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The world can doubtless never be well known by theory: practice is absolutely necessary; but surely it is of great use to a young man, before he sets out for that country, full of mazes, windings, and turnings, to have at least a general map of it, made by some experienced traveler.

– Lord Chesterfield[1]

A descriptive taxonomic classification system for decision problems is intellectually satisfying; however, it provides little instruction on how the taxonomy can be used to guide the decision-maker. Once a classification is established using a taxonomy, the decision-maker is left searching the space of all possible solution methodologies for one that can solve the problem. This paper provides some actionable guidance for the decision-maker to narrow the search. This guidance is presented in the form of several frameworks that are validated using a number of examples.

THE DUALITY OF DECISION ORDERS

The three decision orders (first, second, and third) each have two related descriptors, which will be called the primal and dual elements.[2] It is the alignment, or matching, of the two elements that dictates the optimal solution methodology. The primal elements are called the "characteristics" of the decision problem, while the dual elements are labeled the "approaches." To achieve alignment, the dual element must align to the primal element. In other words, the approaches must align to the characteristics of the decision problem.

Characteristics

Attributes of the decision problem are called the characteristics. They are the descriptors of the decision problem of interest and serve to indicate its essential quality or nature. Reviewing the definitions of first-order, second-order, and third-order exposes many of these characteristic descriptors[3].

- First-order

First-order problems/decisions typically have static properties and are associated with high levels of certainty and simplicity. These problems/decisions are often described by the literature using words like: simple, reversible, certain, low-risk, static, small, short-term, understood, common etc. Problems and decisions that are classified as first-order typically have well established solution methodologies, characterized by rational deterministic "if-then" rules and deductive procedures.

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[1] First published 1774 and reproduced in The Letters of the Earl of Chesterfield to His Son, vol. 1, no. 190, ed. by Charles Strachey, 1901.

[2] The terms "primal" and "dual" are borrowed from the classic operations research methodology called linear programming (LP). The mathematical solution to a linear program requires the simultaneous solution to both the primal and dual formulations. For example, if the primal formulation is about maximizing the sales revenue from the seller's viewpoint, the corresponding dual formulation may be about minimizing the purchasing cost from the buyer's viewpoint. If both the primal and dual problems converge to the same solution, the solution will be optimal for both parties in the transaction (Note: in this example, an optimal solution may not be possible).

[3] For more details on the taxonomic descriptors see (Scherpereel 2002).

- Second-order

Second-order problems/decisions are those that have probabilistic uncertainty, are often complicated, and follow definable dynamic processes. These would be characterized with words like: complicated, stochastic, probabilistic, optimizing, efficient, frequent, irreversible, medium-risk, medium-term, etc. Problems and decisions that are classified as second-order rely on probability theory and inductive logic for solutions. They are typically approached using axioms, computer simulations, and a constrained model of the actual phenomena of interest.

- Third-order

Third-order problems/decisions are those that have genuine uncertainty, complexity, and dynamics. These are characterized with words like: complex, irrevocable, ambiguous, high-risk, important, big, long-term, subjective, tacit etc. Third-order problems/decisions rely on abductive logic and heuristic solutions. The objective is to find an acceptability and effectiveness in the results.

The classification of a new decision problem requires the identification of certain describable characteristics, which are used to place it as a member of a particular decision order. The characteristics become the "essence" of the decision problem. Since characteristics are observable physically or through a mental visualization, they are called the primal elements. The primal elements take the first priority in how the decision problem is classified within the taxonomy funnel in Figure 1.

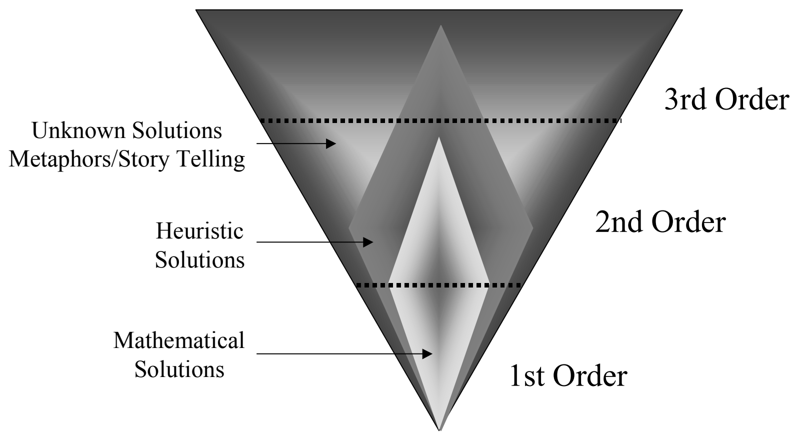

Figure 1: The Decision Order Taxonomy Funnel

Approaches

Unlike characteristics, which are inherent descriptors of the decision problem, approaches represent the derived elements: approaches are derived in the sense that they are manifestations of the decision-maker's previous attempts at solving the particular decision problem. Since they are derived from historical applications and the result of a process called mental simulation,[4] derived approaches have a greater degree of uncertainty associated with them. In a situation in which alignment has occurred, the characteristics will often dictate the approaches. Thus, the approach elements are of secondary importance and can be defined as the dual to the characteristic elements.

In alignment, the same taxonomic classification would be made if only the approach elements are specified and no information is given on the characteristic elements, as when only the characteristic elements are specified and no information is provided on the approach elements. This highlights the basic property of decision order duality. Alignment requires that a decision problem's primal classification be the same as its dual classification. If

[4] The process called "mental simulation" is described by Klein as "the ability to imagine people and objects consciously and to transform those people and objects through several transitions, finally picturing them in a different way than at the start. This process is not just building a static snapshot. Rather, it is building a sequence of snapshots to play out and observe what occurs" (Klein 1998, p. 45).

the primal classification and the dual classification are not equivalent, then the decision problem is in a state of misalignment.

Two generic causes are identified for decision problem misalignment. First the dual elements, or the approaches, are not appropriate for the decision problem of interest. For example, the decision-maker approaches the decision problem assuming a static environment when the actual environment is dynamic. The second cause of decision problem misalignment is that the decision-maker mistakenly perceives the primal elements, or the characteristics. For example, the decision-maker may have characterized the decision problem as complex when in actuality the decision problem is simple and thus, has a deterministic solution that will go unrecognized.
The next section develops a framework to help the decision-maker correct for decision problem misalignment once it is recognized.

DECISION ORDER FRAMEWORK

The primal and dual elements, introduced in the previous section, can be used to define a two-dimensional space in which all decision problems can be located. Application of the decision order taxonomy defines precisely where decision problems lie within this space. By definition, if a decision problem is located on the forty-five degree bisecting line within this space it is considered "aligned," or having approaches (dual elements) that match the characteristics (primal elements). The decision problems located above the bisecting line can be repositioned into alignment either by constraining or by redefining the decision problem's primal elements. This is equivalent to bringing the primal elements into alignment with the dual elements.

For example, the problem of eliminating mice from a house can generate an infinite number of proposals from using dynamite to getting a cat. The decision-maker's allergy to cats and desire to retain use of the house after the removal of the mice starts the process of constraining and redefining the problem. Eventually, this redefinition process will converge on a set of aligned approach solutions that are acceptable. The approach selected by the decision-maker may be the use of a traditional mousetrap. In this process, the decision problem, defined as eliminating mice from a house, is systematically constrained so that acceptable solution methodologies become available. The example illustrates the process of bringing the primal elements into alignment with the dual elements.

Similarly, decision problems that fall below the forty-five degree bisecting line are also considered to be in misalignment. Moving these decision problems into alignment requires a change in the decision-maker's knowledge or understanding of the phenomena. The process involves matching the dual elements to the fixed primal elements. In this move, the decision problem's characteristics are fixed and new approaches are sought.
Returning to the mice elimination example, the decision problem is now constrained in such a way that no acceptable solution methodology can be identified. The decision-maker is an animal rights activist, and cannot allow any harm to come to the mice. The decision-maker also believes that traps that simply incarcerate the mice will psychologically traumatize them. The decision problem characteristics are fixed, but no acceptable approach is available. The decision-maker is now faced with the task of developing a better mousetrap. Through extensive research into mouse psychology, the decision-maker discovers that mice dislike atonal music[5] and will quickly leave the area where atonal music is being played. Thus, a new solution approach is identified. The decision order framework prescribes this process as bringing the dual elements into alignment with the primal elements.
Figure 2 provides a simple visual representation of the decision problem alignment problem. Solid arrows that are parallel to the primal and dual axes indicate the incremental movements toward alignment within the decision order space. Seminal movements are also allowed in this framework but cannot be represented statically. A seminal move implies that the decision problem is fundamentally changed, and can be visualized as a discontinuity in the incremental progression. These changes are perhaps the result of breaking an established paradigm and are indicative of a change in the taxonomic classification.

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[5] Atonal music is designed to deliberately avoid the traditional musical key or tonal center. To the novice's ear, atonal music sounds as if the instruments are not properly tuned.

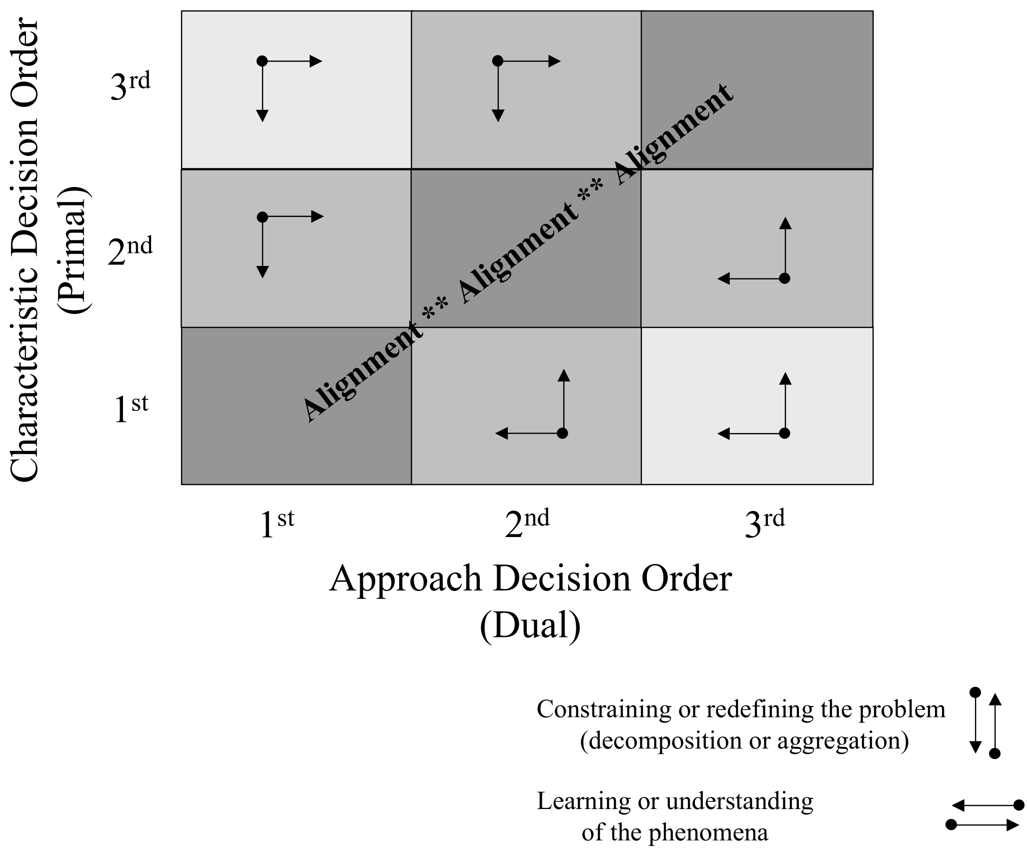

Figure 2: Decision Order Framework

The key insight to be taken from the decision order framework is that the decision problems lying above or below the bisecting line are indicating a misalignment and require some further action by the decision-maker/problem-solver. The next several sections present examples, using the decision order framework to guide the decision-maker/problem-solver behavior. The first example presents the application of the decision order framework as a conceptual toolbox for keeping all known approach methodologies. This toolbox contains the prescriptive guidance needed by the decision-maker. The conceptual toolbox example is followed by several other examples highlighting the prescriptive, communicative, and descriptive value of the decision order framework. The intent of these examples is to provide some validity to the alignment construct, in addition to illustrating how different decision problems might be fit within the framework.

DECISION ORDERS IN ACADEMIC RESEARCH

The first example explores the problem-solving world of academic researchers. Since this is a world where logical thinkers are supposed to be able to explore the problem solution space without bounds, it should be rich in incremental progress and seminal discovery. In the decision order framework, incremental progress is visualized as the alignment of the primal characteristics with the dual approaches, following the constraining or learning arrows in Figure 2. The forty-five degree bisection of the decision-order space contains the academic's aligned metaphorical toolbox. The toolbox contains all known techniques for making decisions and solving problems. Some of the representative contents are illustrated in Figure 3.

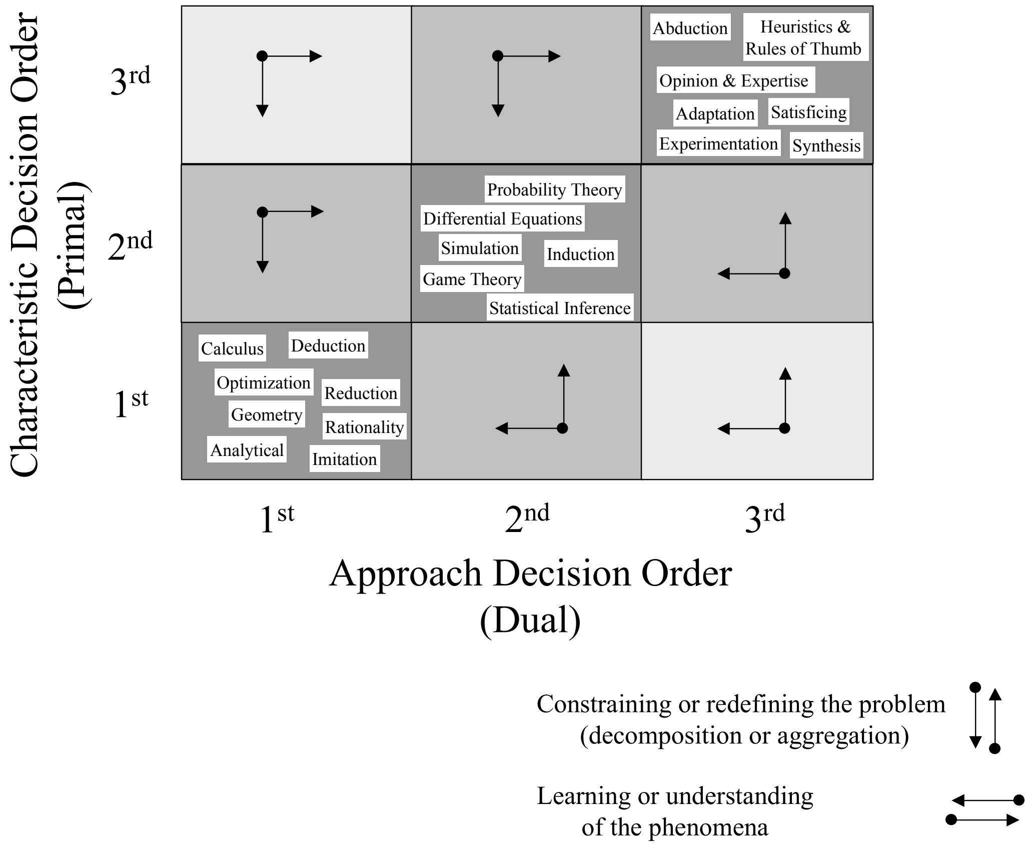

Figure 3: A Generic Decision Order Toolbox

The mission of academics and scientists is to better understand the problem to be solved or the decision to be made and to find new approaches that aid in this effort. This mission is a focus of the decision order framework and is indicated in Figure 3 by a progression along the axes' arrows. Movements that are counter to these arrows represent poor research. For example, if the decision problem can be reasonably characterized as first-order, science should not be searching for methodologies designed for second and third-order problems. Pursuing this search is equivalent to taking a problem having a known, deterministic, first-order solution and attempting to apply a third-order heuristic. This is perhaps an interesting intellectual exercise, but no advance has been made since the aligned first-order solution is still superior. This argument can be illustrated with the problem of finding the third angle of a triangle when two other angles are known. This problem can be solved using the first-order mathematical formula from geometry: $180 - \text{angle}_1^{(\text{known})} - \text{angle}_2^{(\text{known})} = \text{angle}_3^{(\text{unknown})}$. To develop or apply a third-order heuristic that depends on the current sun spot activity might be interesting but it is not likely to provide a superior solution methodology.

A more common pursuit by academic researchers is attempting to apply tools from the known toolbox to problems of different decision orders. This is the trap of searching for applications that don't fit the methodology in the hope that through serendipity and luck the known tool might solve the problem. Often this technique requires the actual problem to be arbitrarily redefined and constrained to fit the available tool. Rather then constraining and redefining the problem a-priori based on theory, the problem is redefined after the solution methodological choice is made. This is the theoretical equivalent to collecting and analyzing empirical data before formulating the hypothesis and then claiming that the data has proven the hypothesis.

These examples illustrate that good research conforms to the decision order framework and poor research violates it. This concept is illustrated in Figure 4. Although it is feasible to conjecture that seminal advancement can come from poor research practices, it is hypothesized that this may be the result of pure chance. It is more likely that major seminal advancements like Einstein's theory of relativity come from good research practices. The decision order framework prescribes those good practices.

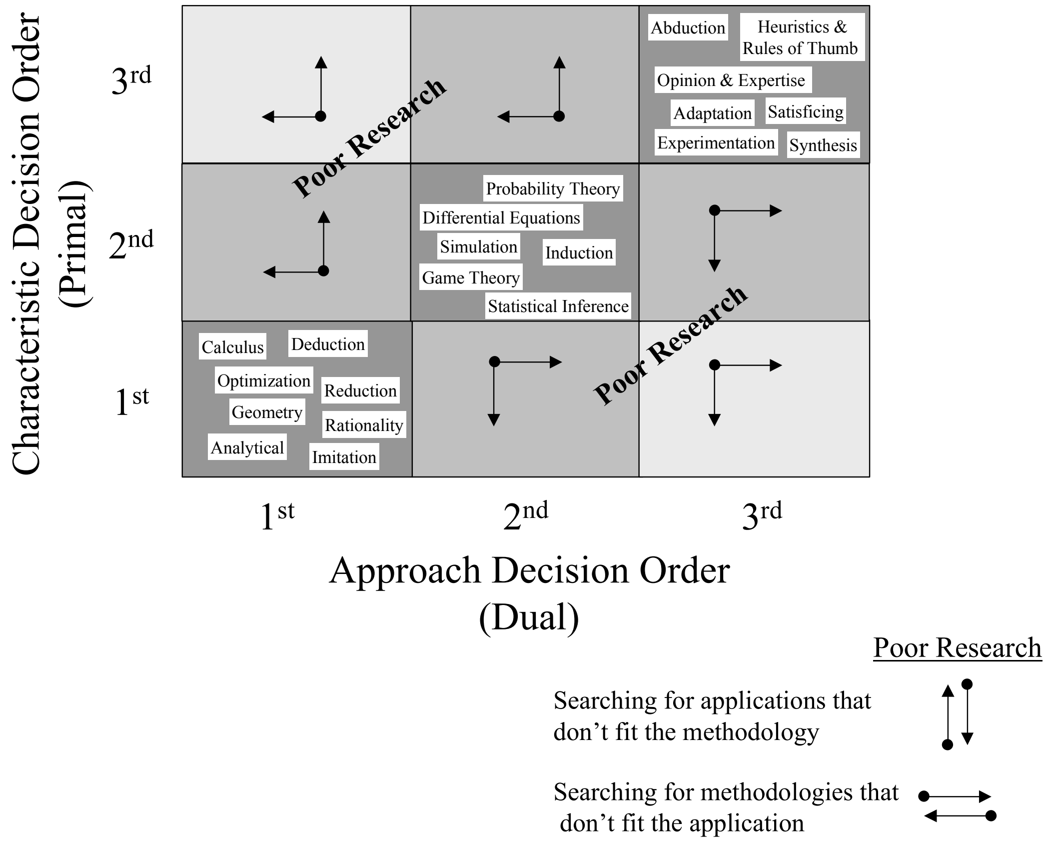

Figure 4: Poor Research in the Decision Order Framework

The Decision Order Toolbox for Decision-Making

Alternative decision-making theories identified from the literature fit like tools into the decision order framework's metaphorical toolbox. Some possible placements are illustrated in Figure 5. These are not absolute placements, but instead represent the decision order region where the theories have garnered the greatest success. The decision theories that fall along the alignment axis have received some level of general acceptance within the field of study. Although the accepted paradigms may give these theories greater application reach than their static locations indicate, decision order framework suggests limiting the application to problems of a particular order. Choosing or developing an alternative tool can better address applications that exist beyond the confines of a particular order.

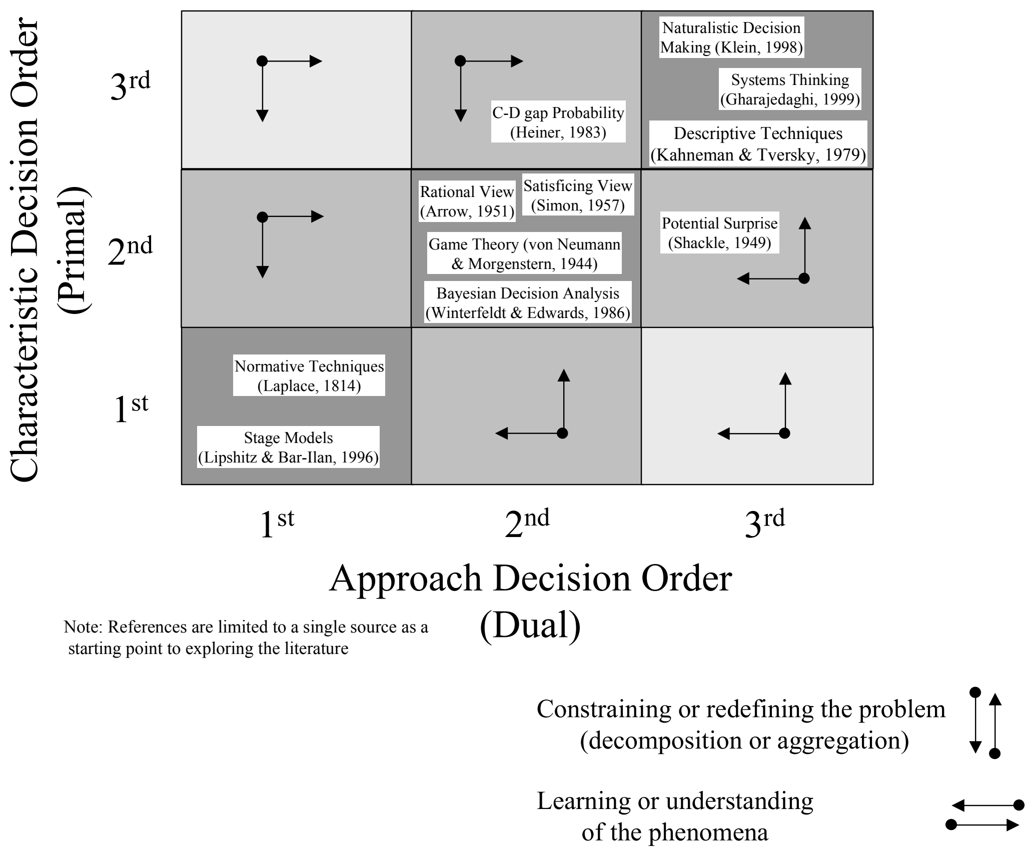

Figure 5: "Decision-Making" Order Toolbox

The theories indicated off the alignment axis represent those theories that afford significant challenges to the existing paradigms or require additional development to fit within the current paradigms. Notably, Shackle's (Shackle 1949) theory on potential surprise challenges the probability theory paradigm, which maintains a central role in game theory and Bayesian decision analysis. To reach wider acceptance, Shackle's theory will require advancement in the generally accepted understanding of second-order problems or it will be grudgingly, and perhaps appropriately, repositioned[6] to the less rigorous toolbox for heuristic third-order solution methodologies.

Heiner's (Heiner 1983) C-D gap probability theory is also positioned off the alignment axis. Although not a direct attack on the established methodologies, it requires some significant changes in the underlying assumptions and constraints common to traditional methodologies. The decision problem addressed by Heiner is clearly third-order, incorporating genuine uncertainty, however the probabilistic tools utilized are second-order. This misalignment is believed to be the reason that Heiner's quantitative techniques have not yet been incorporated into a

[6] Shackle (Shackle 1949) is quite adamant that potential surprise is superior to probability theory in addressing decision problems (see Chapter 7 of "Expectations in Economics," 1949). Unfortunately, his attack focuses on the application of probability techniques to problems that would be classified as third-order decisions by the decision order taxonomy. This focus is evident in Shackle's (Shackle 1949) opening remarks: "The frequency-ratio concept of probability is suitable and essential for the purposes of mathematical statistics. But as a means of analyzing those original acts of mind, involving degrees of doubt and belief assigned to the products of imagination, which are what I mean by expectation, it is essentially and radically inappropriate" (p. ix). Although, generally discounted by the established literature (Arrow 1951), Shackle's (Shackle 1949) theory of potential surprise accurately attacked the misapplication of probability theory. In the process Shackle boasted his theory's generality, and positioned it as a replacement for probability theory (the placement illustrated in Figure 5). A better placement and greater acceptance might be gained by repositioning it to a third-order methodology.

major theory of decision-making.[7] Thus, Heiner's (Heiner 1983) C-D gap theory is viewed as either requiring some additional problem constraints to align it within the second-order problem space, or requiring a loosening of the mathematical rigor to allow the qualitative insights to be supported in the third-order problem space.

The solution methodologies along the alignment axis have proven valuable in approaching decision problems within their defined decision order space. Starting in the lower left corner (first-order decision space) of Figure 5 are the stage models. These models are promoted as generally applicable to all decision orders. However, they find their greatest success in assisting decision-makers/problem-solvers with first-order decision problems. The models in the first-order decision space typically use normative techniques that claim prescriptive capabilities. Aligned research in this region tends to define decision problems as solvable by following an orderly sequence of stages (Dewey 1933).

The middle region could be argued as the most actively researched, at least among the quantitatively inclined research establishment. In this region are found a voluminous number of theories based on logical reasoning, rational argument, and probability calculus. Aligned research in this region tends to view decision problems as choice among "a set of conceivable actions which an individual could take, each of which lead to certain consequences" (Arrow 1951, p. 404).

The promoters of qualitative research typically pursue third-order decision problems, which appear in the upper right hand region of Figure 5. The focus in third-order decision problem research is on providing good descriptive heuristics that apply in real world settings. Third-order decision problems are considered holistically and therefore they tend to support some type of systems perspective. Since there is little attempt at rigorous proof, only circumstantial support, this toolbox tends to support a hodgepodge of sometimes-conflicting methodologies. Decision theories aligned with this region are perceived as occurring in "a world in which there is autonomous or creative decision-making … one in which the future is not merely unknown, but unknowable" (O'Driscoll and Rizzo 1985, p. 2). An unknown future precludes prescriptive prediction. Instead, third-order tools claim to offer prescriptive guidance in crafting an acceptable future.

DECISION ORDERS IN ACTION

The next example presents several economic decision problems and issues that have been decomposed and researched from a number of different perspectives. In this example, the decision order taxonomy is used to map out the historical evolution of perspectives in the decision order space. This process is called decision order mapping. The point of this process is to demonstrate usefulness of the decision order taxonomy in directing the decision-maker/problem-solver toward the right solution methodology for the right decision problem. It should be evident from the development of this example that the decision order framework offers a powerful instrument for organizing the decision-maker's toolbox.

This economic theory example precedes an exploration of the real world decision problem of designing appropriate education/training programs. By identifying where specific education programs fit within the decision order space, it is possible to make aligned program selections. It is reasoned that these aligned selections have the greatest possibility of achieving the decision-maker's learning objectives. Thus, the value of the decision order framework as a decision-making guide is reinforced.

Finally, an example covering decision orders in e-commerce organizations is less rigorously developed. Because this problem is relatively new in its formulation, the number of generally accepted methodologies is limited; therefore, the focus is on using the decision order framework to communicate metaphorically the decision problem that an e-commerce organization presents.

Decision Order Mapping – economic theory example

The example chosen to illustrate decision order mapping covers a broad range of economic theory. The intent is to capture the evolution of economic thought and show how particular methodologies have developed around the alignment of the dual (approaches) elements with the primal (characteristics) elements. References are limited to movements that are considered "good" advancing research in the fields of interest.[8] In all cases, the

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[7] Despite the reluctance to recognize the quantitative contributions, Heiner's (Heiner 1983) qualitative insights remain a seminal contribution to the decision-making literature.

[8] "Good" advancing research is defined by Figure 2 and is contrasted to "poor" research in Figure 4.

debate illustrated centers on the defining characteristics of the decision problem so that appropriate methodologies can be developed and utilized.

Entrepreneurship

The problem of entrepreneurship addressed by this example focuses on what role entrepreneurship takes in economic activity. Some of the decision problems associated with this focus include:

- To what extent can the roles of entrepreneur and capitalist be separated?
- Is the function of the entrepreneur to create profit opportunities or merely to react to those opportunities that exist but have not yet been recognized?
- Is the entrepreneur central to economic analysis?
- Does the economic system create the entrepreneur or does the entrepreneur create the economic system?

These are difficult issues that have produced a number of divergent approaches that have emerged since the term "entrepreneur" was introduced by a Frenchman, Richard Cantillion [1680-1734], as representing the economy's risk taker, opportunist, and decision-maker (Cantillion 1755). A contemporary of Cantillion was Francois Quesnay [1694-1774] who added the concept of capital provider to the characterization of the entrepreneur. This conceptualization spurred the second-order development of entrepreneur's capitalist role in classical English economic analysis. This evolution is depicted in Figure 6. As a second-order decision problem, the entrepreneur issue could be approached as a peripheral factor in economic analysis, and could be analyzed using traditional first and second-order economic methodologies.

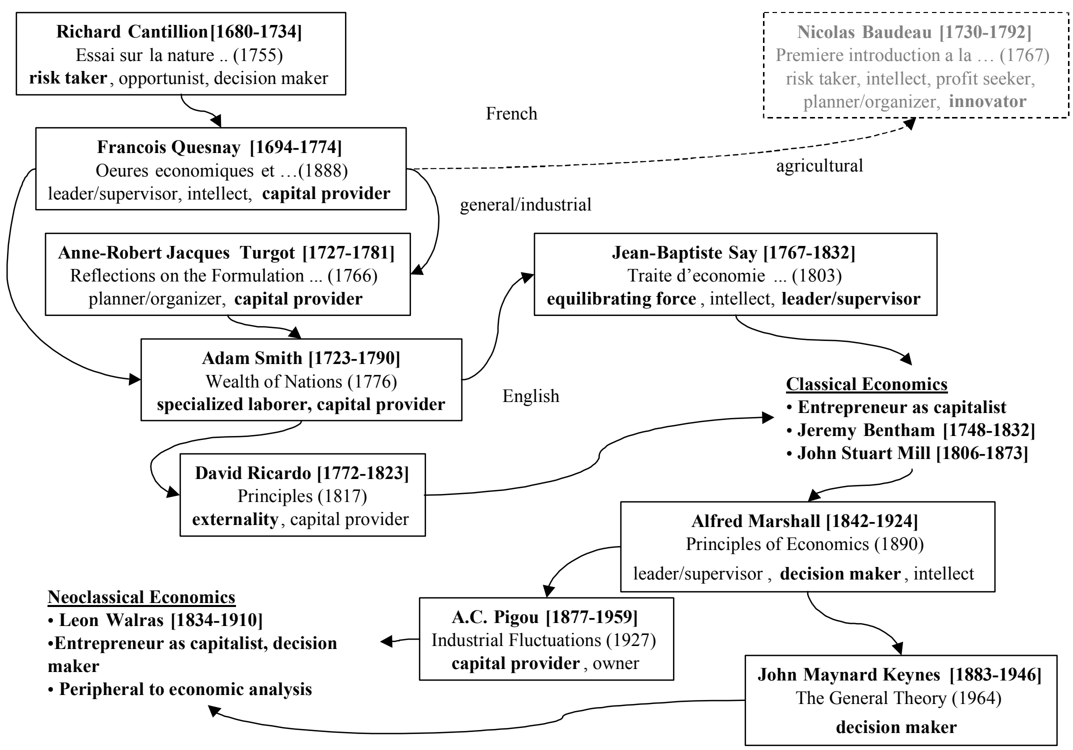

Figure 6: Evolution of the Capitalist Entrepreneur

The insight by Nicolas Baudeau [1730-1792] that an innovative entrepreneur directed the agricultural economy added an additional dimension to the characterization. Adding this innovative dimension redefined the problem as third-order. Both the German and Austrian economists embraced the redefinition. The eventual evolution led to the seminal work of Joseph Schumpeter [1883-1950] that characterized the entrepreneur as an innovator and "dis-equibriating" force, and Frank Knight's [1885-1972] recognition of the entrepreneur as an uncertainty bearer (in contrast to traditional risk bearing role). Other researchers refined these characterizations focusing on the creative and reactive descriptors of the entrepreneur. A more detailed evolution is depicted in Figure 7. These efforts positioned the entrepreneur as central to economic analysis and focused the search on third-order solution approaches.

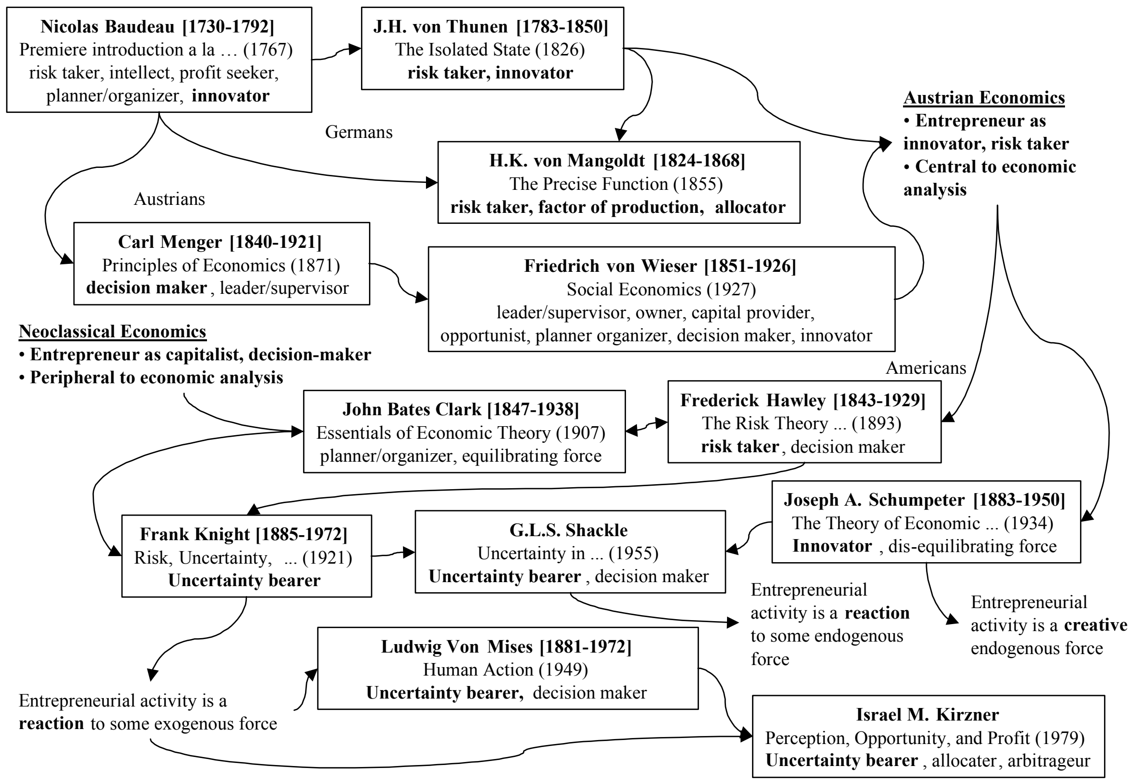

Figure 7: Evolution of the Innovative Entrepreneur

The Theory of the Firm

A similar evolution can be recognized in the "theory of the firm," a theory typically attributed to the seminal work of Ronald Coase. Coase (Coase 1937) asked the fundamental question "Why do firms exist?" In exploring this issue, Coase (Coase 1937) proposed that the existence of three costs is sufficient to answer the question:

- Cost of using the price mechanism
- Cost of executing contracts for market transactions
- Cost of "qualitative coordination"[9] under uncertainty

These three costs roughly demarcate the three approaches to decision problems defined by the decision order framework. First the "cost of using the price mechanism" supported the neoclassical line of economic thought and promoted the inclusion of the economic firm into price theory, profit maximization, and marginal analysis.[10] A theory of the firm assessed as a first-order decision problem gained wide support among the traditional economic establishment since these first-order methodologies allowed precise quantitative assessments. Similar to the discussion of the capitalist entrepreneur, this first-order classification places the firm on the periphery of economic analysis.

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[9] Qualitative coordination is used by Langlois (Langlois 1995) to describe "coordination involving the transmission of information beyond price and quality."

[10] For references to traditional classical economic theory, see Samualson and Nordhaus (Samualson and Nordhaus 1998).

The second cost identified by Coase (Coase 1937), "the cost of executing contracts for market transactions," is now widely accepted as a methodology for evaluating the firm's existence as a second-order problem. The seminal work of Williamson (Williamson 1975; Williamson 1985) resulted in "transaction cost economics," and provided the basic analytical tools explaining the emergence of the second-order firm. Thus, the firm was brought back into the analysis as an essential element that could be understood quantitatively. Other contributions to evolving this theory are illustrated in Figure 8.

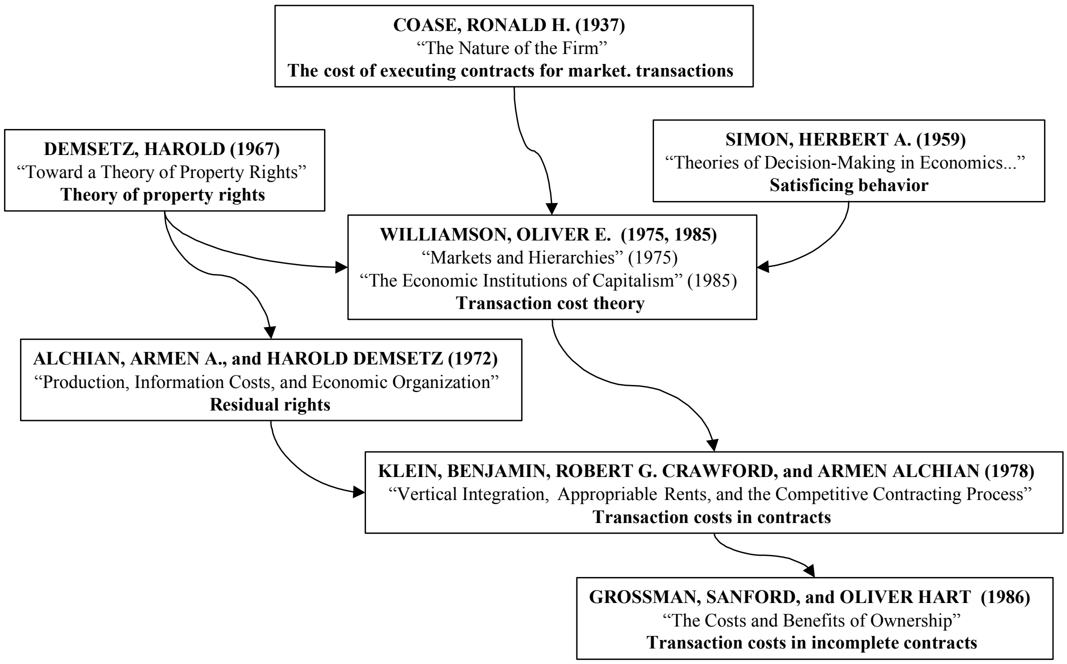

Figure 8: The Cost of Executing Contracts for Market Transactions

Finally, the last cost identified by Coase (Coase 1937), "the cost of qualitative coordination under uncertainty," took the theory of the firm into the region of third-order methodologies. Under this classification, new theories emerged such as the behavioral theory of the firm (Cyert and March 1963), agency theory of the firm (Jensen and Meckling 1976), capabilities theory of the firm (Richardson 1972), and the evolution theory of the firm (Nelson and Winter 1973). Other theorists' contributions to the development of these third-order methodologies can be seen in Figure 9.

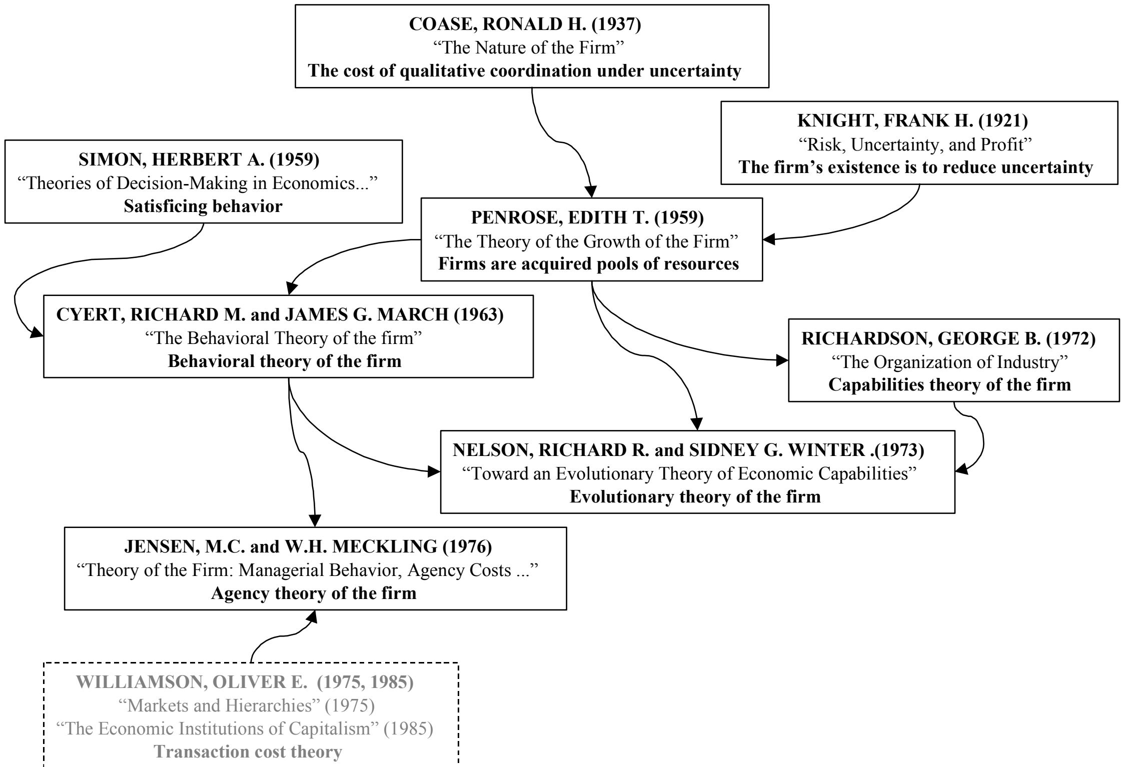

Figure 9: The Cost of Qualitative Coordination under Uncertainty

No single theory aligns exactly to all three costs identified by Coase (Coase 1937). This suggests that a determination of the importance of each cost must be made prior to selection of a solution methodology. Hence, the decision problem's characteristics must be identified and a classification must be made prior to implementing a solution methodology. The decision order taxonomy offers this classification and the decision order framework organizes the analytical methodologies available for application.

Valuation

The theories of the entrepreneur and the firm take aim at the characterization of the decision problem or the primal element. The concept of valuation focuses on developing the approach or dual element. The valuation decision problem is chosen specifically because it highlights a clear example of researchers attempting to apply second-order methodologies to third-order decision problems.[11] Although the qualitative insights of this application may provide some valuable third-order heuristics (Leslie and Michaels 1997; Luehrman 1998; Amram and Kulatilaka 1999; Scherpereel 2002), the direct extension of these quantitative techniques[12] to third-order decision problems exemplifies a misguided effort, under the assumptions of the decision order framework.

The decision problem of valuation in this section is restricted to economic value. Focus is placed on methodologies for assessing the economic value that could be obtained by transferring ownership rights of a tangible or intangible asset. For example the value that could be realized from the following would be included: participating in a fair game of chance, determining the fair purchase price of an asset, and evaluating the value of a capital investment. The evolution of valuation typically begins with third-order approximations that often fail in offering their users reliable information. Motivated by the advantages that reliable valuation provides, new and

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[11] For insight into this effort, see the "real options" literature of Dixit and Pindyck (Dixit and Pindyck 1994) and Trigeorgis (Trigeorgis 1995; Trigeorgis 1996).

[12] The quantitative techniques referred to by this statement are those developed to solve first and second-order decision problems.

better methodologies are conceived. Some of these methodologies progress understanding toward alignment, while others become forgotten attempts.

Three specific valuation decision problems are selected for decision order mapping: fair gambles, financial options, and non-financial options. The first decision problem of valuing a fair gamble, is motivated by the challenge to only participate in a fair gamble when the chance of winning is greater than the chance of losing. This is the decision problem confronting the founders of the frequency branch of probability theory. Using third-order intuition and first-order deductive mathematics, Pascal and Fermat were able to develop a first-order solution methodology to the perceived third-order problem. Their solution methodology clearly placed valuation of fair gambles in the first-order decision space.

The second decision problem of valuing financial options has similar motivations. The goal is to develop a methodology that will allow the decision-maker to purchase options from the marketplace when the chance of profiting is greater than the chance of losing. However, the problem is much more complex than a fair gamble, since the frequency of past valuations is not substantially relevant to future valuations. Black and Scholes (Black and Scholes 1973) and Merton (Merton 1973) overcame this difficulty. Rather than pursuing a strategy to extend frequency probability theory, which proved so effective at valuing the fair gambling decision problem, Black and Scholes (Black and Scholes 1973) and Merton (Merton 1973) sought greater understanding of the decision problem. Through this investigation, they were able to identify a number of unique characteristics present in financial options that clearly classified the valuation problem as second-order.[13] This discovery allowed Black and Scholes (Black and Scholes 1973), Merton (Merton 1973) and others to develop second-order methodologies and led to several reliable techniques for valuing simple financial options.

While the previous two valuation decision problems met with success, the decision problem of discovering a methodology for valuing real non-financial options remains elusive. A possible reason for this difficulty is that these options are not packaged in simple repeatable forms. Every real option is unique and presents a new perceived third-order decision problem. The decision order framework suggests focusing on developing a better understanding of the real options problem and/or investigating third-order solution methodologies.

Motivated by the success in financial option valuations, some qualitatively inclined researchers view the development of third-order solution methodologies as unsatisfying. Therefore, there is continual pressure to artificially constrain real options problems to fit existing second-order financial option valuation methods.[14] Although these attempts demonstrate creative mathematical wizardry, they fail to provide reliable solutions to actual real options problems. Thus, the final analysis of real options has relied on applying the qualitative insights and analogies drawn from financial option valuations.[15] This approach suggests that the real option valuation problem is a third-order decision problem. Given the third-order uncertainty present in these problems, the real option valuation problem is likely to continue its defiance of quantitative attempts at reclassification.

The Decision Order Map

This example of decision order mapping illustrates the alignment of three significant economic decision problems: The theory of the entrepreneur, the theory of the firm, and valuation. As emphasized in the presentation of these decision problems, the alignment process began with seminal insights (and abductive logic) along the third-order characteristic tier of decision problems, or along the third-order approach column. This progression is summarized in the decision order mapping visualization highlighted in Figure 10.

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[13] These assumptions are detailed in Chriss (Chriss 1997) and include: frictionless market, liquid market, competitive market, hedging, no-arbitrage, and an assumption regarding the underlying process (Brownian motion was assumed in these early developments).

[14] This can be seen in the research of Dixit and Pindyck (Dixit and Pindyck 1994) and Trigeorgis (Trigeorgis 1995; Trigeorgis 1996).

[15] The focus on qualitative analogy to financial option valuation can be found in the work of Scherpereel (Scherpereel 2002), Amram and Kulatilaka (Amram and Kulatilaka 1999), Luehrman (Luehrman 1998), and Leslie and Michaels (Leslie and Michaels 1997).

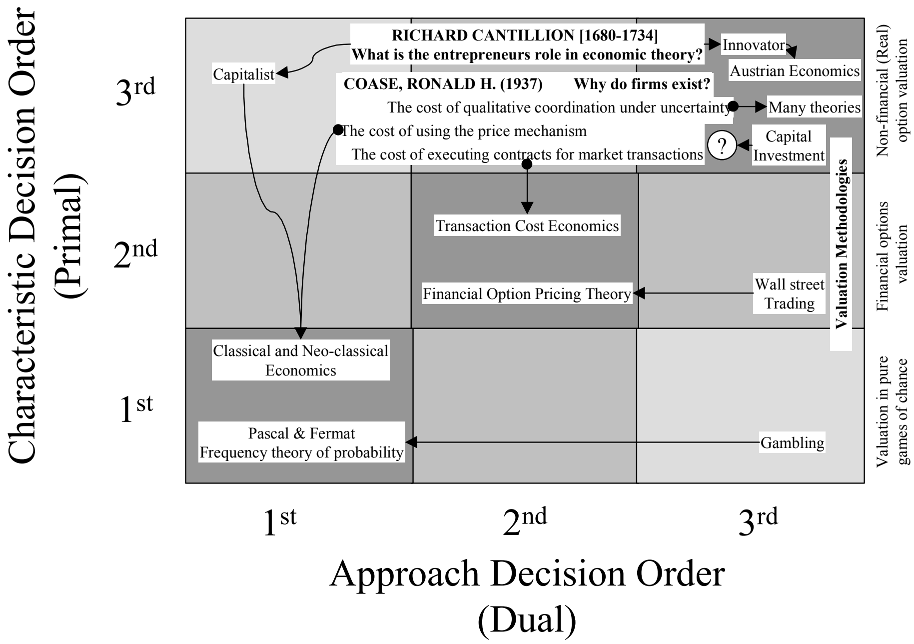

Figure 10: Example of Decision Order Alignment Map

Aligned methodologies represent acceptable characterizations or approaches to be applied to decision problems. Many scientific efforts are launched that deviate from the alignment process and, if they gain wide acceptance, become theoretical paradigms. Other efforts are launched to expand the applicability of successfully aligned theories to neighboring decision problem classes. This latter effort was illustrated in the discussion of applying financial options valuations to other non-financial investment decisions. Although the qualitative insights offered by this attempt may contribute to an emerging theory, directly applying current second-order quantitative theory represents a misalignment and is unlikely to gain broad application or acceptance.

This discussion exemplifies the value that decision order theory offers decision-makers who are attempting to position theories in context and who are hoping to effectively direct theoretical development efforts. When a particular theory's development is mapped out in the decision order framework, it clearly identifies appropriate solution methodologies. If no methodology is available, decision order mapping focuses the search effort on the most likely candidates.

Decision Orders in Education

This example presents a possible toolbox for decision-makers entrusted with the problem of selecting appropriately educated individuals or education methodologies. The decision order framework is used to organize the different education methodologies so that aligned selections can be made based on the decision-maker's hiring or education objectives. If the objective is to increase the organizations basic skills through education, the decision-maker can select aligned methodologies from the first-order region of the decision order framework's toolbox. In contrast, if the objective is to hire creative people the decision maker should be guided toward individuals educated in using the methodologies found in the third-order region.

This hypothetical "education" orders toolbox is illustrated in Figure 11. The aligned first-order region contains basic skills training methodologies needed for the "doers" in an organization. The focus in this region is on deductive logic, defined rules and exact results. Decision-makers interested in this region can typically obtain real-time quantitative verification of success in reaching their objectives.

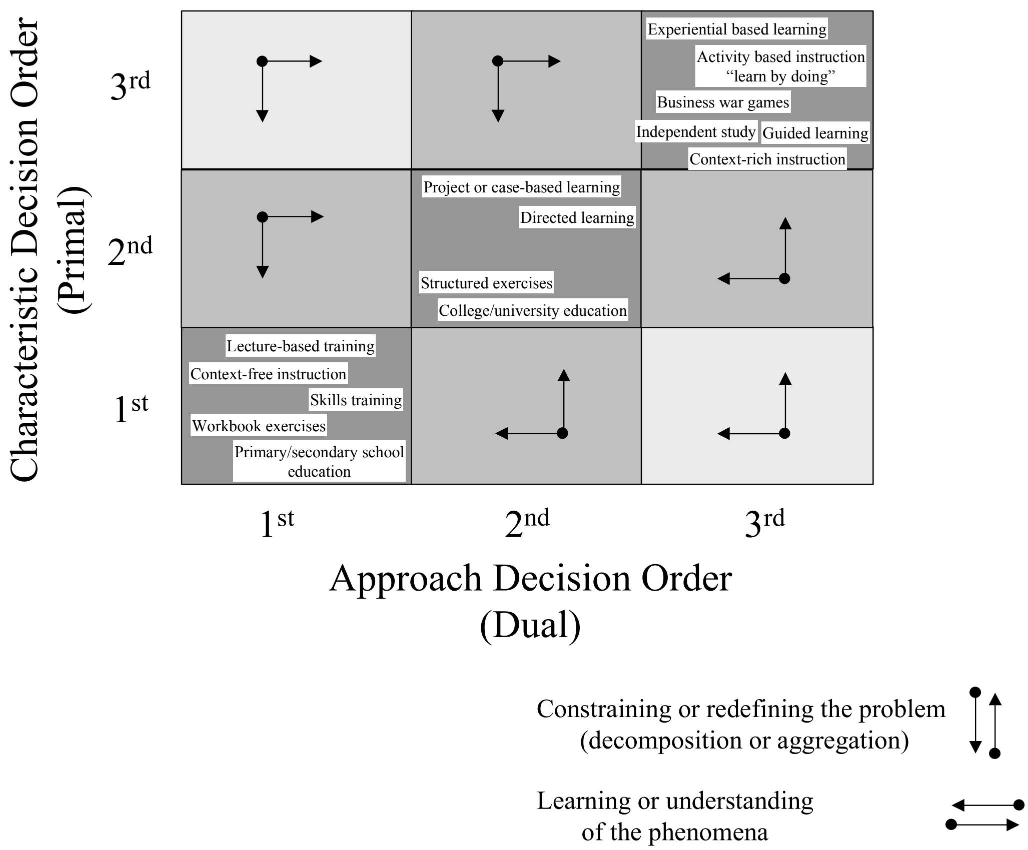

Figure 11: “Education” Order Toolbox

The second-order region of the toolbox offers tactical skills education for the “solvers” in the organization. The focus is placed on developing inductive logic, establishing procedures, and obtaining consistent results. Measuring success in meeting the decision-maker’s objectives often lags the education, and therefore, meaningful quantitative measurement linked exclusively to the education becomes difficult.

The last region in the toolbox is focused on developing abductive logic, synthesizing complex information, and obtaining usable results. This type of education is targeted at the strategic “formulators,” or leaders, in the organization. To measure the success of these education methodologies is extremely difficult because of the long lag time between that actual education and the realization of a measurable result. Instead, third-order education requires the identification of indicator objectives from which success can be inferred.

A logical extension of this “education” orders toolbox is to include aligned measurement and evaluation methodologies. A number of these methodologies were alluded to in the discussion of each decision order region. However, this extension is not pursued, since the purpose of this example is to simply illustrate the possibilities of using the decision order framework to build toolboxes for real-world decision problems.

Decision Orders in eCommerce

The last example illustrates the use of the decision order framework to communicate a major shift in the order of a decision problem. Once the shift is identified and the new classification is communicated, the decision order framework provides guidance in searching for understanding. To illustrate this point, the concept of changing business models is presented. The term “business model” is used in this discussion as a descriptor for the business’s physical organization and how it responds to marketplace dynamics.

The growth of the Internet trade, or e-commerce, has created a new marketplace that is dramatically different from the one faced by traditional businesses. As pointed out by Evans and Wurster (Evans and Wurster 2000) the Internet has deconstructed the traditional tradeoff between “richness and reach.” This implies that products and services available on the Internet can potentially reach geographically distributed consumers with customer-intimate personal richness. Achieving the same levels of richness possible on the Internet required traditional business to physically locate near selected larger consumer populations and often sacrifice the reach into smaller but related population groups.

How can this change be represented in the decision order framework? The deconstruction of the richness and reach tradeoff changes the marketplace so that the first and second-order rules and procedures established in the traditional marketplace no longer apply. The traditional business models no longer function effectively. The net result is a decision problem that is blown to the third-order boundaries of decision order space. The business models take on perceived third-order qualities in approach and characterization. This change is visualized in Figure 12.

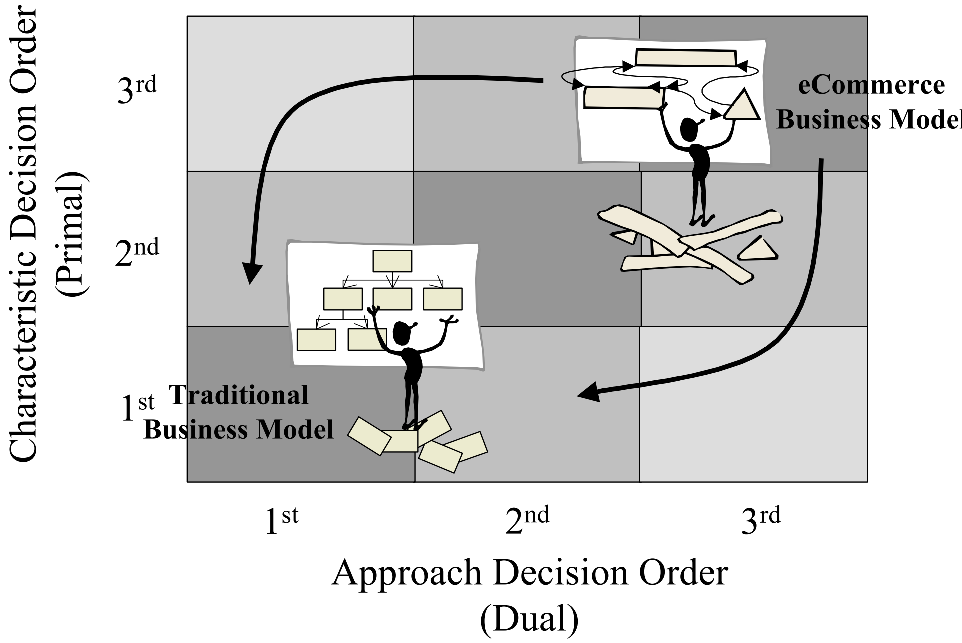

Figure 12: Communication of the eCommerce Decision Problem

The unresolved issue is whether or not e-commerce business models will continue to require third-order methodologies. If the Internet marketplace dynamics stabilize, will the perception of e-commerce business models evolve to be characterized as more of a second or even first-order issue? If this characterization evolves, will standard methodologies and practices be developed for competing in the Internet marketplace? The answers are still to be determined. However, the decision order theory toolbox is available to help the decision-maker cope while waiting for seminal discoveries to be made.

INTRODUCING THE NEXT LEVEL OF COMPLEXITY

It is presumptuous to believe that all decision problems can be classified uniquely by the decision order taxonomy and be subjected smoothly to the decision order framework. This issue is evidenced implicitly in the previous examples. Some decision-problems are only perceived to be of a particular order and this perception is evolved over time. Further investigation of the inherent decomposability of decision problems is needed.
The decision order framework, introduced in this paper, makes a strong case that there exists an underlying pattern to decision problems. To exploit this pattern, the decision order framework is developed to guide researchers and decision makers toward appropriate solution methodologies. Ultimately, it is the alignment of taxonomic characterization with available approaches that determines the adequacy of any decision.

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