiple interdependent

decisions that constitute the task. However, we are not aware of any analysis of the cognitive requirements of (for example) budgeting or transfer pricing, comparable to Bonner and Pennington's (1991) cognitive task analysis of auditing.[1]

Economics (and operations research and statistics) provide models of how to structure and process information in order to perform well on some MA-related tasks, at least when the cognitive demands of the tasks do not exceed individuals' cognitive limitations. We therefore use two representative economic models of MA-related tasks (Balakrishnan and Sivaramakrishnan, 2002; Feltham and Xie, 1994) as starting points to identify decision processes that are likely to be required for effective performance on important MA-related tasks. These models complement the psychology-based literature by providing what it often lacks — that is, a structure that specifies how multiple specific decisions are combined to perform MA-related tasks such as designing a performance evaluation system (Feltham and Xie, 1994) or making an interdependent set of capacity acquisition, product pricing, and product mix decisions (Balakrishnan and Sivaramakrishnan, 2002).

Although the economic models provide a starting point, they do not provide a complete substitute for cognitive task analysis for two reasons. First, they often assume that decision makers have unlimited and costless information-processing capabilities. Because individual cognition is in fact costly and limited, both actual and optimal task performance will sometimes differ from the predictions of economic models. Individuals sometimes simplify MA-related tasks by making the decisions specified by economic models but making these decisions differently (e.g., using low-cost information searches that yield biased results). At other times, they make different decisions altogether (March, 1994). For example, the design of observed performance evaluation systems may be the outcome of inertia, imitation, or quasi-random trial and error rather than (as in many MA-related economic models) the outcome of logical analysis.

[1] Cognitive task analysis may be more challenging for MA-related tasks than for auditing, because regulation imposes a degree of uniformity on auditing that is not likely to be present in MA-related tasks.

The second reason that economic models do not provide a complete substitute for cognitive task analysis is that these models are often radical simplifications of the natural ecology and thus may not always accurately identify the knowledge and cognitive activities required for high performance. As Lambert (2007, p. 244) argues, the purpose of economic models is to "illuminate important structure that is hard to see in the 'mess of so many factors'." This illumination of structure requires simplification, and the simplifications used to make models mathematically tractable may also make their solutions less than optimal for natural settings. In an environment that does not correspond well with available economic models (e.g., an environment including many periods, nonlinear incentives, and many agents with preferences other than wealth and leisure) it is often difficult to know what the utility payoffs would be from basing decisions on alternative simplifications (Hemmer, 2004; Demski, 2007). We often do not know whether the solutions provided by simplified economic models in fact perform better in complex natural settings than decision-makers' cognitively simplified decision models do.

The literature we review below provides a wealth of information about how specific MA-related subjective decisions are made and how subjective decision performance is influenced by individuals' cognitive simplifications and diverse preferences. We organize this information according to five broad decision processes which we derive from representative economic models of MA-related tasks. Psychology-based researchers who want to conduct a cognitive task analysis can then use the five decision processes as a potential structuring tool or checklist; in addition, for each of the subjective decision processes included in the task they analyze, they can find what psychology-based research has learned thus far about the information and individual characteristics required for high decision performance. Economic modelers aiming to incorporate diverse preferences or costly cognition in their models can find summaries of relevant empirical evidence to guide the specification of particular components of these models. Empirical researchers using a variety of theories and research methods can consider which of the five decision processes are involved in their topic of study and what the

insights provided by the psychology-based research reviewed here can add to their ability to predict and explain MA-related behavior.

2.2 Five Subjective Decision Processes in MA

MA tasks are often separated into two types, planning and control (decision-facilitating and decision-influencing uses of MA information, in the terminology of Demski and Feltham (1976)). The Appendix presents representative economic models of MA planning and control decisions: one model of capacity acquisition, product pricing, and product mix decisions based on product-cost information (Balakrishnan and Sivaramakrishnan, 2002), and one model of incentive compensation design for agents with multiple tasks (Feltham and Xie, 1994). In the Appendix we provide a description of the information and specific decisions that would be required for a subjective analysis equivalent to the analyses implied by these economic models. Although the detail of these economic models is valuable to psychology-based researchers in defining the large number of specific decisions involved in these complex tasks (hence the detailed description in the Appendix), we generalize these requirements into five broad processes of subjective decision making.

The first process is the subjective *valuation* of the payoffs that are included in the decision maker's objective. In an economic model, decision makers' objectives are (for example) to maximize utility from wealth (Balakrishnan and Sivaramakrishnan, 2002), or wealth and leisure (Feltham and Xie, 1994), or wealth, leisure, and compliance with social norms (Fischer and Huddart, 2008). Psychology models of decision making usually do not insist on strict maximization, but they do assume that decision makers have objectives that they value and wish to achieve. In order to explain decision making, therefore, researchers need to understand how decision makers value potential payoffs, both monetary and non-monetary. For example, do they value immediate payoffs much more highly or only a little more highly than future payoffs? Do they value honesty as well as monetary payoffs, and is their valuation of honesty stable and exogenous or contextually influenced?

The second process is the *structuring* of subjective decision models. For example, do decision makers conceptualize the decision problem as a single-person or multi-person problem? Do they aim at optimizing or satisficing (i.e., choosing the first available alternative that exceeds some target) (Simon, 1979; March, 1994; Goldstein and Hogarth, 1997)? What constraints, if any, do they identify? Does their subjective decision model allow variables representing desired attributes to be traded off against each other (a compensatory decision model) or not (a non-compensatory decision model)?

The third and fourth processes, though conceptually separate from the second process and each other, are often dependent on decision-model structure and thus are considered together with it in our review of the MA literature. The third process is the choice of *specific variables* to include in subjective decision models. For example, are opportunity costs included in subjective decision models? The fourth process is the choice of the *form of relevant relations* among variables in subjective decision models. For example, do these models include additive or configural, linear or curvilinear relations? (Luft and Shields, 2007; Karelaia and Hogarth, 2008).

The fifth process populates subjective decision models with *specific values of parameters and variables* (e.g., means, betas, the amount of current-period sales). These values and/or information for subjectively estimating them can be acquired from organizational records or from memory. In order to understand how individuals acquire these specific values, researchers need to understand subjective decisions such as the following: How, and how long, do individuals search organizational records to acquire parameter and/or variable values? How, and how well, do individuals learn specific values of parameters and variables from experience with MA?

In Sections 3–6, we present three families of psychology models in the MA literature that represent the subjective decision processes described above and the factors that influence these processes and the resulting decisions. These families of models can be summarized as follows:

(1) Models of *value* (Sections 3 and 4): how do decision makers subjectively value potential decision objectives, i.e.,

monetary payoffs or non-monetary payoffs such as fairness, honesty, reciprocity, social identity, and self-esteem? How do these subjective valuations influence MA, and how does MA in turn influence these subjective valuations?

(2) Models of *decision structure, variable, and relation-form choice* (Section 5): what is the structure of subjective decision models, and what are the performance effects of differently structured subjective decision models? What influences the decision maker's choice of variables to include in the decision model? Are relations subjectively judged to be linear, compensatory, etc.? How does MA influence, and how is it influenced by, these choices?

(3) Models of *parameter and variable acquisition and subjective estimation* (Section 6): how do decision makers acquire information about or subjectively estimate the specific values of parameters and variables in decision models? How does MA influence and how is it influenced by these subjective estimation and information-acquisition decisions?

Each of these families includes a variety of individual models in which concepts from psychology are used to explain causes and/or effects of MA practices or information. A figure in each of Sections 3–6 provides a graphic summary of the links between psychology concepts that have been employed in the literature we review and the MA constructs explained by these concepts. Consistent with the diversity of theory in psychology, a very wide range of explanatory concepts has been employed in the literature, with little attempt to make individual models consistent with a single general theory. In the review that follows, we do not attempt to be comprehensive, but rather to trace common themes through this diverse literature and identify robust results.

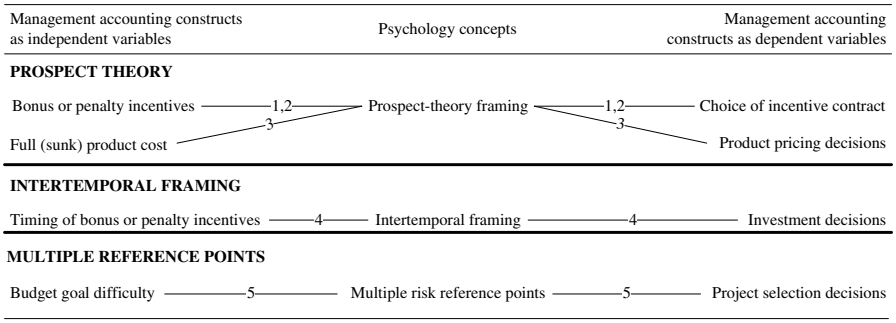
3

Valuation of Monetary Payoffs

Psychology researchers often argue that individual preferences are, at least to some degree, not exogenously given and stable but *constructed* in the process of choice (Slovic, 1995; Ariely et al., 2006). Hence different representations or framing of the same outcomes (sometimes triggered by MA) can affect how people define and value payoffs that constitute their objectives. "We want what we want because of the way we think about it," (Wendt, 1999, p. 119) and MA can affect the way we think about it.

MA can affect individuals' valuation of monetary payoffs by providing a reference point or frame. One of the most familiar examples of framing is the loss-aversion effect specified in prospect theory (Kahneman and Tversky, 2000), whereby a prospective difference in wealth is experienced as more aversive if it is framed as a loss (compared to a higher reference point) than if it is framed as a foregone gain (compared to a lower reference point).[1] In this section we first review MA studies

[1] The idea that individuals' valuation of outcomes depends on how the outcomes compare to a reference point is not unique to prospect theory. Theories of motivation such as aspiration-level theory and goal-setting theory predict that individuals' motivation to achieve a given level of performance depends on whether that level of performance is above



Figures 3.1, 4.1, 5.1 and 6.1 identify psychology concepts (center column) that have been used to explain the causes and/or effects of MA variables (side columns) in the research that we review. The numbers in a link indicate studies that provide theory-consistent evidence on this psychology –MA link. The unit of analysis is a psychology –MA link, not a study. Hence, a study may appear in more than one link, and not all hypotheses of a study may be represented in the figure. A link indicates that a particular psychology concept is employed to explain the relation between MA variables, not necessarily that it is a causal mediator between the variables. In some figures, some MA variables and psychology concepts are repeated between the panels, which are demarcated by thick horizontal lines. Repeated variables or concepts are in italics.

1. Luft (1994)
2. Frederickson and Waller (2005)
3. Buchheit (2004)
4. Shelley and Omer (1996)
5. Sprinkle et al. (2008)

Fig. 3.1 Valuation of monetary payoff.

based on prospect theory (Sections 3.1–3.2) and then a study based on an alternative psychology theory of reference-point effects (Section 3.3). Figure 3.1 provides a graphic summary of the links between MA constructs and psychology concepts used in this literature.

3.1 Prospect Theory

Expected utility theory simplifies the modeling of preferences by assuming that they are exogenously given and stable across alternative representations of outcomes. In contrast, prospect theory posits a value function in which outcomes are expressed as positive or negative deviations (gains or losses) from a neutral reference outcome, which is assigned a value of zero. The location of the reference point depends on both the decision-maker's norms and expectations and on the presentation of the outcome information (framing). The slope of the value function is

or below the individuals' goal or level of aspiration. See Birnberg et al. (2007) for a review of the (mostly older) MA research based on these theories.

steeper in the domain of losses than the domain of gains (loss aversion), and the shape of the value function is concave for gains and convex for losses, resulting in risk aversion for gain prospects and risk-seeking for loss prospects (Kahneman and Tversky, 2000).

Prospect-theory framing effects have been documented in a wide variety of settings, both in the laboratory and in the field. A recent field experiment illustrates both the robustness and the limits of such framing effects (Gächter et al., 2009). In this experiment, economists registering for a conference are randomly assigned to one of two conditions, in which the registration fee is framed as including either a discount for registering early (gain) or a penalty for registering late (loss). Economics faculty members are approximately equally likely to register early regardless of whether they are in the gain (88%) or loss (81%) frame. Doctoral students, however (who might be expected to be more attentive to the fee payment because it represents a larger part of their total wealth) are significantly influenced by the frame. In the loss frame 93% register early, but in the gain frame only 67% register early.[2]

MA provides reference points in a variety of ways. For example, a budget goal can serve as a reference point: holding actual performance and monetary payoffs constant, individuals are likely to value a given monetary payoff more when it exceeds a (low) goal than when it fails to meet a (higher) goal. Moreover, internal reporting of profits for individual products or business units can shift reference points by shifting cost allocations. A decrease in profits for a given product can be viewed as a foregone gain or a more aversive loss, depending on whether the decrease reduces profits below the zero-profit reference point. Whether the decrease results in profits lower than zero can depend on the magnitude of the common or fixed costs allocated to the product. The research reviewed below documents decision effects of these MA-induced reference points.

Luft (1994) uses prospect theory to investigate the decision effects of gain and loss frames based on comparisons of outcomes to a

[2] Although there appears to be an expertise effect in this study (doctoral students are more influenced by framing than faculty members), expertise in general does not reliably eliminate framing effects. For further field evidence of prospect-theory effects, see Camerer (2000).

performance standard. In her experiment, participants choose between a fixed-pay contract and an incentive contract that is framed either as a bonus (a fixed salary plus a bonus if performance is higher than a standard) or a penalty (a higher fixed salary minus a penalty if performance is lower than the standard). For example, the incentive contracts offered for one of the tasks in the experiment pay either $3 base pay plus an $8 bonus if performance meets or exceeds the standard, or $11 base pay minus an $8 penalty if performance fails to meet the standard. Expected utility theory predicts that individuals are indifferent between these two incentive contracts, because their monetary payoffs are identical: $11 for performance that meets standard and $3 otherwise. In contrast, prospect theory predicts that individuals are more likely to choose the incentive contract framed as a bonus, because a penalty is treated as a loss and thus is more aversive than a missed bonus (reduced gain).

Consistent with the prospect theory prediction, 71% of the participants in the bonus condition choose to be paid under the incentive contract that pays either $3 or $11 rather than receive a fixed wage of $6, but none of the participants in the penalty condition choose the incentive contract paying $3 or $11 rather than the $6 fixed-wage contract. Results of other contract choices in the experiment are similar: participants demand significantly higher expected pay to accept a penalty incentive contract than a comparable bonus incentive contract, and additional periods of experience working under either a bonus or a penalty incentive contract increase rather than decrease the pay differential demanded.

Frederickson and Waller (2005) extend Luft (1994) to a setting in which individuals in principal or agent roles repeatedly contract with each other. In their experimental setting, agents receive a fixed salary plus output-based pay plus state-signal-based pay, with the former two sources of pay specified by the experimenter in order to focus participants' attention on the state-signal-based pay. A state signal is a measure of the uncontrollable state that combines with the agents' effort to produce output and therefore provides information about the agents' unobservable effort choices. For each of 40 rounds in the experiment, a principal offers an agent an incentive contract and the agent accepts

or rejects the contract. If the agent accepts the contract, then he or she chooses an effort level given state uncertainty. In one experimental condition the state-signal-based pay is a bonus (along with a low salary), and in another condition it is a penalty (along with a higher salary calculated to make the optimal versions of the bonus and penalty contract as specified by an agency model economically equivalent).

Frederickson and Waller (2005) use the loss-aversion concept from prospect theory (Kahneman and Tversky, 2000) to predict that agents will require (and therefore principals will offer) higher expected pay when only penalty contracts can be offered than when only bonus contracts can be offered. Evidence from Frederickson and Waller's (2005) experiment is consistent with five specific predictions: (1) Agents display loss aversion in that their indifference point for accepting incentive contracts is higher for penalty-framed than for bonus-framed contracts. (2) Principals adjust their contracts for the agents' loss aversion by offering higher expected pay in contracts with penalty framing than in contracts with bonus framing. (3) The higher expected pay for contracts with penalty framing results in higher expected earnings for the agents in the penalty condition and higher expected earnings for the principals in the bonus condition. (4) Principals in both the penalty and bonus conditions underweight the state signal in the early rounds of the experiment, indicating an initial resistance to holding workers responsible for the uncontrollable state signal. (5) In subsequent rounds, however, the weights on the state signal in the accepted contracts converge toward the weight predicted by the agency model in the bonus condition but not in the penalty condition. Converging to the predicted weight after the initial rounds requires increasing the weight (i.e., the bonus or penalty) on the state signal, and individuals resist increases in the aversive penalty.

In both Luft (1994) and Frederickson and Waller (2005), the performance standard associated with a base salary becomes the reference point for individuals and influences their subjective valuation of incentive pay. The difference in valuation in turn influences their choice of incentive contracts in the short term and also over time, through the effects of loss aversion on learning. MA can also set reference points in other ways, for example by including sunk costs in

profit projections and thereby generating book losses for actions that create monetary gains.

Buchheit (2004) investigates decision-makers' tendency to treat the avoidance of book losses as an objective, even at the expense of monetary gains. In his study, participants in a duopoly market experiment make product pricing decisions based on reported product cost information. Participants are compensated based on the profits they earn, and they can maximize their earnings by maximizing contribution margin. The contribution-margin-maximizing choice is unaffected by the magnitude of fixed (sunk) costs, and therefore participants' decisions should not be influenced by these costs if their objective is to maximize their actual earnings. Based on prospect theory, however, Buchheit (2004) predicts that individuals will treat break-even accounting profit as the reference point of their value function, and thus their valuation of earnings will change as sunk costs and their reference point change. A given contribution margin will be more attractive when accounting profit appears as a gain (low sunk costs) than as a loss (high sunk costs). In the experimental market, higher prices provide higher per-unit contribution margins but risk generating a low volume of sales (and thus book losses with high sunk costs) if the competitor prices aggressively, while low prices offer the opposite trade-off.

Buchheit's (2004) experimental evidence is consistent with his prediction that decision makers will be willing to sacrifice contribution margin in order to reduce the frequency of their losses. As relatively low fixed costs increase, sellers decrease their prices, which reduces their contribution margins but also reduces their frequency of reported losses. However, as fixed costs increase to a level at which price reductions can no longer mitigate the frequency of reported losses, sellers switch their pricing strategy and choose higher prices.

3.2 Intertemporal Framing

In the prospect-theory studies reviewed above, the time lag between decisions and payoffs is minimal. Loewenstein (1988) provides theoretical arguments and experimental evidence that prospect-theory framing has additional effects when decisions have a longer time horizon and the

decision-makers' objective function must integrate payoffs received at different times. If the objective is simply to maximize the present value of expected future payoffs, then the same trade-offs between immediate and future payoffs will be made regardless of whether the trade-off is framed as speeding up a future payoff or delaying an immediate one. If individuals' discount rates are consistent across the speed-up and delay frames, then speed-up premiums and delay costs should be identical. That is, if individuals are willing to sacrifice 5% interest in order to receive a given cash payment at the beginning of the year rather than at the end (the speed-up premium), then they should also demand a 5% interest payment as a return for postponing the cash payment from the beginning to the end of the year (delay cost).

Prospect theory, however, predicts that speed-up premiums and delay costs will differ (Loewenstein, 1988). If decision makers have the opportunity to move an anticipated future positive payoff to the present, then it is framed as a gain, compared to their current (reference) situation of not having the positive payoff. But the delay of a positive payoff that is anticipated immediately is framed as a loss and is more aversive: hence the monetary payoff required to accept a delay will be larger than the premium sacrificed to create a speed-up over the same time interval. The temporal effect reverses for negative payoffs: the change in payoffs required to induce an individual to speed up a penalty is larger than the change required to induce the individual to accept a delay over the same interval.

Based on Lowenstein's (1988) intertemporal framing theory, Shelley and Omer (1996) investigate a setting in which decision makers consider whether to make an investment that will reduce current-period profits (and bonuses) but will increase future-period profits (and bonuses). Participants in the delayed-bonus condition play the role of managers who expect to receive immediate bonuses and must decide how large a future bonus resulting from the investment would have to be to compensate them for missing their current bonus as a consequence of making the investment now. Participants in the sped-up-bonus condition play the role of managers who expect to receive deferred bonuses and must decide how much of a reduction in the bonus would make it

worthwhile for them to speed up receipt of it by choosing not to make the investment. Similarly, there are two penalty conditions, a delayed-penalty condition in which participants expect a current penalty and decide how much of an increase in the penalty they would accept in order to delay it by not making the investment, and a sped-up-penalty condition in which they expect a delayed penalty and decide how much reduction in it would make it worthwhile to speed up the penalty by making the investment now.

Participants are assigned to one of three conditions representing different levels of macroeconomic risk. The prediction that bonus delay costs are larger than speed-up premiums is fully supported at a high level of risk: decision makers who expect current bonuses demand much higher bonuses to compensate for the delay caused by making the investment, implying a high discount rate in their objective function. But those who expect deferred bonuses sacrifice much less of it to speed up the bonus, implying a low discount rate. Thus, the shift in temporal reference point changes the effective discount rate at which individuals trade off present and future payoffs. The effect reverses for penalty compensation: delay costs are lower than speed-up premiums. In the lower-risk conditions of the experiment, however, the predictions are only partially supported.

3.3 Multiple Reference Points

The research described in the previous subsections assumes a single reference point against which outcomes are compared and valued. Psychology-based research on risk attitudes and risk-taking has expanded the reference-point concept to identify two reference points that influence decisions about risk: a lower, security or survival point and a higher aspiration point. Two related streams of research provide evidence on multiple reference points and risk: March and Shapira's (1987, 1992) analyses of managerial decision making, based on survey and interview data, and Lopes' experimental tests of security-potential/ aspiration (SP/A) theory (Lopes, 1987, 1990, 1995; Lopes and Oden, 1999).

Based on interview and survey data from executives (MacCrimmon and Wehrung, 1986; Shapira, 1986)[3] and an analysis of research in economics and psychology on risky decision making, March and Shapira (1987) propose that managerial risk preferences and decisions depend on two reference points — a fixed survival point at which resources are exhausted and a level of aspiration that adapts to experience. When performance is barely above either reference point, managers are risk-averse, because (especially in the case of the survival reference point) the dangers of falling below the reference point dominate attention and opportunities for gain are less salient. When performance exceeds the survival point by a substantial amount, managers are less risk averse, and when their performance approaches their aspiration reference point from below, risk-seeking is particularly likely because their desire to reach their aspiration reference point focuses their attention on opportunities for gains (March and Shapira, 1987). (See March and Shapira, 1992, for a mathematical model of decisions that follow this pattern).

SP/A theory (Lopes, 1987) also models individuals' shifting attention between two reference points (security and aspiration) and their consequent differential weighting of outcomes.[4] When individuals' attention is on the security potential of investments, they focus on the worst possible outcomes and weight them heavily in decision making; consequently they reject investments with possible outcomes below their security reference point even if the best possible outcomes and mean outcomes are high. When their attention is on aspiration (for example, when their security needs have been met), they focus on the best possible outcomes and weight these outcomes more heavily in decision making; consequently they are willing to undertake high-risk, high-return investments.

Sprinkle et al. (2008) use SP/A theory to predict how risky decision making is influenced by budget goals, assuming that budget goals are individuals' aspiration levels. (Security or survival reference points do not play a role in their study.) Sprinkle et al. (2008) predict that when

[3] This working paper was later published as Shapira (1995).

[4] The SP/A and March and Shapira (1992) models differ in a variety of specific ways: for example, March and Shapira attend more to situational differences in risk-taking while Lopes attends more to individual differences.

budget goals are at very low levels, individuals are almost certain to achieve them. In consequence, they are willing to take risks by choosing higher-variance investments and exerting effort with a certain cost but with uncertain payoffs. In contrast, when budget goals are at higher levels individuals are less certain to achieve these goals, and they behave in a risk-averse way by choosing lower-variance investments and exerting less effort because the uncertain payoffs are insufficient to compensate for the certain cost.

Sprinkle et al.'s (2008) experimental evidence is consistent with their predictions based on SP/A theory. Individuals make different trade-offs between risk and costly effort (thus between risk and expected pay), depending on the level of their budget goals. They behave in a more risk-seeking way when budget goals are easier to achieve and in a more risk-averse way when budget goals are more difficult to achieve.

3.4 Summary

It is not always easy for individuals to determine how much they value a monetary payoff, in terms that will allow them to determine whether the monetary payoff is high enough to justify increased effort, risk, or less attractive payoff timing. Frames and reference points help in the valuation task by providing standards of comparison. Hence, moving the reference point (all else equal) changes the trade-offs individuals make between payoff amounts and timing, risk, or effort, because it changes the subjective value of the monetary payoffs.

Although MA studies in agency settings tend to suggest that framing can be used to the advantage of the principal — for example, to induce the agent to take more risk without paying a corresponding risk premium — questions remain about whether framing effects would persist if agents became aware they were being used in this way by principals. On one hand, Tversky and Kahneman (1986) argue that some framing effects are the result of intuitive, not deliberative decision making, and they will disappear when they are made transparent enough for individuals to decide whether they want to be influenced by a frame or not. On the other hand, the loss aversion that drives

many of the framing effects in the MA literature seems fairly robust to transparency and deliberation. Luft's (1994) experiment participants persist in their preference for bonus over penalty incentives when the economic equivalence is made clear to them.

More also remains to be learned about the heterogeneity of individual responses to framing. Kahneman (2003a) argues that some individuals learn to base their choices on the long-term values of the alternatives they face, while others are more influenced by the immediate emotions they anticipate when they expect to receive or give up payoffs; the latter group will be more strongly influenced by framing.

Most of the psychology-based MA research on framing has used performance standards and performance-based pay as the reference-point manipulations, but MA can frame monetary payoffs in a variety of other ways that have received less attention thus far. For example, the zero-profit point that demarcates profits and losses can readily serve as a reference point, and as Buchheit's (2004) experiment illustrates, MA reporting changes (e.g., full versus variable costing or other cost allocation changes) can alter economic decisions significantly by changing the economic outcome that is reported as zero profit.

4

Valuation of Non-monetary Payoffs

Individuals often pursue a variety of objectives other than wealth, because they receive utility payoffs from social-psychological objectives such as self-esteem, fairness, honesty, and social identity (Camerer, 2006; Della Vigna, 2009). Identifying these objectives and understanding how people value these payoffs in trade-offs against monetary payoffs is important to understanding decision making, and recent research has investigated how MA influences and is influenced by individuals' valuation of these non-monetary payoffs.

Four points appear repeatedly in the MA literature on this topic. First, people value how they appear to others and in comparison with others, and thus MA can influence behavior by how it affects these social appearances, independently of how it affects monetary payoffs. (See Gilovich et al. (2006) and Taylor et al. (2006) for introductions to social-psychological motivation.)

Second, social norms such as fairness, honesty, and reciprocity help to determine the effects of MA on individuals' behavior. In consequence, MA controls that are designed to take account of these social norms can generate more wealth (or generate the same amount of wealth with less uncertainty) than MA controls such as incentive contracts that are

designed on the assumption of wealth-maximization only (Evans et al., 2001; Kuang and Moser, 2009).

Third, the influence of social norms and social preferences is context-dependent. Whether individuals will sacrifice monetary payoffs to behave honestly or fairly depends not only on their stable personal preferences for such behavior, but also on their interpretation of the decision context — for example, is it an ethical dilemma or a strategic interaction? (Rankin et al., 2008) — or of the motivations of other individuals — for example, is a given amount of proposed compensation intended "kindly" or not? (Hannan, 2005).

Fourth, the complex interplay of social norms, self-interest, and MA can often yield unintuitive results. For example, it might be intuitive to suppose that subordinates with private information about costs will report the costs more honestly when their superiors have more precise information that limits the range of the costs that subordinates can plausibly report. Hannan et al. (2006) find, however, that subordinates paradoxically become *less* honest when their superiors have more precise information (see below for an explanation of these results). Figure 4.1 provides a graphic summary of the links between MA constructs and psychology concepts used in this literature.

4.1 Social Comparison

People are frequently motivated to compare themselves to others in order to support a variety of objectives such as accurate self-evaluations, self-enhancement, and improvement of their abilities, emotions, opinions, and performance (Taylor et al., 2006; Greenberg et al., 2007). MA can be a source of social comparison information, for example by providing relative performance feedback. The desire to avoid unfavorable social comparisons — to perform at least as well as comparable others — can provide a significant incentive for effort, holding monetary payoffs constant.

Frederickson (1992) tests for social comparison effects by examining agents' effort choices in an experimental principal–agent setting where agents are paid based on relative performance, and the experimental manipulation varies the proportion of total uncertainty that is

common across agents. Frederickson (1992) contrasts two predictions about agent behavior in this setting. The first prediction, based on a model assuming that agents value only wealth and effort, is that differences in the magnitude of common uncertainty will have no effect on effort choices. The common uncertainty has no effect on contractual payoffs; and given the contract parameters, probability distributions, and induced utility functions employed in the experiment, the agents' effort choice predicted by the agency model is the same at each of the experiment's three levels of common uncertainty. Frederickson's second prediction, based on social comparison theory, is that agents will choose higher levels of effort as common uncertainty increases. Relative-performance-based pay is a cue to competitive behavior, and

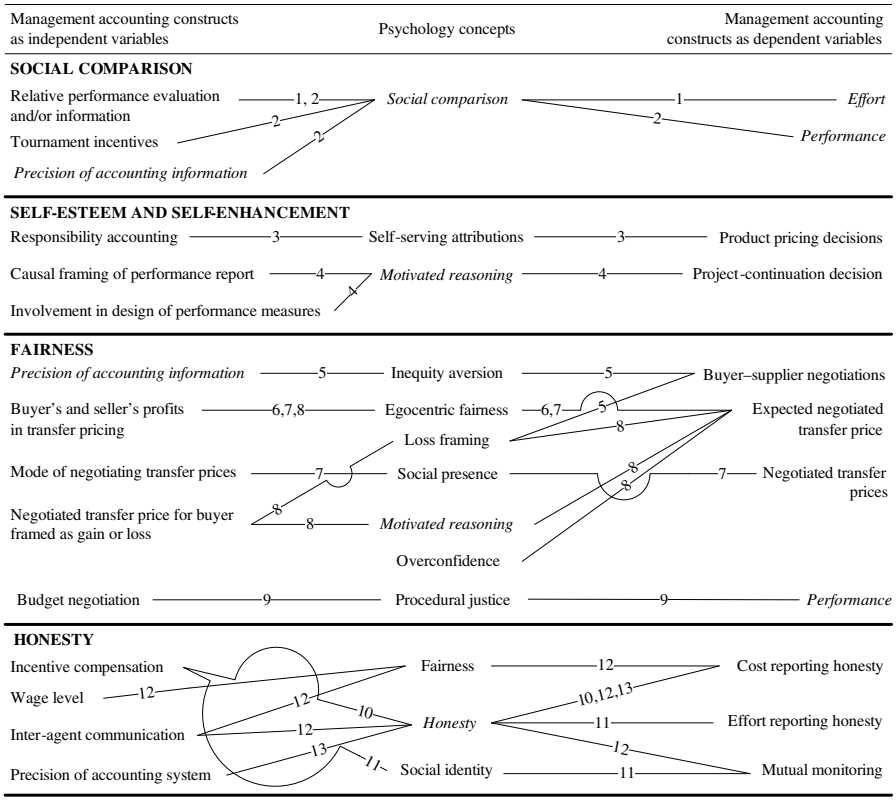
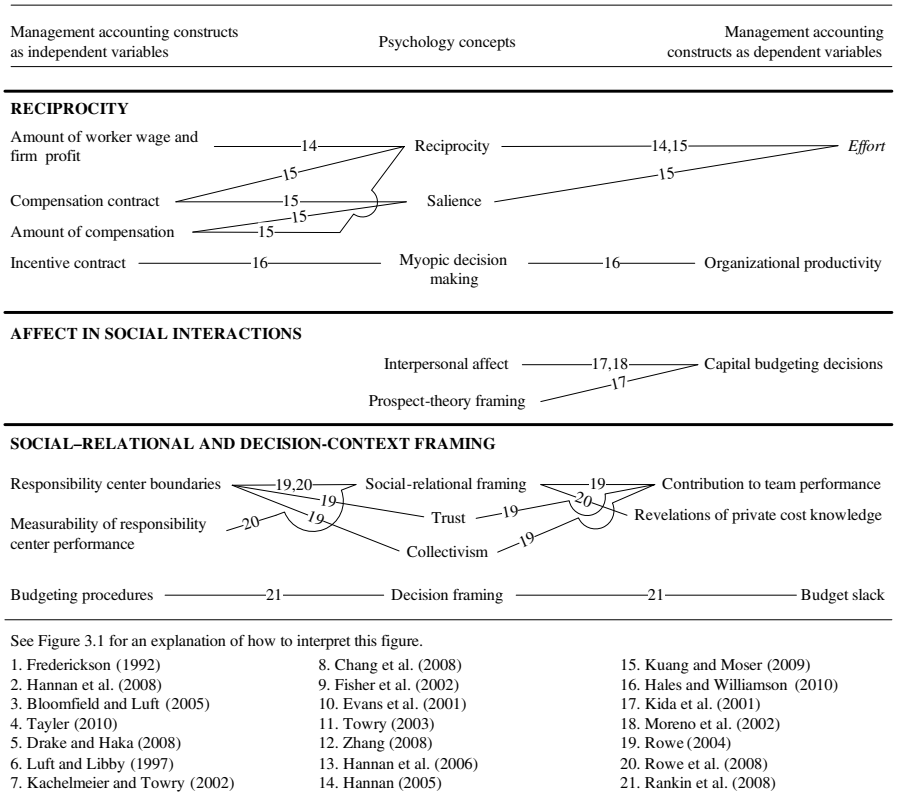


Fig. 4.1 (Continued)



See Figure 3.1 for an explanation of how to interpret this figure.

1. Frederickson (1992)
2. Hannan et al. (2008)
3. Bloomfield and Luft (2005)
4. Tayler (2010)
5. Drake and Haka (2008)
6. Luft and Libby (1997)
7. Kachelmeier and Towry (2002)
8. Chang et al. (2008)
9. Fisher et al. (2002)
10. Evans et al. (2001)
11. Towry (2003)
12. Zhang (2008)
13. Hannan et al. (2006)
14. Hannan (2005)
15. Kuang and Moser (2009)
16. Hales and Williamson (2010)
17. Kida et al. (2001)
18. Moreno et al. (2002)
19. Rowe (2004)
20. Rowe et al. (2008)
21. Rankin et al. (2008)

Fig. 4.1 Valuation of non-monetary payoffs.

as more of the uncertainty is common and less is idiosyncratic (i.e., as agents share a more common environment and their performance is more comparable), relative performance is expected to be more salient, strengthening the agents' tendency to exert more effort to compete. Experimental results are consistent with the second prediction.[1]

In Frederickson (1992), individuals' behavior is influenced by their anticipation that they will receive relative performance information *after* they make effort choices and final performance outcomes have

[1] Frederickson (1992) makes a similar pair of predictions for a setting in which agents are paid under a profit-sharing contract, in which they receive relative performance information but it does not influence their pay. With the profit-sharing contract, differences in common uncertainty have no significant effect on the agents' effort choices.

occurred. MA can also provide interim reports to individuals *before* final performance outcomes are known, indicating how close they are to absolute and/or relative performance goals. Relying on both economic and psychology theories to develop predictions, Hannan et al. (2008) provide theory-consistent experimental evidence on the effects of accounting reports provided as interim relative performance information under either a profit-sharing incentive or a tournament incentive in which only individuals with profit performance in the top 10% receive a bonus.

In Hannan et al.'s (2008) experiment, individuals make a production-planning decision under uncertainty over twelve trials of five periods each. All participants receive information about their individual performance (profit resulting from the production-planning decision) at the end of each period, and some receive interim relative performance information after every three trials. If individuals are motivated to exert effort to learn this relatively difficult task, then they can increase their performance over the 60 time periods of the experiment, and most of Hannan et al.'s (2008) hypotheses address the effects of interim relative performance information on the magnitude of performance increases over the 60 time periods. Models that assume individuals value only wealth and leisure predict that interim relative performance information will not influence the magnitude of increases in individuals' performance under an individual (profit-sharing) incentive because relative performance information is irrelevant to the compensation that is expected to motivate them. In contrast, the social comparison theory employed by Hannan et al. (2008) predicts that interim relative performance information will lead to larger performance increases over time because people are motivated to perform well compared to others in order to avoid a loss of self-identity. Consistent with this prediction, individuals' performance in the individual-incentive condition increases significantly more over time when they receive interim relative performance information than when they do not.

When tournament incentives are present, both economics and psychology theories predict that the effect of interim relative performance information depends on how the information influences individuals' beliefs about their position in the tournament. Economic theory

predicts that as the probability of winning a tournament increases, the expected marginal benefit of effort increases, which motivates additional effort. Similarly, the psychology theory of goal setting (Locke and Latham, 2002) predicts that relative performance information will increase goal commitment and thus will increase effort when this information indicates that individuals have a relatively high probability of winning. Both economic and psychology theories predict that when the relative performance information indicates that individuals have a low probability of winning, they will reduce their effort (in the extreme, give up) and thus performance will decrease.

Hannan et al. (2008) predict that the effect of interim relative performance information under a tournament incentive depends on the precision of the accounting information (coarse or fine). In their experiment, individuals receive either coarse information, which informs them whether their performance thus far is in the top or bottom 50% compared to a previous sample of their peers, or fine information, which informs them of their relative performance decile compared to the previous sample. (Individuals' performance relative to the previous sample is expected to be a useful predictor of performance relative to their current competitors.)

When relative performance information is coarse, Hannan et al. (2008) expect that it will have no effect on mean performance improvement over time. This is because the coarse information informs half of the individuals that they have a relatively high probability of winning, and thus their effort and performance improvement are likely to increase. In contrast, for the remaining individuals the relative performance information will inform them that they have a low probability of winning, and thus their effort and performance improvement are likely to decrease. The increase and decrease in performance improvement will approximately cancel out, resulting in no mean effect of coarse information on performance improvement.

In contrast, when interim relative performance information is fine, Hannan et al. (2008) predict and find *less* mean increase in performance relative to the no-information and coarse-information conditions. This is because individuals not in the top decile are likely to believe that they do not have a sufficiently high probability of winning the tournament.

In consequence, they either decrease their effort or — as predicted by goal-setting theory (Locke and Latham, 2002) and more commonly observed in the experiment — they develop and test different strategies in an attempt to generate big increases in their performance. In the short to medium term this decreases profit performance because of the time consumed in developing and testing strategies and the likelihood of implementing poor strategies during this trial and error process.

Social comparisons thus can result in somewhat unintuitive effects of accounting information. Information that should not influence effort choice if individuals only value wealth and leisure *does* influence effort choice (common uncertainty information in Frederickson (1992) and interim relative performance information with individual incentives in Hannan et al. (2008)). Moreover, "better" (finer) information can lead to worse outcomes, as in the case of the fine interim relative performance information with tournament incentives in Hannan et al. (2008).

4.2 Self-esteem and Self-enhancement

Individuals can react to potentially disadvantageous social comparisons in a number of ways: not only by attempting to improve actual performance through higher effort (Frederickson, 1992) or new decision strategies (Hannan et al., 2008), but also by selecting and interpreting information — for example by choosing peer groups or definitions of performance — in ways that allow them to judge their existing level of relative performance as high (Dunning et al., 1989). Thus when individuals are trying to improve their future performance, and this improvement requires them to recognize that they are currently not performing well, one dimension of self-interest (increasing future performance-based payoffs) conflicts with another dimension of self-interest (maintaining current self-esteem).

The social psychology theory of attribution suggests that self-serving attributions for current performance can limit individuals' ability to correctly identify the causes of their low performance and thus can hinder performance improvement.[2] According to attribution

[2] Psychologists have debated over the extent to which the self-serving attribution bias and overestimates of one's performance are actually motivational (resulting from a desire for

theory, individuals tend to attribute their successes to factors that are controllable and internal to them and to attribute their failures to factors that are uncontrollable and external to them (Miller and Ross, 1975; Zuckerman, 1979). This bias is particularly strong for individuals who already have high self-esteem and are performing challenging, skill-dependent tasks in competitive settings, when competitors are of equal status, and in settings where failure implies a significant threat to their self-concept (Campbell and Sedikides, 1999) — that is, in many settings in which managerial decisions are made.

Bloomfield and Luft (2006) examine how allocation of organizational responsibilities affects attributions and learning when product-cost information is imperfect and profit performance can be attributed to a variety of causes in an uncertain environment. In their experiment, all participants are responsible for product pricing in an auction market and must judge the likely success of a recent cost-management initiative in order to determine how aggressively they can price their products. Half of the participants are responsible for cost management as well as product pricing and thus choose the cost-management initiative themselves; the other half are responsible for product pricing only and are told that another manager chose the cost-management initiative. Because product-cost estimates are imperfect, the auction market in which products are sold is vulnerable to the winner's curse: the seller with the largest cost underestimate is likely to price the lowest, win the most business, and lose money because realized costs are much higher than expected. Sellers thus need to learn to pad their bids sufficiently to allow for cost-estimate error.

Individuals without responsibility for cost management learn from experience how to make better pricing decisions with their imperfect cost information: they increase their bid-padding by over 60% in the course of the experiment's 42 trials and stop losing money. In contrast, individuals with responsibility for choosing the cost-management

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self-esteem) versus cognitive (resulting from differential availability of information about self and others), and how much of the motivational component is associated with self-esteem and how much with managing others' impressions (Brown and Rogers, 1991; Metcalfe, 1998; Schlenker and Pontari, 2000). All of these factors appear to play a role, although it is difficult to partial out their relative effects.

initiative show no sustained increase in padding and their losses remain statistically significant. Their responses to post-experiment questions are consistent with self-serving attribution biases. Sellers with cost-management responsibility incorrectly believe that they have a stronger cost-competitive position (i.e., lower costs) than those without cost-management responsibility, and the stronger they believe their competitive position is, the less they pad their bids. Analysis of individual trial-by-trial bids shows that sellers with cost-management responsibility learn less from their losses than those without responsibility. Thus, participants in this setting behave *as if* they have an objective of maintaining or enhancing their self-image as capable managers, which prevents them from fully taking into account the profit information that indicates their performance is poor.

Tayler (2010) not only documents similar biasing effects of responsibility on individuals' interpretation of the project's reported performance but also tests methods of constructing performance-information systems that can mitigate this judgment bias. Based on the theory of motivated reasoning, Tayler (2010) predicts and finds that when individuals are responsible for selecting a project intended to increase profits, they believe that the project is more successful than do individuals who are not responsible for selecting it, holding reported performance of the project constant. The theory of motivated reasoning (Kunda, 1990) argues that individuals' motivation to arrive at particular conclusions (e.g., the conclusion that they made a good choice of project) biases their cognitive processes (attention, memory, evidence evaluation, etc.) in ways of which individuals are not fully conscious. Motivated reasoning leads responsible individuals in Tayler's (2010) experiment to overweight customer-satisfaction measures in a balanced scorecard, which make their choice of project look successful, and underweight financial measures that reflect more negatively on the project, even though the short operating cycle of the business means that a real increase in customer satisfaction will increase financial performance in the current period if it does so at all.

Tayler (2010) then tests two mechanisms for reducing motivated reasoning about the success of the project. First, he manipulates the presentation of the balanced scorecard either as a causal chain or as

four perspectives with unspecified causal relations. The causal-chain presentation is expected to make participants more skeptical about the success of the project by reminding them that an improvement in customer satisfaction ought to lead to improved financial performance and is of questionable value if it does not. Second, Tayler (2010) manipulates the involvement of participants in the construction of the performance measurement system: either they choose the specific customer measure used in the balanced scorecard or the measure is chosen by others. Only the combination of the causal presentation *and* involvement in performance measure choice succeeds in mitigating motivated reasoning. Tayler argues that both are needed because the causal presentation prompts the cognition needed to identify the project's lack of success, and involvement in performance measure choice provides the motivation to use this cognition: it "fights fire with fire" by motivating individuals to think well of the performance measurement system and rely on it, counteracting their motivation to think well of the project they chose and make insufficient use of evidence from the performance measurement system that the project is not a success.

4.3 Fairness

In the research previously reviewed, individuals sometimes compare their payoffs (e.g., profits) to others' payoffs in order to evaluate their own performance and decide whether or how they should try to improve it. In the research reviewed below, in contrast, they compare their own and others' payoffs in order to evaluate the fairness or equity of an actual or proposed outcome. Individuals tend to be averse to unequal payoffs that are not justified by unequal contributions, and this aversion can play an important role in MA-related decisions (Kahneman et al., 1986; Luft, 1997).

For example, Drake and Haka (2008) predict and find that inequity aversion influences the value of more precise cost accounting information in buyer-supplier negotiations. Fine information, which identifies the costs of a variety of specific properties of the product being traded, has the potential to increase the common surplus from trade because it provides buyers and suppliers with better opportunities to identify

Pareto-superior trade-offs in product design than coarse (aggregate cost) information does. But Drake and Haka (2008) argue that the potential often will not be realized because bargainers with fine information are less likely to share their information than are bargainers with coarse information. Fine information provides an aggressive bargainer with better opportunities to force the price nearer to the other party's reservation price, rather than agree on a more equal share of the surplus from trade. Consistent with these expectations, buyers and sellers who share fine information in Drake and Haka's (2008) experiment succeed in capturing more of the potential common surplus than those who share coarse information. But sharing fine information occurs less frequently than sharing coarse information, because participants who have fine information are more concerned about the potential for inequitable results.[3]

The role of fairness or equity concerns in MA-related decisions is complex, because fair is an ambiguous term. Individuals often agree *approximately* on how a common surplus should be split — equally, or in proportion to differential contributions — but their approximations are likely to differ somewhat. For example, the price that a seller defines as fair is likely to be somewhat higher than the price that a buyer defines as fair, even when both "fair prices" are close to a price that splits the surplus from trade equally (Luft and Libby, 1997). Similarly, when individuals work for different amounts of time on a joint task, they tend to agree that that it is fair for those who have worked longer to receive more pay; but those who have actually worked longer expect the differential to be larger than do those who have worked less (Messick and Sentis, 1979).

These egocentric definitions of fairness appear self-interested but can often work against individuals' economic self-interest. Defining one's own interests as fair hinders people from realizing that other people will define *their* (different) interests as fair. This egocentrism distorts predictions about what others will do, leading to costly

[3] A "market pressure" condition in the experiment, in which bargainers face loss rather than gain prospects, increases their willingness to take the risks of information-sharing, consistent with prospect theory.

decision errors in economic settings.[4] Thompson and Loewenstein (1992) provide evidence that costly impasses in bargaining are driven by egocentrically biased definitions of fairness, and that the magnitude of the egocentric bias (i.e., the difference in fairness judgments between individuals with opposing interests) increases with the complexity of the information relevant to the negotiation, since more complex information provides more opportunities for alternative (egocentric) interpretations of what constitutes a fair outcome.

Luft and Libby (1997) document the effects of egocentric definitions of fairness on individuals' expectations about negotiated transfer pricing. In their experimental setting, both buyer and seller are free to trade in the external market, and if buyer and seller value only the magnitude of their own profits (not how their profits compare with their bargaining partner's) then there is no reason for them to set a transfer price other than the market price, adjusted for any transaction cost savings from internal trade. Luft and Libby (1997) predict, however, that managers will be influenced by a concept of fairness defined as roughly equal shares of the profits from internal trade, consistent with Bolton's (1991) behavioral-economic definition of fairness and Eccles' (1985) field evidence of managers' beliefs in equal sharing of firm profits associated with internal trade. In consequence, managers will expect transfer prices to be influenced not only by the market price but also by the price that provides buyer and seller with equal profits. If definitions of fairness are egocentric, however, then buyers and sellers will have different expectations about *how much* each of these two potential anchors — market price and equal-profit price — will affect their negotiated transfer price.

To test this prediction experimentally, Luft and Libby (1997) offer a pair of transfer-price scenarios to experienced managers. In one experimental scenario, a transfer price at the market price provides equal profits to the buyer and seller; in the other scenario, a transfer price

[4] It is unclear how deliberate these egocentric definitions of fairness are. When such egocentrism has negative effects on individuals' economic self-interest, it may be because they are unaware how biased their definitions are, or because they are aware of the bias but unaware of its negative economic consequences, or because they are willing to incur such consequences in order to adhere to their preferred definitions.

at the market price provides higher profit to the seller. Experiment participants are randomly assigned to either the buyer's or the seller's role and state expectations of the seller's reservation price and the final negotiated transfer price. As predicted, both reservation price and final price expectations diverge more from the market price when the market price does not provide equal profits, indicating an effect of fairness. However, buyers significantly underestimate sellers' reservation prices and expect a lower final price than sellers do. This divergence between buyers' and sellers' expectations is consistent with egocentric definitions of fairness and has the potential to increase bargaining costs.

Kachelmeier and Towry (2002) replicate and extend Luft and Libby (1997), making four changes in the experimental design: participants are students rather than experienced managers, they perform complete negotiations rather than only stating expectations, they participate in repeated trials rather than a single trial, and they are paid based on their earnings from negotiation rather than being unpaid volunteers. Kachelmeier and Towry's (2002) study is motivated in part by prior experimental evidence indicating that incentives for wealth maximization eventually overpower expectations of fairness (Franciosi et al., 1995). Because this prior evidence comes from anonymous, limited-communication laboratory markets that do not capture many features of actual transfer price negotiations, Kachelmeier and Towry (2002) test for effects of the mode of negotiation.

Based on social psychology theories, they predict that the persistence of differences between the market price and the transfer price will depend on the mode of negotiation, specifically, computerized anonymous negotiation involving only bids, asks, and acceptances versus face-to-face negotiation with unrestricted communication. These modes are at polar ends of a social presence continuum in which different modes exert different social pressure on negotiators (Bazerman et al., 2000). Face-to-face negotiation compared to anonymous computerized negotiation is expected to increase negotiators' preferences for more equal profit splits because it increases identification with the other party (which Kachelmeier and Towry, 2002, call humanization) and provides an opportunity for persuasive communication, whereas the computerized market negotiation does not.

Participants' initial expectations about transfer pricing in Kachelmeier and Towry's (2002) experiment are very similar to the expectations in Luft and Libby (1997). But as Kachelmeier and Towry (2002) predict, actual negotiated transfer prices converge rapidly to the market price in computerized, limited-communication negotiations. In contrast, in face-to-face negotiations transfer prices diverge persistently from the market price in the direction of an equal-profit-split price.

Prospect-theory framing can explain additional variation in the behavior of negotiators who are concerned about relative payoffs. In Drake and Haka (2008), a loss frame (their "market pressure" setting) prompts more information sharing and thus increases benefits from trade, regardless of the fineness of the information. Information-sharing is risky, because bargainers are uncertain how aggressively their bargaining partner will take advantage of it; and the loss frame increases risk-seeking. In contrast, in Chang et al.'s (2008) transfer pricing experiment (based on Luft and Libby, 1997), a loss frame induces *less* cooperative approaches to negotiation. In Chang et al.'s (2008) setting, unlike Drake and Haka's (2008), there is no possibility of increasing the common surplus by sharing additional information: bargainers are simply dividing a given common surplus. In this setting, negotiators who exhibit loss aversion (Kahneman and Tversky, 2000) will bargain harder to avoid a loss than to capture a gain (Neale and Bazerman, 1985). Literature on motivated reasoning Kunda (1990) and negotiator overconfidence (Neale and Bazerman, 1985) suggests that negotiators will tend to underestimate their bargaining partner's tendency also to bargain harder in a loss setting. Consistent with these theories, Chang et al. (2008) find that the "expectation gap" about the final price that egocentric fairness creates between buyer and seller is larger when the negotiation goal is framed as a loss than when it is framed as a gain.[5]

[5] Chang et al. (2008) also manipulate an indicator of whether the bargaining partner displays interest only in maximizing his or her own profit or displays concern for others. Based on the concepts of concern for others and reciprocity, Chang et al. (2008) predict and find that bargainers expect the negotiated transfer price to be farther from the market price and nearer to the equal-profit price when one bargainer displays concern for the other (rather than a primary interest in maximizing own profit), leading the other to reciprocate and agree on a roughly equal share of the common profits.

In addition to the fairness in outcomes (distributive justice) that these transfer-pricing studies investigate, individuals are often concerned about fairness in process or procedural justice and are willing to sacrifice monetary payoffs to maintain what they regard as procedural justice (Greenberg, 1990b). Fisher et al. (2002a) investigate the effect of procedural-justice concerns on budget negotiations in an experimental setting where subordinates' compensation depends on how much they can produce compared to a budget goal, and superiors' compensation depends on production and how much they agree to pay subordinates. Fisher et al. (2002a) predict that when superiors do not come to agreement with subordinates about a negotiated budget but unilaterally impose a budget after a negotiation impasse, subordinates will believe that procedural justice has been violated. They will penalize the superior for this violation by performing less well, which reduces firm profit and hence the superior's compensation. It also reduces the subordinates' compensation, but they are willing to incur this cost to penalize what they regard as an unjust action by the superior. The results of Fisher et al.'s (2002a) experiment support this prediction.[6]

4.4 Honesty

MA control systems depend on communication of private information from many individuals in an organization: for example, sales forecasts from sales representatives who are closely involved with customers, or estimates of time spent on various activities as a basis for dividing an individual's compensation across multiple activity pools. Like effort, honest communication can be induced by monetary incentives in MA control systems, at least up to a point. But in a world of imperfect information, divergent motivation, and no preferences for honesty as such, completely honest communication is sometimes too costly to induce with monetary incentives. If individuals value honesty, however, then

[6] This study is one of a series of studies investigating budgeting procedures (Fisher et al., 2000, 2002a,b, 2006). Most of the results in these three studies can be explained by either economic and psychology theories that support the same directional predictions. Hence they are not included in this review, which focuses on incremental contributions of psychology to our understanding of MA.

they may be willing to report private information honestly even when such reporting does not maximize their monetary payoffs.

Several MA control system studies have explored the effects on incentive contracting (especially budgeting) of individuals' preferences for honesty and of contextual factors that appear to influence these preferences. Evans et al. (2001) provide experimental evidence that participants acting as agents in a principal–agent budgeting experiment sacrifice monetary payoffs (up to nearly $300 in a high-payoff condition) to report their private cost information honestly. Increasing the monetary payoffs by a factor of five between low- and high-payoff conditions has virtually no effect on the distribution of honest reporting. In both conditions, about a quarter of reports were completely honest, about a quarter maximized monetary payoffs via misrepresentation, and the remaining half misrepresented their private cost information somewhat, but not enough to maximize their monetary payoffs. In consequence of this heterogeneity of agent behavior, an incentive contract that assumes some honesty among agents generates higher mean earnings for the principal than a contract that assumes agents are uniformly dishonest.

Evans et al. (2001) also find that the level of honest reporting is lower when the incentive contract distributes payoffs unequally between principal and agent. This result is unanticipated in their study but is consistent with the view that dishonesty increases in response to perceived unfairness (Greenberg, 1987, 1990a; Murphy, 1992). Subsequent studies have provided further evidence that individuals' willingness to sacrifice monetary payoffs in order to report honestly is not a stable individual characteristic but rather is contingent on a variety of contextual influences.

An experiment by Towry (2003) compares two work-team incentive compensation plans with the same unique Nash equilibrium strategy, in which agents report honestly on their own and their teammates' effort (that is, they engage in mutual monitoring). In one plan, agents on the team can earn more pay by colluding against the principal rather than honestly reporting their mutual monitoring, but collusion is an off-equilibrium strategy that is not sustainable if agents value only monetary payoffs. Towry (2003) finds that teams in which she experimentally induces a strong social identity collude against the principal

more than do teams with a weak social identity. Social identity does not have this negative effect under the incentive plan with the same Nash equilibrium but with no off-equilibrium payoff for collusion.

Zhang (2008) uses Towry's mutual-monitoring setting to test the ex post suggestion in Evans et al. (2001) that individuals will report more honestly when they believe that their compensation is fair. When individuals believe they are treated unfairly, they can rationalize not reporting honestly as a means of correcting what they regard as unfair treatment (Greenberg, 1987, 1990a; Murphy, 1992).

Like Towry (2003), Zhang (2008) bases her experiment loosely on an economic model by Ma (1988), in which a well-designed mutual or peer monitoring system motivates wealth-maximizing agents to report honestly about both themselves and their peers. Social psychology theory predicts, however, that managers can be reluctant to report dishonesty or shirking by their peers even when provided with monetary rewards for doing so. Research in economics and social psychology indicates that the magnitude of this reluctance depends on both agents' communication with each other and on their beliefs that they are being treated fairly by the principal. Experimental research in economics and social psychology on cheap talk finds that non-binding communication can lead to agents' colluding more often as their communication increases (see Zhang, 2008). Moreover, social psychology research indicates that when individuals believe that they have been treated unfairly, communication between them can reinforce their feelings of unfairness (Folger and Kass, 2000; Lind et al., 1998), which then increase the likelihood of successful collusion.

In Zhang's (2008) experiment, participants are randomly assigned the role of principal or agent, and firms are composed of one principal and two agents. In one experimental condition, agents can communicate with each other as well as with the principal, and in the other condition they cannot. Each principal decides whether to pay the agents a low or high wage. As expected, agents rate the low wage as less fair than the high wage in a post-experiment manipulation check. Agents receive information about their own production costs and report it (honestly or otherwise) to the principal; each agent also knows the other agent's production costs and can report to the principal whether the other agent

has misrepresented these costs. All interactions among principals and agents are anonymous, and principals and agents are rematched for each round, but in the condition with inter-agent communication present, agents can send messages to each other after learning their wage and before reporting costs to the principal. As predicted, agents report more honestly when they believe that the principal is fair, and they collude more against an unfair (low-paying) principal when they have more opportunity to communicate. The presence of inter-agent communication has no effect on honesty or collusion when agents believe the principal is fair.

In Zhang (2008), components of the MA control system — wage level and inter-agent communication — reduce honest reporting. In Hannan et al. (2006), the MA control system influences honesty in a more complex and paradoxical way. Hannan et al. (2006) provide a theoretical argument and experimental evidence that complex trade-offs among monetary payoffs, honesty, and the appearance of honesty can result in individuals being less honest when MA information is more precise.

Hannan et al. (2006) begin with the assumption that individuals value honesty as well as monetary payoffs. If they expect others to value honesty as well, and if they care what others think about them, as social psychology theory predicts they do (Fiske and Taylor, 2008), then they are likely to value *appearing* honest to others as well as knowing in private that they are in fact honest. The benefits of appearing honest can include not only extrinsic benefits like increasing the likelihood of future transactions with others that will generate monetary payoffs, but also intrinsic benefits such as the self-esteem associated with social approval, which can arise from adherence to social norms like honesty even when there are no economic benefits from such adherence (Leary and Kowalski, 1990; Leary et al., 2003; Schlenker and Pontari, 2000). Hannan et al. (2006) assume that managers' preferences for extrinsic benefits are uncontroversial and do not require testing; they therefore use an experimental setting in which extrinsic benefits are held constant at zero and any actions taken to appear honest must be driven by intrinsic benefits.

In Hannan et al.'s (2006) experiment, participants play the role of either managers with private information about production costs or

owners who will earn money from production (revenues minus managers' reported costs). Owners have either no information system of their own, a coarse information system, or a precise information system. If they have no information system, then they only know the ex ante probability distribution of production costs (uniformly distributed between 4 and 6 lira per unit). With a coarse information system, owners receive information that production costs are in a specific half-lira range (e.g., 4.00–4.50 lira) with 70% probability; there is a 30% probability (uniformly distributed) that costs are somewhere else in the 4–6 lira range. With a fine information system, owners receive similar information, but the 70% likelihood range is a quarter rather than a half lira (e.g., 4.00–4.25 lira). Managers know the exact cost of production as well as the information (if any) received by the owners; they report a cost to the owners and can keep any difference between actual and reported costs for themselves. (The owners cannot reject a cost report that appears "too high.") Owners and managers are rematched after each period, so that managers cannot expect extrinsic benefits in the future from owners to whom they have given an honest-looking report in the past.

Hannan et al. (2006) predict and find that managers tend to report costs that are consistent with the information from the owners' information system when the owners have such a system, in order to gain social approval from the appearance of being honest. Managers' cost reports are higher (less honest) when the owners do not have an information system. Although casual intuition might suggest that honest reporting would increase monotonically with the precision of the owner's information system (lowest with no information system, medium with a coarse information system, and highest with a precise information system), Hannan et al. (2006) argue that this is not necessarily the case. They develop two opposing directional predictions about the effect of coarse versus fine information systems, which depend on the exact magnitude of the value managers place on the appearance of honesty. Because there is little basis for reliable ex ante estimation of this magnitude, Hannan et al. (2006) do not make an ex ante choice between the two predictions.

To see how the opposing directional predictions are generated, consider managers with private cost information of 4.0, who would report

production cost of 6.0 if they valued monetary payoffs but did not value appearing (or being) honest. When a coarse information system indicates that production cost is between 4.0 and 4.5, then the highest cost the managers can report and still appear honest is 4.5, resulting in a sacrifice of 1.5 in potential information rent $(6.0 - 4.5)$. When the owner has a precise information system, however, indicating production cost between 4.0 and 4.25, then managers must make lower reports (4.25) and sacrifice more of their potential information rent $(6.0 - 4.25 = 1.75)$ in order to appear honest. If managers put a sufficiently high value on appearing honest, then they will be willing to sacrifice the additional information rent and make lower reports when the owner has a fine information system. If they put a somewhat lower value on appearing honest, however, then it will not be sufficient to make up for the lost information rent; and once managers decide that appearing honest is too costly, there may be little reason for them not to report maximum production costs (6.0 lira). Thus if the value of appearing honest is only moderate, the fine information system will result in *less* honest reporting than the coarse system.

The results of their experiment are consistent with managers' putting a moderate value on appearing honest. When owners have a coarse information system, 96% of the managers decide to appear honest by reporting within the range of the owner's cost information, but when the owner has a fine information system, only 69% of managers do so. Moreover, in the fine information system condition most of those who report anywhere outside the range of the owner's information report within 0.05 lira of the wealth-maximizing (6.0 lira) report, consistent with Hannan et al.'s prediction for settings in which managers put a moderate value on appearing honest.

4.5 Reciprocity

Research reviewed in the previous section indicates that individuals sometimes communicate private information more honestly than their organization's MA control system can induce them to do by monetary payoffs. Similarly, individuals sometimes exert more costly effort than the MA control system can enforce by monitoring and monetary

rewards. Behavioral-economic studies of compensation invoke theories of reciprocity or gift exchange, based on psychology theories of fairness and anthropological research on gift exchange, to explain observations of such excess effort (Akerlof, 1982; Rabin, 1993; Fehr and Falk, 2002). According to these theories, workers believe that a firm that offers a higher wage than the labor market requires is offering a costly gift or kindness, and workers reciprocate by providing additional voluntary effort — a costly gift or kindness in return; failure to reciprocate would be seen as unfair (Rabin, 1993). Conversely, if a firm takes advantage of poor labor market conditions to lower wages, then workers reciprocate this "unfair" treatment by lowering effort levels. Reciprocity or gift exchange does not depend on an expectation of future interaction with or benefits from others. Rather, reciprocity theories assume that, even when such behavior is costly to themselves, people prefer to support social norms of reciprocity by providing benefits (punishments) to people who treat them kindly (unkindly).

Studies of reciprocity in the MA literature focus on contextual factors that influence the strength of reciprocity effects. For example, Hannan (2005) provides evidence that, like fairness effects, reciprocity effects can be modified by gain or loss framing and by egocentric definitions of the "kindness" or "unkindness" that begins a sequence of reciprocity.[7]

In order to measure reciprocity effects unconfounded by monetary incentives, Hannan's (2005) experiment uses a setting in which firms cannot monitor workers' exact effort levels and reward them for higher effort. Firms can only offer a wage; after accepting wage contracts, workers choose their effort levels, which (along with the effect of random exogenous shocks) determine the firms' profits. Workers cannot earn more for high effort by building a reputation, because the labor market is anonymous. In such a setting, a model that assumes individuals are motivated only by monetary payoffs predicts that firms will pay minimum wages and workers will exert minimum effort. Consistent with prior research on reciprocity (Fehr and Falk, 2002), however, Hannan

[7] While Hannan (2005) uses the concept of reciprocity to develop predictions, she notes that her predictions are also supported by psychology theories of fairness or equity (Adams, 1965; Walster et al., 1973).

predicts and finds that workers exert more costly effort when they are paid higher wages even though they receive no *ex post* reward for doing so, because they reciprocate their employer's kindness of increasing wages by increasing their effort.

The novelty of Hannan's (2005) study lies in an examination of the asymmetric effects of exogenous shocks to firm profit. In her experiment, after workers have accepted a wage contract, the exogenous shock to profits is announced and firms can re-set wages unilaterally to respond to the new economic conditions. If workers respond only to the magnitude of the wage offer, then their effort levels will depend on the sign and magnitude of the wage change, not on the change in firm profits. But Hannan (2005) predicts and finds that the shock to firm profits affects workers' response to wage changes because it affects how they interpret the wage change. They interpret a wage decrease as more unkind and thus decrease their effort more when the wage decrease follows a profit increase than when it follows a profit decrease. Similarly, they interpret a wage increase as a greater kindness and thus increase their effort more when it follows a profit decrease than when it follows a profit increase.

Based on limited prior literature, Hannan (2005) also speculates that workers' effort decreases in response to wage decreases will be larger than effort increases in response to wage increases, perhaps because of a stronger emotional response to unkindness and/or because workers' judgments of kindness are egocentrically biased toward lowering, not raising effort. Her experimental evidence is consistent with this expectation: decreases in workers' wages result in a decrease in effort that is two to three times as much as their increase in effort when wages increase.

Both firms and workers in Hannan (2005) earn higher payoffs than a self-interest-based agency model (without reciprocity) would predict, given the fixed-wage contract that experiment participants are required to use. In a related study, Kuang and Moser (2009) predict and find that individuals' preferences for reciprocity not only make the fixed-wage contract perform better than self-interest-based agency models would predict, but also make the "optimal" agency contract perform worse than such models would predict.

In Kuang and Moser's (2009) first experiment, there are two labor markets in which different compensation contracts are available. All firms in one labor market offer a forcing contract, i.e., a contract which pays agents less than their cost of effort if profit and thus effort are not at the maximum, and pays more than their cost of maximum effort — but still much less than the firm's payoff — if effort and profit are at the maximum. Effort is unobservable but can be inferred with certainty from firm profit; in consequence, wealth-maximizing workers will certainly exert high effort under this compensation contract. In the other experimental labor market, as in Hannan (2005), firms can only offer a fixed wage independent of profits and effort, but they can choose a high wage high in the hope of prompting high effort as a return gift.

As anticipated, the forcing contract results in higher mean profit than the fixed-wage contract, but the fixed-wage contract performs better and the forcing contract performs worse than predicted by a self-interest-based agency model. Some (but not all) workers sacrifice a portion of their own payoff to reward generous firms with high effort in the fixed-wage market or to punish firms in the forcing-contract market for offering such a meager-looking "high wage" (the minimum necessary to force high effort if workers value monetary payoffs only).

In Kuang and Moser's (2009) first experiment, forcing contracts and fixed-wage contracts are offered in different markets that have no communication with each other. In a second experiment, in contrast, all firms and workers are in the same market, and firms can offer either a forcing contract or a fixed-wage contract. As predicted, the ability to compare contracts makes the unkindness of firms offering forcing contracts more salient. In consequence, firm profit from the forcing contract decreases significantly in repeated trials because workers are willing to incur costs to punish firms for offering it, either by rejecting the contract or by accepting it and providing low effort. (Because firms and workers interact anonymously in all of Kuang and Moser's experiments, such punishment behavior is costly to workers: it cannot benefit them by allowing them to build individual reputations for providing high effort only when given higher payoffs than the forcing-contract payoffs.) By the later periods of the second experiment, the forcing contract provides no more profit to firms than the fixed-wage contract

does, and firms learn to offer the fixed-wage contract more often than the forcing contract.

In a third experiment, firms can offer either a fixed-wage contract, the forcing contract, or a hybrid contract that combines a forcing feature (low pay for low effort) with a reciprocity feature (high profits result in higher pay than the minimum required to motivate a self-interested, wealth-maximizing worker). In this labor market, the hybrid contract generates the same mean profits for firms as the forcing contract and does so with less volatility; it also results in significantly higher employee payoffs and social welfare. Hence in repeated trials, firms quickly shift from offering a mix of contracts to offering the hybrid contract almost exclusively.

Because reciprocity can support relatively high-wage, high-effort (high-productivity) outcomes even in a setting without reputation-building (Hannan, 2005; Kuang and Moser, 2009), it might appear that adding further support for high outcomes via reputation-building opportunities in repeated transactions would result in even higher productivity. However, Hales and Williamson (2010) identify a limit to reputation and reciprocity as substitutes for explicit incentive contracts that measure and reward high effort. Investing in reputation (and/or trusting in reciprocity) in Hales and Williamson's (2010) high-uncertainty setting requires a sacrifice of certain, immediate payoffs in return for uncertain, future payoffs. Psychology research indicates that individuals do not readily make this sacrifice: instead, they engage in myopic decision making based on a "certainty effect" — for example, placing a higher value on reducing risk from a small amount to zero than on reducing risk by comparable amounts when certainty is not attained (Tversky and Kahneman, 1986; Keren and Roelofsma, 1995). In Hales and Williamson's (2010) setting, myopia appears to prevent individuals from making profitable investments in reputation; thus in the absence of explicit performance-based contracts, organizational productivity remains low.

In their experimental setting, an owner invests resources in a firm, an employee makes productive use of some portion of the resources and consumes the rest, and a manager (who observes the employee's choice) decides ex post how to divide the resulting surplus (productivity)

between the owner and the employee. The manager's incentive compensation is a percentage of firm productivity plus a percentage of the amount allocated to the owner (profit), and the relative size of these two percentages differs across experimental conditions.

When managers decide at the end of each period how to allocate firm productivity between owners and employees, their own payoff for allocating a large amount to owners is immediate and certain, whereas their payoff for allocating a large amount to employees depends on both employees' and owners' uncertain future actions. Therefore, when a large portion of managers' incentive compensation depends on owners' payoffs, Hales and Williamson (2010) predict that managers will tend to allocate most of the firm's productivity to owners' payoffs, resulting in an immediate, certain payoff for themselves, rather than investing in reputation by paying employees well with the uncertain prospect of motivating high effort from them in the future.

Results of the experiment are as predicted. Managers underinvest in reputation development and organizational productivity remains low when a substantial portion of managers' pay depends on the owners' payoffs. In this condition managers appear to behave myopically, providing high returns to owners' investment and low returns to employees' productive effort. In consequence, employees choose low effort, organizational productivity is low, and owners reduce their investment in subsequent periods. Paradoxically, owners earn more — that is, managers make decisions that benefit owners more — when managers' pay is made *less* sensitive to owners' payoffs.[8]

4.6 Affect in Social Interactions

Much of the research previously described assumes that individuals' decisions are influenced by anticipated affect (mental states like emotion or mood) arising from contractual payoffs: for example, they anticipate feeling worse about a prospective loss than a prospective

[8] Although it is difficult to be certain whether managers' decisions are the result of ordinary risk aversion or of suboptimally overweighting certain compared to uncertain payoffs, Hales' and Williamson's (2010) ex post calculations suggest that the level of risk aversion required to account for their results is two to three times higher than that observed in prior experimental studies.

foregone gain (see Zhang and Fischbach, 2005, for direct evidence on this point), and they feel angry when they believe that they are paid too little. Studies by Kida et al. (2001) and Moreno et al. (2002) focus on affect arising not from payoffs but from social interactions within an organization.

Kida et al. (2001) predict that individuals' capital budgeting decisions will be influenced not only by the economics of the proposed projects (e.g., expected net present value of future cash flows) but also by interpersonal affective reactions that differ across capital projects. They specifically predict that managers will make decisions that sacrifice expected monetary payoffs in order to avoid experiencing negative interpersonal affect associated with a project.[9]

In Kida et al.'s (2001) experiment, participants are experienced managers who assume the role of a division manager who chooses between two capital projects that have been proposed by two managers in the firm. Participants in the treatment condition are given information that there will be high negative-affect costs of working with the manager who has proposed the project with the higher expected net present value. Although the manager has a good reputation for completing high-quality work on time and there is no doubt that the project will be completed successfully, the manager is described as arrogant and condescending, or a disorganized complainer, or unpleasant to work with in other ways. (Participants receive one of four scenarios with different negative-affect-inducing behaviors.) Participants in the control condition are not provided with any information about the behavior of the managers proposing the capital budgeting projects.

The experienced managers in Kida et al.'s (2001) study clearly expect negative interpersonal affect to have an important effect on business decisions. Most of the participants in the control group choose the capital project with the higher expected economic performance, but in the treatment condition 75-80% of the participants choose the capital

[9] The cost of experiencing negative affect (e.g., from working with a competent but difficult colleague) can be considered as a kind of effort cost: managers will require higher expected NPV to compensate for the negative affect just as they will require higher expected NPV for a higher-effort project.

project with the lower expected economic performance but with no potential for negative affect.

Kida et al. (2001) provide evidence that avoiding negative interpersonal affect is an objective for which managers are willing to sacrifice expected monetary payoffs. Similarly, Moreno et al. (2002) provide evidence that avoiding negative interpersonal affect is an objective for which managers are willing to sacrifice an otherwise preferred risk position. Moreno et al. (2002) ask experienced managers to choose between capital projects with certain or risky payoffs framed as either gains or losses. When the information provided does not suggest that the projects would have different interpersonal affective costs and benefits from dealing with pleasant or unpleasant colleagues, managers' choices are consistent with prospect theory (i.e., risk-averse in the domain of gains and risk-seeking in the domain of losses). But, as Moreno et al. (2002) predict, managers' choices change when the project descriptions are altered so that the prospect with the more attractive risk framing (according to prospect theory) is associated with negative interpersonal affect (e.g., dealing with an arrogant and condescending colleague) or the project with less attractive risk framing is associated with positive interpersonal affect (e.g., dealing with a particularly likeable colleague).

4.7 Social–Relational and Decision-Context Framing

In many of the models of social preferences used in the studies reviewed above, it is assumed that individuals trade off multiple sources of utility or value: for example, they engage in reciprocity or honest reporting only up to the point where the value of these behaviors equals their cost in terms of monetary payoffs. Another way of dealing with multiple potential payoff sources, however, is through framing which limits the sources that are relevant in any particular context, thus limiting the need for trade-offs. (For evidence of the cognitive difficulty of making such trade-offs, see Section 5.5 below.) This kind of framing is unrelated to the framing described in Section 3. Instead of providing a reference point for treating monetary payoffs as gains or losses, this kind of contextual framing assists individuals in interpreting complex social situations and answering questions like the following: Should I

be trying to increase anyone's payoffs besides my own? Is this a social setting in which competitive or cooperative behavior is the norm? The research summarized below provides evidence that MA can play a role in this kind of framing as well.

4.7.1 Social–Relational Framing

The social psychology theory of social–relational framing predicts that individuals can have either an individual or a group frame, which then motivates them to compete or cooperate with other people (Fiske, 1991; Haslam, 2004; McGraw and Tetlock, 2005). When people are framed as individuals by physical and/or conceptual relational boundaries, they have an "I" orientation and engage in self-interested competitive behavior. In contrast, when people are framed as being in a group, they have a "we" orientation and engage in more cooperative behavior aimed at improving the group's welfare.

MA can affect social–relational frames. For example, responsibility center (RC) boundaries can be such that each department manager is a separate center, or all department managers involved with an organizational process or product can be in the same center. Similarly, budgets, performance measures, or incentives can be designed for each manager or for groups of managers.

In a cross-functional team context, Rowe (2004) provides experimental evidence consistent with the prediction that the framing effects of RC boundaries created by MA influence individuals' decisions to free ride or contribute to team performance (i.e., make a costly revelation of private knowledge to the other team members to improve a team decision). The setting in his experiment is a public goods dilemma in which team performance is higher and each team member benefits if all team members contribute fully; however, each team member is individually better off if he or she free rides (does not contribute to team performance). An economic model that assumes utility only for wealth and leisure predicts that no team member will contribute anything in this situation. In contrast, social psychology theory predicts that individuals' decisions to contribute will depend on social framing.

Rowe (2004) uses two social–relational framing manipulations: responsibility center boundaries (operationalized as accounting report

structure) and team structure (face-to-face or distributed). The accounting report is structured so that each participant receives either a report on his or her own payoffs from various possible decisions (individual frame) or on the total payoffs of the team as well as the individual's payoffs (group frame). Because it is common knowledge that all members have the same payoff table, total team payoffs can easily be calculated from the individual payoff information. The team structure is either distributed (individual frame), in which the team members are in physically separate locations when they decide how much to contribute to team performance, or face-to-face (group frame), in which team members are in the same room when they decide how much to contribute to team performance. (In order to hold information exchange constant across conditions, team members are not allowed to communicate with each other.)

Rowe (2004) predicts and finds experimental evidence that team members contribute more to their team's performance when both accounting report and team structures provide group framing than when the accounting report structure and/or the team structure provide an individual frame. Consistent with prior research (Fiske and Taylor, 2008; Gaertner et al., 2002; Kramer, 1999), the individual frame dominates the group frame when both individual and group frames are present. Further analysis and evidence in Rowe (2004) traces a causal chain by which group framing increases trust, which in turn increases collectivism (a norm of contributing rather than free-riding in group situations), which then increases individuals' costly contributions to team performance.

A related study by Rowe et al. (2008) provides field-study evidence on the same issue in a setting where department managers work on a common organizational process (e.g., logistics, manufacturing) and are assigned to a cross-functional team to solve a non-routine problem of how to increase the economic performance of the organizational process. To solve their problem, the managers must reveal private information about their own department's performance capability and slack resources. While such revelations can result in higher organizational performance, they can also result in individual managers' being assigned more difficult performance targets and/or giving up resources.

In Rowe et al.'s (2008) field study, individual and group frames are created by RC boundaries, which are influenced by a variety of practices such as shared accounting information, consolidated budgets, and physical proximity. Rowe et al. (2008) predict that RC managers' behavior will be influenced by how these boundaries are drawn: framing a set of managers as a group by including them within the boundaries of an RC prompts more cooperative behavior. High revelation of private information is expected when there is group framing *and* RC performance can be measured only at the group level. If the managers working on a common organizational process belong to different RCs (i.e., are separated by RC boundaries) and/or if their performance is individually measured, then Rowe et al. (2008) predict that the department managers' revelations of their private information to solve their problem will be lower. The evidence in their field study is consistent with these predictions.

4.7.2 Decision-Context Framing

Another kind of contextual framing guides behavior by prompting individuals to interpret social situations, not in terms of the social relations among the parties as in social–relational framing, but in terms of the decision context. For example, among a group of individuals with given social relations, deceptive behavior can be considered more or less acceptable and can be more or less prevalent depending on whether the decision context is (for example) a poker game or a joint contribution to a favorite charity.

Rankin et al. (2008) use the theory of decision framing (Tenbrunsel and Messick, 1999) to provide and test an explanation of the honest reporting of private information by subordinates that is often observed in experimental research, even when subordinates could earn considerably more by lying. This theory proposes that, depending on institutional features, a given situation can be framed either as an ethical dilemma or a strategic interaction, and the ethical-dilemma framing is more likely to result in individuals' choosing ethical behavior as an objective and engaging in such behavior (holding monetary payoffs constant across frames).

Rankin et al. (2008) suggest that the widespread honesty observed in prior budgeting experiments is driven, at least in part, by the discretion over budget-setting provided to subordinates in these experiments. They argue that if superiors have no ability to reject or modify the budgets that subordinates propose, then subordinates frame the decision as an ethical dilemma of whether to take advantage of the superior. In contrast, a setting where subordinates make proposals but superiors have final authority frames budgeting as a strategic interaction, in which each party acts in his or her self-interest.

Rankin et al. (2008) measure honesty as the difference in slack between a condition in which the budget proposal requires a factual assertion about production cost that results in a division of profit between superior and subordinate and a condition in which the proposal merely offers a division of profit between superior and subordinate without making any assertion about product cost. This measure enables the researchers to distinguish between two reasons why slack differs between a superior-authority and subordinate-authority condition. If subordinates propose lower-slack budgets in the superior-authority condition only because they fear that higher-slack budgets will be rejected, then superior authority will have the same effect on slack regardless of whether the budget proposal makes a factual assertion about cost or simply proposes a division of profits. However, if the superior-authority condition also affects subordinates' beliefs about the normative appropriateness of honesty, then it will have different effects on slack depending on whether the budget proposal requires a factual assertion and thus provides an opportunity to be honest or not.

As predicted, Rankin et al. (2008) find that the locus of budget authority influences subordinates' propensities to report honestly. When subordinates have final authority, they include less slack in their budgets when the proposal requires a factual assertion than when it does not. When superiors have final authority, however, the effect of the factual-assertion manipulation (i.e., the honesty effect) is significantly smaller. Participants' responses to post-experiment questions also support the claim that subordinates have a greater desire to be honest when the superior has no final authority over the budget.

4.8 Summary

The outcomes that individuals value include not only monetary payoffs and leisure but also non-monetary payoffs derived from social psychological objectives such as fairness, reciprocity, honesty, and affect in social interactions. The amounts of money individuals are willing to sacrifice in the laboratory to achieve these payoffs are sometimes non-trivial (Evans et al., 2001) — though there is considerable heterogeneity across individuals in these preferences — and experienced managers expect that non-trivial amounts of money will also be sacrificed to achieve these payoffs on the job (Luft and Libby, 1997; Kida et al., 2001; Moreno et al., 2002; Rowe et al., 2008).

Non-monetary payoffs influence the functioning of MA control systems — sometimes for the better by inducing more cooperation and honest communication (Evans et al., 2001; Rowe, 2004), but their influence is not always benign. For example, fairness concerns, social comparisons, and the desire to appear honest can lead to potentially costly misjudgments in negotiations (Luft and Libby, 1997) and limit the value of "better" (finer) accounting information in reducing contracting costs (Drake and Haka, 2008; Hannan et al., 2006, 2008). Similarly, the decisions that bolster individuals' self-esteem as successful profit-makers can reduce the profits that they actually make (Bloomfield and Luft, 2006). Such self-deceiving decisions seem unlikely to be deliberate; they seem more consistent with intuitive processes in which individuals make gut-feel decisions without being fully conscious of why one decision alternative feels better than another.

Non-monetary objectives are not independent of each other, and like preferences for monetary payoffs, they are not entirely stable and exogenously given. Fairness concerns influence the value that people put on honesty (Zhang, 2008), prospect-theory reference points influence the value people put on fairness and reciprocity (Chang et al., 2008; Hannan, 2005), and institutional features such as organizational structure and budgeting procedures can cue individuals as to whether they are in a situation where non-monetary objectives are important (Rankin et al., 2008; Rowe, 2004).

5

Models of Decision Structure, Variable, and Relation-Form Choice

Decision-makers' valuations of the payoffs they anticipate from their decisions are only one component in a larger mental representation of the task in which they are involved. We now analyze research on how decision makers structure these larger mental representations. When managers set budget goals, for example — regardless of whether they are trying to maximize absolute monetary payoffs, framed monetary payoffs, or a mix of monetary and non-monetary payoffs — how do they mentally represent the task of budgeting? What variables and constraints enter into their thinking? Do they fully take into account the decisions of relevant others — for example, do principals designing incentive contracts fully think through the decisions that are likely to be made by the agents they are trying to influence?

The literature on subjective model structures of MA-related decisions reviewed in this section documents a number of important and related behavior patterns in subjective decision making:

(1) *Sequential instead of simultaneous decisions.* Many MA-related tasks can be represented by constrained-optimization

models that require multiple specific decisions to be made simultaneously (e.g., simultaneous choice of initial capacity acquisition, future product prices, and additional as-needed capacity purchases in Balakrishnan and Sivaramakrishnan (2002)). Individuals tend to simplify these simultaneous decisions by breaking them down into a series of simpler decisions that can be made sequentially (Section 5.1).

(2) *Simple causal models.* Individuals' subjective decision-model structures tend not to incorporate complexities like nonlinear, indirect, delayed, and bidirectional (feedback) causal relations (Section 5.2).

(3) *Heuristic decision models.* Common heuristics like representativeness or anchoring and adjustment often substitute for more complex decision models (Sections 5.2 and 5.3).

(4) *Qualitative and incomplete models.* Subjective decision models sometimes resemble incomplete and qualitative versions of quantitative scientific models. They are incomplete in that they include most but not all variables in the scientific model, or they omit later links in long causal chains. They are qualitative in that they incorporate the signs of relations between variables in the model and gross differences in the relative magnitude of these relations but not exact magnitudes. For example, individuals may know that two factors have expected positive effects on profits and that one of these factors typically has a much larger effect than the other, but they do not know the exact dollar amount of these effects (Section 5.4).

(5) *Non-compensatory models.* In part because subjective decision models are qualitative, they often do not provide strong guidance for trade-offs. Without quantification, the model cannot inform decision makers how many units of one attribute it is worthwhile to give up in order to gain five units of another attribute. In consequence, individuals often avoid trade-offs by omitting some attributes or information from their subjective decision model, or by avoiding the decision altogether (Section 5.5).

(6) *Variable inclusion as a function of individual characteristics.* Individuals with different experience and knowledge include predictably different sets of variables in their subjective decision models (Section 5.6).

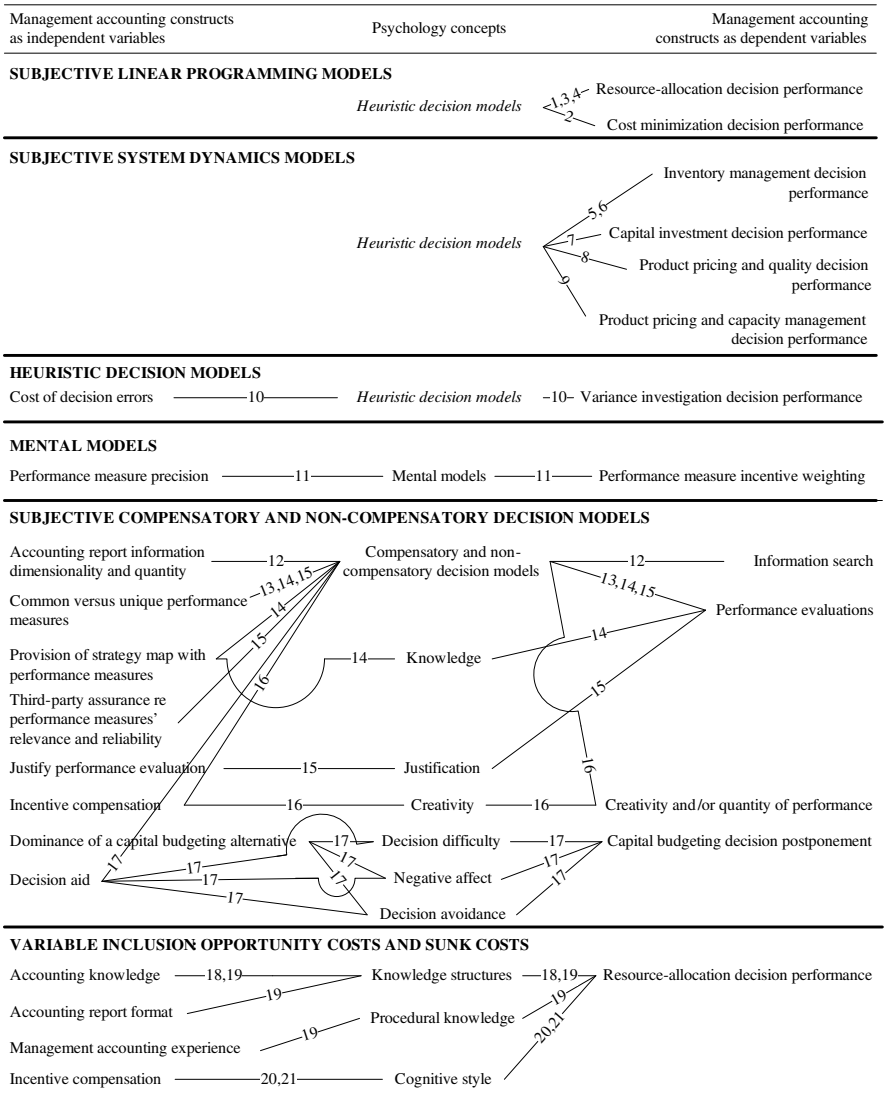
As noted in Section 2 of our review, psychology-based research on MA tends to focus on how specific decisions are made rather than how multiple interdependent decisions are combined in tasks like capacity, pricing and product-mix planning or MA control system design. Thus in Section 5 more than elsewhere, we reach beyond the MA literature to studies of MA-related tasks (e.g., inventory planning, capital budgeting, cost-minimizing resource-allocations) in other literatures that provide information on subjective decision-model structures. (This is particularly apparent in Sections 5.1 and 5.2.) Figure 5.1 provides a graphic summary of the MA constructs and psychology concepts used in this literature.

5.1 Subjective Linear Programming Models

Research on subjective decision models for mathematical programming problems is important because many economics-based models used in MA are mathematical programming models — for example, agency models like Feltham and Xie (1994) and capacity-planning and pricing models like Balakrishnan and Sivaramakrishnan (2002). Survey evidence introduced in Section 1 indicates that while linear programming is used relatively often by managers (more often than most other quantitative techniques, including other mathematical programming models), it is often not used in settings where its use appears relevant. Instead, managers make subjective decisions in what appear to be constrained-optimization problems.

Psychology-based MA research has not directly investigated subjective models of these decisions. However, a stream of psychology research examines subjective decision making in resource-allocation problems that can be modeled with linear or integer programming (Langholtz et al., 1993, 1994, 1995, 1997; Ball et al., 1998; Gonzalez et al., 2002). Some of the studies use Coast Guard personnel to perform tasks similar to those they perform on the job (scheduling boats or helicopters to

provide maximum monitoring of an area, given constraints on personnel hours and fuel) while others use student participants to perform similar work-scheduling tasks or everyday tasks like allocating a food budget between eating at home and at restaurants. The tasks in these studies vary in a number of ways: some are two-dimensional while others are three-dimensional, some include only decisions under certainty while



See Figure 3.1 for an explanation of how to interpret this figure.

1. Ball et al. (1998)
2. Gonzalez et al. (2002)
3. Langholtz et al. (1995)
4. Langholtz et al. (1997)
5. Sterman (1989a)
6. Diehl and Sterman (1995)
7. Sterman (1989b)
8. Sterman et al. (1997)
9. Paich and Sterman (1993)
10. Lewis et al. (1983)
11. Krishnan et al. (2005)
12. Shields (1980)
13. Lipe and Salterio (2000)
14. Banker et al. (2004)
15. Libby et al. (2004)
16. Kachelmeier et al. (2008)
17. Sawers (2005)
18. Vera-Muñoz (1998)
19. Vera-Muñoz et al. (2001)
20. Chenhall and Morris (1991)
21. Awasthi and Pratt (1991)

Fig. 5.1 Models of decision structure, variable, and relation-form choice.

others introduce risk (known probabilities) or uncertainty (unknown probabilities), and some are set in benign environments with abundant resources while others are set in harsh environments where resources are more likely to run out.

Results of these studies, which are largely consistent across participant and task types, can be grouped under three main headings. First, two simplifying approaches describe the subjective decision-model structures of almost all participants. Both of these approaches split the linear programming task into specific decisions that are then made sequentially. Second, anchor-and-adjustment heuristic decision models (Epley and Gilovich, 2006) often substitute for more complex decision models. Third, individuals using these simplifying approaches generally perform well: after several trials, individuals making subjective decisions achieve about 90% of the performance that would be achieved by solving the relevant linear program mathematically.

All of the tasks Langholtz and colleagues use in these experiments create complexity by including multiple constraints that apply to different time intervals. The tasks require individuals to optimize a variable over a period of several days, given some constraints that apply to the entire period (e.g., a weekly budget) and some that apply to part of the period (e.g., a minimum or maximum number of work

hours or meals each day). Solving to satisfy both types of constraints simultaneously is a complex task, and individuals typically use one of two strategies to divide the task into specific decisions that can then be made sequentially. Ball et al. (1998) identify these two strategies in a concurrent verbal protocol study.[1] They also identify patterns of decision behavior consistent with each strategy, enabling a subsequent study (Gonzalez et al., 2002) to identify probable strategies from decision-behavior data alone.

Some individuals follow what Ball et al. (1998) call a solve-and-schedule (SAS) strategy: they first calculate a total solution for the longer time period (e.g., 20 meals in a week, with 10 at home and 10 in a restaurant) and then allocate the total solution across days in a way that satisfies each daily constraint. Others follow a consume-and-check (CAC) strategy that omits the first step of developing a total solution. They make decisions one day at a time, adjusting daily decisions to fit the remaining weekly resources.

Ball et al. (1998) argue that the CAC strategy is simpler because it does not require the first, often difficult, step of calculating a total solution. Consistent with this argument, CAC is a more common strategy: 79% of participants use it in Ball et al. (1998) while 21% use an SAS strategy. CAC performs somewhat less well, however: it produces 94% of the efficiency that would be generated by the linear programming solution, compared to 97.5% for SAS, with constraint violations in 1% of daily decisions versus 5% with CAC (Ball et al., 1998). Gonzalez et al. (2002) predict and find that as complexity increases, individuals shift to the simpler strategy: in a cost minimization problem under certainty, 50% of their participants use SAS and 50% use CAC. In a risky condition, where the resources available can change from day to day with a known probability, the proportions change to 14% SAS and 86% CAC; and in an uncertain condition, where resources can change with unknown probabilities, all participants use CAC.

[1] Concurrent verbal protocol analysis is a research method frequently used in cognitive psychology research to investigate how people construct mental representations of decisions (Ericsson and Simon, 1993). Concurrent verbal protocols are obtained while participants in a research study verbalize what they are thinking about when they are searching for and processing information to make a decision.

When individuals develop either a total solution in SAS or a first daily solution in CAC, they attempt to take resources and constraints into account but do not always know exactly how to do so. In consequence, their initial decisions are often influenced by a focal point or salient anchor such as equal use of two available options; they then adjust (often inadequately) from this anchor based on information provided, for example using somewhat more of the option that appears to have a better cost–benefit trade-off. Langholtz et al. (1997) document use of an anchoring and adjustment heuristic decision model by comparing three versions of the meal-planning problem: in one the optimum is an equal split between two meal options (home and restaurant), in one the optimum is skewed (one option should be chosen more often), and one is an "all-and-nothing" decision in which only one of the options should be chosen. Experiment participants' actual decisions tend to be equal splits in both the equal-split and skewed conditions, and to be somewhat unequal in the all-and-nothing condition, consistent with anchoring on the equal-split solution and adjusting insufficiently. Coast Guard personnel assigning two different boats to patrol duty exhibit the same tendency to anchor on equal use of both boats and adjust insufficiently for differences in their fuel and personnel costs (Langholtz et al., 1995).

Although Ball et al. (1998) and Langholtz et al. (1995, 1997) document high performance by decision makers using simplified subjective decision models, some caution is in order in generalizing from these studies. As Langholtz et al. (1997) point out, the parameters in the experimental tasks are such that participants can achieve high levels of efficiency (around 90% of the linear program solution) even when they make choices that are substantially different from those prescribed by the linear program (e.g., a 9, 9 mix of two options when the linear-programming solution is 6, 15). Thus, making a choice that is different from the linear programming solution in this setting does not always have high opportunity costs because very different resource-allocation solutions often do not result in very different efficiency outcomes. Some real-world environments are probably equally forgiving, while others are less so.

This literature raises interesting questions for MA research about the effects of time-interval focus (deciding on resource use for an entire budget period initially or only for subperiods), degree and type of uncertainty, and the distance between the anchor and the linear programming solutions. Although the tasks employed by Langholtz and colleagues are somewhat challenging for subjective decision making, they are considerably less complex than some MA-related tasks (e.g., Balakrishnan and Sivaramakrishnan, 2002; Feltham and Xie, 1994). The next section reviews research on subjective decision making using much more complex decision problems modeled as systems of differential equations. Simplified subjective models in which anchoring and adjustment heuristics play a large role are characteristic of decision making in this domain, as in the studies reviewed earlier in this section.

5.2 Subjective System Dynamics Models

System dynamics models represent complex causal systems connected by closed feedback loops (Sterman, 2000). For example, in a model of new product diffusion, an increase in the customer base increases the amount of word-of-mouth advertising, which (if positive) increases the customer base further (Paich and Sterman, 1993). The customer base $\rightarrow$ word of mouth $\rightarrow$ customer base relation is a closed feedback loop in which the effects are delayed and nonlinear. Individuals who buy a new product because of positive word-of-mouth often do not buy it immediately (delay), and the magnitude of the word-of-mouth effect on the future customer base is small when the current customer base is small (because there are few mouths), larger as the customer base grows, and smaller again as a saturation point is reached and large increases are no longer possible (nonlinearities).

System dynamics models are usually much more complex than a single feedback loop, as they include numerous variables with differently lagged and nonlinear effects. For example, in the new product diffusion model, marketing expenditures and price reductions also increase the customer base. As the base becomes larger and approaches the saturation point, it increases more slowly, but as individuals replace

old versions of the product because they are obsolete or worn out, the effective customer base increases again (Paich and Sterman, 1993).[2]

System dynamics models have been used to represent MA-related tasks such as inventory management (Sterman, 1989b; Diehl and Sterman, 1995), capital investment (Sterman, 1989a), product pricing and capacity acquisition (Paich and Sterman, 1993) and product pricing and quality management (Sterman et al., 1997). Several studies provide experimental evidence on subjective decision models of system-dynamics problems. These complex problems provide a less forgiving environment than the two-dimensional linear programming problems used by Langholtz and colleagues in the prior section, and subjective decision performance is accordingly farther from the performance prescribed by the model.

Three predicted results recur robustly across system dynamics experiments using different problems and participants. First, individuals' subjective decision-model structures often omit lagged and nonlinear relations, and they are particularly likely to be "open loop" (unidirectional causation) rather than "closed loop" (bidirectional causation) models (Sterman, 1989b,a; Paich and Sterman, 1993). For example, when changes in demand influence individuals' investment decisions and their investment decisions in turn change subsequent demand, individuals' subjective models include the demand $\rightarrow$ investment portion of the loop but not the investment $\rightarrow$ demand portion Sterman (1989a). Decision makers treat as exogenous shocks some outcomes that are actually endogenous but delayed results of their own prior decision making. Thus, their subjective models omit later links in the chain of causation that follows from their actions.

Second, individuals' decisions can often be well explained by heuristic decision models, in particular, anchoring and adjustment (Sterman, 2000). These heuristic models include a small number of variables and do not incorporate delayed effects of earlier decisions or indicators of future changes in the environment (Paich and Sterman, 1993; Diehl and Sterman, 1995).

[2] Ashton (1976) provides analysis of how MA provides positive and negative feedback loops that can result in unintended consequences.

Third, subjective decision performance compared to the performance of decisions generated by systems dynamics models is generally low, although some environments are more forgiving than others (Paich and Sterman, 1993; Diehl and Sterman, 1995). Subjective decision performance often improves with practice, but individuals' insight into the decision-problem structure typically does not improve: practice enables them to fine-tune their significantly incomplete heuristic models rather than develop more complete models (Paich and Sterman, 1993).

To expand on these points we examine three studies in more detail. In Sterman (1989a), experiment participants include scientists, economists, and executives (company presidents and CEOs) as well as MIT students. In each of 36 periods participants receive information on capital goods orders from the consumer-goods sector in the current period, unfilled capital goods demand from the previous period, and loss of capital goods to depreciation. They then decide how much new capital (capacity) to order to meet the production needs of future periods.

The anchor-and-adjust heuristic model most participants use is to order enough new capital to replace what has depreciated (the anchor), with an adjustment (usually in insufficient amounts) for large discrepancies between current demand and production capacity. This model explains participants' actual decisions with a pooled R^2 of 85%. It also performs very poorly in managing production capacity. Performance is measured as the average deviation between desired and actual production capacity over all periods of the experiment. According to the systems-dynamics model used to create the experimental task, the smallest deviation between desired and actual capacity that can be achieved is 19 (given the problem parameters, not all demand can be satisfied immediately). The mean deviation achieved by experiment participants is more than 30 times as large. Sterman (1989a), in considering why individuals use a decision model that performs so poorly, observes that the model works quite well in an environment where demand is completely exogenous. What individuals seem to find extremely difficult to incorporate into their subjective decision models is the positive feedback effect of the investment multiplier — i.e., the fact that large unfilled orders for capital can be the result not only of

exogenous shocks to the demand for consumer goods but also the result of the decision-makers' own prior decisions to place large orders.

If individuals' subjective decision models typically do not include delayed effects and positive feedback effects, then subjective decision-making performance will vary systematically with the magnitude of these effects in the decision environment. To test this prediction, Paich and Sterman (1993) manipulate product lifetime (delay in feedback from repeat purchases) and the strength of word-of-mouth (strength of the positive feedback loop) in a product pricing and capacity-acquisition task. As expected, decision performance is significantly lower with longer delays, stronger positive feedback, and the interaction of the two. With weak positive feedback effects and little delay, individuals' mean profit performance is over 60% of the performance predicted by a relatively simple benchmark model; but with strong feedback effects and long delays, the ratio of mean actual profits to benchmark profits is less than a *negative* 40%.

Similarly, Diehl and Sterman (1995) manipulate length of delay and the existence and sign of closed-loop feedback (none, positive, or negative) in a problem where decision-makers' task is to manage inventory so as to minimize the costs of deviation from target inventory. When feedback delay is longer and feedback is positive rather than negative or absent, there is more divergence between individuals' subjective decision models (estimated from their observed decisions) and the systems dynamics model. Interestingly, actual decision performance relative to the performance of model-prescribed decisions is no worse in this case as a result of individuals' poorer models. Mapping of the deviation-cost surface shows that the task has a relatively flat optimum, as a number of dynamic decision tasks do (but others do not), hence highly simplified subjective models do not lead to much worse decision performance.

5.3 Heuristic Decision Models

Complex tasks modeled with systems dynamics are not the only settings in which individuals use heuristic decision models. For example, Lewis et al. (1983) document these heuristics in variance

investigation decisions, using concurrent verbal protocol analysis. The decision-theory model used to create the experimental materials in Lewis et al. (1983) prescribes investigation of a variance when the posterior odds ratio that the process is out of control, given a report about the process's current output, exceeds the ratio of the marginal costs of Type I and Type II decision errors. The experiment tests for the inclusion of relevant factors in participants' subjective decision models by manipulating the prior probability that the process is in control and the cost of not investigating when the process is out of control. If participants' subjective models do not include these elements of the decision-theory model, then their protocols and decisions will be unaffected by the manipulation.

The experiment provides a setting favorable to the use of a subjective model much like the decision-theory model. Participants are MBA students who have completed at least two statistics courses, and they receive all of the information required by the model. They make 12 decisions, and thus have considerable opportunity to become familiar with the decision. The prior probability and error cost manipulations are within-subject and therefore salient. Participants' compensation is contingent on their decision performance, measured as the deviation of their decisions from decisions based on the decision-theory model.

While participants are making their decisions, the experimenters cue them to keep verbalizing what they are thinking about while reading the instructions and making their decisions. The transcribed tape recording of each participant's concurrent verbal protocol for each decision is then classified as belonging to one of three models suggested by prior research on variance investigation decisions and cognitive psychology research: a control-chart strategy, a control chart with anchoring and adjustment, and the expected-value-maximizing model used as a basis for constructing the experimental task.

A control-chart strategy consists of investigating a variance if it is more than some specified distance from the mean of the in-control distribution.[3] In its simplest form, this strategy is invariant to changes in

[3] Magee and Dickhaut (1978) provide evidence that control chart strategies are used in subjective variance investigation decisions.

prior probabilities or the costs of Type I and Type II decision errors and is based solely on whether the output of the process is similar to the in-control or out-of-control distribution. Thus it is consistent with the widely used representativeness heuristic (Kahneman and Frederick, 2002) in which decisions are based on the degree to which an object from one class (here, the variance report) is similar to or representative of another class (the in-control distribution), disregarding decision-relevant factors like prior probabilities or sample sizes.

A more complex strategy, midway between the simple control chart and the decision-theory model, incorporates an anchoring and adjustment heuristic (Epley and Gilovich, 2006). In this strategy the individual begins with a control-chart strategy and adjusts the control-chart limits — but insufficiently — for information like decision error costs. The most complex strategy employs an expected-value-maximizing decision-theory model.

Lewis et al. (1983) find that of their ten participants, eight can be classified as using the simple control-chart strategy; one uses a strategy that anchors on the control chart and adjusts for changes in prior probabilities and decision error costs, and one uses an expected value strategy as prescribed by the decision model. Consistent with the predominant use of control chart strategies in which decision error costs and prior probabilities do not have major influences on decisions, prior probabilities are verbalized by participants when making 26 (22%) of the 120 decisions (10 participants $\times$ 12 decisions), costs of decision errors are verbalized when making 24 decisions (20%), and the integration of probabilities and decision error costs are verbalized when making nine decisions (8%).

Although participants' heuristic decision models appear substantially different from the decision-theory model used to create the experimental materials (omitting two important variables, decision error costs and prior probabilities) researchers cannot conclude without further analysis that the use of the heuristic models results in substantially different economic outcomes. Lewis et al. (1983) use simulation analysis to estimate the long-run opportunity cost of using a control-chart strategy that investigates all outcomes more than one standard deviation above the in-control mean, compared to a multi-period Bayesian model. The

results indicate that the opportunity cost depends on the marginal cost of Type II errors and the prior probability that the process is in control. For the parameter values included in the simulation, using the control-chart strategy instead of a multi-period Bayesian model resulted in an increase of four to nine points in the percentage of total production costs attributable to ex post incorrect investigation decisions.

5.4 Mental Models

Research reviewed in the previous sections documents a number of specific simplifications in individuals' subjective decision models. A more general overview of simplifications in subjective decision models is provided by psychology research on mental models (Markman, 1999; Markman and Gentner, 2001). Mental models are subjective representations of systems of causal relations, which can be used to support decisions as well as explanations and predictions of complex phenomena (Markman and Gentner, 2001). Mental models usually differ from formal scientific models with respect to three properties (Markman, 1999; Markman and Gentner, 2001).

First, mental models are *qualitative* rather than quantitative: they represent directional relations (e.g., X increases or decreases Y) and approximate relative magnitudes of relations but not exact amounts (e.g., X_1 has a larger effect on Y than X_2 does).

Second, mental models often *substitute* more familiar attributes for the attributes in formal scientific models. Statistical attributes like conditional probability and covariance are often replaced by attributes like similarity, familiarity, and causal propensity, which individuals assess more naturally or spontaneously when examining their environment and access more readily in decision making (Kahneman and Frederick, 2002). In some but not all cases, using the natural attribute (e.g., causality) results in the same judgments and decisions as using the formal statistical attribute (e.g., covariance).

Third, mental models are often *incomplete* compared to quantitative scientific models. They typically omit some relevant information (Markman and Gentner, 2001). They are likely to include direct effects

or short causal chains (e.g., X influences Y) while omitting indirect effects (e.g., W influences X which influences Y) and more complex (e.g., nonlinear, lagged) causal relations (Sterman, 1989b,a; Diehl and Sterman, 1995).

Krishnan et al. (2005) use these expectations about mental models to develop hypotheses about how individuals who are not compensation experts decide subjectively on the weights to attach to performance measures in an incentive compensation plan. Their study focuses specifically on individuals' use of two properties of accounting performance measures — the precision of a given measure and the covariance of the errors of two measures.

Because mental models are *qualitative*, Krishnan et al. (2005) develop predictions about the existence and direction, rather than the exact magnitude, of the effects of precision and error covariance on subjective weighting decisions. They then use the *substitution* and *incompleteness* properties of mental models to develop five hypotheses about how subjective performance measure weighting decisions will resemble and differ from the weights predicted by Feltham and Xie (1994).

Many subjective decisions are insufficiently influenced by statistical properties like the error variance (precision) or covariance of information because statistical information is too abstract to capture the attention of many people (Kahneman and Frederick, 2002). For the incentive weighting decision, however, individuals are expected to *substitute* the cognitively more accessible but (in this setting) statistically identical attribute of controllability for precision and error covariance.[4] Thus Krishnan et al. (2005) predict that the precision of a performance measure will influence individuals' subjective weighting of the measure, and error covariance between two measures will influence subjective weighting of both measures.

Because mental models are *incomplete*, however, Krishnan et al. (2005) predict that the use of precision and error covariance information will exhibit a characteristic pattern of decision errors (i.e., deviations

[4] The more that uncontrollable events affect two measures in opposite directions (i.e., the more negative the error covariance of the two measures is), the less the combination of the pair of measures is influenced by uncontrollables.

from the predictions of the Feltham and Xie (1994) model that was used to create the experimental materials). First, individuals will usually realize that the precision of a measure should affect the weight on that measure in an incentive contract, but they will less often perform the additional reasoning required to realize that the precision of a measure should also affect the weights on *other* measures in the contract as well. For example, in an incentive contract based on cost and quality measures, an increase in the precision of a cost measure not only allows the weight on the cost measure to be higher (because a more precise measure imposes less risk on employees) but also allows the weight on the quality measure to be higher than it would be when the cost measure is less precise. The higher weight on the (precise) cost measure allows the organization to put a higher weight on the quality measure as well without inducing an undesired shift of employees' effort allocation away from cost.

The second effect of mental-model incompleteness predicted by Krishnan et al. (2005) is that individuals are more likely to make *directional* errors in the use of precision and error covariance than to ignore them altogether. Most individuals will reason far enough to understand that risk-averse employees require additional pay (a risk premium) to compensate for the risk imposed by an imprecise measure, but then they do not do the further reasoning that this additional pay is more efficiently provided as a part of salary rather than as an increase in the incentive weight on the performance measure, because the latter would increase risk still further and require a still higher risk premium.

The experimental results in Krishnan et al. (2005) provide support for the hypotheses. About half of the participants have mental models that are complete qualitative versions of an agency-theory model: that is, they make decisions that are qualitatively (directionally) consistent with the agency-theory model. Most of the other participants' mental models are incomplete versions of the agency-theory model, resulting in the predicted patterns of decision error. That is, they make directionally incorrect changes in performance measure incentive weights in response to changes in performance measure precision and error covariance, and they fail to take into account the spill-over effect of changes in one measure's precision on another measure's incentive weight.

5.5 Subjective Compensatory and Non-compensatory Decision Models

Individuals' limited cognitive capacity and the qualitative nature of their subjective decision models can pose problems for common MA-related decisions that require individuals to compare multiple alternatives (e.g., business units, products, capital investment proposals) on multiple dimensions. Models of the form $y_i = b_1 x_{i1} + b_2 x_{i2} + \cdots + b_n x_{in}$ can provide an effective way of mathematically combining an alternative's values on multiple attributes (the x_i's) into a single value (y_i,) and then comparing the y_i's. In these compensatory decision models a high value of x_1 can compensate for a low value of x_2 in determining the overall value of an alternative. But the information-processing requirements of compensatory decision models are high, and they require exact quantitative estimation — for example, estimation of the parameters b_1 and b_2 in order to determine *how much* x_1 is required to compensate for a low value of x_2. Psychology research has shown that, in consequence of the high cognitive demands of compensatory decision models, individuals often use non-compensatory decision models instead. (Payne et al., 1993; Bonner, 2008; Karelaia and Hogarth, 2008).

Compensatory models tend to require more information use than non-compensatory models. Consider, for example, 15 projects competing for budget funds, which are evaluated based on five attributes (e.g., expected contribution to profit, riskiness, strategic fit, credibility of the proposals, social responsibility criteria). Compensatory models require evaluators to combine 75 (15×5) items of information, weighting the five attributes appropriately. Determining appropriate weights can require the acquisition and processing of additional information.

Psychology research indicates that individuals frequently use non-compensatory models to reduce cognitive demands, especially for more complex decisions (Payne et al., 1993). For example, a lexicographic model reduces cognitive information-processing load by determining an order of relative importance of the attributes without determining exact weights. The decision maker then chooses the alternative with the highest value on the most important attribute, without examining values on the other attributes. If this procedure results in a tie, then the decision

maker breaks the tie by examining values on the next most important attribute, and so on. Another non-compensatory model, elimination by aspects, also begins by determining an order of relative importance for the attributes. It establishes a cutoff value for the most important attribute and eliminates all alternatives that do not surpass this cutoff value. If multiple alternatives remain, then the decision maker establishes a cutoff for the next most important attribute and eliminates alternatives that do not meet this cutoff, and so on. If the cutoffs are set at relatively extreme levels, then the decision maker is likely to be able to make a choice without having to evaluate all of the alternatives on all of the attributes.

In addition to their cognitive demands, compensatory models have affective consequences that can influence decision making. The cognitive conflicts involved in making trade-offs often generate negative affect, especially when the attributes being traded off are highly valued (Hogarth, 1987; Luce et al., 2001). Decision makers can avoid negative affect by avoiding the decision itself (Luce, 1998) or by using non-compensatory models that avoid explicit trade-offs.

Decisions that use non-compensatory models are not based on all of the available information and are therefore likely to result in poorer decisions. Payne et al. (1993) propose that individuals' use of compensatory and non-compensatory models is consistent with a benefit (decision accuracy) and cost (effort) trade-off. Compensatory models are more likely to be used for making decisions with low information-processing demands (e.g., few alternatives) and trade-offs that generate low cognitive conflict. As the decision becomes more complex, people are more likely to use non-compensatory models in order to reduce cognitive effort and cognitive conflict.

Because MA provides and structures information for decision makers, it can help to determine the cost of using compensatory decision models and thus the likelihood that they will be used. Below, we review six studies that illustrate different ways in which MA affects the cost of using compensatory models and in consequence affects decision performance.

Shields (1980) provides theory-consistent experimental evidence on how different performance-report structures prompt the use of different

compensatory and non-compensatory models in performance evaluation by experienced managers. The dependent variables in the study are measures of information search; as noted above, the information requirements of compensatory and non-compensatory models are different, and therefore measures of individuals' information search can provide evidence about their decision models. Individuals who use compensatory models require information about every attribute of each alternative, or at least the same subset of attributes for each alternative, if they determine that not all attributes are sufficiently relevant to use in their decisions. In consequence, they search for information about all attributes (or the same subset of attributes) for every alternative. In contrast, decision makers who use non-compensatory models search more selectively and less consistently. For example, if they use a model that requires alternatives to exceed a cutoff value on a particular attribute, then they will not search for further information on an alternative that fails the cutoff on the first attribute they examine, but they will search for further information on alternatives that exceed the first cutoff.

In Shields' (1980) experiment, participants evaluate the performance of either three or nine subunit managers, based on either 6 or 13 performance measures, resulting in total information available ranging from 18 to 117 items. When participants evaluate more managers, they exhibit several patterns of information search that are consistent with more use of non-compensatory decision models. As predicted, participants search a smaller percentage of the total information available (though a larger amount of information absolutely) when they evaluate more managers. In addition, their search patterns are more variable, and their search patterns shift from looking across performance measures within a given manager's report (as if they were combining the measures to create a single performance score for the manager) to looking across managers within a given performance measure (as if they were using lexicographic or elimination-by-aspects models). Increases in the number of performance measures per manager do not have comparable effects.

Another way in which individuals can avoid compensatory-model trade-offs, besides cutoff-based non-compensatory decision models, is

to restrict the number of attributes they consider to a subset that is more easily comparable. For example, suppose the manager of a marketing-intensive subunit is evaluated based on the unit's profitability and market share, while the manager of a production-intensive unit is evaluated based on the unit's profitability and physical productivity. Providing a relative performance evaluation of the managers is much easier if it is based only on profitability and the evaluator does not have to decide how much market-share improvement would be equivalent to a given improvement in productivity. Accordingly, psychology research finds that in settings where individuals choose between alternatives with some comparable and some non-comparable attributes, they tend to economize on cognitive effort by basing their decision on attributes that are common to all alternatives (Slovic and MacPhillamy, 1974).

Lipe and Salterio (2000) use this concept to predict that when an organization uses a set of performance measures, some of which are common to all subunits and some are strategy-specific and thus unique to particular subunits, performance evaluations of the subunits' managers will be influenced more by the common measures than by the unique measures. This prediction is supported by the results of an experiment in which participants evaluate two business-unit managers based on balanced scorecards that include both common and unique performance measures (Lipe and Salterio, 2000).

Further studies replicate Lipe and Salterio (2000) and extend it by investigating techniques for increasing the use of unique measures. Potential explanations for low use of unique measures include uncertainty about the relevance and/or reliability of the unique measures and insufficient effort to determine weights that would allow comparison of unique measures. Markman and Medin (1995) propose that if individuals exert enough cognitive effort, then they can establish a basis for making such comparisons. Techniques for inducing more use of unique measures therefore depend on either providing more explicit assurance about the relevance and/or reliability of the unique measures or increasing the cognitive effort that evaluators exert. (Increased effort is no guarantee that the unique measures will be correctly weighted, however. It only reduces the likelihood that they will be ignored.)

In an extension of Lipe and Salterio (2000), Banker et al. (2004) provide participants in one condition of their experiment with a graphic representation and detailed description of the organization's strategy to insure that they have the knowledge relevant to choosing measures for performance evaluation. Not all performance measures presented in the experiment are linked to the organization's strategy, and the provision of strategy information insures that participants know that some unique (as well as common) measures are strategically relevant. This information does not eliminate the tendency to put smaller weights on unique measures — among the strategy-linked measures, common measures have larger weights in performance evaluations than unique measures do.[5] However, consistent with Banker et al.'s (2004) prediction, the effect of strategy linkage is stronger than the effect of measure uniqueness: strategy-linked unique measures have (marginally) larger weights than non-linked common measures do.

Libby et al. (2004) provide a different source of assurance about unique measures. They cite prior research indicating that individuals are reluctant to base their performance evaluations on performance measures with unknown or low reliability or relevance, and they speculate that a performance measure used by only one subunit may be regarded as lower-quality (less reliable or relevant) than measures used by all units. Hence they predict that unique measures are more likely to be used in performance evaluations when evaluators receive third-party assurance that the measures are relevant and reliable.

Libby et al. (2004) also investigate the effects of increases in cognitive effort by informing participants in one condition of the experiment that they will have to justify their evaluations to a higher-level manager. Prior psychology (Lerner and Tetlock, 1999) and auditing research (Kennedy, 1995; Tan and Kao, 1999) report evidence that when individuals know before making a decision that they will have to justify their decision, they are motivated to increase their cognitive effort in order to process the available information more completely. Consistent with their predictions, Libby et al. (2004) find that either third-party

[5] Participants put little weight on unlinked measures, and therefore there is no significant difference between common and unique unlinked measures.

assurance or the justification requirement alone, or both in combination, increase the weights on unique relative to common measures in performance evaluations.

The studies described thus far in this section — Shields (1980), Lipe and Salterio (2000), Banker et al. (2004) and Libby et al. (2004) — all investigate subordinate performance evaluations in which no explicit incentives are provided for making the best possible evaluations, and it is not always clear what would constitute the best evaluation. For example, in the balanced scorecard studies, the information provided is insufficient to determine appropriate weights on the multiple performance measures. Kachelmeier et al. (2008) extend the research on non-compensatory decision models by investigating a different decision context, in which "better" decisions are more straightforwardly identifiable, incentives are provided, and therefore it is possible to provide a monetary measure of the cost of individuals' failure to make effective trade-off decisions.

In Kachelmeier et al. (2008), individuals design puzzles and make effort choices that aim at increasing the quantity and/or creativity of their output. They work for either a flat wage or for one of three different incentives. The incentive is based either on the quantity of puzzles individuals produce, the mean creativity score of their puzzles (determined by a team of raters), or the quantity of puzzles multiplied by their mean creativity score. Low-creativity puzzles can be produced quickly by imitating the examples provided in the instructions, while more creative puzzles presumably require more effort and time. Thus, in order to maximize their monetary payoffs in the condition where both are rewarded, individuals need to decide how much quantity to sacrifice in order to devote more attention to increasing their mean creativity score. If they make this trade-off reasonably well, then the combined quantity-creativity score should be higher in the condition where this score is rewarded than in the conditions where only quantity or only creativity is rewarded.

Compensation plans that require no trade-offs have the expected effects in the experiment: the highest mean quantity of output occurs in the quantity-incentive condition and the highest average creativity of output occurs in the creativity-incentive condition. However, consistent

with psychology-based predictions that individuals will not manage trade-offs well (Payne et al., 1993), performance as measured by quantity × creativity is *not* highest in the condition that rewards this measure; in fact it is highest in the condition that rewards quantity only.

Kachelmeier et al. (2008) explain these results as a consequence of features of the task, combined with participants' use of a non-compensatory decision model when faced with a potential quantity-creativity trade-off. The relevant feature of the task is that creativity is not completely dependent on effort; it is to some extent spontaneous (Amabile, 1996). Hence participants who are simply trying to produce as many puzzles as possible produce some that are rated as highly creative, although they also produce a large number of creatively mediocre puzzles that simply imitate the examples provided to them. In consequence, their output exhibits both quantity and creativity even if they have not aimed at both, and their quantity × creativity scores are relatively high.

In contrast, participants who are rewarded based on both quantity and creativity do not combine the two objectives in a way that generates high payoffs. Instead of making a trade-off that increases their quantity × creativity score — i.e., quickly producing a number of mediocre puzzles when further effort at creativity has little effect — they appear to avoid producing low-creativity puzzles altogether. Kachelmeier et al. (2008) describe the participants' implicit decision model as maximizing the quantity of puzzles produced that exceed a creativity cutoff. This may not be a fully deliberate decision-model choice; in any case, it is ineffective in supporting a high score on the quantity × creativity measure on which individuals' incentive compensation in this condition is based.

Decision makers are often aware of the difficulties of making trade-offs and the likelihood that trade-offs will be made poorly; in consequence, they are willing to incur costs to avoid such decisions altogether when they can. Psychology theory and evidence indicate that when decisions are more difficult to make because the decision alternatives are difficult to compare or the decisions require trade-offs of highly valued objectives, the decision generates more negative affect (e.g., feelings of nervousness, distress, anxiety, worry, unease) (Janis and Mann, 1977;

Luce, 1998; Tversky and Shafir, 1992). In consequence, individuals have an increased desire to avoid or postpone making the decision.

Sawers (2005) documents the influence of compensatory trade-off difficulties on decision avoidance in a capital budgeting setting. Participants in her experiment receive information on two capital investment projects, either of which will prevent a significant loss of market share at their firm. In all three conditions of the experiment, Project A has higher NPV and higher projected customer satisfaction than Project B. In the control condition, there is no reason to prefer the low-NPV Project B. In one treatment condition, Project A is expected to generate higher product quality than B while B is expected to generate higher operational efficiency than A, making the alternatives somewhat more difficult to compare. In the other treatment condition the investment choice forces a trade-off between highly valued goals — Project A is environmentally friendly but will result in a large number of employees being laid off in a firm that has a goal of no layoffs, while Project B will result in substantially fewer layoffs but also environmentally unfriendly waste disposal. Although postponing the choice between the projects is costly, it is not impossible. Consistent with psychology research on decision avoidance, Sawers (2005) predicts that, compared to the control condition, individuals will experience more negative affect and be more likely to postpone the investment choice when the alternatives are difficult to compare or highly valued objectives must be traded off.

Sawers (2005) also predicts that a decision aid which provides additional structure or direction in decision making will reduce affect-based coping strategies like postponing the decision in order to avoid immediate negative affect. The aid encourages participants to think about each alternative separately and to search for information by alternative, which results in a more problem-focused, less affect-focused strategy. As predicted, Sawers' (2005) experiment participants (experienced managers) report more negative affect and more inclination to postpone the investment choice when project attributes are difficult to compare or highly valued attributes must be traded off. Also as predicted, the decision aid reduces managers' negative affect and their inclination to postpone the difficult investment choice.

5.6 Variable Inclusion: Opportunity Costs and Sunk Costs

The heuristic decision models and non-compensatory decision models documented in the previous subsections of Section 5 often allow individuals to simplify their decision models by omitting variables. Psychology-based MA research has used the traditional MA topics of opportunity costs and sunk costs to investigate variable-inclusion issues more intensively. A stream of studies beginning in the 1970s documents mixed decision performance in the inclusion of relevant opportunity costs in subjective resource-allocation decisions and finds that more explicit reporting of opportunity costs increases the likelihood that they will be used in decisions (Becker et al., 1974; Neumann and Friedman, 1978; Friedman and Neumann, 1980; Hoskin, 1983). These studies are not informed by psychology theory, however, and provide no explanation for the observed variation in the use of opportunity costs within any given reporting format.

Vera-Muñoz and colleagues (Vera-Muñoz, 1998; Vera-Muñoz et al., 2001) draw on psychology research about mental representations and problem-solving to explain the (not always benign) effects of accounting education and experience on the use of opportunity costs in decision making. Psychology research finds that individuals with more experience in a domain typically have better-developed knowledge structures in that domain. These knowledge structures help to form individuals' mental representations of specific decisions, and the mental representations in turn influence the information individuals attend to in their environment or recall from their memory and the way they combine this information in subjective decision making (Anderson, 2000, 2005). Knowledge structures tend to be domain-specific and therefore are activated by cues to the domain (Bonner, 2008).

Vera-Muñoz (1998) argues that a business context will activate accounting knowledge structures in individuals who have more accounting knowledge ("accounting is the language of business"). These accounting knowledge structures will be dominated by GAAP, which does not report opportunity costs. In consequence, she predicts that individuals with extensive accounting knowledge (measured by number of accounting courses taken) will tend to ignore opportunity costs

in business-context decisions, though not in non-business contexts that do not activate GAAP-dominated knowledge structures.

In her experiment, individuals provide analysis to a client who is considering advancing the date of a decision with important resource-allocation implications. Each alternative (take action now or later) has both outlay and opportunity costs, and information about these costs is provided in a case memorandum. The experiment manipulates the context by using two versions of the decision — closing a retail outlet (business) or leaving a current job (personal) — with identically matched outlay and opportunity costs. Vera-Muñoz (1998) predicts and finds that in the business context, participants who have completed more accounting courses and thus presumably have more accounting knowledge include fewer opportunity costs in their analyses than do participants who have completed fewer accounting courses (less accounting knowledge). Also as predicted, accounting knowledge does not have the same effect on using opportunity costs in the personal context: high-accounting-knowledge individuals include significantly more opportunity costs when their decision is in the personal context than in the business context. It seems unlikely that the omission of more opportunity costs in the business context is the result of a deliberate judgment that they are less relevant in this context: responses to post-experiment questions measure individuals' conscious beliefs about the relevance of opportunity costs, and controlling for these beliefs does not eliminate the context effect. Rather, the business context appears to cue an automatic shift of attention to out-of-pocket costs that would be recorded by the accounting system.

A subsequent study by Vera-Muñoz et al. (2001) further probes the effects of experience and knowledge on the omission of opportunity costs. While Vera-Muñoz (1998) uses students as participants and measures accounting knowledge as number of accounting courses taken, Vera-Muñoz et al. (2001) use experienced accountants as participants and measure knowledge as months of experience in either MA or public accounting. This study examines the business context only and manipulates the accounting report format as either accounting earnings or cash flow. Participants have sufficient information to convert one format to the other.

Because the problem is one of maximizing (discounted) future cash flows, a representation of the decision as being about future cash flows is more relevant and more likely to promote the inclusion of opportunity costs (lower future cash flows if one alternative is chosen) than a mental representation of the decision as being about future earnings. Vera-Muñoz et al. (2001) argue that more extensive accounting experience, either in MA or public accounting, will increase individuals' development of multiple knowledge structures (cash flow and earnings representations) and the ability to access the appropriate knowledge structure for the decision. In consequence, they predict and find that when the historical information in the case is presented in an accounting-earnings format, more experience makes it more likely that accountants will convert it to a cash-flow format to estimate future costs and benefits. Less experienced accountants are more influenced by the accounting report format they receive and more likely to represent the problem as one of maximizing future earnings when they receive historical earnings information.

Vera-Muñoz et al. (2001) argue further that, although experience in public accounting generates sufficiently well-developed knowledge structures to allow individuals to *produce* cash-flow representations of the decision problem, public accounting experience supports less effective *use* of these representations than does experience in MA. MA experience is likely to provide more practice with resource-allocation decisions using cash-flow representations. Practice is expected to develop procedural knowledge, which includes more task-specific models for analysis of resource-allocation decisions and stronger mental links between general knowledge structures and specific procedural models (Anderson, 2000). Vera-Muñoz et al. (2001) find experimental evidence consistent with their prediction that, holding decision representation (cash flow versus earnings) constant, more MA experience is associated with inclusion of more opportunity costs, but more public accounting experience is not.

Vera-Muñoz (1998) and Vera-Muñoz et al. (2001) focus on education and experience as a source of heterogeneity in individuals' inclusion of relevant costs in their decision models — that is, they focus on individual characteristics that can be changed over time. Vera-Muñoz (1998)

also controls for a measure of analytic ability that is presumably more stable and also has a significant influence on performance: individuals with higher analytic ability omit fewer opportunity costs, regardless of decision context or accounting knowledge. Chenhall and Morris (1991) and Awasthi and Pratt (1990) also investigate stable individual traits — cognitive styles — that are expected to influence the inclusion of relevant costs in subjective decision models.

Cognitive style refers to how individuals think, perceive, and remember information and how they use information to solve problems (Sternberg and Zhang, 2001). Multiple measures and theories of cognitive style have been developed. Chenhall and Morris (1991) rely on a theory developed by Myers and Myers (1980) that distinguishes between two ways individuals perceive information in their environment: sensation and intuition. According to this theory, people who perceive information by sensation prefer information that is present, tangible, concrete, objective, and specific, while people who perceive information by intuition prefer information that is abstract, symbolic, theoretical, and capable of being associated with other information. Individuals with an intuitive cognitive style focus their attention on the overall situation and can make intuitive leaps from information to decisions.

Chenhall and Morris (1991) expect that individuals with an intuitive style will focus their attention on the overall situation and move from specific information to the broad abstract interpretation of that information. Hence they expect that, other things equal, intuitive individuals are more likely to consider the possibility that existing assets have alternative uses and thus have opportunity costs. Other things may not be equal, however: for example, individuals who have sponsorship involvement with a product are likely to ignore opportunity cost information that reflects negatively on their project, regardless of their cognitive style. Chenhall and Morris (1991) predict that individuals who have a sensation cognitive style will focus on concrete specific information and thus will be less likely to consider alternatives associated with the existing assets when these alternatives are not explicitly provided. The decision performance of individuals with a sensation style will not be influenced by sponsorship because they will largely ignore opportunity costs even when not motivated to do so by sponsorship.

Participants in Chenhall and Morris' (1991) experiment are middle and senior level managers who examine information on a new product launch decision and indicate which costs are relevant at various stages of the decision. In one condition, participants are told that their division is excited about the potential launch of the product and that they themselves have been closely involved in its development; in the other condition, they do not receive this information. Consistent with their predictions, Chenhall and Morris (1991) find that participants who have an intuitive cognitive style include fewer opportunity costs in their decision when they sponsor a project than when they do not sponsor it. Participants who have a sensation cognitive style are more likely to exclude opportunity costs than those with an intuitive style, and their exclusion of these costs is unaffected by whether they are the sponsor of the project.

Cognitive style has also been investigated as an influence on individuals' tendency to include sunk costs inappropriately in their subjective decision models. In a fixed asset replacement decision, Awasthi and Pratt (1990) examine the effects of a cognitive style they call perceptual differentiation, which is individuals' ability to perceptually differentiate an object from its context (e.g., separate figure and ground) (Sternberg and Zhang, 2001; Witkin et al., 1962; Witkin and Goodenough, 1981). (It is also called psychological differentiation and field independence.) High perceptual differentiation allows individuals to abstract familiar concepts or relationships successfully from a complex setting. Awasthi and Pratt (1990) argue that individuals who have high differentiation are more likely to exclude sunk costs from their decision making than individuals who have low differentiation, because they will be better able to abstract the familiar rule, "Sunk costs are irrelevant to decisions," from relatively complex decision scenarios.

Awasthi and Pratt (1990) also predict that perceptual differentiation will interact with performance-contingent monetary incentives, which are expected to increase effort. Prior research in psychology and accounting finds that the performance effects of incentive-induced effort depend on whether a task is primarily effort-dependent or skill-dependent (see Bonner, 2008). Awasthi and Pratt (1990) predict that increased effort in their decision task will increase performance

only when individuals have the skill (high perceptual differentiation) required for the task.

As predicted, performance-contingent financial incentives increase effort (measured as time spent on making the decision) in Awasthi and Pratt's (1990) experiment. Also as predicted, the incentive does not influence the use of sunk costs by individuals with low differentiation. But contrary to prediction, the incentive also does not influence the use of sunk costs by individuals with high differentiation, nor does perceptual differentiation influence the use of sunk costs. The unexpected results appear not to be due to manipulation failures: performance on two probability-judgment tasks also included in the experiment (sample-size and conjunction-probability tasks) is consistent with the prediction that incentives will improve performance for individuals with high perceptual differentiation but not low perceptual differentiation. Possibly the framing effect of sunk costs is powerful enough to dominate the effects of the moderate variation in perceptual differentiation and monetary payoffs exhibited in the experiment, or possibly the decision to ignore sunk costs has additional cognitive requirements not identified in Awasthi and Pratt's (1990) study.[6]

5.7 Summary

Subjective decision models are often simpler in structure than the quantitative models created by accountants, economists, management researchers, and others. Individuals use a number of characteristic strategies to reduce complexity in their subjective decision models. They limit the number of sub-decisions and information items that they consider simultaneously; they decompose large decisions into multiple smaller decisions and make the smaller decisions sequentially (Ball et al., 1998; Gonzalez et al., 2002). They omit the last links in long chains of causal reasoning (Paich and Sterman, 1993; Krishnan et al., 2005) and variables that do not fit into widely used decision

[6] Stanovich and West (1999), using a large sample of undergraduates, find that exclusion of sunk costs in individuals' decisions is associated with higher SAT scores and higher scores on a personality trait called need for cognition, which indicates more intellectual engagement, more thorough information processing and information search, and higher levels of reflection.

heuristics like anchoring and adjustment and representativeness (Lewis et al., 1983; Diehl and Sterman, 1995). They limit their need to consider multiple attributes in choosing between alternatives by using noncompensatory decision models (Shields, 1980; Kachelmeier et al., 2008), using only attributes that are easily compared across alternatives (Lipe and Salterio, 2000), or avoiding decisions that require difficult trade-offs between multiple attributes (Sawers, 2005).

Individuals making a given decision can often be divided into two or three distinct groups that use different subjective decision models (Lewis et al., 1983; Ball et al., 1998). Subjective decision-model choice is influenced by mental representations developed through education and work experience (Vera-Muñoz, 1998; Vera-Muñoz et al., 2001) and by individual traits such as cognitive abilities and styles that enable individuals to handle differing levels of decision complexity (Chenhall and Morris, 1991; Vera-Muñoz, 1998). The observed decision-model choices are a mix of deliberate and intuitive: for example, some participants in Vera-Muñoz et al. (2001) deliberately change the earnings representation of the decision problem they receive to a cash-flow representation, but participants' use (or omission) of opportunity costs in their subjective decision models remains at least partly intuitive and not fully consistent with their deliberate statements about the relevance of opportunity costs.

6

Models of Parameter and Variable Acquisition and Subjective Estimation

The last decision process we consider is how people acquire the information needed to populate their subjective decision models with specific values of parameters (e.g., means, regression coefficients) and variables (e.g., current-period sales). Sometimes individuals acquire these values by purchase or searching through organizational records; sometimes they know the values from experience and retrieve them from long-term memory into short-term working memory; and sometimes they make their own subjective estimates from available data. All of these information-acquisition processes — information purchase or search, memory storage and retrieval, and subjective estimation — are costly. In consequence, individuals often do not acquire maximally accurate parameters and variables. Determining the trade-offs between the benefits of decision accuracy and the costs of information acquisition is itself a difficult judgment task (Payne et al., 1993), and thus the trade-offs that are actually made are not necessarily those that would be made if the payoff-maximizing trade-off could be calculated costlessly.

Research on acquiring information about variables from organizational records and from memory has focused on how individuals cope with quantities of information that exceed their cognitive capac-

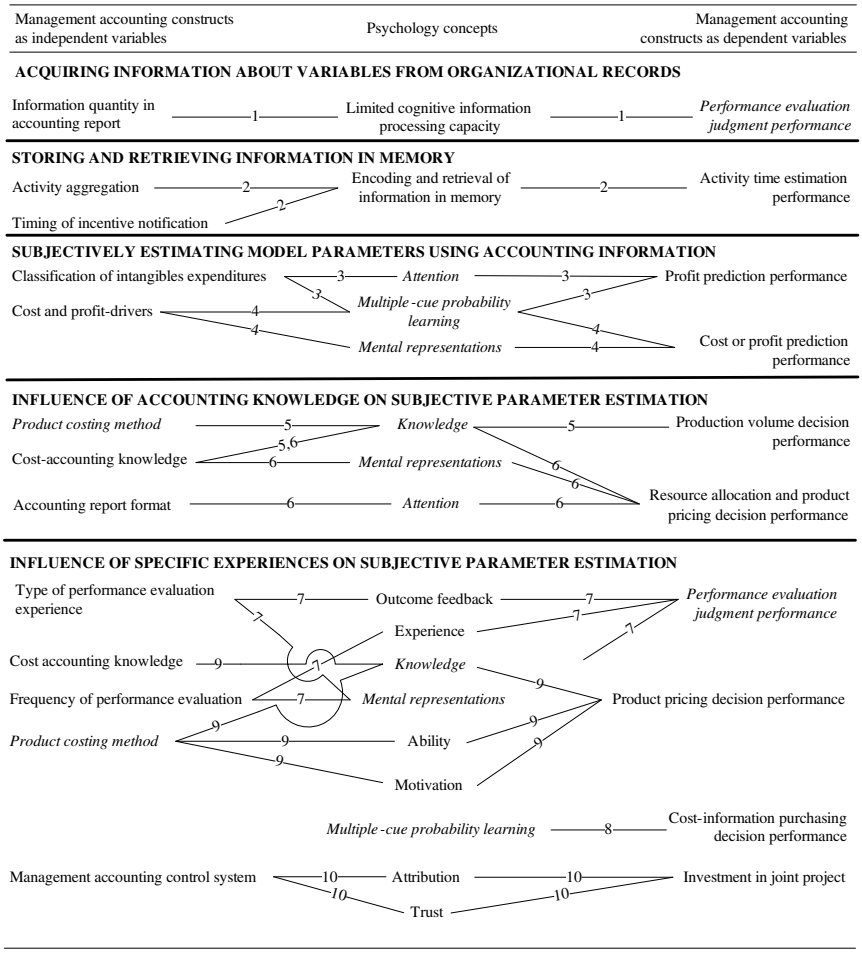
ity. Research on subjective parameter estimation has focused on how MA characteristics combine with individuals' accounting knowledge and specific experiences to influence the accuracy of decisions that are dependent on correct parameter estimation. Figure 6.1 provides a graphic summary of the MA constructs and psychology concepts used in the literature reviewed in this section.

6.1 Acquiring Information About Variables from Organizational Records

Accounting information systems can often produce more information than decision makers have the cognitive capacity or willingness to acquire and process. The availability of additional information would not reduce decision performance if decision makers could simply ignore the information that is not cost-effective for them to use. Psychology research indicates, however, that the availability of large quantities of information can have a negative influence on decision performance (Payne et al., 1993; Schroder et al., 1967). Decision performance peaks at a moderate quantity of information and declines as the quantity of information increases further, for at least two reasons.

First, as the absolute quantity of information available increases, the *relative* quantity of information acquired (i.e., the percentage of the total information available) decreases, because an additional item of information is likely to have decreasing marginal value and/or increasing marginal cognitive processing cost (Payne et al., 1993). If individuals' information-selection strategies are less than optimal, as Payne et al. (1993) suggest, then increasing selectivity (lower relative information usage) can imply poorer-quality information and thus less accurate decisions.

Second, as the quantity of information available increases, the selection task itself can put heavy demands on limited cognitive information-processing capacity, reducing the resources available for the decision itself, and hence decision performance can decrease. In consequence, decision performance (accuracy) is an inverted-U function of the quantity of information available (Schroder et al., 1967). Initially, as information quantity increases from a low level,



See Figure 3.1 for an explanation of how to interpret this figure.

1. Shields (1983)
2. Cardinaels and Labro (2008)
3. Luft and Shields (2001)
4. Farrell et al. (2007)
5. Dearman and Shields (2001)
6. Cardinaels (2008)
7. Frederickson et al. (1999)
8. Krishnan et al. (2002)
9. Dearman and Shields (2005)
10. Coletti et al. (2005)

Fig. 6.1 Models of parameter and variable acquisition and subjects estimation.

decision performance increases, but as the information quantity increases further and approaches individuals' cognitive capacity limits, subjective information-processing costs exceed the realizable benefits of additional information.

Based on this psychology research, Shields (1983) provides theory-consistent evidence on how the quantity of information available in a performance report influences the quantity of information individuals acquire and the accuracy of their judgments about the cause of the reported performance. In this experiment, consistent with psychology research on information displays (Payne et al., 1993), the performance report is formatted as a two-dimensional matrix with multiple performance measures (rows) for each of the multiple subunits (columns). In this research, a unit of information is a cell and the total quantity of information available in the report is the total number of cells.

Shields (1983) predicts and finds that the absolute quantity of information selected from the report by experienced managers increases, but the relative quantity of information selected (i.e., percentage of information units available in the report) decreases as the number of performance measures and/or subunits increase. Further, based on Schroder et al. (1967), Shields (1983) predicts and finds that decision accuracy (measured as consistency with the evaluations of a panel of experts) is an inverted-U function of the quantity of information available in the report. Overall, these results in Shields (1983) (and also in Shields, 1980, as previously presented) are consistent with individuals' selection of information in performance reports becoming less effective as larger quantities of information become available. As the quantity of information available increases, decision accuracy first increases because of the increase in absolute quantity of information used, but then decreases as poor information selection and higher cognitive processing demands outweigh the effects of increased information quantity used.

6.2 Storing and Retrieving Information in Memory

Besides acquiring information from external sources such as accounting reports, individuals can also acquire (retrieve) information from their long-term memory for use in making a decision. Information in memory is crucial for several of the MA-related decisions represented in economic models in like those in the Appendix. For example, agents making effort decisions often base their decisions on information in their memory about the costs and benefits of effort on specific tasks.

Even when the accounting system includes indicators of employees' efforts, some of these indicators are provided by employee surveys and are therefore memory-based.

Cardinaels and Labro (2008) provide experimental evidence on factors that affect the accuracy of individuals' memory-based estimates of activity times. These estimates are important because, "Surveys on how much time employees spend on a variety of activities are a fixture of many costing systems," (Cardinaels and Labro, 2008, p. 736) and many employees rely on memory for such estimates rather than keeping contemporaneous records of their activities.

Larger quantities of information pose a problem for storage and retrieval of information in memory, just as they do for acquisition of information from organizational records. Cardinaels and Labro (2008) observe that the level of activity aggregation in a cost system affects the quantity of information that must be stored and retrieved: a system that requires individuals to estimate their time on three activities is less demanding than a system that disaggregates the three activities into six and requires time estimates for each of the six. Cognitive psychology research finds that splitting an event category into smaller subcategories decreases the accuracy of the recall of the frequency of the events (Fiedler and Armbruster, 1994). Because accurate recall of the frequency of various tasks is likely to be an important determinant of accuracy in individuals' estimates of the percentage of their time spent on these tasks, Cardinaels and Labro (2008) predict and find that time estimates are more accurate when activities are more aggregated.

Information quantity is not the only factor that influences the accuracy of time estimates based on information in memory, however. Incentives can be constructed to be more or less effective in increasing time-estimate accuracy, and these incentive effects in turn depend on activity structure. Because encoding of information into memory as well as subsequent retrieval of information from memory is effort-sensitive (Boltz, 1998), Cardinaels and Labro (2008) predict and find that activity time estimates are more accurate when individuals are told *before* they perform the activities that accurate time estimates will be required and rewarded (prospective notification) because they allocate

effort to consciously keep track of time. Activity time estimates are less accurate when individuals learn of the required estimates and incentive only after they have performed the activities (retrospective notification) because they must rely on less accurate unconscious recording of time. Moreover, the effect of this announcement timing is larger when activities are more aggregated. With decreasing aggregation the number of information items to be processed increases beyond the amount that individuals can encode effectively even with the additional conscious effort induced by prospective notification.

A further characteristic of activities investigated in this study is their coherence. Coherent activities are performed in a structured and systematic sequence, while incoherent activities are "addressed as they come in" (Cardinaels and Labro, 2008, p. 739), in an as-needed, relatively random sequence. The structure of coherent activities allows their nontemporal (e.g., content) information to be encoded more easily in memory, thus releasing more cognitive resources for encoding temporal information about the activity (Brown and Boltz, 2002). Hence individuals can make relatively accurate memory-based time estimates for coherent activities even without the additional encoding effort induced by the prospectively announced incentive. But for an incoherent task, more conscious encoding effort is required. Based on the psychology research on task coherence and memory, Cardinaels and Labro (2008) predict and find that prospective (versus retrospective) announcement increases time estimation accuracy more for an incoherent than for a coherent task. These results highlight the complex trade-offs inherent in cost system design, where the potential benefits of multiple activity-cost pools can be diminished by increased inaccuracy in activity time estimates or consumed by the increased costs of record-keeping to substitute for faulty memory.

6.3 Subjectively Estimating Model Parameters Using Accounting Information

In order to make decisions about how best to allocate their efforts, individuals not only need information about their measured performance (available from the organization's accounting system, as in Shields,

1983) and information about the time they have spent on various activities (available from their own memories, as in Cardinaels and Labro, 2008). They also need to estimate the parameters that relate efforts to outcomes, in order to determine whether their return on effort from an activity is higher than their return on effort from other activities. A variety of other parameter estimates, often made subjectively, are needed in order to evaluate the performance of others and to allocate resources besides the individuals' own effort (cf. models in the Appendix). Managers often judge the relations between financial performance and its drivers subjectively, based on information in balanced scorecards or other internal reports for multiple periods and/or business units (Ittner et al., 2003a,b; Kaplan and Norton, 2001, 2004; McKinnon and Bruns, 1992). Uncertainty about these relations or parameters — for example, about the relative contribution to financial performance of activity x and activity y — often contributes to the difficulty in making trade-offs documented in Section 5.

MA plays an important role in subjective parameter estimation. MA information can be used to estimate parameters, and MA can provide incentives for accurate parameter estimation. More problematically, MA characteristics that are chosen for other reasons can have unintended effects on parameter estimation by influencing individuals' attention, memory, and other elements of their cognitive processing.

The research we review below typically infers individuals' subjective parameter estimates from their decisions in controlled experimental settings where the parameter-to-decision mapping is relatively unambiguous. Predictable heterogeneity in individuals' use of MA is a recurring theme: the same MA information has different decision effects for individuals with different experiences, technical accounting knowledge, or cognitive abilities. Combinations of knowledge, ability, specific experiences, and cues from MA influence individuals' parameter estimates by guiding their attention to and interpretation of information, but not always in beneficial ways.

Under favorable conditions (e.g., linear relations with a small number of predictor variables and not too much noise), individuals can estimate and use subjective equivalents of regression coefficients reasonably accurately, as a large volume of research has demonstrated

using the lens model paradigm (Karelaia and Hogarth, 2008).[1] Recent MA research using the lens model paradigm has examined more complex settings in which lagged and nonlinear effects could reduce decision performance.

Luft and Shields (2001) use the lens model paradigm to investigate how accounting for intangibles expenditures influences individuals' use of accounting information to learn the profit effects of these expenditures. Based on multiple-cue probability learning[2] studies, Luft and Shields (2001) predict that when the quantity of potentially relevant information is large relative to individuals' cognitive information-processing resources, they will direct their limited attention unequally across the potentially relevant relations in the information (e.g., current and lagged relations) and thus not learn all of the relations equally well. MA — in this case, the classification of intangibles expenditures as either an expense or an investment for internal reporting purposes — provides a cue to individuals about where to direct their attention.

In Luft and Shields' (2001) experiment, participants receive information from each of 20 identical plants on gross profit for the just-completed quarter and intangibles expenditures in the just-completed quarter and the previous three quarters. The expenditure–profit relation has a three period lag. The intangibles expenditure is labeled either an expense or investment. Participants use this information to learn the expenditure–profit relation subjectively (i.e., no calculators). Next, participants receive information on intangibles expenditures for the just-completed and previous three-quarters for another 20 similar plants and are asked to predict gross profits for the just-completed quarter, based on what they learned from the expenditure and profit information from the first 20 plants.

[1] The lens model paradigm is employed to study how individuals use information (cues) to make criterion judgments (e.g., to predict profits or make a performance evaluation). Lens model researchers estimate an individual's subjective judgment model by regressing his or her judgments on the cues available. This estimated model can then be compared with an optimal model for the environment or with other individuals' estimated subjective models. For further detail, see Hammond and Stewart (2001) and Karelaia and Hogarth (2008).

[2] Multiple-cue probability learning research uses the lens model paradigm to investigate how individuals learn to predict a criterion variable (e.g., profit) from cues (predictors) that are probabilistically related to the criterion and how their learning is influenced by feedback (Karelaia and Hogarth, 2008).

As predicted, Luft and Shields (2001) find that when intangibles expenditures are capitalized (expensed), individuals have higher (lower) judgment performance,[3] holding constant the statistical relation between intangibles expenditures and profits. This result is not driven by naïve beliefs that an expense classification means the expenditure has no future benefits. Luft and Shields (2001) verify in pre-experiment measurement that participants believe that the intangibles expenditure will increase future profits even when it is expensed, and the predictions made by participants in the expense condition imply that they are putting positive weights on prior expenditures in predicting current-period profits. But these weights are not as accurate as the weights implicit in the predictions of participants in the investment condition. Responses to post-experiment questions indicate that participants in the investment condition devoted more attention to the lagged expenditure–profit relation when examining the information, while participants in the expense condition devoted more attention to the same-period relation. Because the lagged relation was a stronger predictor, less accurate learning of the lagged relation led to less accurate profit prediction performance.

The shape of a relation as well as the lag can have a significant influence on subjective parameter estimation. Lens model and multiple-cue probability learning research find that all else equal, accuracy is highest for positive linear relations, followed by negative linear, positive curvilinear (inverted-U), and negative curvilinear (U-shaped) relations (Hammond and Summers, 1965; Deane et al., 1972; Brehmer et al., 1974).

Farrell et al. (2007) use this literature and the system dynamics literature reviewed in Section 5.3 to develop hypotheses about the effects of different financial performance measures (production costs versus gross profit in manufacturing plants) on individuals' learning of curvilinear

[3] Consistent with research using the lens model, judgment performance is operationalized as mean prediction error, achievement (the correlation between an individual's predictions and the realized outcomes), consistency (the degree to which an individual uses the same model from prediction to prediction), consensus (the degree of similarity of predictions across individuals), and self-insight (the degree to which an individual's ex post explanations for how he or she made his or her predictions correspond to how he or she actually made his or her predictions).

relations between financial performance and its drivers. Farrell et al. (2007) focus on curvilinear relations because psychology research indicates that they are more difficult to learn than linear relations, and MA research provides evidence that the curvature of cost-driver and profit-driver relations is strong enough even within limited ranges to be important to business decisions. For example, according to an accounting firm's study of firms in several industries, managers believe that the top two problems in implementing initiatives related to customer satisfaction (a key financial performance driver) are "(1) linking customer satisfaction and profitability, and (2) understanding the point of diminishing returns for customer satisfaction initiatives" (Ittner and Larcker, 1998, p. 3).

In Farrell et al.'s (2007) experiment, participants receive information about expenditures on a particular initiative (employee training) and financial performance (either total production costs or total gross profit) at a number of similar subunits. Based on what they learn from this information, participants predict future financial performance at similar subunits given various levels of spending on employee training. Their subjective models of the relation between financial performance and spending on the initiative can then be estimated from their predictions. The information is constructed so that the degree of curvature and the statistical predictability of the relations are the same in the cost-driver and profit-driver conditions.

The use of cost-driver versus profit-driver reporting has two psychological effects that could influence individuals' performance in subjectively processing the information in the reports. First, the sign of the overall relation is positive for the profit-driver (expenditure on training increases gross profits) and negative for the cost-driver (expenditure on training reduces production costs excluding the training expenditures). Second, individuals are likely to mentally represent the training expenditure–cost relation as direct and the training expenditure–profit relation as indirect, even though both relations would be statistically modeled as two-variable (direct) relations. Individuals are likely to mentally *represent* the profit-driver relation as a longer casual chain (training expenditure to production costs to gross profits) than the cost-driver relation (training expenditure to

production costs), and indirect causal relations are more cognitively difficult to process (Sterman, 2000). Moreover, even if the actual uncertainty in the direct and indirect relations is identical, each additional link in the mentally represented causal chain can increase subjective uncertainty about the relation, because each additional link can be another prompt that reminds individuals of additional reasons why the expected effect might not occur.

These two psychological factors — the cognitive difficulty of processing negatively signed and indirect relations — support opposite predictions about the effects of cost-driver versus profit-driver relations. The positive sign of the profit-driver relation should make it easier to process than the cost-driver relation, resulting in better prediction performance; but conversely, the indirectness of the profit-driver relation should make it more difficult to process, resulting in poorer prediction performance. Additional psychology research provides the basis for an expectation about which of these conflicting effects is expected to be more powerful (see Farrell et al., 2007, for references). First, mental representations are, in effect, individuals' theory of the financial performance driver relation, and prior research indicates that individuals' causal theories (e.g., the causal chains linking drivers to gross profits) often influence their judgments more than do the statistical properties of information (e.g., sign). Second, prior research finds that the effect of sign on learning and judgment accuracy is significantly diminished when individuals have clear prior beliefs about the sign rather than learning it entirely from the information provided. Farrell et al. (2007) report that participants did believe that the profit-driver relation was more indirect and that the expenditure would reduce production cost or increase gross profit. Thus, the conditions are met for the indirectness of the relation to be more important than the sign of the relation.

Consistent with these predictions, Farrell et al. (2007) find experimental evidence that individuals' subjective predictions of financial performance are more accurate when financial performance is reported as production cost (direct negative) than when it is reported as gross profit (indirect positive). On average, individuals' predictions of production cost are quite accurate. But when they are predicting gross profits, individuals' subjective models are too linear on average: they

underestimate both how quickly gross profits increase as training expenditures increase from very low levels, and how quickly gross profits will level off and begin to decrease as training expenditures increase from already high levels.

6.4 Influence of Accounting Knowledge on Subjective Parameter Estimation

Even in the limited information environment of Luft and Shields (2001), where the only information available is three predictor variables (expenditures) and one outcome variable (profits), the attention-directing effects of MA have a significant effect on parameter estimation. In more information-rich environments, identification of relevant information for parameter estimation can be more difficult, and accounting knowledge is likely to play a role in guiding individuals' attention to multiple items and types of information.

Dearman and Shields (2001) use a relatively rich decision scenario based on a Harvard case and ask experiment participants — experienced managers with varying levels of cost-accounting knowledge — to make production volume decisions for multiple products in this setting. To make these decisions participants need, in effect, a model linking the volume of specific products to total profits. The accounting system provides a misleading proxy for the relevant parameter, in the form of profit per unit: the volume-based cost accounting system indicates that low-volume specialty products have high per-unit profit, but other information available on the products' use of resources suggests that high-volume products in fact generate lower costs and higher profits.

Dearman and Shields (2001) predict that participants' cost-accounting knowledge content and knowledge structure (the pattern of linkages between individual knowledge items) will influence their decision performance. These predictions are based on psychology research showing that decision performance increases when individuals have more task-relevant knowledge content[4] and/or their knowledge is more

[4] Knowledge content refers to information that is in memory, including general information about the world and information specific to particular tasks (Bonner, 2008). Knowledge structure refers to the way individual items of knowledge are linked to each other in

structured by task-relevant cause-and-effect relations and has more refined partitions of knowledge categories (Bonner, 2008). Dearman and Shields (2001) predict and find that decision performance is higher for participants who have more ABC knowledge content and less volume-based knowledge content. ABC knowledge provides a more accurate representation of cost causality when products have diverse resource consumption, and thus ABC knowledge makes participants more likely to attend to information suggesting that low-volume products have high costs. More knowledge of volume-based cost systems, in contrast, cues participants to attend to the (misleading) unit profit numbers produced by the volume-based system.

Dearman and Shields (2001) also predict and find that decision performance is higher when individuals' cost-accounting knowledge is structured more consistently with an activity knowledge structure. When participants' knowledge has an activity-based structure, one item of activity knowledge is more likely to cue others in memory, and more relevant knowledge is thus brought to bear on the decision problem.[5] Dearman and Shields (2001) also predict but do not find that decision performance is lower as participants' cost knowledge is structured more consistently with a physical-resource (materials-labor-overhead) knowledge structure.

In Dearman and Shields (2001), both the type of cost-accounting knowledge (volume-based or activity-based) and the level of that knowledge vary, while the accounting information provided is held constant. In contrast, Cardinaels (2008) holds type of knowledge constant and allows the level of knowledge and the format of accounting information to vary. Here also, the value of MA information in supporting accurate parameter estimation is dependent on levels of knowledge, but knowledge level interacts with the format of the MA information.

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memory (e.g., causally, hierarchically, spatially, temporally). Knowledge that individuals possess can be more or less accessible (and thus more or less likely to be used), depending on how it is structured and how the knowledge structure corresponds to the task structure (Anderson, 2000, 2005).

[5] Note that having a less activity-based structure does not necessarily imply having a more physical-resource-based structure: individuals' knowledge could be structured in a third way or have little structure. Hence the significant results for the ABC-structure hypothesis do not necessarily imply significant results for the other structure hypothesis.

In Cardinaels' (2008) experimental task, participants make decisions about how to price products and allocate resources (provide costly services) to three major customers so as to increase profits. Participants receive ABC information about the profitability of each customer given various pricing and resource-allocation decisions, and this information allows them (in effect) to estimate the parameters relating prices and resource-allocations to profits. The ABC information is formatted in either a graph or a table, and both formats provide the same information content.

Cardinaels (2008) argues that participants with more cost-accounting knowledge (as measured in a test before the decision task in the experiment) are expected to have more refined mental representations of cost accounting that include specific relations among cost accounting variables. Because these participants, in effect, know what they are looking for, they can easily acquire relevant detailed information from tables and use this information to learn and verify profit-driver relations. In contrast, participants with less cost-accounting knowledge and less well developed mental representations are likely to have more difficulty in identifying relevant information and seeing informative patterns in the tables.

The graphic format of the customer profitability information in Cardinaels (2008) makes trends in profits and profit-drivers more salient and directs the attention of low-knowledge participants to patterns in the information. Thus low-knowledge participants benefit from graphic format because it prompts them to identify relevant patterns that are crucial to parameter estimation (e.g., profit increases more when resource-allocation to service x increases than when resource-allocation to service y increases). High-knowledge participants do not need the help of graphics to identify these patterns; and the graphics, with their salient presentation of broad patterns, hinder these participants from focusing on information details that their knowledge would enable them to use. Thus high-knowledge participants are expected to make better decisions with tables than with graphs, while low-knowledge participants are expected to make better decisions with graphs than with tables. Cardinaels' (2008) experimental results are consistent with this prediction.

6.5 Influence of Specific Experiences on Subjective Parameter Estimation

The accounting knowledge that influences decision making in the studies reviewed in the previous section is acquired through work (direct) experience as well as education and training (indirect experience). However, specific experiences with MA can have a variety of effects on parameter estimation in addition to the development of technical accounting knowledge. Specific experiences influence individuals' attention to and interpretation of new information. The first two studies in this section document this phenomenon, and the third study documents the combination of individual characteristics (ability, knowledge, and motivation) that is required to overcome the influence of prior experience.

Frederickson et al. (1999) argue that specific experiences with outcome information, outcome-based performance evaluations, and outcome-based incentive compensation strengthen the link between outcomes and evaluations in individuals' mental representations.[6] The consequent salience of outcomes and the strength of the outcome-evaluation links in these individuals' minds will make them more likely to use outcomes when evaluating others, even when they have information on their evaluatees' decision quality and they know in principle that decision quality is a better basis for evaluation than outcomes. In contrast, prior experience with evaluations based on decision quality will make decision quality salient and thus direct individuals' attention to decision quality when they evaluate others.

Frederickson et al. (1999) also predict that the frequency of evaluations will affect knowledge differently, depending on the type of evaluation that individuals have experienced (outcome-based or decision-quality-based). The effect of outcome-based evaluation experience is expected to be stronger when evaluations are received frequently: each additional instance of evaluation reinforces the link between outcomes and performance evaluation in individuals' minds. In contrast, when individuals have been frequently evaluated based on

[6] The combination of information, performance evaluation, and incentive compensation will be referred to simply as performance evaluation in the description of this study.

decision quality, outcome feedback is not relevant, and this reinforces the absence of a link between outcomes and performance evaluation.

Consistent with these predictions, Frederickson et al. (1999) find that the experience of outcome-based evaluation significantly reduces mean agreement with the belief that evaluation based on decision quality is appropriate and increases the likelihood that individuals will evaluate others based on outcomes. Their evaluations of others' performance are most influenced by outcomes when the evaluators have been evaluated based on outcomes in the past and when these evaluations have been frequent (i.e., an evaluation after each of 12 decisions rather than a single evaluation of all 12 decisions). On average, individuals are least influenced by outcomes when they have been frequently evaluated based on decision quality in the past; their evaluations are in between these extremes when they have been less frequently evaluated on either basis.

It is worth noting that the experimental manipulations do not affect all participants the same way. The observed mean effects result from a heterogeneous mix of individual decision patterns, in proportions which differ across the experimental conditions. For example, in the condition with prior outcome-based evaluation, 84% of the new evaluations of others are based on outcome rather than decision quality, while the remaining 16% are based on decision quality only. In contrast, in the condition with prior evaluations based on decision quality, the proportions are 56% and 44%, respectively.

In Frederickson et al. (1999), individuals' experience with performance evaluation stimulates attention and memory processes that militate against the individuals' making full use of their initial belief about the appropriateness of evaluations based on decision quality. In a more complex setting where information is more subject to interpretation, however, initial beliefs can limit the effectiveness of individuals' learning from experience. Psychology research on multiple-cue probability learning indicates that when individuals learn causal relations from observation, they tend not to make equal use of all the observations. When outcomes of a particular action (e.g., a resource-allocation decision) are mixed and can have multiple causes, outcomes consistent with individuals' initial theories receive more attention and have more

impact on subsequent decisions, while outcomes inconsistent with these theories can be treated as noise and receive less attention; hence individuals learn less from them (Klayman, 1988; Broniarczyk and Alba, 1994).

Krishnan et al. (2002) draw on this psychology research to predict the effects of changes in market competition on individuals' decisions about how much cost information to collect to support more accurate product-cost estimates. In Krishnan et al.'s (2002) experiment, participants decide how much cost information to purchase at pre-set prices in order to estimate product costs: more information purchase results in more accurate product cost estimates. The product-cost estimates are then used to make decisions about production quantities and levels of investment in activities to reduce product costs (these two decisions are automated in the experiment to simplify the task and allow profit outcomes to be driven by the information-purchase decision only). Participants make a series of 10 cost-information purchase decisions in each of three markets — monopoly, duopoly, and four-firm competition — and receive profit feedback after each decision. Some participants experience increasing competition (monopoly first, followed by duopoly and four-firm competition), while others experience decreasing competition (reverse order).

The decision setting in Krishnan et al. (2002) is taken from Hansen's (1998) model, in which the value of more accurate product-cost estimates is highest for monopoly markets, lowest for duopoly markets, and at an intermediate level for four-firm markets. This U-shaped function is due to the shifting balance between two conflicting forces: the benefits of accurate product costing increase with competition because better production-quantity decisions matter more with more competition. At the same time, however, the benefits of accurate product costing decrease with increases in competition for a constant sized market because the reduction in each firm's sales volume resulting from the arrival of additional competitors results in less total contribution margin to cover the fixed costs of investments. Investments therefore become smaller, and choosing them accurately has less impact on profits.

This U-shaped pattern conflicts with individuals' naïve theories that the benefits of more accurate product costing are a monotonically

increasing function of competition. Naïve theories are likely to have considerable influence, because the optimal solution to Hansen's (1998) model is too complex (three-stage backward induction to a Bayesian-Nash-Cournot equilibrium) for easy intuitive processing.

Krishnan et al. (2002) predict that participants will learn rapidly from outcome (profit) feedback in the duopoly market when they have previous experience in the four-firm market, because — consistent with the naïve theory — the economically optimal expenditure on improved cost estimation is lower in duopoly than in the four-firm market. In contrast, decision making is expected to be less accurate in duopoly when individuals' previous experience is in the monopoly market, because they expect that the increase in competition requires an increase in product-costing accuracy, and they have difficulty in processing outcome feedback that is inconsistent with this theory. Consistent with their prediction, Krishnan et al. (2002) report experimental evidence that individuals' excess purchases of cost information are greater in a duopoly market when it follows a monopoly market than when it follows a four-firm market.[7]

While Frederickson et al. (1999) and Krishnan et al. (2002) focus on mean decision behavior in adapting to change (i.e., change from evaluatee to evaluator role in Frederickson et al., 1999, and from one level of competition to another in Krishnan et al., 2002), Dearman and Shields (2005) provide information on the sources of variation in individuals' performance in adapting to change.

Dearman and Shields (2005) develop their prediction using the judgment performance model developed by Libby and Luft (1993), which predicts that judgment and decision performance depends on knowledge, motivation, and ability. Dearman and Shields (2005) predict that decision performance in a product pricing task following a change

[7] Krishnan et al. (2002) collect information about the individuals' pre-experiment theories to test the effect of theories on decision performance in the early trials of the duopoly market, controlling for last data purchase decision made in the previous market. Their results indicate that the extent to which participants decide to purchase more than the optimal quantity of data is positively associated with their belief of a positive relation between competition and the importance of accurate cost accounting information. Thus the results appear to be driven by naïve theories about competition rather than simple resistance to change.

in a cost accounting method is a function of the three-way interaction of general problem-solving ability, intrinsic motivation, and relevant cost-accounting knowledge. In particular, they predict that only participants who have relatively high levels of general problem-solving knowledge, intrinsic motivation, *and* relevant cost-accounting knowledge will adjust the parameters of their product-pricing decision model in the appropriate direction in response to a change in the cost accounting from volume-based to ABC or vice versa.

Results are consistent with this prediction. Participants lacking high levels of all three variables either make no change or make an incorrect directional change in the parameters of their subjective decision model when the costing method changes. These results indicate that, at least in this setting, high motivation cannot substitute effectively for high ability or high task-relevant knowledge (and vice versa) as a source of high decision performance.

Although most of the studies reviewed in this section focus on the negative economic consequences of biases in subjective estimation, positive consequences are also possible. For example, Coletti et al. (2005) provide experimental evidence about a bias that supports profitable cooperative behavior in a collaborative setting. Psychology research has documented a tendency to attribute others' behavior disproportionately to their disposition rather than to their situation (Fiske and Taylor, 2008). Consistent with this research, Coletti et al. (2005) predict and find in their first experiment that participants tend to attribute prior cooperative behavior by another participant to the other's inherent trustworthiness (disposition), even though the cooperation is in fact induced by the presence (versus absence) of an MA control system (situation).

In a second experiment, each participant is paired with another participant as a potential collaborator and decides whether to invest a high or low level of resources in a joint project. High investment in the joint project results in a high payoff if the collaborator also makes a high investment but results in zero earnings if the collaborator makes a low investment. Participants can earn a moderate payoff if both make a low investment in the joint project. Thus participants' payoffs are structured as in a Prisoner's Dilemma, in which the Pareto

optimum is cooperation, i.e., high investment in the joint project by both participants, but the Nash equilibrium is low investment by both.

In one experiment condition an MA control system induces high investments in the joint project in early time periods. As in the first experiment, participants attribute the resulting cooperation to the inherent trustworthiness of their collaborators. Therefore they tend to trust their collaborators and continue to make high (cooperative) levels of investment after the MA control system is eliminated. Although the mean level of trust and investment deteriorates after the elimination of the MA control system, it remains higher than in a condition in which participants initially worked without an MA control system. Because cooperation generates a Pareto-superior (high payoff) outcome, the attribution bias can have economically beneficial results.

6.6 Summary

MA-related decision performance depends on information acquisition: decision makers need accurate values for key variables and parameters in their subjective decision models. Large amounts of information are often available from organizational records and/or from experience, but acquiring and processing this information is cognitively costly. Hence individuals do not acquire all relevant information from records or encode and retrieve all relevant information in memory (Shields, 1980; Cardinaels and Labro, 2008). Individuals' information selection processes are not necessarily optimal, and in consequence, their decision performance can decrease when information availability — and thus the demands of information selection — are high.

Information selectivity also plays an important role in subjective parameter estimation. Selective attention, guided by knowledge and sometimes interacting with the format of accounting information, means that some information is processed more accurately in subjective parameter estimation than other, equally relevant information, resulting in biased parameter estimates in some subjective decision models (Luft and Shields, 2001; Dearman and Shields, 2001; Farrell et al., 2007; Cardinaels, 2008). The effect of knowledge is not always benign, because

it can make some relevant information in a new setting less salient or less apparently interpretable, at least for some subset of heterogeneous individuals (Frederickson et al., 1999; Krishnan et al., 2002). Adapting successfully to a new setting requires high ability, knowledge, and motivation (Dearman and Shields, 2005).

Much of the MA literature assumes that unbiased parameter and variable estimates will lead to decisions with higher expected monetary payoffs. If these payoffs are highly motivating, then with sufficient ability and appropriate knowledge, individuals will improve their subjective estimates. This assumption of higher payoffs for unbiased estimates is not always valid, however: Coletti et al. (2005) offer a useful counterexample, in which individuals receive higher monetary payoffs when they misestimate each other's characteristics. When they overestimate each other's trustworthiness, they cooperate more than they otherwise would, and in consequence they earn more from a collaborative project.

7

Conclusion

Our review of the psychology-based MA literature reveals a variety of opportunities for future research. In this concluding section we summarize these opportunities under three main headings. First, the existing psychology-based MA research identifies opportunities for integrating economics-based research with psychology models that have proved to be robust predictors of MA-related behavior. Second, additional themes for MA research emerge from the existing research as recurrent, sometimes unanticipated findings that are likely to reward further investigation. Third, the organizing framework of this review helps to identify areas of MA-related decision making with low psychology-based research coverage, indicating potentially important gaps in our knowledge of the psychology of MA-related decision making.

7.1 Existing Research: Main Themes

The first major theme of the research we have reviewed is that MA (e.g., budget targets) can create framing and reference points which influence individuals' valuation of monetary payoffs. Because individuals do not have internal utility meters from which they can automatically read off the value to themselves of (for example) a $500 expected cash payment,

their values (preferences) are often constructed in context, not simply exogenously given and stable (Lichtenstein and Slovic, 2006). MA can play a role in this construction by framing anticipated monetary payoffs and thus providing individuals with indications of how to value these payoffs. For example, all else equal, individuals' choices of risky investments and compensation plans can be influenced by a shift in reference points via incentive-contract labels or budget goals (Luft, 1994; Frederickson and Waller, 2005; Sprinkle et al., 2008).

Second, non-monetary payoffs influence and are influenced by MA. Social relations typically play a larger role in organizational life than in transactions in anonymous markets, and hence social norms can guide individuals' MA-related decisions. As Elster (1989, p. 121) observes, "The workplace is a hotbed of norm-guided activity." MA both influences and is influenced by social preferences and norms. Sometimes these socially based payoffs support high levels of cooperation and Pareto-superior outcomes that cannot be cost-effectively induced by monetary payoffs alone (e.g., Evans et al., 2001), but social influences are not always benign. For example, conflicting egocentric definitions of fairness can lead to costly impasses in transfer pricing negotiation (Luft and Libby, 1997). Similarly, individuals' desire to maintain self-esteem based on the belief that they are good cost managers motivates them to ignore feedback that their product costs are high. In consequence they price products too low and earn less than comparable individuals whose self-esteem is less dependent on the level of product costs (Bloomfield and Luft, 2006).

Third, subjective models of MA-related decisions often have predictably simplified structures that influence performance on MA-related decisions and can also be influenced by MA. Subjective decision making breaks down large decision tasks into sub-decisions that can be solved sequentially rather than simultaneously — for example, minimizing costs separately in each of several short subperiods rather than taking a longer view and accepting higher costs in one sub-period in order to minimize total costs over a longer period (Gonzalez et al., 2002). Subjective decision models often include fewer variables and relations than the structure of the phenomena that individuals observe, especially when the actual structure is complex. Decision makers sometimes use

heuristics such as anchoring and adjustment in complex decision tasks like capital investment (Sterman, 1989a). They also tend to avoid trade-offs between desired attributes that are required by compensatory decision models; instead they use non-compensatory models that prioritize attributes, using sequential cutoffs to attend first to one attribute and then to another. For example, in Kachelmeier et al. (2008), when participants are rewarded based on a combination of output quantity and creativity, they do not make optimal trade-offs between these two objectives but appear to first set a creativity cutoff and then try to maximize quantity above that cutoff.

Fourth, there are limitations on learning through information acquisition and subjective estimation of parameter and variable values. Learning limitations influence MA, for example when activity time estimates from individuals' memories of their experience are used in product costing (Cardinaels and Labro, 2008). Conversely, MA can limit or bias learning through its influence on individuals' attention, memory, and other elements of subjective information processing. For example, the more that the MA information available for evaluating subordinates' performance exceeds individuals' ability or willingness to use it all, the more selective they will be in acquiring information. Because selectivity is not always optimal, the mean accuracy of subordinate evaluations decreases when the information available about the subordinates increases sufficiently (Shields, 1983). Biases in learning are not always costly, however: for example, over-estimation of collaborators' inherent trustworthiness induced by an MA control system can engender trust and further profitable cooperation (Coletti et al., 2005).

7.2 Emerging Themes

Recurring observations in the psychology-based MA literature suggest two additional themes for research on MA-related decisions. The first set of observations is the limited heterogeneity of subjective MA-related decision models, and the second is the variation in the degree to which subjective decision processes are deliberative or intuitive. Although these two sets of observations have important implications for MA, the existing literature has not explored these implications extensively and has rarely proposed hypotheses about

them. Here we sketch some opportunities for future research suggested by these recurring observations.

7.2.1 Limited Heterogeneity

The models implicit in individual subjective MA-related decision behavior are often neither clustered around a single modal type nor distributed across a wide variety of different individual models. Instead, two or three distinctly different subjective decision models often account for most of the observed behavior. For example, in the linear programming problems studied by Ball et al. (1998) and Gonzalez et al. (2002), two models describe almost all subjective decision making by experiment participants. Similarly, in the variance investigation task used by Lewis et al. (1980), 80% of the participants use a subjective decision model that omits prior probabilities and decision error costs, while 20% use a subjective decision model that includes both of these variables. In Krishnan et al. (2005), about half the participants make decisions consistent with a complete qualitative version of an agency model, while slightly less than half make decisions consistent with a truncated version of the agency model, in which the omission of the last links in a causal chain of reasoning leads to directionally incorrect decisions about performance measure weighting.

Limited heterogeneity is also observed in research on individuals' objectives. In Evans et al.'s (2001) Experiment 1, in which participants (agents) could increase their monetary payoffs by misrepresenting their private information about production costs, 25% of reports are completely honest, 27% maximize the participants' monetary payoffs with no regard for honesty, and the remaining 48% misrepresent moderately. Increasing monetary payoffs for misrepresentation by a factor of five in this study's Experiment 2 does not significantly change this distribution.

Camerer (2006, p. 192) identifies two important classes of questions about heterogeneity that need more attention in behavioral economic research:

> First, how heterogeneous are agents? And how detectable is heterogeneity? (This question is important

> because heterogeneity drives the division of labor in organizations, the development of expertise and human capital, and market interaction of rational and limitedly-rational agents.) And second, how do institutions sort heterogeneous agents, supply market substitutes for individual irrationality, and create organizational outcomes on the supply side?

These questions also have implications for MA research. One implication is that more studies ought to report (and, when a sufficient theoretical basis is available, predict) the distribution or clustering of observed behavior. Some studies do so (e.g., Evans et al., 2001) but many do not, and reporting only means and standard deviations can sometimes lose or hide valuable information. A mean-zero effect of an MA variable (e.g., reporting format, incentive plan) may indicate that the factor in fact has little or no effect on most decision makers (with some random, widely scattered exceptions, resulting in a large standard deviation). Or it may indicate that the factor has a positive effect on about half of the sample and a negative effect on about half, with relatively few individuals unaffected (also resulting in a zero mean and a large standard deviation). These two situations are different both theoretically and practically and should be distinguished.

A second implication is that there are many opportunities for research directly addressing the effects of limited heterogeneity. For example, members of cross-functional teams are likely to bring heterogeneous mental models to the team decision-making process. When does MA enable individuals to reconcile their different mental models by providing shared evidence and decision-model representations, and when does it not do so because individuals attend to and interpret the information differently based on their different mental models?

As another example, how can MA practices (perhaps developed by "more rational" individuals) counteract biases of "less rational" individuals within an organization? Heath et al. (1998) argue that many organizational practices can be explained as "organizational cognitive repairs" (i.e., ways of preventing or correcting common shortcomings in

subjective decision making).[1] For example, a top-management policy of emphasizing negative evidence (e.g., high expected costs) about proposed projects might counteract lower-level individuals' over-optimism about the financial success of projects for which they are responsible (for evidence of this over-optimism and its effects see Bloomfield and Luft, 2006; Tayler, 2010).

7.2.2 Deliberative and Intuitive Decision Making

MA-related decisions can be deliberative (consciously controlled) or intuitive (automatic or gut feel) decisions. Although intuitive decisions typically exhibit systematic patterns, just as more deliberative decisions do, individuals are unlikely to be completely aware of how various factors have influenced their intuitive decisions. A mix of deliberative and intuitive decision processes is consistent with dual-process theories in psychology, which argue that cognition can occur in two systems (Kahneman, 2003a,b; Evans, 2008). System-1 cognition (sometimes called intuition) is unconscious, automatic, low effort, fast, not capacity-limited, and parallel — it can process information extremely rapidly but is easily influenced by factors like anchors and frames. In contrast, system-2 (deliberative) cognition is conscious, controlled, high effort, slow, capacity-limited, and sequential. Deliberative cognition can sometimes reduce or eliminate framing effects, for example when individuals develop explicit rationales for choices that enable them to identify and thus reduce framing effects (Miller and Fagley, 1991; Levin et al., 1998). Because deliberative decision making is slow and capacity-limited, it does not always support better decision performance than intuitive decision making. Moreover, it is not automatically triggered on all occasions when it would support better decision performance, and when it is triggered it does not always eliminate the effects of heuristics. For example, deliberate attempts to reduce judgment biases due to anchoring and adjustment tend not to be successful (Chapman and Johnson, 2002).

[1] Heath et al.'s (1998) "cognitive repairs" are much like the "nudges" — institutional practices designed to reduce decision bias–recommended by Thaler and Sunstein (2008).

The causes and effects of deliberative versus intuitive decision making have important implications for MA research and practice. MA education and organizational policies typically assume and/or encourage deliberative decision making. Decision aids are usually aimed at replacing intuitive decisions or faulty deliberative decisions with better deliberative decisions. Decision making in practice often remains intuitive, however (Wailgum, 2009), and research on decision aids in auditing indicates that individuals often avoid or circumvent aids that are inconsistent with their intuitive decisions (Messier Jr, 1995). Little is known thus far about either actual or desirable mixes of deliberative and intuitive processes for different decisions and decision contexts. It is likely that MA often has different effects in deliberative and intuitive decisions — for example, intuitive decision making often creates anchoring and framing effects, which decrease when decision makers are made aware of them (Tversky and Kahneman, 1986; Epley and Gilovich, 2005) — but MA research has rarely addressed this issue thus far.

7.3 Gaps in Psychology-Based MA Research

The four main themes and two emerging themes identified in our review certainly do not exhaust the possibilities of psychology-based MA research. At least three gaps in current information about MA-related decision making are clearly visible. First, the typical study included in our review addresses a single, relatively simple decision — for example, a specific parameter estimate or variable choice — that is likely to be a sub-part of a larger and more complex decision task. We know relatively little about how individuals divide large decision tasks into sub-parts and structure the relations among sub-parts, and how MA influences and is influenced by these processes. Section 5.1 above draws on a relatively small literature about large subjective decision-model structures, most of which is outside accounting journals. A few MA studies have used simulation to investigate the performance of heuristic models of large complex decision tasks like cost system design (Balakrishnan et al., 2008) or cost-based pricing and capacity decisions (see review by Balakrishnan and Sivaramakrishnan, 2002). But much

remains to be learned about which heuristics are employed in practice, how MA affects the choice of heuristics, and what the consequences are.

The second notable gap is in research on information acquisition (Sections 6.1 and 6.2). Given the large quantities of information that can now be produced by MA and the diverse experiences to which individuals are exposed in changing environments, cross-functional teams, etc., the selective acquisition of information from organizational information systems and selective encoding and retrieval of experience in memory are likely to be important influences on decision making. Psychology research often suggests that individuals acquire information selectively to confirm their existing beliefs, though this selectivity is not always deliberate (Nickerson, 1998). Understanding the diverse cognitive mechanisms by which (sometimes biased) selective acquisition occurs is important in understanding how individuals use (or fail to use) the extensive MA information that is often available to them.

A third gap in the MA literature is the near absence of recent non-laboratory studies based on psychology theories. Such theories can provide valuable explanatory power in archival, field, and survey studies. For example, Ittner et al. (2003a) test two economics-based hypotheses and six psychology-based hypotheses about the incentive weights on financial and nonfinancial performance measures in a large bank's balanced scorecard. One economics-based and one psychology-based hypothesis make the same prediction on different theoretical grounds, and the results are partially consistent with this prediction. The other economics-based hypothesis is not supported; of the five remaining psychology-based hypotheses, three are supported by the results and two are partially supported. Ittner et al. (2003b, p. 754) conclude that their "... evidence suggests that psychology-based explanations may be equally or more relevant than economics-based explanations in understanding measurement practices in some settings."

Results of field and laboratory tests of psychology theories are often similar, though not identical. Reviewing social-psychology-based management research published in the 1960s–1980s on various topics (e.g., goal setting, participation) using both field and laboratory settings, Locke (1986) concludes that the directional effects documented in well-designed laboratory tests and the statistical and practical

significances of these effects generally replicate in the field, although exact parameter values are unlikely to be the same across settings.

Although field tests of some of the psychology theories described in our review (e.g., social preferences, heuristics, and biases) have not been comprehensively compared to laboratory results, evidence also exists that the results of well-conducted laboratory tests of these theories can be replicated in field settings. Comparisons of laboratory and field results in behavioral economics and finance indicate considerable convergence (Barberis and Thaler, 2003; Camerer et al., 2004; Hirshleifer, 2001); examples in the MA domain are rarer as yet but have begun to appear. For example, Hossain and List (2009) document persistent incentive-framing effects (bonus versus penalty effects, cf. Section 3.1) in a high-tech manufacturing facility. Similarly, Bandiera et al. (2005) find results in a field setting much like the results of Towry's (2003) experiment (see Section 4.4), in which an incentive plan designed to discourage collusion by agents against the principal fails to do so when two conditions are met: first, the incentive plan generates an economic payoff from collusion, although collusion is not sustainable as an equilibrium by purely self-interested agents, and second, social identity among work-group members is high. Further use of psychology theories in investigating decision making outside the laboratory has considerable potential for increasing our understanding of MA.

7.4 Summary

Of the studies examined in our review, about half were published in the last 10 years, while the other half were published in the previous 30 years. Earlier studies tend to be more purely cognitive (e.g., studies of information search or variable choice), while more recent studies expand the domain of MA research to include preferences, valuation of payoffs, and the affect that underlies preference and valuation phenomena. For example, the prospect-theory value function on which the studies in Section 3 are based "... reflects an anticipation of the valence and intensity of the emotions that will be experienced" when payoffs are received or withheld (Kahneman, 2003a, p. 1457), and emotions play a

strong role in generating the fairness effects documented in Section 4 (Barclay et al., 2005).

The preponderance of more recent research in our review reflects the growth and dynamism of psychology-based research on MA. This research has been stimulated in recent years by innovations in both practice and theory. From practice, the rise of MA innovations such as new costing systems and strategic performance measurement systems have generated research questions that can be fully addressed only with contributions from psychology-based research. From theory, the rise of behavioral economics has provided support by combining the analytic power of economic modeling with the relatively sophisticated understanding of human cognition, motivation, and social interaction derived from psychology. In consequence, a robust MA literature has developed around the four themes highlighted in our review: framing and reference points, non-monetary (social) payoffs, simplified decision-model structures, and limitations on learning. Emerging themes and remaining gaps in the MA literature provide further opportunities for research that draws on psychology models of decision making.

A

Appendix: Economic Models of MA

In economic theory, MA plays two important roles in organizations (Demski and Feltham, 1976; Sprinkle and Williamson, 2007). In its planning (or decision-facilitating) role, MA provides information to reduce pre-decision uncertainty; thus it enables decisions that generate higher expected utility for the decision maker. In its control (or decision-influencing) role, MA helps align the interests of multiple individuals in an organization by providing information that allows some individuals to monitor, measure, evaluate, and reward the actions of others.

In this Appendix we present economic models of two MA-related decision tasks. A joint decision about product prices and production plans based on product-cost information provides an example of a planning (decision-facilitating) use of MA information, and incentive compensation design provides an example of a control (decision-influencing) use.

An Example of Decision Facilitation: Cost-Based Product-Capacity Planning and Pricing

An important decision-facilitating use of MA information is product capacity-planning and product pricing. Balakrishnan and

Table A.1. Grand Model in Balakrishnan and Sivaramakrishnan (2002).

$$\underset{P_{it},R_{jt},L_j}{\text{Max}} \; \text{E}\left[\sum_t \left(\sum_i [P_{it} - v_i](A_i + \varepsilon_{it} - B_i P_{it}) - \sum_j \Theta_j c_j R_{jt}\right)\right] - T\sum_j c_j L_j \quad \text{(A.1)}$$

Subject to:

$$\sum_1 m_{ij}(A_i + \varepsilon_{it} - B_i P_{it}) - R_{jt} - L_j \leq 0 \quad \forall j,t, \quad \text{(A.2)}$$

$$(A_i + \varepsilon_{it} - B_i P_{it}) \geq 0 \quad \forall i,t,$$

$$P_{it} \geq 0 \quad \forall i,t.$$

Legend:
E = expectation;
P_{it} = price for product i for time period t;
v_i = variable cost per unit of product i;
A_i = market size for product i for time period t;
ε_{it} = error term for product i for time period t;
B_i = demand elasticity for product i;
Θ_j = emergency purchase price premium per unit of resource j;
c_j = per-period cost of a unit of resource j when purchased at the time of capacity planning;
R_{jt} = emergency purchase quantity of resource j for time period t;
T = number of periods that capacity resources last;
L_j = units of installed capacity of resource j possessed by the firm; and
m_{ij} = units of capacity resource j consumed by a unit of product i.

Sivaramakrishnan (2002) provide a review and analysis of the economically optimal use of MA information for these decisions. They develop models that vary in their assumptions and information requirements and hence in their decision complexity and difficulty. We focus on their grand model which includes features of their other models (Table A.1).

The grand model (Table A.1) assumes that the firm is a monopolist[1] and demand is a stochastic function of price. In each time period, product prices, the intercept of the demand function, the quantity of each product produced, and the number of units of capacity acquired on as as-needed basis can change, but input costs and the slope of the demand function are constant over time periods. This model assumes there is no inventory and the firm has a Leontief technology (fixed input proportions). With this model, to maximize total contribution margin,

[1] Some versions of the model allow the firm to be a price-taker in a competitive market.

the decision maker chooses the optimal product prices (P_{it}), initial capacity (L_j), and as-needed incremental capacity (R_{jt}) as follows:

(1) estimate the fixed capacity available for each resource j (L_j);
(2) estimate the cost per unit of purchasing additional fixed resource j (c_j);
(3) estimate the quantity of capacity resource j required to produce product i, for each product i and resource j (m_{ij});
(4) estimate the variable cost per unit of each product i(v_i);
(5) estimate the demand for each product i as a function of price ($= A_i + \varepsilon_{it} - B_i P_i$), taking into consideration the stochastic element of demand (ε_{it}).
(6) estimate the cost per unit of resource j for additional capacity of resource j purchased on as as-needed basis ($\Theta_j c_j$); and
(7) combine the information specified above to choose product prices (P_{it}), initial capacity (L_j), and as-needed incremental capacity purchases (R_{jt}) in such a way as to maximize total contribution margin subject to the resource constraints — that is, solve the quadratic program.

An Example of Decision-Influencing: Incentive Weights on Performance Measures

In agency theory, incentive compensation plays an important role in attracting agents to work for a principal and/or inducing agents to take actions that benefit the principal. Feltham and Xie (1994) develop a theoretical agency model of incentive contracting when agents can choose among multiple actions that affect the principal's expected gross payoff (Table A.2).[2] This model assumes that the principal is risk neutral and the agent is risk-averse (negative exponential utility function) and that actions by the agent that increase the principal's expected payoff impose direct personal costs on the agent. The model assumes that the principal's gross payoff is not contractible information, the

[2] Datar et al. (2003) also provide a model of this problem, which focuses more on weighting the measures, while Feltham and Xie's (1994) analysis focuses more on the value of the measures. Cognitive requirements of the two models are similar, however.

Table A.2. Equations in Feltham and Xie (1994). (Equations are numbered consistent with the numbering in Feltham and Xie (1994).)

$$\boldsymbol{y} = \boldsymbol{\mu} a + \varepsilon \tag{A.3}$$

$$w(\boldsymbol{y}) = \beta + \boldsymbol{v}^t y \tag{A.4}$$

$$V(\boldsymbol{a}, v, \eta) \equiv B(\boldsymbol{a}) - [1/2 r v^t \sum \boldsymbol{v} + C(\boldsymbol{a})] \tag{A.5}$$

$$\boldsymbol{a} = \boldsymbol{\mu}^t v \tag{A.6}$$

$$\boldsymbol{v}^\dagger = \boldsymbol{Q} \mu b \tag{A.7}$$

$$\boldsymbol{a}^\dagger = \boldsymbol{\mu}^t v = \boldsymbol{D} b \tag{A.8}$$

$$V(\boldsymbol{\eta}) = 1/2 \boldsymbol{b}^t \boldsymbol{D} b \tag{A.9}$$

Legend:
$\boldsymbol{y}$ = vector of publicly reported performance measures;
$\boldsymbol{\mu}$ = matrix of performance measure parameters (sensitivity);
$\boldsymbol{a}$ = vector of agent's actions;
$\boldsymbol{\varepsilon}$ = vector of normally distributed mean-zero random errors;
w = wage payment;
V = principal's expected surplus (i.e., principal's expected gross payoff minus the agent's personal cost);
β = fixed component of compensation;
$\boldsymbol{v}$ = price paid per unit of performance measure;
$\boldsymbol{\eta}$ = performance measurement system $(= \boldsymbol{\mu}, \Sigma)$;
B($\boldsymbol{a}$) = principal's expected gross payoff;
r = agent's absolute risk aversion;
C($\boldsymbol{a}$) = agent's direct personal cost if actions $\boldsymbol{a}$ are implemented;
$\boldsymbol{\Sigma}$ = variance–covariance matrix representing precision of performance measures and the error covariance of the measures;
$\boldsymbol{Q} \equiv [\boldsymbol{\mu}\mu^t + r \sum]^{-1}$;
$\boldsymbol{b}$ = vector of coefficients indicating the effects of the agent's actions on the principal's expected gross payoff; and
$\boldsymbol{D} \equiv \boldsymbol{\mu}^t Q \mu$.

principal cannot observe and contract on the agent's actions, and a linear relation exists between the agent's action and the expected levels of each performance measure. In this model, an agent can allocate effort among multiple actions that have different effects on the performance measures and on the principal's gross payoff.

Economically optimal performance measure weights, given the assumptions of this model, depend on three attributes of the measures: sensitivity, precision, and congruity. A measure is more *sensitive* when the agent's action has a larger expected effect on it. A measure is more *precise* when there is less variation in it due to uncontrollable events (i.e., events other than the agent's action). A measure is more

congruent when the agent's action that does more to increase a performance measure also does more to increase the principal's gross payoff.

To identify the properties of economically optimal contracts, Feltham and Xie (1994) develop seven equations (Equations A.3–A.9)[3] that identify what information is required and how to use that information to determine the economically optimal incentive weights on the performance measures. Table A.2 displays the equations and identifies the information required to estimate the equations and solve the program to determine an optimal incentive contract. Equation (A.3) specifies a linear relation between the agent's actions and the expected levels of the performance measures. Equation (A.4) exogenously restricts incentive pay to be a linear function of the performance measures. Equation (A.5) indicates that the principal's expected surplus is a function of the agent's actions $\boldsymbol{a}$, the payments to the agent for performance on each measure $\boldsymbol{v}$, and the information system $\boldsymbol{\eta}$ (the matrix of performance measure sensitivities $\boldsymbol{\mu}$ and the matrix of error variance and covariance of the performance measures $\boldsymbol{\Sigma}$). Equation (A.6) represents the agent's actions as a function of the pay per unit of performance measure and the sensitivity of each measure. Equations (A.7) and (A.8) specify the solution to the principal's problem of maximizing her expected gross payoff. Equation (A.9) specifies the second-best expected surplus.

To determine the optimal incentive contract, the principal needs to:

(1) choose an objective to be maximized (e.g., expected wealth);
(2) identify all performance measures that provide information about the agent's actions that affect the objective;
(3) estimate the parameters that link the agent's actions to each performance measure (sensitivity) and to the principal's expected gross payoff;
(4) estimate the error in each performance measure as an indicator of the agent's actions (precision);
(5) estimate the correlations among the errors in the performance measures;

[3] Equations (A.1) and (A.2) in Feltham and Xie (1994) are the first-order condition and the expected surplus under the first-best contract, respectively.

(6) estimate the degree to which maximizing the chosen performance measures also maximizes the principal's objective (congruity);
(7) estimate the reservation wage that would be acceptable to the agent; and
(8) choose the equilibrium weights on the performance measures.

The agent needs to:

(1) identify the value of outside opportunities (reservation wage);
(2) estimate the effort required to achieve a range of expected payoffs under the proposed contract, and estimate the variance of the expected payoffs caused by factors other than the his actions;
(3) judge whether the incentive contract offers better payoffs (taking risk and effort into account) than the best alternative. If no, then refuse the contract; if yes, then accept the contract; and
(4) if accept the contract, then choose actions with the best risk-adjusted expected return to effort.

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