

Valuation of Green Projects with Social Considerations

Capital budgeting for green projects has become important in both academia and managerial practice. As green projects are usually subject to high Knightian uncertainty or social controversy, capital budgeting for them is a particularly delicate process. Existing approaches are polarized: financial economists tend to apply the variations of traditional discounted cash flow models while strategy and organization researchers emphasize social / environmental responsibilities upon qualitative socio-political processes of valuation. This paper attempts reconcile the competing views by extending the framework of Carnegie School, especially the Behavioral Theory of the Firm (“BTF”; Cyert & March, 1963). Two social factors in regard to green projects are central to the behavioral theory of the firm (BTF) – Knightian uncertainty (Knight, 1921; Keynes, 1921) and controversy (Cyert and March, 1963; Burton, DeSanctis, and Obel 2006). Hence, we develop a framework of capital budgeting about green projects that incorporates existing approaches considering the extent of Knightian uncertainty and controversy. We argue that (1) financial approaches are appropriate when Knightian uncertainty and controversy are both low, and (2) qualitative socio-political approaches will work when both Knightian uncertainty and controversy are high. We address the other cases by suggesting the plausibility approach for high Knightian uncertainty and low controversy, plus the coordination approach for low Knightian uncertainty and high controversy applying recent research about green capital budgeting (Kang, Burton & Mitchell, 2010).

Keywords: green project, green financing, the behavioral theory of the firm, capital budgeting, Knightian uncertainty, controversy, green capital budgeting model

Investments in green projects have become significant. Green technology ventures have attracted large attentions from venture capitalists, big firms and government. For example, Google has invested over \$100 million as of Apr 2011 in environmental technology ventures¹. US government has directed sizable financial and political resources to green technologies and energy sources and declared green sector as the source of future economic growth (e.g. Obama administration's green budget and Sputnik moment). Green financing is sometimes believed to aim at generating green and good profits instead bad profits. Despite various definitions, green finance means investing or funding to promote program "that works for the environment, not against it" and that align financial investment with sustainability².

However, green financing is a hard issue in practice despite rhetoric and enthusiasm around it. Valuation and capital budgeting in green investment opportunities are challenging. Traditional capital budgeting approaches focus on expected cash flows and systematic risks to compute net present values. However, green projects are often full of controversy and Knightian uncertainty, so that it can be very difficult to apply traditional methods in practice. For example, controversies have existed over Kyoto protocol and the extent to which countries should make investment to limit greenhouse-gas emission. Knightian uncertainty, which is qualitative and immeasurable uncertainty, is evident over what will be the winning technology in green sector and what investment in green technologies will generate innovation to resolve global warming, the ramification of which is in turn still under controversy and Knightian uncertainty. It is certainly full of controversy and Knightian uncertainty whether to invest in nuclear plants especially after the Fukushima nuclear disaster: Is it a green financing to invest in building nuclear

¹ <http://www.google.com/corporate/green/investments.html>

² <http://www.greenpeace.org>

reactors?

Knightian uncertainty and controversy in green projects and corporate social responsibilities are well investigated many literature. For example, Koppenjan and Klijn (2006) discuss managing uncertainty and controversy in social interactions. Lepoutre, Dentchev and Heene (2006) extends Koppenjan and Klijn (2006) to discuss uncertainties in corporate social responsibilities classifying uncertainties into (1) substantive, (2) strategic, and (3) institutional uncertainty and suggest how to manage the three types of uncertainties in corporate social responsibilities and green projects. Substantive uncertainty focuses on the information and knowledge on the nature of social issues. Strategic uncertainty relates to the strategic deeds of stakeholders. Institutional uncertainty recounts the relations between the institutional settings of stakeholders such as the development of the processes of institutional design.

There is no definitive academic framework of capital budgeting to assess green projects and conduct green investment. A few existing approaches are polarized, either applying traditional discounted cash flow models or emphasizing social / environmental responsibilities with cursory cash flow analysis. Financial economists tend to support the former approaches while strategy and organization researchers support the latter.

First, financial economics offers the most influential framework about valuation based on the variations of discounted cash flow approach. However, many studies show large heterogeneity in capital budgeting valuations. Little research seriously investigates what methods a firm should apply to make decisions about green financing. See, for instance, Walker (1961), Ackerman (1970), Neuhauser and Viscione (1973), Vandell and Stonich (1973), Burton and Damon (1974), Gitman and Forrester (1977), Hayes and Abernathy (1980), Stanley and Block (1984), Bruner, Eades, Harris, and Higgins (1998), Maritan (2001), and Graham and Harvey (2002) and Kang, Burton and Mitchell (2010).

Such heterogeneity is puzzling because firms should use similar capital budgeting practices if they all use standard budgeting techniques like net present value or internal rate of return as finance textbooks argue. Kang, Burton and Mitchell (2010) show with structured case studies that the variation of capital budgeting practices can arise due to the variation in social factors such as controversy and Knightian uncertainty. Similarly, we will argue that the capital-budgeting methods for green programs need to consider the social factors explicitly.

Second, pioneered by Bower (1970) and those in Bower and Gilbert (2005), strategy and organization researchers about investment decision note political and social influences in investment decision. Abundant literature demonstrates how social, political or organizational factors interfere with investment decisions. Institutional environment like political structure, party system, feasibility of policy change, alignment of government branches and corruption can influence investment in infrastructure, cross border and telecommunication (Henisz 2000, 2002; Henisz and Zelner 2001). Social network can determine deals for investment (Chung, Singh and Lee 2000). Social relationship affects cost of capital (Uzzi and Lancaster 2003). Socially responsible investment grows fast and reaches maturing state with strong connection to corporate social responsibility (Sparkes and Cowton 2004). Granovetter (2005) argues that social structure is a significant determinant of economic behaviors like investment although mainstream economics has ignored social factors.

Bower (1970) even states that financial models of capital budgeting are “not very useful and if you are a manager you probably know that”, whereas offering the socio-political framework as a better alternative. Nevertheless, this literature suggests only superficial analysis about financial variables like expected cash flow, systematic risks and opportunity cost of capital. Few papers in this stream examine financial factors or conduct

financial modeling of investment decision. In fact, many firms use financial valuation models (Graham and Harvey 2001) as well as social-political approaches.

Two streams of the literature aforementioned do not investigate which valuation models a firm applies to consider social and institutional factors as well as financial variables all together. In this paper, we develop a model of capital budgeting to green projects overcoming limits of existing approaches. We extend Kang, Burton, and Mitchell (2010; “KBM” hereafter)’s analysis about how a firm selects heterogeneous capital budgeting approaches in varied contexts. However, KBM focus only on capital budgeting in general, and do not examine how the context of green financing factors into the choice of valuation and capital budgeting process.

We consider social factors internal and external to a firm in explaining how a firm evaluates green projects. Knightian uncertainty is a chosen outside factor (Knight, 1921; Keynes, 1921). Controversy is the inside factor (Cyert and March, 1963; Bower, 1970; Burton, DeSanctis, and Obel, 2006). These two variables are central to the behavioral theory of a firm (“BTF” hereafter; Cyert and March, 1963) in examining organizational decision making. Bower’s socio-political model (Bower, 1970; Maritan, 2001) also depicts how Knightian uncertainty and controversy influence resource allocation process in a firm. KBM argue that Knightian uncertainty and controversy can explain why the lack of consensus about the capital investment process emerges. They demonstrate that polar cases of capital budgeting behavior, such as standard capital budgeting models such as NPV, IRR, etc. and Bower’s socio-political approaches, can be regarded as special cases of a more general model.

Prior literature has much investigated controversy and Knightian uncertainty. First, controversy occurs as sub-coalitions within an organization differ on goals or beliefs about states of the world. Controversy among coalitions generates the need for bargaining and

consensus to make decisions. The resolution of controversy produces organizational goals. See Cyert & March (1963), Bower (1970), Bower & Gilbert (2005). Second, Knightian uncertainty occurs when decision-makers cannot determine a probability distribution for the likelihood that an event will occur. This contrasts risk for which distributions can be described. Uncertainty can arise from various sources. Internal uncertainty can result from interdependency of information processing and measurement of agents' performance, while environmental uncertainty is from the lack of knowledge about external influences (Thompson, 1967; Galbraith, 1973; Williamson, 1975, 1979). See Knight (1921), Keynes (1921), Nelson & Winter (1982), Spender (1989) for details.

Next sections will illustrate how social factors can interfere with capital budgeting process and develop an extended model to evaluate green projects with attention to Knightian uncertainty and controversy.

Social Factors in Green Financing

A core idea of our approach is that a firm chooses not only projects for investing, but also the valuation methods for recognizing values, in contrast to the conventional idea in which valuation methods are not a choice variable. Let us illustrate how green and other social factors can enter into valuation methods with a simple example. Table 1 illustrates two distinct valuation strategies in which the perception on uncertainty differs. For instance, both methods can be NPV, but with different intuitions. Or Method 1 is a quantitative method and Method 2 is a qualitative method.

***** Table 1 *****

The shaded area denotes the selected combination of valuation strategy and investment opportunity, (Method 2, Project 2). To explain the situation: The realization of either state 1 or 2 is independent of systematic factors, i.e. it is idiosyncratic. This simplifying assumption prevents the cash-flow fluctuations from influencing the discount rate of the project; the first column denotes

two valuation strategies. Method 1 involves a more diffuse distribution for Project 1 than Method 2 does; the second column denotes how much confidence the firm has about the accuracy of each valuation strategy. For simplicity, we assume that they are the same; the third column denotes what will be the returns to (Team 1, Team 2) from the investments Project 1 and Project 2 respectively if state 1 is realized. The fourth column shows the returns in case state 2 is realized; The first row states that state 1 and state 2 are equally likely (50% each).

Project 1 disrupts consensus in an organization and generates two undesirable consequences, and as a result, most members of the organization would choose Project 2 over Project 1. First, the decision-making would be costly in terms of time and resources. Some teams in a firm may reject Project 1 because of the distribution of the returns. And the firm may have to design additional contracts to redistribute payoffs after the project is over. Second, such controversies will make the coordination and communication difficult in the implementation stages. If implementation requires the effort of both teams, the losing team may sabotage the project. Managers can communicate the choice in two ways. First, they assert that they used Method 1 and made a suboptimal choice. Second, they declare that they used Method 2 and made an optimal choice.

We argue that firms will choose the second way of communication. The second way is less likely to create cognitive dissonance, easier to communicate, and easier to build consensus. For instance, firms can argue that Method 1 does not fit their culture, goal or vision, which Method 2 may take into account. Thus, a firm considers social factors and the easiness of communication in choosing Method 2.

Table 2 is an application to green financing projects. Let us consider (Green-Low, Green-High) projects, and (internal, external) stakeholders. Internal stakeholder can be simply a firm. External stakeholders may be government, community or pressure groups.

***** Table 2 *****

Similar to the previous example, Method 2 evaluates Green-Low investment at half of benefit/ costs in each state compared with Method 1. Method 1 proposes that Green-Low is better

than Green-High from the perspectives of both the firm and external stakeholders. If the firm uses Method 1 to evaluate Green-Low, the investment at state 1 will benefit the firm by 100, but hurts the external stakeholders by 60. At state 2, the payoff to the firm and the external stakeholder is (50, -30). Thus, the expected payoff becomes (75, -45). Similarly, the pair (Method 1, Green-High) produces expected payoff (18, -1.5). Thus, Green-Low is better for the firm ($75 > 18$) and for the society as a whole ($75-45=30 > 18-1.5=16.5$). In comparison, when the firm uses Method 2, Green-Low is better for the firm ($37.5 > 18$), but Green-High is better for society ($37.5-22.5=15 < 18-1.5=16.5$). Consequently, the firm should choose either (Method 1, Green-Low) or (Method 2, Green-High).

Given the highly negative consequence to the external stakeholder in state 1, Green-Low project may generate controversies. Thus, the firm prefers Green-High projects. The Green-Low project may even be infeasible due to the relationship with external stakeholders. Given the similar accuracy of Method 1 and Method 2, we expect the firm chooses (Method 2, Green-High) pair over (Method 1, Green-Low) or (Method 1, Green-High) in order to obtain the support from the external stakeholder.

***** Table 3 *****

Table 3 is another example how communication consideration can change valuation for a green project. The valuation strategy FINE can distinguish state 1 and state 2, but COARSE cannot. However, GREEN-LOW always generates higher expected return regardless of the valuation strategies. We propose that firms communicate the pair (COARSE, GREEN-LOW) in case (1) managers stop valuation at COARSE, not proceeding to FINE, or (2) managers proceed to FINE, but only communicate COARSE as official. Case (1) arises because COARSE is good enough (satisficing; Simon 1955) to make decision and communicate. Case (2) occurs because managers intend to make GREEN-LOW legitimate without generating conflicts between team 1 and team 2, while maximizing firm value. Simply speaking, it is easier to justify (COARSE, GREEN-LOW) than (FINE, GREEN-

LOW).

***** Table 4 *****

Procedural justice generates more parsimonious example as Table 4. In the example, the pair (Participation, GREEN-HIGH) is selected over (Domination, GREEN-LOW). The participation of team 2 in decision-making process may decrease the accuracy of valuation if the information of team 2 overlaps that of team 1 except pure noise. It is also possible that the participation involves very different valuation methods from the domination. For instance, political considerations can define costs in transfer-pricing conflicts (Granovetter, 1985). Nevertheless, participation in decision-making raises perceived procedural fairness. Procedural justice increases the satisfaction of teams and performance as a result (Lind & Tyler, 1988). Communication and participation also increase group longevity (Katz, 1982). Such social consideration leads a firm to choose (Participation, GREEN-HIGH).

Formalization

This section develops Green Capital Budgeting Model (GCBM) with two core concepts: value space and social factors. Value space means the two-dimensional space of investment opportunities and valuation methods. Key social factors include controversy and Knightian uncertainty. Thus, GCBM means selecting pair of investment opportunity and valuation method under the consideration about social factors. This leads us to hypothesize that a firm conducts following GCBM-optimization when the set of valuation methods (S) and raw investment opportunities (K) are given. GCBM is defined in association.

We use following notations: {V, B, A, E, C, U} are the functions of s (a valuation method/ strategy) and k (a project). They are the perceived value (V), net accuracy (B),

gross accuracy (A), effort (E), controversy (C) and uncertainty (U). Net accuracy is gross accuracy minus effort. X denotes situation factors and may include S and K. Let us call {C, U} as social factors. We assume well-defined second order conditions. C and U capture internal and external influences in a broader view. $V = V(s, k)$ is the derived value of a project k using a valuation method s. For instance, V can increase with mean, but decrease with its variance if s is mean-variance optimization. If s is NPV method, V increases with expected cash flow, but decreases with the beta of the cash flow. Using these notions, we have following definitions. Table 5 summarizes core concepts used in GCBM.

Definition 1: GCBM-optimization means,

- Maximize: $G(V, B, C, U, X)$, in which $B \equiv A - E$
- With respect to $s \in S$ and $k \in K$

Definition 2: GCBM is the set of s that solves GCBM-optimization given k.

$GCBM(k) \equiv \arg.\max_{\{s\}} GCBM\text{-optimization for a given } k \text{ and } s \in S.$

***** Table 5 *****

Once we presume the choice set as $S \times K$ (value space) instead of just K, it is clear that simply maximizing perceived firm value (V) is unrealistic. Otherwise, firm would choose the most optimistic valuation method for a given k. This situation may hold only in particular contexts such as exaggeration, strategic disclosure or moral hazard. Instead, the GCBM-optimization hypothesizes that organizations conduct capital budgeting in order to accomplish goals (G). Cyert and March (1963) argues that firms pursue goals or aspiration levels. Four of the most important goals are (a) choosing high value project, (b) increasing the accuracy of the investment decision, while reducing the organizational resources required for the decision, (c) reducing the controversy in investment decision, and (d)

decreasing uncertainty in investment. Next assumption expresses them.

Assumption 3: $G_V \geq 0$, $G_B \geq 0$, $G_C \leq 0$ and $G_U \leq 0$.

Organizations make decision on the value space $S \times K$ which is the Cartesian product of valuation strategies and investment opportunities. A raw investment opportunity becomes a perceived opportunity after it meets a valuation strategy. In other words, a valuation strategy ($s \in S$) determines the perception of an investment opportunity ($k \in K$) in an organization. S includes intuition, heuristics, exploration, environmental scanning, scenarios, goal setting, analysis, issue list, voting, bargaining and communication. Exploration includes fieldwork and the aggregation of information from both in and outside of an organization. Scenario analysis includes qualitative studies as well as quantitative tools of standard capital budgeting models. Communication matters because it affects the perception of subgroups in an organization.

SCBM is a special case of GCBM

Let us start from the formal definition of standard capital budgeting model (SCBM) in the context of GCBM.

Definition: SCBM is the solution of s to maximize B given k .

$SCBM(k) = \arg.\max_{\{s\}} B$ for a given k and $s \in S$.

Under well defined first- and second-order conditions, $SCBM(k)$ solves $B_s(s, k) = 0$. We define SCBM as the most accurate method of valuating a project in consideration of effort. Numerous textbooks and articles discuss NPV and its variations ending up rationalizing them as the accurate tool for investment decision. In addition, NPV is very

flexible to account for the cognitive or organizational costs. An analyst can change the assumption or a specification of an NPV model, so that she can make it simple or sophisticated depending on the preference and the opportunity cost of doing the analysis. For instance, it is possible that she performs valuation only up to satisficing level to reduce the cognitive resource. Thus, SCBM covers the case of bounded rationality and heuristics.

It is clear that SCBM is not always the best valuation method to maximize the organizational goal. To the contrary, SCBM is optimal only in special situation.

Lemma 4: SCBM (s^*) is the optimal valuation strategy if and only if

$$G(V(s^*, k), B(s^*, k), C(s^*, k), U(s^*, k), X) \geq G(V(s, k), B(s, k), C(s, k), U(s, k), X) \text{ for all } s \in S \text{ and } k \in K.$$

Notice ‘if and only if’ in the proposition. SCBM is in general suboptimal valuation strategy (even without social factors). Let me illustrate why we need ‘if and only if’ with Table 6.

Suppose that a firm has two projects and two valuation methods: {Green-high, Green-low} x {NPV, interview}. NPV is a representative SCBM. Expert interview is a popular qualitative method that firms use before launching new projects. The sets of projects and valuation methods generate the following hypothetical table as a value space. The first and second numbers in parenthesis are value and net accuracy respectively.

***** Table 6 *****

Clearly, the firm is in dilemma. NPV is always more accurate and supports green-low. On the other hand, while interview is less accurate, it is overwhelmingly for green-high and against green-low. Thus, even if the firm perceives NPV as the most accurate valuation strategy, the firm may not always choose (green-low, NPV) pair instead of

(green-high, interview). One solution is Bayesian encompass: taking weighted average of the qualitative and quantitative information in the example. However, it is a semantic issue whether we can call it as SCBM. We may not want to call the linear combination of NPV and a qualitative index as SCBM. Rather than arguing everything is the variation of NPV, we regard SCBM specific in order to find richer implications. The problem in the example is that the ordering of perceived value (V) changes significantly as the valuation method (s) changes. If all $s \in S$ generate similar ordering, such problem would not exist. In this case, however, there is no reason to stick to NPV over other methods because all methods produce similar results anyway.

Lemma 5: Suppose social factors do not exist. If $V_s = 0$ for all s and k , SCBM is always the optimal valuation strategy.

We allow more general class SCBM than commonly presumed ones. For instance, we allow the possibility that a firm may not always choose the highest NPV project as Table 7 illustrates. Suppose NPV is the only valuation method a firm has. (V, B) pair for project can be,

***** Table 7 *****

In this situation, the firm values green-low the twice of green-high, but only with the half of confidence/ accuracy. It might be hard to model the post-green-low situation or to consider all complexities involved in green-low contracts. It is uncertain which strategy the firm selects. Then, when does a firm select the highest NPV project? Next lemma answers the question.

Lemma 6: Suppose social factors do not exist. If $V_s = 0$ and $\Delta V_k / \Delta B_k \geq 0$ for all s

and k , a firm selects the project with the highest value measured with SCBM.

If the perceived value and accuracy tend to move with the types of projects, we have the well-known situation of choosing highest NPV projects. In sum, SCBM is in general suboptimal method of valuation. In addition, even if SCBM is the only valuation tool a firm has, it is generally suboptimal to select a project with highest NPV.

Social factors and the deviation from SCBM

Next, let us discuss the importance of organizational/ social factors. Without loss of generality, let us assume $V_s = 0$ and introduce only the controversy with a weighting parameter δ . Then the goal becomes $G(V, B, \delta C)$. The formula reverts to the previous with $\delta = 0$. We will show that δ increases the deviation from SCBM. The first order condition with respect to s and k becomes:

$$G_B B_s + \delta G_C C_s = 0.$$

$$G_V V_k + G_B B_k + \delta G_C C_k = 0.$$

The first equation in the first-order conditions is relevant because it expresses s as the implicit function k in consideration of B and C . Let us rewrite it as: $B_s = -\delta G_C C_s / G_B$. In contrast to SCBM, we do not have $B_s = 0$ unless δ , G_C or C_s is zero. δ and G_C have the same intuition to determine the relative importance of controversy. C_s specifies how sensitively subgroups respond to the change of valuation method. Same intuition holds for uncertainty (U). Thus, we have following proposition.

Proposition 7: Suppose $V_s = 0$ for all s and k . SCBM is always optimal valuation strategy if

- The relative importance of social factors, controversy and uncertainty, are zero. Or,
- The sensitivities of social factors with respect to valuation methods are zero. Or,
- The social factors cancel their effects each other.

As the social factors become important, an organization needs to balance the impact of valuation strategies on accuracy and on social factors. $G_B B_s$ term measures how the change of valuation strategy affects the level of accuracy and consequently the organizational goal. In case accuracy is the only concern of valuation, an organization would change valuation method until the marginal value of further change becomes zero. By definition, such valuation method is SCBM. Notice G_B is always positive.

On the other hand, $-\delta G_C C_s$ is the cost of changing valuation strategy. The change in valuation method generates social impact by δC_s , which in turn affects the organizational goal by G_C . Given this cost, an organization cannot mindlessly pursue accuracy in valuation, but allows valuation method to deviate from SCBM in order to balance the social factor and accuracy as: $G_B B_s = -\delta G_C C_s$. Next empirical predictions summarize such intuition.

Predictions 8: To denote $NSCBM \equiv GCBM \setminus SCBM$ for green projects,

- The more important the social factors become; the more NSCBM is used.
- The more sensitive the social factors become with respect to valuation methods; the more NSCBM is used.
- The importance of controversy and uncertainty increases the use of NSCBM.

Kang, Burton and Mitchell (2010) classify capital budgeting practices into four groups to enrich the set of NSCBM \equiv GCBM\SCBM. They argue that, (1) for low Knightian uncertainty and low controversy, the financially-oriented SCBM works well; (2) under high Knightian uncertainty and high controversy, firms instead turn to qualitative socio-political methodologies; (3) high Knightian uncertainty and low controversy leads to what they label the plausibility approach; (4) low Knightian uncertainty and high controversy leads to what they refer to as the coordination approach.

The plausibility approach includes environmental scanning, scenario planning, goal setting, and related techniques. This reasoning is in line with Cyert and March (1963) which propose the assumption of uncertainty avoidance. Schmeidler (1989), Boudreaux and Holcombe (1989), and Gilboa and Schmeidler (1989) similarly discuss how firms attempt avoiding Knightian uncertainty, even under risk neutrality. It is important to note that some plausibility approaches like scenario planning can overlap with SCBM. However, the plausibility approach helps a firm avoid and manage uncertainty, rather than begin by analyzing uncertain projects in order to make a choice as SCBM.

The coordination/ negotiation approach contains various negotiation mechanisms such as issue list, voting, bargaining to enlarge the opportunity set as one group wins one issue in exchange for winning on a different issue, consensus-building meetings, and top-down resolution by the CEO. Underlying assumption is that the firm needs to resolve controversy at the point of decision while controversy can be beneficial before reaching the decision points. Jacobides and Croson (2001), Gulati, Lawrence, and Puranam (2005), Kretschmer and Puranam (2008), and Kaplan (2008) discuss organizational processes about communication, coordination, and contests that firms apply to address controversies.

The socio-political methods are variations of Bower Model. Bower discusses his

model as follows.

The processes by which resources are committed in turn involve (1) intellectual activities of perception, analysis, and choice which are often subsumed under the rubric ‘decision making’; (2) the social process of implementing formulated policies by means of organizational structure, systems of measurement and allocation, and systems for reward and punishment, and finally (3) the dynamic process of revising policy as changes in organizational resources and environment change the context of the original policy problem. (Bower, 1970: 7-8)

Social construction and value space

Value space is a key framework in this paper. It presumes a strong version of constructive epistemology since it can allow environmental variables to influence the choice of frames in order to perceive reality. Berger and Luckmann (1966) are well-known proponents of social constructionist argument. Our value space idea is subtly different from theirs discussed in their 1966 book, *The Social Construction of Reality*. The book argues that social relations construct knowledge. Social interactions result in institutionalization, the process of which embeds meaning in society. Since people live in the society covered with the layers of institutions, they perceive socially constructed reality.

Value space idea is slightly different from that of Berger and Luckmann. Since it allows people to select frames (i.e. valuation methods), it includes the neoclassical economist’s view on choices. It is possible that people choose the frames of perceiving object in order to optimize their goals such as preference. Thus, value space idea incorporates the views of both neoclassical economists and constructionists like Berger and Luckmann. If the institutional restriction on the set of frames is strong, value space

idea converges to the sociologists' views. If the restriction is weak enough, it becomes neoclassical views. Of course, it can be arguable to distinguish the sociologists and economists perspectives only with the restriction on the set of frames. For instance, standard financial economics argues that NPV is the optimal frame for valuation. It regards other methods as suboptimal. In that sense, the standard view imposes strong restriction on the set of frames. However, since the choice of NPV does not involve any social influences explicitly, NPV is not sociological.

To summarize, value space is an important concept in valuation. It stresses that firms make choice in two-dimensional space of valuation strategies and investment opportunities. The key idea of value space is the separation of objects and frames, in which actors observe objects through the choice of frames. Since objects and frames can be correlated with each other, value space rejects the assumption of the dichotomy between objects and frames. In this sense, the intuition of value space becomes similar to The Social Construction of Reality (Berger and Luckmann, 1966) as social factors influence the choice of frames.

Discussion

We extend existing approaches in order to explain broader patterns about capital budgeting for which traditional literature offers less practical and adequate explanations. We presume that a firm makes selection on the set of valuation methods and investment opportunities to maximize the goal of an organization seeking green agendas. The goal increases with financial factors (value, accuracy) and decreases with disruptive social factors (controversy / lack of consensus, uncertainty). In comparison, traditional approaches are the valuation strategies given an investment opportunity to generate the most accurate ordering of the projects.

Traditional approaches achieve optimality under special circumstances such as: (1) A firm considers accuracy only. (2) A firm wants to maximize its perceived firm value, but value and accuracy co-move with respect to valuation strategies and investment opportunities. (3) A firm wants to optimize environmental consideration, but social factors and accuracy co-move with respect to valuation strategies and investment opportunities. (4) A firm wants to balance value, accuracy and social factors when those variables all co-move with respect to valuation strategies and investment opportunities.

One of the significant generalizations of our approach is to model firms to make choice in the value space, the two-dimensional space of valuation strategies and investment opportunities. This setting overcomes the dichotomy between valuation strategies and perceived value, which we argue is an implicit assumption of traditional approaches. Rejecting the dichotomy, our approach makes it possible to model investing decisions with fewer assumptions, to consider the social construction of the meaning of investment opportunities, to incorporate organizational influences, and to generalize capital budgeting subject to the social and organizational influences. Intuitively, the absence of social influence can be thought of as a special case of social influence. Thus, traditional approaches are the special cases of our approach.

Importantly, simple firm value maximization may not be a proper goal of firms when we expand the choice set of firms into the two dimensional value space from one-dimensional space of investment opportunities. If the value maximization is the sole purpose in capital budgeting, a firm will choose the valuation method that inflates the value of investment opportunities most. This case may be realistic in explaining some extreme moral hazards such as Enron and the valuation of Level-3 assets by some investment banks in 2008 credit turmoil, but it offers limited generalizability to other cases.

Let us explain how our approach nests traditional approaches as a special case in

further detail. First, traditional approaches like net present value are optimal when a firm sorts pre-determined projects only upon accuracy. When accuracy is the only factor, traditional approaches are the optimal solution by definition. This case can be less desirable because valuation is not an end, but a means to conduct proper investment.

Second, traditional approaches are optimal when a firm wants to maximize its perceived firm value, but value and accuracy co-move with respect to valuation strategies and investment opportunities. This case admits that accuracy maximization is not the only concern in capital budgeting. Indeed, capital budgeting is for investment, which in turn is for increasing firm value. However, as we explained, the firm-value maximization may not be the sole objective either when the choice set is the value space. This problem disappears when accuracy co-moves with valuation. In this situation, a firm just applies a valuation strategy that inflates the value of investment opportunities most. And, by assumption, the most inflating method happens to be the most accurate method as well. Thus, traditional approaches are optimal. However, this case may not occur too often in practice.

Third, traditional approaches are optimal when a firm wants to optimize social/environmental consideration, but social factors and accuracy co-move with respect to valuation strategies and investment opportunities. It is possible that the objective of investment is purely to increase organizational consensus on green financing projects or to resolve uncertainty in business environment. Nevertheless, it would be less interesting to examine an investment purely for green consideration. In addition, this case is similar to the second case: just swap perceived value with environmental consideration. Thus, this condition requires that the solution to optimize environmental consideration becomes also the solution for accuracy maximization. Clearly, this case is as rare as the second one.

Finally, traditional approaches are optimal when a firm wants to balance value, accuracy and social/ social factors when the variables all co-move with respect to valuation

strategies and investment opportunities. If all factors move together with respect to both valuation strategies and investment opportunities, it is sufficient to optimize in one variable such as accuracy in order to achieve global optimality. However, this assumption of co-movement implies very specific and strong functional forms for value, accuracy and social factors. Therefore, this fourth case is very rare.

The above conditions have a common property. Traditional approaches are optimal only under certain correlation structure: if the marginal values of perceived value, accuracy and social/ social factors co-move with respect to both valuation strategies and investment opportunities. Since the marginal value of accuracy is zero in traditional approaches, the marginal values for others should be zero too in order for traditional approaches to become optimal. If they are not zero, the optimality of traditional approaches to maximize the goal fails. In particular, the marginal values of social factors matter if the goal is sensitive to social factors or the social factors are sensitive to valuation strategies and investment opportunities. We call the first and the second as the importance and sensitivity of social factors to organizational goals. Therefore, when the social factors are important and sensitive, the optimality of the traditional approaches breaks down.

In conclusion, it is possible to understand traditional approaches as special cases of our approach, or our approach as a generalized theory of capital budgeting in the presence of green financing projects. In addition, such special cases in which traditional approaches are optimal are atypical. However, it is important to remind that our approach is the extension rather than the rejection of traditional approaches, and makes the boundary of traditional approaches sharper. Knowing such boundary conditions and limitations would help managers to understand and implement traditional approaches for green financing projects. While standard corporate finance textbooks details traditional approaches extensively, they usually neglect its boundary conditions. In contrast, our

approach warns managers from applying traditional approaches perfunctorily during capital budgeting without considering organizational, social and social factors.

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Table 1: Evaluating a green financing project with two different evaluation approaches

(1's payoff, 2's payoff)	Perceived accuracy	State 1 (Prob. = 50%)	State 2 (Prob. = 50%)
Method 1: <i>High diffusion</i>	50%	Project 1:(100, -60)	Project 1:(-60, 100)
		Project 2:(15, 15)	Project 2:(15, 15)
Method 2: <i>Low diffusion</i>	50%	Project 1:(50, -30)	Project 1:(-30, 50)
		Project 2:(15, 15)	Project 2:(15, 15)

The first and second elements in parentheses mean the payoff to 1st and 2nd players respectively.

Table 2: Evaluating Green-low and Green-high projects with two valuation methods

(Internal payoff, External payoff)	Perceived accuracy	State 1 (Prob. = 50%)	State 2 (Prob. = 50%)
Method 1: High- diffusion	60%	Green-Low :(100, -60)	Green-Low :(50, -30)
		Green-High:(24, -2)	Green-High:(12, -1)
Method 2: Low- diffusion	50%	Green-Low :(50, -30)	Green-Low :(25, -15)
		Green-High:(24, -2)	Green-High:(12, -1)

The first and second elements in parentheses mean the payoff to internal and external stakeholders respectively.

Table 3: Choosing accuracy of valuation under social conflicts

(team1, team2)	Perceived accuracy	State 1 (Prob. = 50%)	State 2 (Prob. = 50%)
FINE	60%	GREEN-LOW:(100, -60)	GREEN-LOW:(-60, 100)
		GREEN-HIGH:(18, 12)	GREEN-HIGH:(12, 18)
COARSE	40%	GREEN-LOW:(20, 20)	
		GREEN-HIGH:(15, 15)	

The first and second elements in parentheses mean the payoff to team 1 and team 2 respectively.

Table 4: Procedural justice

(team1, team2)	Perceived accuracy	GREEN-LOW	GREEN-HIGH
Domination	60%	(100, -60)	(15, 15)
Participation	50%	(50, -30)	(15, 15)

The first and second elements in parentheses mean the payoff to team 1 and team 2 respectively.

Table 5: Concept summaries about Green Capital Budgeting Model (GCBM)

GCBM concepts	Definition	References
Goal	Objective function that firms maximize, increasing in perceived value and accuracy, but decreasing in controversy and uncertainty	Cyert & March (1963), Simon (1964)
Valuation strategy	Theoretical tool to perceive raw investment opportunities. When a valuation strategy meets raw investment opportunities, four meanings are generated: perceived value, accuracy, controversy and uncertainty	Baldwin & Clark (1992), Porter (1992), Brealey, Myers, & Allen (2005), Ross, Westerfield & Jaffe (2002)
Investment opportunities	Raw investment opportunity: investment opportunities before they are recognized with valuation strategy. They originate from inside or outside of firms. Perceived investment opportunity: investment opportunities after they are recognized with valuation strategy	Baldwin & Clark (1992), Porter (1992), Brealey, Myers, & Allen (2005), Ross, Westerfield & Jaffe (2002)
Internal resource allocation	Redistribution of resources that a firm has property right over in order to realize investment opportunities.	Cyert & March (1963), Bower (1970), Bower & Gilbert (2005)
Net accuracy	Gross accuracy minus cost of accuracy when a valuation strategy is used for an investment opportunity	Simon (1947, 1955), Bettman, Luce, & Payne (1998)
Controversy	The interaction of social ties in terms of strength, density, stickiness, positivity/ negativity and asymmetry in response to perceived investment opportunity. Agency problems in economics. It is the issues occurring in any multi-agent organization.	Cyert and March, 1963; Bower (1970); Burton, DeSanctis, and Obel 2006
Uncertainty	Knightian uncertainty which is immeasurable and qualitative	Knight (1921), Keynes (1921), & Winter (1982), Spender (1989)

Table 6: Accuracy and valuation

(V, B)	GREEN-HIGH	GREEN-LOW
NPV	(-1, 1)	(1, 1.2)
Interview	(10, 1/2)	(-10, 1.2/2)

Table 7: Perceived value and projects

(V, B)	Green-high	Green-low
NPV	(1, 2)	(2, 1)